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OFINU

Open Food Innovation University (OFINU)

Study module

“Milk processing technology”

WORKBOOK

for students

2024

Summary

The workbook is elaborated within the project “Open Food Innovation University" (OFINU), being in implementation with support of the European Union Erasmus+ Programme.

Overall objective of the project - to modernise food innovation and technology related higher education in Uzbekistan and Tajikistan, thereby increasing the quality and ensuring relevance of the higher education to the needs of the socio-economic growth of the countries concerned and especially of their regions.

Full partners:
- Lead partner: Latvia University of Life Sciences and Technologies
- Uzbekistan: Samarkand Agro-innovations and Research University, Andijan Institute of Agriculture and Agro-technologies
- Tajikistan: Technological University of Tajikistan, Kulob Institute of Technology and Innovation Management, Isfara Branch of the Technological University of Tajikistan
- Slovakia: Slovak University of Agriculture in Nitra

Associated partners in Uzbekistan:
- A group of companies "AGROMIR"
- "Navigul" MCHJ QK
- “Samarqand don mahsulotlari” JC (Samarkand grain products)

Associated partners in Tajikistan:
- CJSC “Combinati Shiri Dushanbe”
- LTD "Orion Rustam"
- Association of Entrepreneurs of Khatlon

The project implementation period: 01/02/2024 - 31/01/2027.

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Partner universities and their academic staff, involved in the development of the study course:

P1 LBTU. Latvia University of Life Sciences and Technologies

Jelena Zagorska - milk processing technology, jelena.zagorska@lbtu.lv, zoom

Tatjana Kince - dairy processing equipment, tatjana.kince@lbtu.lv

Evita Straumite - sensory evaluation of dairy products, evita.straumite@lbtu.lv

Egija Sproge - HACCAP, egita@pardotprieks.lv

Sandra Muižniece-Brasava - dairy processing equipment; packaging, sandra.muizniece@lbtu.lv

P2 SAMARU. Samarkand Agroinnovations and Research University

Shakhista Ishniyazova, ishniyazova04@gmail.com

Jurabek Nuraliev, jurabeknur1992@gmail.com

P3 AIAA. Andijan Institute of Agriculture and Agro-technologies

Rakhim Mirzaev, jurabeknur1992@gmail.com

P4 TUT. Technological University of Tajikistan

Khurshed IKROMI, x_teshaev@yahoo.com

P5 KITIM. Kulob Institute of Technology and Innovation Management

Mirzo AZIZOV, mirzoazizov60@gmail.com

P6 BTUTI. Branch of the Technological University of Tajikistan in the city of Isfara

Kimyohon Musayamova, Kimyohonmusayamova@gmail.com

P7 SUA. Slovak University of Agriculture in Nitra

Miroslav Šlosár, miroslav.slosar@uniag.sk

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Theme of the study course

The study module “Milk processing technology” includes the following topics: technological process and equipment, packaging materials and equipment, raw materials and product quality evaluation, including sensory evaluation. Quality management assurances in milk processing. A lecturer with knowledge in the specific field is involved in the implementation of each section in order to achieve the goal of the study module.

Learning methods

The main pedagogical methods taught are as follows: learner-centred approach, competence-based approach, experiential learning, cooperative learning, and interactive learning. The training includes practicing methods, as well as an introduction to modern learning analytics, which can be used to support the engagement and responsibility of a student, and to support assessment.

Highly appreciated are the knowledge and skills to produce and deliver classes and lectures in the distance learning format, because the application of this method broadens the availability of the experts and worldwide knowledge (inviting entrepreneurs, foreign academic staff etc. as lecturers), can be applied in the case of double diploma studies, provide opportunity to study for persons having limited possibilities to take part in full-time studies (young mothers, students with disabilities). Distance learning is very effective for specific courses when the participation of lecturers from foreign partner universities is crucial and discussions between students with diverse experiences and visions are needed to explain and demonstrate possibilities and various solutions and options. The first feedback from the academic staff who have introduced the new methods has demonstrated positive effects, such as:

1) Transformation of teaching approaches at faculties.

2) The learner-centred approach has empowered students to take charge of their own learning, leading to increased engagement and motivation.

3) Students have become more proactive in seeking knowledge and are more participative in class discussions.

4) The use of digital tools for interactive learning has made classes more dynamic and accessible – the students can access learning materials from anywhere, leading to increased flexibility and convenience.

5) The collaborative nature of some of these methods has also led to increased interaction and rapport between the faculty and the students.

Master classes – open lecture discussions, involving internal and external stakeholders, is a new form of teaching and communication of higher education to the society, adopted at the involved UZ universities during the implementation of the project.

Course Schedule

Thematic Study Plan for the "Milk Processing Technology" Module

Date, Time	Study form	Theme	Lecturer
Theme 1 - Chemical composition and quality of milk			
1st day	Lecture (1h)	1. L. Preliminary lecture.	J. Zagorska
	Lecture (2h)	Synthesis and secretion of milk, composition (milk of different agricultural animals), production (breakdown by country, production volumes, prices) (2 h, T).	J. Zagorska
	Laboratory work (4h)	L. w. Analysis of the chemical composition of milk (protein, fat, lactose, dry matter content by different methods) (3 h, T).	J. Zagorska
2nd day	Lecture (4h)	Characteristics of individual milk ingredients (water, protein (distribution techniques), lipids, lactose, vitamins, minerals, enzymes, bactericides and antibodies) (4 h, T).	J. Zagorska
	Laboratory work (3h)	L. w. Milk protein coagulation techniques (3 h, T).	J. Zagorska
3rd day	Lecture (2h)	2. L. Milk quality, regulatory legislation, internal company standards and requirements.	J. Zagorska
	Laboratory work (2h)	L. w. Microbiological quality analysis (total, *enterobacteria, lactic acid bacteria*) and milk storage temperature.	J. Zagorska
4th day	Lecture (2h)	L. Milk sensory, physicochemical and microbiological indicators, quality factors. Quality control needs and capabilities.	J. Zagorska
	Laboratory work (3h)	L. w. The importance of milk quality (acidity, pH determination, freezing temperature, antibiotic presence with different method).	J. Zagorska

	Seminar (1h)	Evaluation of results obtained during laboratory work.	J. Zagorska
Theme 2 - Milk processing – different treatment methods, milk and cream			
5th day	Lecture (2h)	3. L. Mechanical (cooling, filtration, separation, bactofugation, microfiltration, standardisation, decontamination) and heat treatment (types, meaning, affecting milk ingredients) of milk (**2 h, T**).	J. Zagorska
	Laboratory work (3h)	L. w. Milk separation, standardisation, calculations, determination of fat content, preparation of normalized mixture, homogenisation (**3 h, T**)	J. Zagorska
6th day	Lecture (3h)	General equipment (tanks, meters, pumps washing) L.: Machinery for mechanical and thermal treatment of milk, principle of operation (**3 h, T.e**). (L)	S. Muižniece-Brasava
	Laboratory work (3h)	Machinery for mechanical and thermal treatment of milk, principle of operation (**3 h, T.e**). T.eL)	S. Muižniece-Brasava
7th day	Lecture (2h)	4. L. Acquisition of heat-treated milk and cream (**2 h, T**).	J. Zagorska
	Laboratory work (5h)	L. w.: Calculation of heat treatment regimes, verification of effectiveness and impact on milk quality (**2 h T, 3 h T.e.**).	J. Zagorska+
Theme 3 - Fermented dairy products: production and quality evaluation			
8th day	Lecture (3h)	5. L. Characteristics of technology, main components of acid milk drinks (3 h, T).	J. Zagorska
	Laboratory work (5h)	L. w. Verification of starter and the effects of various factors on the quality of acid milk products, analysis of lactic acid bacteria (5 h, T).	J. Zagorska
9th day	Lecture (2h)	6. L. Manufacture of dairy products (2 h, T).	J. Zagorska

	Laboratory work (3h)	L. w. Assessment of factors affecting whey synthesis, assessment of the quality of cottage cheese (3 h, T).	J. Zagorska
	Laboratory work (1h)	L.w. Sensory evaluation of fermented dairy products.	E. Straumite
10th day	Lecture (2h)	Equipment for production fermented products (2 h, T.e.) (L).	S. Muižniece-Brasava
	Laboratory work (2h)	Equipment for production fermented products (2 h, T.e.) (2h).	S. Muižniece-Brasava
	Seminar (2 h)	Evaluation of laboratory work results, discussion.	J. Zagorska
11th day	Excursion	Visit to a milk processing company: fermented dairy products.	J. Zagorska
Theme 4 - Butter and ice cream: production technology and quality evaluation			
12th day	Lecture (2h)	7. L. Packaging materials, equipment, principles (2 h, T.e.) for dairy products (liquid and paste).	S. Muižniece-Brasava
	Laboratory work (2h)	L. w. Selection and machinery of packaging materials for products (2 h, T.e.).	S. Muižniece-Brasava
13th day	Lecture (1h)	8. L. Classification of ice cream, raw materials, recipes, calculations, production, ice cream equipment (1 h, T).	J. Zagorska
	Laboratory work (3h)	L. w. Ice cream preparation and quality assessment (3 h, T).	J. Zagorska
	Laboratory work (2h)	L. w. Principles for the operation of refrigeration and refrigeration equipment (2 h, T.e.).	
14th day	Lecture (4h)	9. L. Classification, quality and production of butter and its products, butter-making facilities (2 h, T +2 h, T.e.).	J. Zagorska+
	Laboratory work (3h)	L. w. Preparation and quality assessment of butter (3 h, T).	J. Zagorska
Theme 5 - Cheese: classification, production technology, quality assessment			

15th day	Lecture (6h)	10. L. Cheese, manufacturing processes, assistive products, equipment (4 h, T+ 2 h, T.e.).	J. Zagorska+\S. Muižniece-Brasava
	Seminar (2h)	Cheese variation students reports.	J. Zagorska
16th day	Lecture (2h)	11. L. Cheese production technology, biochemical processes for cheese ripening (4 h, T).	J. Zagorska
	Laboratory work (4h)	L. w. Preparation of cheese, evaluation of cheese quality and microflora (2 h+2h, T).	J. Zagorska
17th day	Lecture (2h)	12. L. Packing, types, materials, equipment of preserved butter, cheese and milk (2 h, P).	J. Zagorska S. Muižniece-Brasava
	Laboratory work (3h)	L. w. Fresh cheese production (3 h, T).	J. Zagorska
	Laboratory work (2h)	L. w. Product packaging solutions (2 h, P).	J. Zagorska
18th day	Lecture (4h)	15. L. Principles, methods, standards (4 h, S) for the sensory evaluation of milk products.	E. Straumite
	Laboratory work (4h)	L. w. Sensory evaluation of dairy products (4 h, S).	E. Straumite
19th day	Excursion	Visit to a milk processing company: cheese production.	J. Zagorska
Theme 6 - Milk products with long shelf life			
20th day	Lecture (4h)	13. L. Milk conservation technology, plants (2 h, T +2 h, T.e).	J. Zagorska+ S. Muižniece-Brasava
	Laboratory work (4h)	L. w. Operation of evaporation and drying equipment, newest solutions (2 h, T.e). L. w. Evaluation of the quality of condensed milk (2 h, T).	 J. Zagorska
Theme 7 - By-products: quality parameters, processing options			
21th day	Lecture (2h)	14. L. By-products of the milk industry, processing technologies and plants (2 h, T).	J. Zagorska

	Laboratory work (3h)	L. w. Principles for the operation of membrane equipment and use of derived products to create new products (3 h, T).	J. Zagorska
Theme 8 - HACCP in dairy processing companies			
22th day	Practical work (8h)	16. P. w. Product safety, definition and monitoring of control and critical control points (8 h, H). 8. Test	E. Sproǵe

Theme 1

Chemical composition and quality of milk

Theoretical materials

Chemical composition of milk

Synthesis and secretion of milk, composition (milk of different agricultural animals), production (breakdown by country, production volumes, prices).

Milk is defined as the **secretion of the mammary glands of mammals**, its primary natural function being:

- nutrition,
- development,
- and providing immunity to the young for some time after birth.

1. Plasma - all components without fats dissolved in water.
2. Serum solution where all components are dispersed in water.
3. Chemical composition of milk.

Table 1.1.

Nutritional composition of milk from different mammalian species (per 100 g) (Muehlhoff et al., 2013)

Parameter	Cow	Camel	Buffalo	Sheep	Human
Water (g)	87.7	84.8	83.2	82.1	87.5
Lactose (g)	4.7	4.2	4.4	5.1	6.9
Total protein (g)	3.3	3.9	4.0	5.6	1.0
Total fat (g)	3.3	5.0	7.5	6.4	4.4
Calcium (mg)	112	154	191	190	32
Phosphorus (mg)	91	132	185	144	14
Potassium (mg)	145	186	112	148	51
Magnesium (mg)	11	8	12	18	3
Sodium (mg)	42	66	47	39	17

B1 (thiamine) (mg)	0.04	0.01	0.05	0.07	0.01
B2 (riboflavin) (mg)	0.2	0.12	0.11	0.34	0.04
B6 (mg)	0.04	0.05	0.33	0.07	-
Retinol (µg)	35	-	69	64	60
Carotenes (µg)	16	-	-	-	7
E (tocopherol) (mg)	0.08	0.15	0.19	0.11	0.08

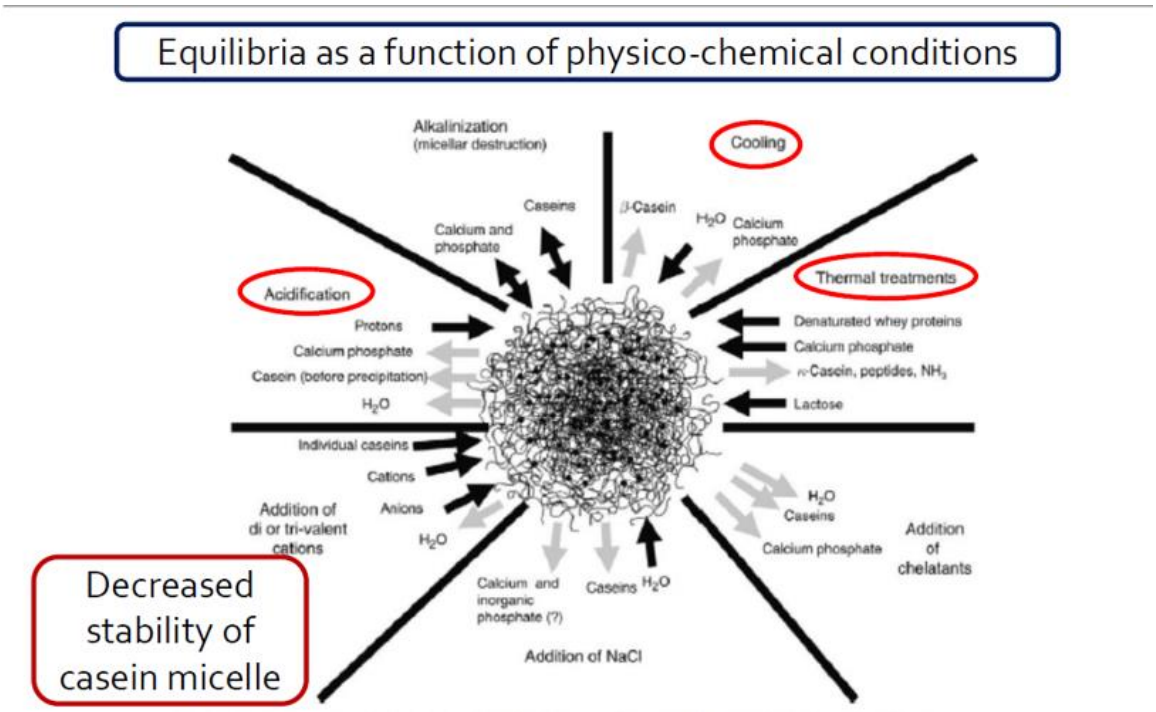


Fig. 1.1. Protein precipitation and coagulation techniques
https://link.springer.com/article/10.1007/s13594-015-0220-y

Abnormal substances in milk

- antibiotics and others medicaments,
- pesticides,
- disinfection and cleaning agents,
- preservatives,
- neutralising substances (H_2O_2, sodium),
- heavy metals,
- mycotoxins.

Table 1.2.

Physico-chemical parameters of cow's milk
https://www.legislation.gov.uk/eur/2004/853/annex/III/section/IX

No.	Parameters	Value
1	acidity	16-18 ºT
2	pH	6,5 – 6,7
3	density	1028 to 1032 kg/m^3
4	freezing point	–0,52 ºC to –0,59 ºC
5	somatic cell count	> 400 000 /mL

Raw bulk milk:

- Colony forming unit, 30^{o}C 1 mL milk not more than 100 000*,
- Milk free from inhibitor, including antibiotics.

Laboratory work

Analysis of the chemical composition of milk

1. Determination of fat content

Separation of fat from milk in butyrometer by centrifuging after dissolving the protein with sulphuric acid, the separation being aided by the addition of a small quantity of amyl alcohol.

Procedure:

Add 10 mL sulphuric acid to the butyrometer followed by 10.77 mL of well-mixed milk. Avoid wetting the neck of the butyrometer. Next add 1 mL of amyl alcohol, insert stopper and shake the butyrometer carefully until the curd dissolves and no white particles can be seen. Place the butyrometer in the water bath at 65 ºC and keep it there for more than 5 minutes. The butyrometer must be placed in the centrifuge with the scale pointing towards the centre of the centrifuge. Spin for 5 min at 1000 rpm. Remove the butyrometers from the centrifuge.

(Note: When transferring the butyrometers from the centrifuge, make sure that the butyrometers are held all the time with the NECKS POINTING UP).

The fat column should be read from the lowest point of the meniscus of the interface of the acid-fat to the 0-mark of the scale and read the butterfat percentage.

The butyrometers should be emptied into a special container for the very corrosive liquid of acid-milk, and the butyrometers should be washed in warm water and dried before the next use.

2. Determination of protein content

Procedure:

20 mL of the milk measured into the conical flask, 2-3 drops of phenolphthalein solution is added and then slowly from the burette, 0.1 M NaOH under continuous mixing until a faint pink colour appears. Then add to the conical flask 4 mL of formaldehyde solution, mix well and slowly from the burette, 0.1 M NaOH under continuous mixing, until a faint pink colour appears that persists for 30 seconds.

Protein content is obtained using the equation:

$$\%=\text{volume of 0.1 M NaOH (in mL)} \times 0.959$$

3. Determination of density of milk

Procedure

The temperature of the milk should be around 20 ^{o}C prior to density measurement. Mix the milk sample gently and pour it gently into a measuring cylinder. Let the aerometer sink slowly into the milk. Read and record the last aerometer degree (kg m^{-3}) just above the surface of the milk. If the temperature of the milk is different from the calibration temperature (calibration temperature may be 20 ^{0}C) of the aerometer, calculate the temperature correction.

European standards expect milk to have a specific gravity of 1027 -1029 kg m^{-3} which implies an aerometer reading range of 27–29 ºA. If the reading is consistently lower than expected and the milk

supplier disputes any wrong doing arrange to take a **genuine sample from the supplier (i.e. inspect milk right from source).**

4. Determination of freezing point of milk

The freezing point of a solution depends on the number of particles in the solvent (water phase of milk), rather than the kind of particles. Water without solutes will freeze at 0° C. The presence of any solutes will depress the freezing point below 0°C. The freezing point of milk depends upon the concentration of water-soluble components.
As milk is more diluted, the freezing point will raise closer to zero. The current official freezing point limit (-0.520 °C).

Pure distilled water freezes at 0^{o}C under normal atmospheric pressure. Milk freezes at a temperature slightly lower than that of water due to the soluble constituents such as lactose, soluble salts, etc., which lower or depresses the freezing point.

The freezing point of cow milk ranges from -0.515^{o} to -0.550^{o} C. The addition of 1% water to milk will raise the freezing point by 0.006 ^{o}C.

Despite the variation in the normal freezing point of milk, it is one of the most constant physical properties of milk. It is therefore considered to be very useful in detecting adulteration of milk with water. The instrument used to determine the freezing point of milk is known as cryoscope. It gives fairly accurate results within a short period. Certain cryoscope indicates the percentage of adulterations (addition of pure water) to milk and the test is considered quite useful for the milk industry.

Procedure
Put the milk sample with pipette into the tube ~ 2.2 mL, then put tube to the CrioStar socket. To start measuring, select with the arrow „Start measurement" and press ENTER. The measurements will start, and values will change, the curve will be created. The temperature will be presented on the vertical axis, but time on the horizontal axis. To stop measuring, ENTER should be pressed one more time. When the freezing point is detected, for example -0,557 °C, the CrioStar starts looking for Plato's regime.

5. Determination of titratable acidity

Titratable acidity is expressed in different units; in Latvia we use Therner degree. Therner's degree is the amount in millilitres of a 0.1 M naOH required to titrate 100 mL of the product to standard pink colour and expressed in ^{o}T (Therner) degree.

Procedure
Take 10 mL of the milk into a conical flask, add 20 mL of distillate water and 2-3 drops of phenolphthalein and then slowly titrate with 0.1 M NaOH under continuous mixing, until a faint pink colour appears that persists for 30 seconds.
Titratable acidity is obtained using the equation:

$$^{o}T = \text{volume of 0.1 M NaOH (ml)} \times 10$$

6. Determination of pH

Procedure

Put a clean and dry electrode into milk and press the *Read* button on the screen of the pH-meter. When the small signal is heard, read the result on the screen**.**

7. Calculation of total solids and not fat solids content in milk

Calculation of Solids-not-fat:

$$SNF=(D+2)/4+0,225*F$$

SNF- Solids not fat, %
D-density of milk sample 20 °C, °A
F-fat content, %

Calculation of total solids:

$$TS=(4.9*F+D+0.5)/4$$

TS – total solids

8. Milk composition testing by Milkoscan Mars™

Procedure

Gently mix the milk sample prior to pouring it into a beaker (around 50 mL). The sample is placed in an apparatus Milkoscan sampler. Students press the Read button and wait 45 seconds before the results appear on the apparatus' screen.
[1]

[1] The laboratory work was developed in collaboration with prof. I.Ciprovica

Results

Table 1.3.

Chemical composition of analysed milk sample

Sample	Fat content, %	Protein content, %	Density of milk, kg/m^3	Freezing point of milk,˚C	Total solids	Non Fat Solids	Acidity of milk, °T	pH

Conclusions:

Approved by _____

(Name, surname, signature)

Date _____

Laboratory work

Milk protein coagulation techniques

1. Precipitation of casein from milk with acids

With organic acids

Procedure

Weigh the empty beaker and record the weight. 250 g of milk is measured into a 400 mL beaker. The pH and milk appearance should be recorded. Milk is heated up to 35 ^{o}C. Add 10 mL of 10% acetic acid solution, and allow the milk to sit for 5 minutes. During coagulation, the temperature should be maintained. Coagulation time is measured. The casein will precipitate into heavy white curds.

Take cheesecloth or an appropriate material bag to cover the top and 2 inches down the sides of a beaker. Using the rubber band, fasten the cheesecloth over the top of the beaker. Pour the curdled milk into the beaker, collecting the curds (casein) in the cheesecloth and allowing the whey to drain off into the bottom of the beaker.

Gather up the cheesecloth with the casein and squeeze the casein until almost dry and then spread out the cheesecloth to let the casein dry for 5 minutes.

Weigh the precipitate together with the cheesecloth, subtracting 18 g (the weight of the cheesecloth) from the total weight and record your results.

The pH of whey and protein structure evaluation should be recorded.

With inorganic acids

Procedure

Weigh the empty beaker and record the weight. 250 g of milk is measured into a 400 mL beaker. The pH and milk appearance should be recorded. Milk is heated up to 35 ^{o}C. Add 10 mL of 10% hydrochloric acid solution, and allow the milk to sit for 5 minutes. During coagulation, the temperature should be maintained. Coagulation time is measured. The casein will precipitate into heavy white curds.

Take cheesecloth or an appropriate material bag to cover the top and 2 inches down the sides of a beaker. Using the rubber band, fasten the cheesecloth over the top of the beaker. Pour the curdled milk into the beaker, collecting the curds (casein) in the cheesecloth and allowing the whey to drain off into the bottom of the baker.

Gather up the cheesecloth with the casein and squeeze the casein until almost dry and then spread out the cheesecloth to let the casein dry for 5 minutes.

Weigh the precipitate together with the cheesecloth, subtracting 18 g (the weight of the cheesecloth) from the total weight and record your results.

The pH of whey and protein structure evaluation should be recorded.

2. Enzymatic coagulation of casein from milk with rennet

Procedure

Weigh the empty beaker and record the weight. 250 g of milk is measured into a 400 mL beaker. The pH and milk appearance should be recorded. Milk is heated up to 35 ^{o}C. Add 0.5 mL of 40% $CaCl_2$ and 1 mL of 1% rennet solution, stir slowly for 2 minutes, and allow the milk to coagulate. Coagulation time is measured. The casein will precipitate into a soft coagulum.

Take cheesecloth or an appropriate material bag to cover the top and 2 inches down the sides of a beaker. Using the rubber band, fasten the cheesecloth over the top of the beaker. Pour the curdled milk into the beaker, collecting the curds (casein) in the cheesecloth and allowing the whey to drain off into the bottom of the baker.

Gather up the cheesecloth with the casein and squeeze the casein until almost dry and then spread out the cheesecloth to let the casein dry for 5 minutes.

Weigh the precipitate together with the cheesecloth, subtracting 18 g (the weight of the cheesecloth) from the total weight and record your results.

The pH of whey and protein structure evaluation should be recorded.

3. Precipitation of casein from milk with calcium chloride

Procedure

Weigh the empty beaker and record the weight. 250 g of milk is measured into a 250 mL beaker. The pH and milk appearance should be recorded. Milk is heated up to 90 ^{o}C holding for 5 minutes. Add 2 mL of 40% $CaCl_2$ solution, stir slowly for 1 minute, and allow the milk to coagulate at the same temperature. Coagulation time is measured. The casein will precipitate into the different sizes of protein grains

Take cheesecloth or appropriate material to cover the top and 2 inches down the sides of a beaker. Using the rubber band, fasten the cheesecloth over the top of the beaker. Pour the curdled milk into the beaker, collecting the curds (casein) in the cheesecloth and allowing the whey to drain off into the bottom of the beaker.

Gather up the cheesecloth with the casein and squeeze the casein until almost dry and then spread out the cheesecloth to let the casein dry for 5 minutes.

Weigh the precipitate together with the cheesecloth, subtracting the weight of the cheesecloth from the total weight and record your results.

The pH of whey and protein structure evaluation should be recorded.

4. Denaturation of whey proteins

Procedure

Weigh the empty beaker and record the weight. 400 g of whey is measured into a pot. The pH and whey appearance should be recorded. Whey is heated up to 90 ^{o}C holding 30 minutes. Denatured whey proteins will precipitate into light flakes (see at the bottom on the beaker).

Take cheesecloth or an appropriate material bag to cover the top and 2 inches down the sides of a beaker. Using the rubber band, fasten the cheesecloth over the top of the beaker. Pour the whey into the beaker, collecting the whey proteins in the cheesecloth and allowing the clarified whey to drain off into the bottom of the beaker.

Gather up the cheesecloth with the whey proteins and squeeze the whey proteins until almost dry and then spread out the cheesecloth to let the protein dry for 5 minutes.
Weigh the protein together with the cheesecloth, subtracting the weight of the cheesecloth from the total weight and record your results.
The pH of whey and protein structure evaluation should be recorded.

5. Precipitation of casein from milk with a lactic acid bacteria starter

Procedure
Weigh the empty beaker and record the weight. 250 g of curdled milk (milk is fermented at 30 ^{o}C for 12 hours) is measured into a 250 mL beaker. The pH and curdled milk appearance should be recorded. The curdled milk is heated up to 48 ^{o}C, slowly stirred, and the protein allowed to precipitate for 5 minutes.
Take cheesecloth or an appropriate material bag to cover the top and 2 inches down the sides of a beaker. Using the rubber band, fasten the cheesecloth over the top of the beaker. Pour the content of the sample into the beaker, collecting the curds (casein) in the cheesecloth and allowing the whey to drain off into the bottom of the beaker.
Gather up the cheesecloth with the casein and squeeze the casein until almost dry and then spread out the cheesecloth to let the casein dry for 5 minutes.
Weigh the precipitate together with the cheesecloth, subtracting the weight of the cheesecloth from the total weight and record your results.
The pH of whey and protein structure evaluation should be recorded.

Results

The study of protein coagulation/denaturation techniques

Table 1. 4.

Comparison of different protein coagulation/denaturation techniques

Product	The weight of product, g	Coagulation/denaturation of proteins				Mass		Whey		
		Coagulation agent	Time, s	acidity of coagulum, °T	Characterisation of mass	g	%	g	%	°T

Conclusions:

Approved by _____

(Name, surname, signature)

Date _____

Laboratory work

Microbiological quality analysis and milk storage temperature

Influence of milk quality and microbiological quality of milk

Students work in a group; students receive raw milk obtained from a milk processing company. 200 mL of milk for 1 sample, for 1 student. Students choose 1 sample from Table 1. The samples should be prepared according to the following scheme (see Table 1.5.).

Table 1. 5.

Samples preparation

Samples	Milk, mL	YF-L811, mL	H_2O_2, mL	Antibiotics	Sodium, mL	Formalin, mL	NH_3OH, mL
1	200	10	-				
2	200	10	0,6				
3	200	10		1 tablet			
4	200	10			0.6		
5	200	10				0.6	
6	200	10					0.6

Milk samples should be stored at 20 ^{o}C temperature for 2 hours**.** After 2 hours, microbiological parameters should be detected.

1. Total plate count detection at 30 °C

The total plate count (TPC) is suitable for estimating bacterial populations in most types of dairy products, and it is a reference method to be used to examine raw and pasteurised milk.

The test employs dilution techniques for easy quantification of the microorganisms. The appropriate dilutions of the milk sample are mixed with a sterile nutrient medium that can support the growth of the microorganisms, when incubated at a suitable temperature. Each bacterial colony that develops on the plate is presumed to have grown from one bacterium or clump of bacteria in the inoculums. The total number of colonies counted on the plates multiplied by the dilution factor represents the number of viable microorganisms present in the sample tested.

Procedure

Samples must be tested within 36 hours after the initial collection, and the time of plating must be recorded. Mark each plate with sample number, dilution, and other desired information before making dilutions.

Before opening a sample container, remove from the closure all obvious materials that could contaminate the sample. If desired, wipe the tops of unopened sample containers with a sterile cloth or paper towel saturated with 70% ethyl alcohol. Invert filled retail containers containing air space 25 times or until the contents are homogeneous. To ensure a homogeneous sample, where no air space is present, open the container aseptically and pour the product from the filled carton into a sterile container. The interval between mixing and removing the test aliquot must not exceed 3 minutes. Immediately before transferring the test portions of milk and of dilutions thereof, shake the container, making around 20 complete up-and-down (or back-and-forth) movements of about 30 cm in 7 seconds. Mechanical shaker may be used, if desired, to shake the dilution blanks uniformly for 15 seconds.

Dilution of samples

For TPCs, select dilution(s) so that the total number of colonies on a plate is between 30 and 100. For example, where a TPC is expected to reach 3000, prepare plates containing 10^{-2} dilutions.

Use a sterile pipette for initial and subsequent transfers from the same container, if the pipette is not contaminated. If the pipette becomes contaminated before transfers are completed, replace it with another sterile pipette. Dilution procedure is given in 1.2.figure.

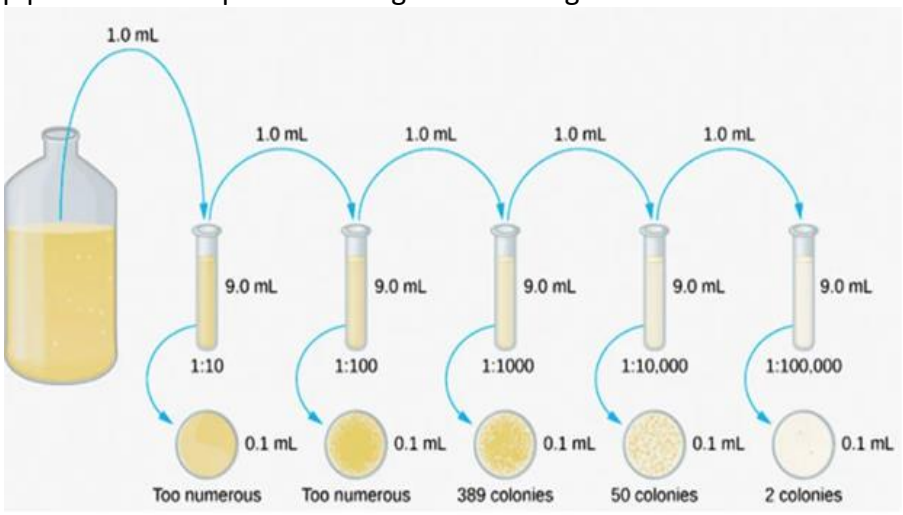


Fig. 1.2. Sample dilution scheme https://examtube.in/post/serial-dilution

Precautions to be taken

Do not prepare or dispense dilutions or pour plates in direct sunlight. When removing a sterile pipette from the pipette container, do not drag the pipette tip over the exposed exteriors of the pipettes remaining in case because the exposed ends of such pipettes are subject to contamination. Do not wipe or drag the pipette across the rims and necks of vials or dilution bottles. Do not insert the pipette more than 2.5 cm below the surface of the sample or dilution. Draw test portions above the pipette

graduation; then raise the pipette tip above the liquid level and adjust to the desired mark by allowing the lower side of the pipette tip to touch the inside of the container so that drainage is complete and excess liquid does not adhere when the pipette is removed from the sample or dilution bottle. Do not flame sterile pipettes.

When delivering a diluted sample of a dairy product, hold the pipette at an angle of about 45 degrees while the tip is touching the inside bottom of a Petri dish or the inside neck of a dilution bottle. Lift the cover of the Petri dish just high enough to insert the pipette. Deposit the sample away from the centre of the dish to aid in mixing the sample with medium. Allow 2 to 4 seconds for the diluted milk or cream to drain from the graduation mark to the rest point in the pipette tip; then, holding the pipette in a vertical position, touch its tip once against a dry spot on Petri dish or on the inside of the dilution bottle neck. Do not blowout. When 0.1 mL quantities are measured, hold the pipette as directed and let the diluted sample drain to the proper graduation point but do not retouch the pipette to the plate. After depositing the test portions in each series of plates, pour the medium.

Plating. Melt the required amount of medium (Plate count agar - PCA) quickly in boiling water, but avoid prolonged exposure to unnecessarily high temperatures during and after melting. Discard melted nutrient agar that develops a precipitate. Cool the melted medium promptly to approximately 45 °C. Wipe water from the outside of the medium bottles before pouring. Introduce 12 to 15 mL of liquefied medium at 44 to 46 °C into each plate by gently lifting the cover of the Petri dish high enough to pour the medium. Carefully avoid spilling the medium on the outside of the container or on the inside of the plate lid when pouring. As each plate is poured, thoroughly mix the medium with the test portions in the Petri dish by rotating the dish first in one direction and then in the opposite direction, rotating and tilting the dish by hand or using mechanical rotators. Take care not to splash the mixture over the edge. Having done so, spread the mixture evenly over the bottom of the plate, allow it to solidify on a plain surface. After solidification, invert the plates to prevent spreading colonies from developing because of accumulated moisture, and place the plates in the incubator.

Incubating. Incubate plates at 30 °C for 48 hrs for TPC.

Counting of colonies on agar plates. Count the plates after the desired incubation period. Record the dilutions used and number of colonies counted on each plate. If it is impossible to count at immediatly after the required incubation, store the plates at 0 to 4.4 °C, butfor no longer than 24 hours.

Count colonies with the aid of magnification under uniform and properly controlled artificial illumination. Plates should be examined in subdued light. Routinely use a colony counter equipped with a guide plate ruled in square centimetres.

Calculating and recording of microbial counts. When calculating the TPC, report only the first two significant digits to avoid creating a fictitious impression of precision and accuracy.

Table 1.6.

Total plate count

Sample number	Total plate count
1	
2	
3	
Mean	

Conclusions

2. Lactic acid bacteria count

Procedure

Samples preparation is the same as it was described for TPC.

Melt the required amount of medium (de Man Rogosam Sharpe agar - MRS) quickly in boiling water, but avoid prolonged exposure to unnecessarily high temperatures during and after melting. Discard melted nutrient agar or tryptone dextrose agar that develops a precipitate. Cool the melted medium promptly to approximately 45 °C.

Wipe water from the outside of the medium bottles before pouring. Introduce 12 to 15 mL of liquefied medium at 44 to 46 °C into each plate by gently lifting the cover of the Petri dish high enough to pour the medium. Carefully avoid spilling the medium on the outside of the container or on the inside of the plate lid when pouring. As each plate is poured, thoroughly mix the medium with the test portions in the Petri dish by rotating the dish first in one direction and then in the opposite direction, rotating and tilting the dish by hand or using mechanical rotators. Take care not to splash the mixture over the edge. Having done so, spread the mixture evenly over the bottom of the plate, allow it to solidify on a plain surface. After solidification, invert the plates to prevent spreading colonies from developing because of accumulated moisture, and place the plates in the incubator.

Incubating. Incubate plates at 37 °C for 48 hrs for LAB in aerobic conditions. Plates must reach the temperature of incubation within 2 hrs.

Counting of colonies on agar plates. Count the plates after the desired incubation period. Record the dilutions used and number of colonies counted on each plate.

Calculating and recording of microbial counts. When calculating the LAB, report only the first two significant digits to avoid creating a fictitious impression of precision and accuracy.[2]

Table 1.7.

Lactic acid bacteria count

Sample number	LAB plate count
1	
2	
3	
Mean	

Conclusions

Approved by _____

(Name, surname, signature)

Date _____

[2] The laboratory work was developed in collaboration with prof. I.Ciprovica

Laboratory work

The importance of milk quality

1. Detection of inhibitors

Different methods are used to detect inhibitors. In the current laboratory work the following methods will be used:

- Test with the indicator resazurin;
- Delvotest SP;
- Charm test.

Inhibitors detection with the indicator resazurin

For the detection of inhibitors, using the **indicator resazurin**, a pure culture of *Streptococcus thermophilus* susceptible to inhibitors is added to pasteurised and cooled milk. In the absence of inhibitors in the milk, the microorganisms multiply and the reductase they release reduces the indicator resazurin. If there are inhibitors in the milk, then the reproduction of *Streptococcus thermophilus* is inhibited, and at the same time the reduction of the indicator is inhibited.

Fig. 1.3. Explanation of the results obtained by the test the indicator resazurin

Procedure

Pour 10 mL of the milk to be tested into a clean test tube and close it not too tightly with a rubber stopper.

The contents of the test tube are heated to 85-90 °C in a water bath for 10 minutes, then milk should be cooled to 43-45 °C. Add 0.3 ml of *Streptococcus thermophilus* with a sterile pipette. The contents of the test tube are mixed and kept at a temperature of 42-43 °C for 2 hours.

After 2 hours, pour 1 mL of 0.05% resazurin solution into the test tube, the temperature of which should not be lower than 18-20 °C. The contents of the test tube are thoroughly mixed and kept at a temperature of 42-43 °C for 15 minutes.

In the absence of inhibitors, the contents of the tube are pink or white. If the milk contains **inhibitors, the contents of the tube will be steel blue, blue violet or violet in colour.**

Delvotest SP

The "Delvotest SP" test is intended for the detection of antibiotics in milk. This method also uses an antibiotic-sensitive test culture of *Bacillus stearothermophilus var calidolactis*.

The method is based on the colour change of the culture medium containing *Bacillus stearothermophilus var calidolactis* from purple to yellow, as a result of spore reproduction. The medium contains spores of *Bacillus stearothermophilus var calidolactis* and the purple dye. In the antibiotic-free milk, spores multiply rapidly and release various metabolic products into the environment, incl. also lactic acid. As the concentration of acids increases, the colour of the medium changes from purple to yellow. If the milk sample contains antibiotics, the spore reproduction is inhibited and the colour of the culture medium does not change. The violet-yellow colour of the culture medium indicates the presence of antibiotics in milk in small concentrations, which are below the permissible concentration of the detection threshold.

The multiply of spores in milk depends on the incubation temperature and holding time of the samples. Temperatures that are too high or too low slow down these processes. Failure to observe the temperature may affect the sensitivity of the test to detect antibiotics.

Procedure

Each student receives 1 sealed ampoule with a medium for determining the presence of antibiotics in milk. Carefully, without completely tearing off the aluminium foil cap, open the ampoule. Measure 0.1 mL of the analysed milk with a pipette and pour it into the ampoule. Seal the ampoule with an aluminium foil cap, label it and place it in an incubator at a temperature of 64±0.5 °C. The ampoule is kept in the incubator for 3 hours (minimum analysis time is 2 h 45 min). At the end of the analysis, evaluate the colour of the medium in the ampoule. A yellow colour indicates that the sample does not contain antibiotics. A yellow-violet colour indicates the presence of antibiotics in the sample, but their content is close to the allowed concentration of inhibitors in milk. A purple colour indicates that the sample contains antibiotics.

The results of the analyses must be read immediately after removing the ampoule from the incubator.

Fig. 1.4. Procedure and results of Delvotest https://device.report/delvotest

Charm MRL

With the help of this test, the presence of certain antibiotic residues in milk can be detected within a few minutes. This test is used in milk processing companies as a routine method for indirect testing of milk quality. If positive results are found, the milk sample should be examined with the help of the Delvotest SP test, in order to obtain more objective and representative analysis results.

The Charm MRL Beta-lactam and Tetracycline Test uses receptors that bind beta-lactam and tetracycline drugs. As milk flows through the test strip, a beta-lactam line forms at the BL position and a tetracycline line forms at the TE position when the sample contains no beta-lactam or tetracycline drugs. A weaker intensity BL or TE line forms when beta-lactam and/or tetracycline is present in the sample. The BL and TE lines are compared to the C (control) line that is designed to discriminate beta-lactams/tetracycline close to the MRLs. If both the BL and TE lines are darker than or equal to the C line, the sample is negative. If either the BL or TE line is lighter than the C line, or the BL or TE line does not form, the sample is positive (Fig. 3.1.).

Procedure. The student receives the strip and, after carefully opening the packaging, places it in the ROSA incubator with the wider end downwards in the incubator. Using a disposable pipette to measure 0.3 mL of milk, and on the strip close to the inscription Peel to Here, drop a sample of milk into the incubator. Tightly seal the tape around the edge of the strip, close the incubator lid and tighten the latch, from this moment ROSA starts an automatic 8-minute countdown.

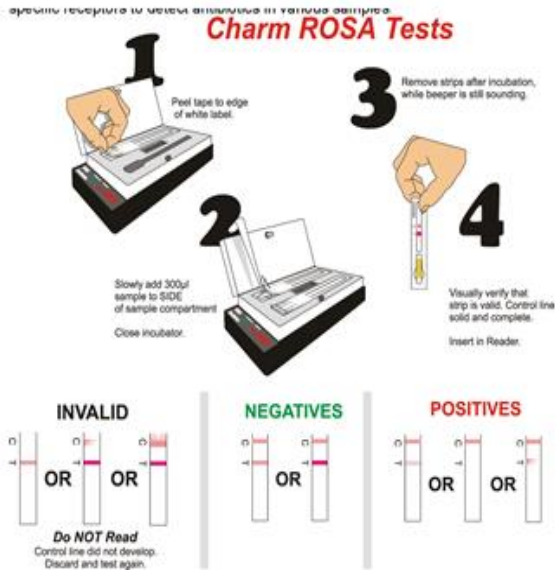


Fig. 1.5. Sample preparation for the Charm MRL test
https://www.tirlanfarmlife.com/shop/product/Charm-Antibiotic-Test-Strip-Incubator-and-Test-Strips/B9125033

After 8 minutes, the ROSA incubator signals the end of the incubation, a yellow light comes on. Carefully, without compressing the sample, remove it from the incubator. Compare the results of the removed strip with the examples given in Fig. 1.5.

2. Milk coagulation test

Procedure

10 mL of milk is heated to 35 °C and 2 mL of 0.02% enzyme preparation solution is added. The mixture is carefully mixed and coagulation at 35 °C, fixing the coagulation time. Every 2-3 minutes, the contents of the test tube are examined, observing changes in the viscosity of the milk. The end of clotting is determined by the consistency of the formed clot. Depending on the duration of coagulation, milk is divided into:

1) Fast curdling, clot formation time up to 600 seconds;

2) Normal clotting, clot formation time from 600 to 900 seconds;

3) Slow curdling, clot formation time over 900 seconds.

Students make a conclusion about the suitability of milk for curdling, waiting for the results of the fermentation-coagulation test.

3. Detection of the presence of certain detergents in milk

In some cases, the detection of the presence of certain detergents helps to reveal the sources of the entry of inhibitors.

3.1.Detection of hydrogen peroxide in milk

Milk with hydrogen peroxide added is adulterated. Hydrogen peroxide is added to milk to neutralise it and prevent a faster increase in acidity. The detection method is based on the ability of hydrogen peroxide to release free iodine from KJ, which gives a blue colour with starch. The sensitivity of the method is 0.001% hydrogen peroxide.

Procedure

Add 1 mL of milk in a tube, and without mixing add 2 drops of H2SO4 and 0.2 mL of solution of KJ and starch. Observe change of colour in a tube after 10 minutes. Blue colour testifies for H2O2 presence in the milk sample.

3.2. Detection of formaldehyde in milk

The method is based on the reaction of colours with formaldehyde in an acidic environment. Formaldehyde is added to milk to preserve it.

Procedure

Add 2 mL of milk in a tube, and without mixing along the tube wall add 2 mL of mixture of H_2SO_4 and HNO_3. Observe the change of colour in a tube. Violet and dark blue colours testify about formaldehyde presence in the milk sample.

3.3. Detection of soda in milk

The method is based on the colour change of bromothymol blue by adding it to milk containing soda. The sensitivity of the method is 0.05% added sodium carbonate or bicarbonate. Soda is added to milk to reduce its acidity

Procedure

Add 5 mL of milk in a tube, and without mixing along the tube wall add 7-8 drops of bromothymol blue dye solution. Observe the colour changes in a tube. A green colour indicates the presence of soda in the milk sample.

3.4. Detection of urea in milk

Procedure

Pour 5 mL of milk into a test tube and add 5 mL of Nesler reagent. The appearance of a distinct yellow colour indicates the presence of added urea, whereas the development of slightly yellow colour is due to natural urea in the milk.[3]

Table 1.8.

Quality of the analysed milk sample

Sample	The presence of inhibitors	The presence of antibiotics		Suitability for cheese production	The presence				The alcohol test
		Delvotest	Charm test		H_2O_2	soda	formalin	urea	

Conclusions:

Approved by _____

(Name, surname, signature)

Date _____

[3] The laboratory work was developed in collaboration with prof. I.Ciprovica

Theme 2

Milk processing – different treatment methods of milk and cream

Theoretical materials

- Cooling
- Filtration
- Bactofugation
- Deaeration
- Homogenisation
- Separation
- Heat and pressure treatment

During **bactofugation** it is possible to split 95-98% of microorganisms, two-phase bactofugation 99.5%;

Composition of bactofugate:

•98.1% anaerobic microorganism spores;

•95.1% aerobic microorganisms spores;

•92.2% lactic acid bacteria.

Deaeration - separation of volatile compounds from milk

Concentration of air in cream, causing:
– inaccurate in-line fat standardisation,
– incrustation of cream heaters,
– 'pre-churning' resulting in loss of yield in butter production

Separation - exposing milk to centrifugal force produces products with a significantly different fat content, such as cream and skimmed milk.
The effectiveness:
• size of fat globules,
• cleanliness and freshness,
• supply intensity,
• temperature,
• fat content.

Standardisation - regulation of fat content in milk, cream or other products. Principle of the standardisation process is given in Fig. 2.1.

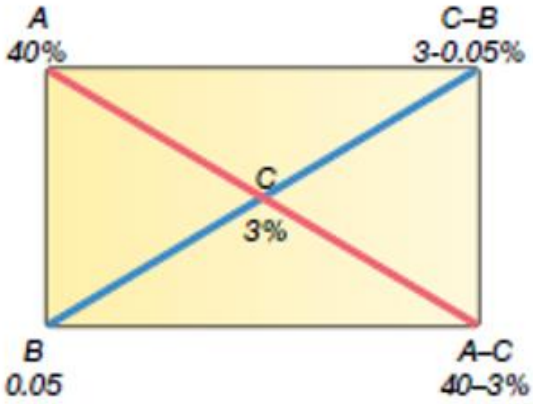


Fig. 2.1. Batch standardisation
https://dairyprocessinghandbook.tetrapak.com/chapter/pasteurized-milk-products

Homogenisation primarily causes the break up of fat globules into much smaller ones; see figure 4. Consequently, it diminishes creaming and may also diminish the tendency of globules to clump or coalesce. Essentially all homogenised milk is produced by mechanical means. The milk is forced through a small passage at high velocity. The disintegration of the original fat globules is achieved by a combination of contributing factors such as turbulence and cavitation. The net result is a reduction of the fat globules to approximately 1mm in diameter, which is accompanied by a four- to six-fold increase in the fat/plasma interfacial surface area. The newly created fat globules are no longer completely covered with the original membrane material. Instead, they are coated with a mixture of proteins adsorbed from the plasma phase.

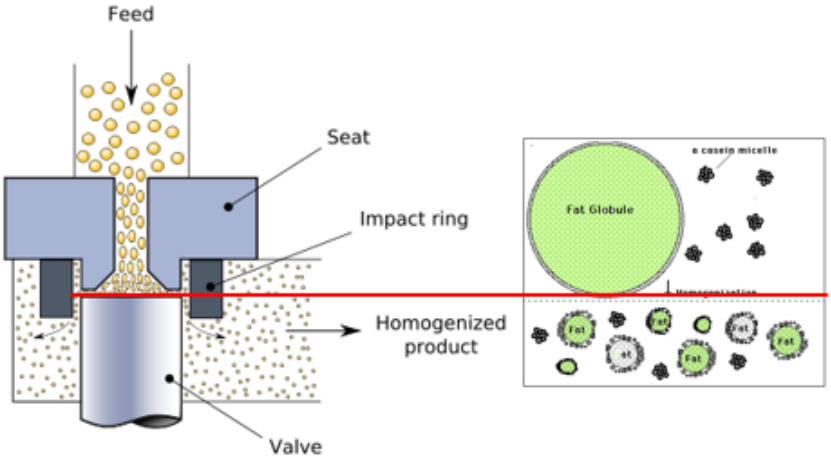


Fig. 2.2. Homogenisation
https://en.wikipedia.org/wiki/Homogenization_%28chemistry%29

Membrane technology is a proven separation method used on the molecular and ionic levels. In the dairy industry, the membrane technology is principally associated with:

• Reverse Osmosis (RO) – concentration of solutions by removal of water,

• Nanofiltration (NF) – concentration of organic components by removal of part of monovalent ions like sodium and chlorine (partial demineralisation),

• Ultrafiltration (UF) – concentration of large and macro molecules,

• Microfiltration (MF) – removal of bacteria, separation of macromolecules.

Thermal treatment

The **purpose** of heat treatment is to minimise the microorganisms in the milk, to eliminate all pathogens, to inactivate enzymes, while trying to maintain the nutritional and biological value of the milk at the same time**.**

- *Pasteurization – 63-95 ºC, 15 sec-30 min.*
- *Sterilisation - 120-130 ºC, 10-20 min.*
- *Ultrahigh-temperature heating- 135-138 ºC, 3-5 s.*

Changes in the composition of milk caused by an increase in temperature may be reversible or irreversible. Here we are mainly interested in the irreversible or slowly reversible reactions; such changes hardly occur with heat treatments of lower intensity than low pasteurisation.

- The amount of colloidal phosphate increases and the [Ca2+] decreases.
- Lactose isomerises and partly degrades to yield, for instance, lactulose and organic acids.
- Phosphoric esters, those of casein in particular, are hydrolysed. Phospholipids are also split. Consequently, the amount of inorganic phosphate increases.
- The pH of the milk decreases, and the titratable acidity increases.
- Most of the serum proteins are denatured and thereby rendered insoluble
- Part of the serum protein (especially of β-lactoglobulin) becomes covalently bound to κ-casein and to some proteins of the fat globule membrane.
- Enzymes are inactivated.
- Reactions between protein and lactose occur, Maillard reactions in particular. This involves the loss of available lysine.
- Free sulfhydryl groups are formed. This causes, for instance, a decrease of the redox potential.
- Casein micelles become aggregated. Aggregation may eventually lead to coagulation.
- Several changes occur in the fat globule membrane.
- Some vitamins are degraded.

Laboratory work

Milk separation, standardisation and thermal treatment

Methods and Procedures

1. Milk separation

Students share the duties: head of the process, operator, laboratory assistant, bookkeeper, and the persons responsible for cleaning (at least 2 students).

The separator is ready for the process. Students weigh the milk and record it in the table, students analyse the milk composition, especially the fat concentration, using the Milkoscan Mars TM analyser.

Milk should be warm (temperature around 40 ^{o}C) prior to separation. Please also weigh the dishes for skimmed milk and cream. Switch on the separator and pour in the separator basin milk. During the separation process, the milk flow can be changed in the separator.

At the end of separation, please add 1 L of skimmed milk into the separator basin to remove cream traces from the separator bowl.

After separation, the skimmed milk and cream composition and density should be analysed, as well as the weight will be determined for both products.

The Skimmed milk and cream density is measured:

The temperature of the skimmed milk or cream should be around 20 ^{o}C prior to the density measurement. Mix the sample gently and pour it gently into a measuring cylinder. An aerometer with a scale of up to 1000 kg m^{-3} (940-1000) has been used to determine the cream density, but the aerometer with the scale of 1000 - 1040 kg m^{-3} is used for skimmed milk. Let the aerometer to sink slowly into the sample. Read and record the last aerometer degree (kg m^{-3}) just above the surface of the milk. If the temperature of the milk is different from the calibration temperature (calibration temperature may be 20 ^{0}C) of the aerometer, calculate the temperature correction.

The data obtained are used to calculate the milk yield for 1 kg of cream production, as well as the loss of milk has been determined during the separation in kg and %.

Equations for calculation of milk yield and losses

$$\text{Yield= milk/cream}$$

where:

Yield – the milk yield for 1 kg cream production;

Milk – the amount of milk, kg;

Cream – the amount of milk, kg.

$$\textit{Losses (kg) = Milk - (Cream + Skimmed milk)}$$

When the separator is fully stopped, disconnect the power supply to the separator. The separator should be dissembled prior to cleaning (please do it in a sink). Separator parts should be washed with detergent and in hot water. At least all parts of the separator should be wiped and kept dry.

Table 2.1.

The summary of the separation process

Parameters	Results
Milk Amount of milk, kg Fat content, %	
Skimmed milk Amount of skimmed milk, kg Fat content, % Density, kg/m3	
Cream: Amount of cream, kg Fat content, % Density, kg/m3	
The milk yield for 1 kg cream production	
Milk losses during separation, kg	
Milk losses during separation, %	

Conclusions

2. Standardisation

Students have the following products for the standardisation task: drinking milk (fat content %, density 1028 kg m^{-3}), skimmed milk (fat content was determined in the separation task), and cream (fat content was determined in the separation task). The students calculate the necessary amount of ingredients for 100 g of standardised milk/cream production with the following fat content:

1%, 1.5%, 3.5%, 6%, 10% and 12%

The students choose one of the proposed options. The calculation should be done using a rectangle method given in the lectures or equations (see below).

The cream calculation for a standardised mixture

$$Mc = \frac{Ms\ (Fs-Fm)}{Fc-Fp},$$

where:
M_c - the amount of cream, g;
M_s - amount of the standardised mixture, g;
F_s - fat content in the standardised mixture, %;
F_c - fat content in cream, %;
F_p - fat content in milk, %.

Milk calculation for a standardised mixture

$$M_m=M_s-M_c$$

where:
M_m - the amount of milk, g;
M_s - the amount of the standardised mixture, g;
M_c - the amount of cream, g.

The cream calculation for a standardised mixture

$$Msm = \frac{Ms\ (Fp - Fs)}{Fm - Fsm}$$

where:
M_{sm} - the amount of skimmed milk, g;
M_s – the amount of the standardised mixture, g;
F_s - fat content in the standardised mixture, %;
F_{sm} - fat content in standardised milk, %;
F_p - fat content in milk, %.

Milk calculation for a standardised mixture

$$\boldsymbol{M_m=M_s-M_{sm}}$$

where:
M_m -the amount of milk, g;

M_s - the amount of the standardised mixture, g;
M_c - the amount of cream, g.

After calculation, carefully weigh the calculated products in a baker (precisely ±0.01 g), gently mix, and heat up to 45 °C. The fat content in a standardised mixture should be measured using a milk analyser.
If the result differs by more than 0.5%, students should repeat the calculation, sample preparation, and fat content determination.
The students make conclusions about the standardisation and its influencing factors.

The prepared samples should be used for the completion of the 3rd task.

Conclusions

4. The study of milk quality and parameters changes during the thermal treatment

Students choose one of the proposed parameters for the thermal treatment:

- 60 ^{o}C 15 sec.;
- 72 ^{o}C 15 sec.;
- 78 ^{o}C 15 sec.;
- 80 ^{o}C 5 sec.;
- 85 ^{o}C 5 sec.;
- 90 ^{o}C 5 min.

Before the treatment, the pH and acidity (^{o}Th) should be measured. Students heat the samples to the chosen temperature and hold for some time (proposed holding time). After the treatment, the samples are cooled down until the temperature is around 20 ^{o}C. If tap water is used for cooling, please ensure that during the cooling process no water drops get into the product. After cooling, milk pH and acidity are measured.

pH determination

Put clean and dry electrodes into the milk and press the *Read* button on the screen of the pH meter. When the sound signal is heard, read the result on the screen.

Acidity determination

Take 10 mL of the milk into a conical flask, add 20 mL of distillate water, and 2-3 drops of phenolphthalein and then slowly titrate with 0.1 M NaOH under continuous mixing until a faint pink colour appears and persists for 30 seconds.
Titratable acidity is obtained from the equation:

$$^{o}T = \text{volume of 0.1 M NaOH (in ml)} \times 10$$

The results are summarised in the table.

After the thermal treatment, the presence of phosphatase and peroxidase should be measured.

Determination of phosphatase

2 mL of milk, and 1 mL of sodium phenolptaleinphosphate are added into a tube. After the addition of the chemicals, the content of the tube is mixed carefully and closed with the cork. Put the tube into a water bath at a temperature of 40-45 ^{o}C and after 10 minutes evaluate the sample colour. If the colour of the sample turns slightly pink or dark red, the milk sample includes phosphatase.

Determination of peroxidase

Place 5 mL of milk into a tube and add 5 drops of KJ starch solution, and 5 drops of H_2O_2. Shake the content of the tube carefully. If the colour of the sample doesn't change, the presence of peroxidase has not been observed in the sample. All results should be summarised in the table.

Table 2.2.

The summary of the thermal treatment process

Sample (milk or cream)	Fat content, %	Thermal treatment parameters	Prior thermal treatment		After thermal treatment		Presence of	
			pH	°Th	pH	°Th	phosphatase	peroxidase
		60 °C 15 s.						
		72 °C 15 s.						
		78 °C 15 s.						
		80 °C 5 s.						
		85 °C 5 s.						
		90 °C 5 min.						

Conclusions

Approved by _____

(Name, surname, signature)

Date _____

Practical work

MILK PROCESSING TECHNOLOGY – equipment: separators

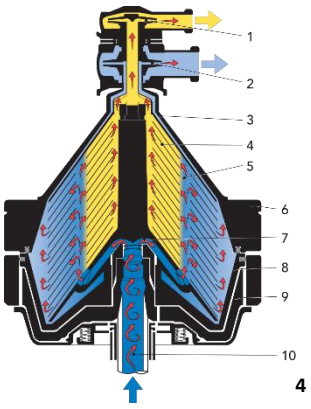
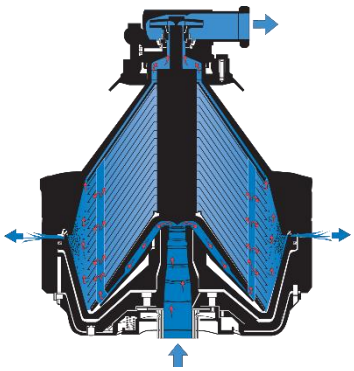
The aim of the work is to gain knowledge of basic milk processing equipment: the separator. The group of students is divided into teams and each team analyees the importance of components and equipment in the implementation of processes.

Materials
Students get acquainted with the separation equipment, the components, and the principles of operation.

Procedures and Results
The results obtained in the experiments should be reflected in the table 2.3.

Table 2.3.

Results of experiments

Illustration, Questions	**Comparable equipment**	
	 4	 8
Name the main parts. Operating principle. What are the 3 main differences?		
How often should the machine be washed?		

[4] https://dairyprocessinghandbook.tetrapak.com/chapter/centrifugal-separators-and-milk-standardization

Can device shortening happen automatically?		
What is the spindle speed of each machine?		
Into how many fractions is the product divided?		
What do both machines have in common?		

Conclusion

During the practical activities, students acquire and consolidate knowledge and skills in the operation of equipment.

Approved by _____

(Name, surname, signature)

Date _____

Practical work

MILK PROCESSING TECHNOLOGY – equipment: heat exchangers

The aim of the work is to gain knowledge about basic milk processing equipment: heat treatment equipment. The group of students is divided into teams and each team analyses the importance of components and equipment in the implementation of processes.

Materials

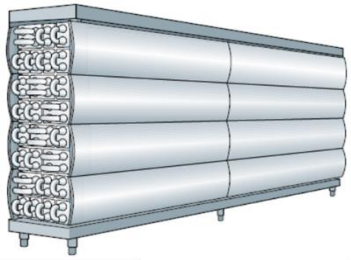
Students get acquainted with heat treatment equipment, its components, and the principles of operation.

Procedures and Results

The results obtained in the experiments should be reflected in the table 2.4.

Table 2.4.

Results of experiments

Illustration, Questions	**Comparable equipment**	
	Heat exchanger (plate)	**Heat exchanger (tube)**
	https://www.indiamart.com/proddetail/plate-type-heat-exchanger-11738602830.html	 https://dairyprocessinghandbook.tetrapak.com/chapter/heat-exchangers
Main parts		
What products are they used for?		
How many sections does it consist of?		

What temperature is used for heat treatment?		
What is the heating/cooling environment?		
How can the pasteurisation/sterilisation result be ensured?		

Conclusions

During the practical activities, students acquire and consolidate knowledge and skills in the operation of equipment.

Approved by _____

(Name, surname, signature)

Date _____

Practical work

MILK PROCESSING TECHNOLOGY – equipment: HEAT EXCHANGER SCHEME

The aim of the work is to gain an understanding of the sections of the plate heat exchanger, its importance and necessity. As well as being able to draw the processes that take place in the plate heat exchanger at a given list of temperatures.

Materials

Students are divided into groups and given the following text tasks:

1. Tasks: Draw an expanded diagram of the plate heat exchanger by sections.
   Initial milk temperature 5 ° C, fat content 3.9%; separation at 42 °C, homogenisation at 42 °C, pasteurisation of milk with a fat content of 2.5% at a temperature of 77 °C and cooling to a temperature of 7 °C.

2. Tasks: Draw an expanded diagram of the plate heat exchanger by sections.
   Initial milk temperature 15 °C, homogenisation 42 °C, pasteurisation of skim milk at 72 °C and cooling to 4 °C.

3. Tasks: Draw an expanded diagram of the plate heat exchanger by sections.
   Initial milk temperature 10 °C, fat content 3.9%; separation at 42 °C, pasteurisation of milk with a fat content of 2.5% at 77 °C, homogenisation at 60 °C, and cooling to 25 °C.

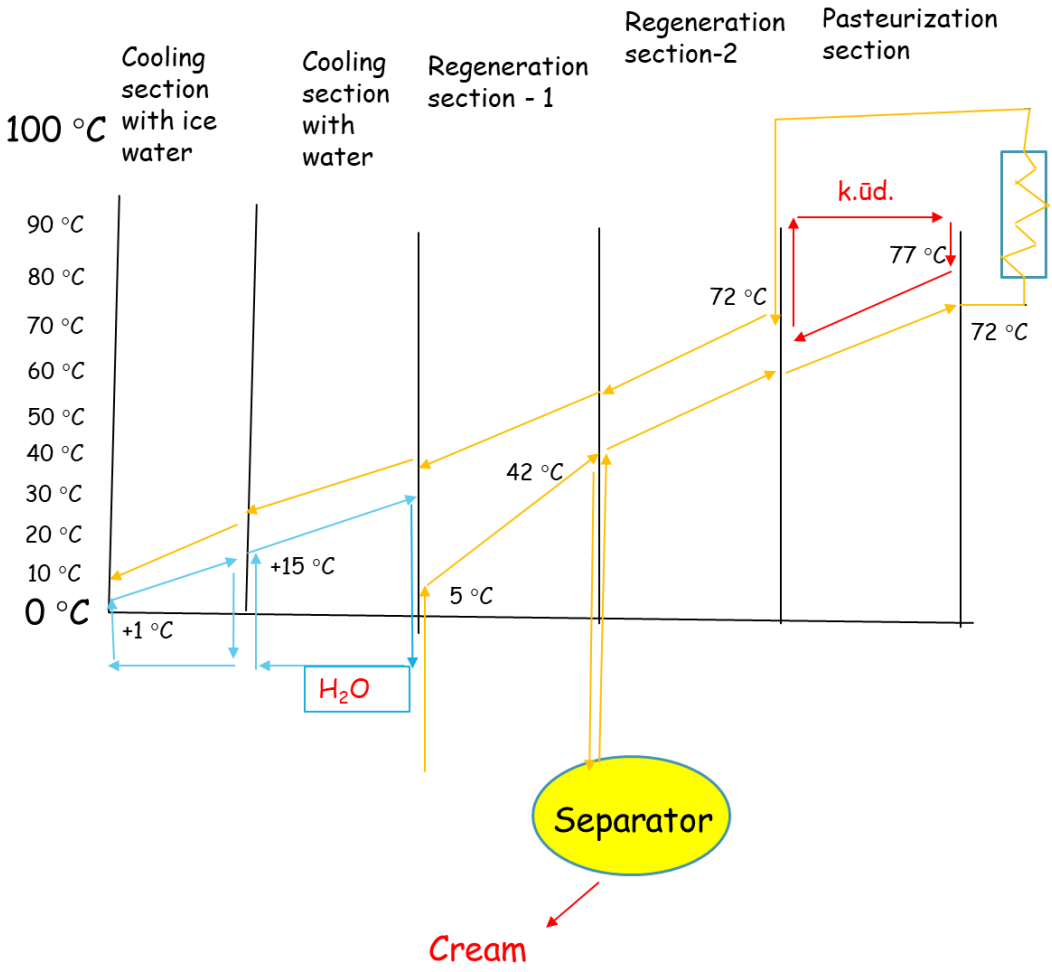
4. Tasks: Draw an expanded diagram of the plate heat exchanger by sections.
   Initial milk temperature 4 °C, fat content 4.2%; separation at 42 °C, homogenisation at 60 °C, pasteurisation of milk with a fat content of 2.5% at 74 °C and cooling to 8 °C.

5. Tasks: Draw an expanded diagram of the plate heat exchanger by sections.
   Initial milk temperature 30 °C, fat content 4.8%; separation at 42 °C, homogenisation at 60 °C, pasteurisation of milk with a fat content of 2.5% at 74 °C, homogenisation at 67 °C, and cooling to 25 °C.

Procedures and Results

The solution of each task should be shown in the picture, where you can see the representation of the heat exchanger by sections, and the drawing of the temperatures on the scale whiletaking into account the temperatures specified in each task.

For instance:



Conclusions

During the practical activities, students learn and strengthen knowledge and skills in the operation process and the importance of the plate heat exchangers.

Approved by _____

(Name, surname, signature)

Date _____

Theme 3

Fermented dairy products: production and quality evaluation

Theoretical materials

Fig. 3.1 Fermented dairy products[5]

Starter is the basis of dairy product production.

Starter culture microorganisms inoculum, which ensure taste, aroma and texture of the product. As an instrument against undesirable microorganisms (*Enterobacteriaceae*, *Bacillus spp., Staphylococcus aureus, Clostridium turobutyricum,* bacteriophage).

Role of starter:

- Prevention of food spoilage and **extension of shelf life**, assurance of food safety;
- Formation of desirable **sensory properties;**
- Formation of desirable **therapeutic and functional** properties;
- Control and regulation of the **technological process;**
- Better economy of technological process, **shorter fermentation** time;
- Decreased use of some **chemical additives;**
- Better nutritional value (**vitamins, lactose, digestibility**).

[5] https://dairyprocessinghandbook.tetrapak.com/chapter/fermented-milk-products

Starter quality:

• Hygienic criteria: strains are not infectious or toxicogenic, do not produce antibiotics – are safe (GRAS - Generally Recognised and Safe);

• Contain declared number of live microorganisms: during fermentation are metabolically active, to overgrow the autochthonous microbiota and direct the fermentation in desired way;

• Different forms: liquid, frozen, lyophilised;

• Different ways of manipulation: revitalisation, pre-fermentation, direct inoculation;

• Producer specification.

Starter characterisation:

• Ecological approach: isolation of certain strains from ecological niches, where we want to use them (milk, non milk product);

• Testing technological properties: *certain conditions, acid production, enzyme activity;*

• Compatibility test: mixed cultures;

• Bacteriophage sensitive;

• General characteristics;

• Successful in medium with *sugars, proteins, vitamins and low oxygen concentration.*

Starters could be:

• Mono strain: one strain of certain species;

• Multi strains: more strains of one species;

• Multi strains mix: more different strains of different species;

• Mixed: species/strains partially known or unknown.

Table 3.1.

Examples of starter mixtures

Genus	Species	Subspecies	Strain
Lactobacillus	*delbrueckii*	Subsp. bulgaricus	GLB 44
Enterococcus	*faecium*	/	LMG11423
Lactobacillus	*acidophilus*	/	LA5
Bifidobacterium	*animalis*	subsp. lactis	BB12
Kluyveromyces	*lactis*	/	M-I2
Penicillium	*camemberti*	/	ATCC 10387

Starter according to **temperature**:

• Mesophilic: 10-40 °C, optimum ~30 °C
    - *Yeast*
    - *Moulds*
    - *Lactobacilus lactis subsp. lactis/cremoris, Leuconostoc, Lact. Lactis dyacetylactis, Lactobacillus casei*

• Thermophilic: 20-50 °C, optimum 37-42 °C
    - *Lactobacillus, Streptococcus, Bifidobacterium, Propionibacterium*

Starters according to final **metabolic products** of lactose:

• Homofermentative
• Heterofermentative

Starters according **microorganisms**:

• Lactic acid bacteria and other bacteria
• Yeats
• Moulds

Table 3.2.

Fermented products - production parameters

Product	°C	Starter	h	°T
Kefir	18-22	*Lactococcus lactis, Lactococcus cremoris, Leuconostoc, Lactobacillus kefir, Lactobacillus casei, Acetobacter aceti, Candida kefir, Kluyveromyces marxianus* u.c.	8-16	85-120
Kefir*	18-22	*Lactococcus lactis, Lactococcus cremoris, Leuconostoc, Lactobacillus kefir, Lactobacillus casei, Acetobacter aceti, Candida kefir* vai *Kluyveromyces marxianus*, *Lactobacillus acidophilus, Bifidobacteria ssp.*	8-16	85-120
Sour milk	20-24	*Lactococcus diacetylactis, Lactococcus lactis*	7-16	75-80
Yogurt	42-45	*Lactobacillus delbrueckii subsp. bulgaricus*, *Streptococcus thermophilus*	3-6	90-100
Yogurt*	42-45	*Lactobacillus delbrueckii subsp. bulgaricus*, *Streptococcus thermophilus*, *Lactobacillus acidophilus, Bifidobacteria ssp.*	3-6	80-120
Ryazhenka	18-24	*Lactococcus diacetylactis, Lactococcus lactis*	8-12	90-95
Lakto*	36-38	*Lactobacillus acidophilus, Streptococcus thermophilus, Bifidobacteria ssp.*	4-6	80-130
Butter milk	20-24	*Lactococcus diacetylactis, Lactococcus lactis*	8-12	80-120

Table 3.3.

Characterisation of microorganisms

Microorganisms	Optimal temperature, °C	Max NaCl konc, %	Lactic acid production, %
L. lactis	25-30	4-6.5	0.5-0.7
L. cremoris	25-30	<4	0.5-0.7
L. diacetylactis	25-30	4-6.5	0.3-0.6
Leuc. cremoris	20-25	-	0.2-0.4
Lb. helveticus	40-45	2	2.0-2.7
Lb. lactis	40-45	2	1.2-1.5
Lb. bulgaricus	40-45	2	1.5-2.0
Lb. acidophilus	35-40	2	1.5-2.0
Str. thermophilus	40-45	2	0.7-0.8
Bifidobacteria	37	-	0,4-0,9

•Cottage cheese is a fresh, soft, unripened cheese made from sweet, pasteurised skimmed milk by lactic culture with or without the addition of rennet.

Fig. 3.1 Cottage cheese

https://cheesemaking.com/products/cottage-cheese-recipe

Table 3.4.

Cottage cheese characterisation

Cottage cheese	**Fat content, %**	**Max water content, %**	**Max acidity, T**
low fat	-	80	240
table	2	75-80	235
with high fat content	5	75	230
with very high fat content	9-18	65-73	200-215

Laboratory work

Study of evaluation of fermented milk quality

Fermented dairy product production

Students receive chilled, skimmed milk obtained from the retail seller, homogenised and pasteurised at 90 °C for 5 minutes. Additionally, milk samples should be pasteurised (90 °C for 5min.) and cooled prior to the experiments. 200 mL milk for 1 sample. The samples should be prepared according to the following scheme (see table 3.5.).

Table 3.5.

Sample preparation

Amount of milk	*YF-L811, g*	*CHN 22*	*Kefir*
200 mL	**0.1**		**+**
200 mL	**0.1**		
200 mL	**0.1**		**+**
200 mL	**0.1**		

Then heat 400 mL of milk at 43/20/18 °C before using a water bath to inoculate it with the starter culture. The milk samples are incubated at 43/20/18 °C temperature for 4 to 6 hours until the pH of coagulum reaches pH 4.6. To understand the influence of the different starters on properties of the fermented product samples, the pH of the samples should be measured during fermentation. Determine the pH of the samples prior to the incubation and every hour during the fermentation. The pH of samples is checked using a pH-meter '3520 pH Meter' Jenway. All measurements are done in triplicate. Analysed parameters are summarised in table.

Table 3.6.

Summary of analysed yogurt parameters

Samples	pH	Sugar concentration	Water holding capacity	Sensory evaluation
During fermentation				
After fermentation				
After maturation				
During storage				

When the pH of the samples reaches pH 4.6, stir the samples and cool them to 10-15 ^{o}C using a water bath. Mature the samples at 4-6 ^{o}C for 10-12 hours in the refrigerator.

Students will summarise the pH and viscosity data of analysed samples, and also the results of the sensory evaluation using descriptive statistical methods. The comparison between data obtained from all yogurt samples with different starters will be made and explanations and conclusions will be drawn.

Conclusions

Approved by _____

(Name, surname, signature)

Date _____

Laboratory work

Determination of quality parameters of fermented dairy products

1. Determination of the acidity of fermented products

Add to a conical flask 10 mL of the product and 20 mL of deionised water, 2-3 drops 1% phenolphthalein solution in alcohol, mix it well and titrate with 0.1 M NaOH until a pale pink colour persists for 30 seconds. Acidity is expressed in °Th (Thorner degree). The acidity is calculated based on the equitation:

°Th =volume of used o.1 M NaOH (counted in mL) *10

2. Determination of fat content of fermented milk

Weigh 1 g of the product into the butyrometer, and add 10 mL of sulphuric acid (ρ=1.81 g/cm^3) into the butyrometer by letting it slowly flow down the glass walls. Add 1 mL of amyl alcohol using a pipette. Clean the neck of the butyrometer. Close the butyrometer tightly using a clean, dry stopper. Shake the butyrometer and invert it in a water bath at 65-75 °C for 5 minutes. Mix the butyrometer from time to time. Centrifuge for 5 min at 1200 rpm in the Gerber centrifuge. Remove the butyrometer from the centrifuge and adjust the meniscus to accomplish the reading. The sample must be 65 °C when reading the fat percentage. If the centrifuge is not adjusted to the right temperature, the butyrometer must be heated in a water bath.

Adjust the bottom meniscus to zero on the butyrometer's scale using a stopper. Read out the fat content from the low part of the upper meniscus. Express the fat content to an accuracy of 0.05%. Measurements are carried out in duplicate.

3. Determination of amount of separating whey

Carefully mix the samples of fermented milk and pour into a special graduated tube to the 10 mL border, close with a stopper. Put the tube into a water bath for 10 minutes at 30-35 °C, further centrifuge the tubes for 30 min at 1500 rpm, then students examine the content of the tube and determine the amount of separated whey in mL.

4. Determination of phosphatase

Measure 2 mL of fermented milk into a tube and 2 mL of deionised water, 2 mL of sodium phenolphthalein phosphate. Shake the tube and leave it in a water bath at 40-45 °C. After 1 hour, examine the colour of the product. If colour doesn’t change it is free from phosphatase. If the sample dyes from pale rose to dark pink, the sample contains phosphatase. If the change of the colour is observed during 10 minutes of tube incubation, further examination of the test tube isn't necessary.

Table 3.7.

Comparison of the acidity in milk during fermentation

Starter	Amount of added starter, g	Incubation temperature, C	Acidity					Characteristic of coagulum		
			0	30 min	60 min	90 min	120 min	consistency	Aroma + taste	Acidity, °Th

Sample:

Table 3.8.

Study of evaluation of fermented milk quality

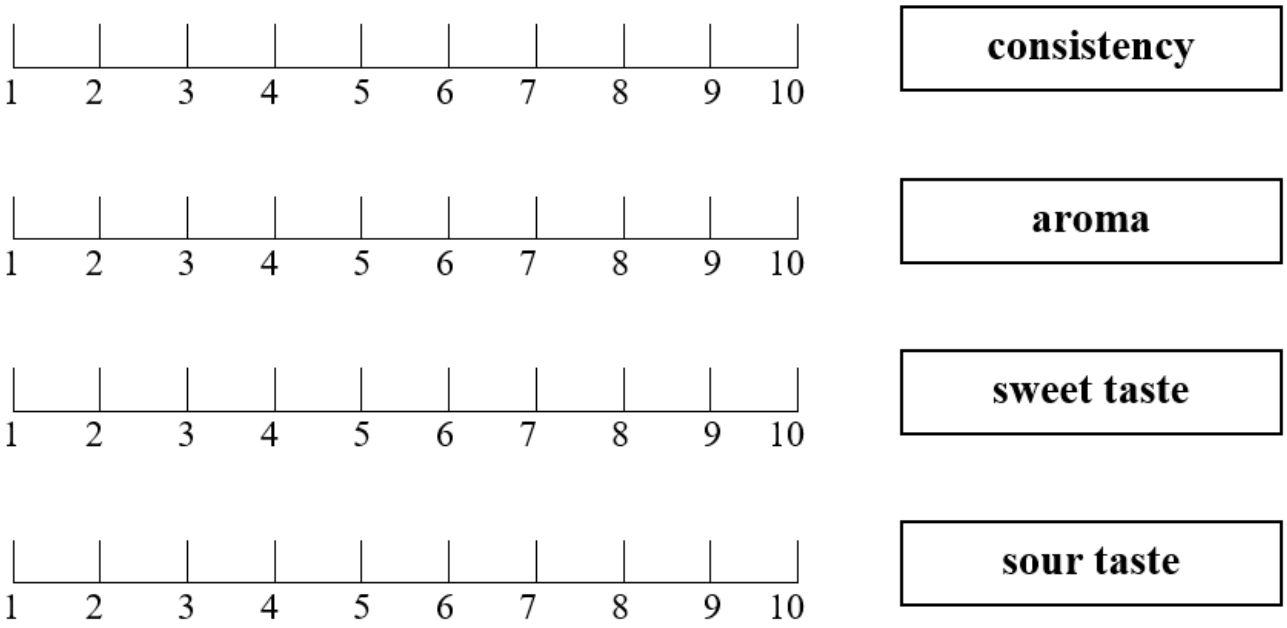
Acidity, °Th	Fat content, %	Amount of separating whey	Presence of phosphatase

5. Sensory evaluation of fermented dairy products

10-point Line scale

TRAY NO. _____

Please mark the intensity of the sensory property of the fermented samples presented on the Line scale and write the sample number below the marking.



Conclusions

Approved by _____

(Name, surname, signature)

Date _____

Practical works

Equipment for production fermented products

The aim of the work is to gain knowledge about sour milk production equipment. Compare the equipment used for the production of different types of sour milk products. The group of students is divided into teams, and each team analyses the set of equipment necessary for the production of a specific sour milk, and then presents it to the other groups.

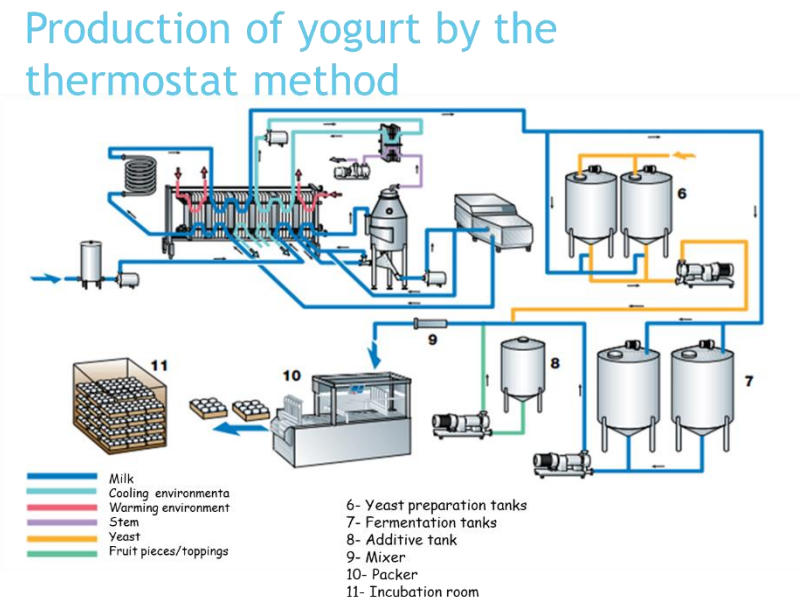
Materials

Students, considering the information according to the production technology of sour milk products, try to find the equipment to achieve the required result. By lining up the equipment to achieve a result. Provide a brief explanation of what each chosen device provides.

Procedures and Results

As a result, it is necessary to draw a diagram (or assemble a diagram from equipment stencils, if such have been prepared) in order to create different production lines of sour milk products.

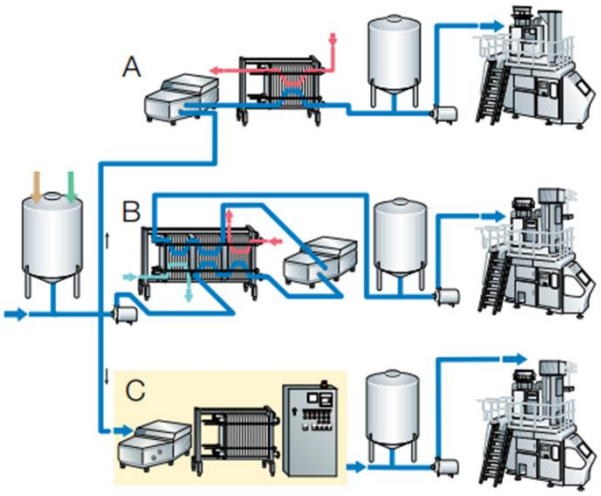
Such as the following:



OR

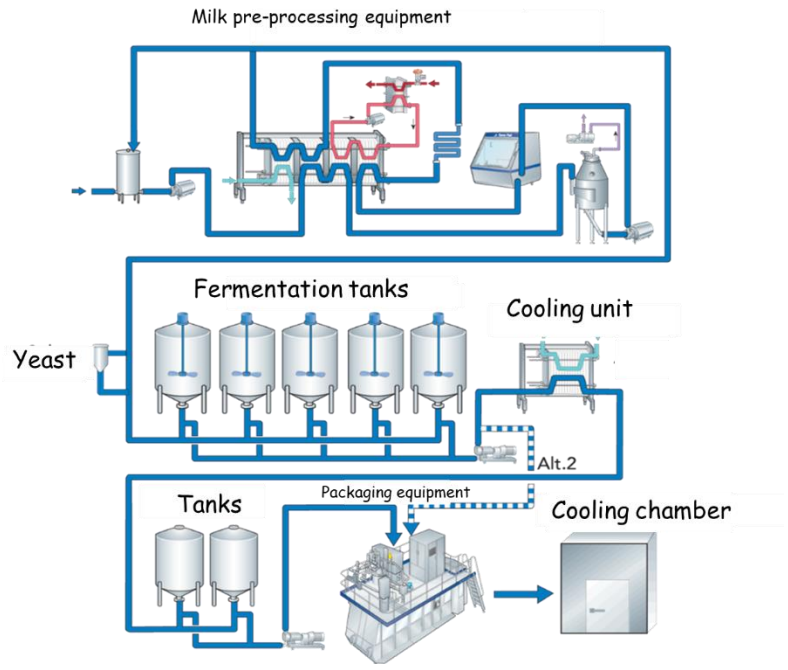
Drinkable yogurt

A - Homogenized and chilled yogurt
(Storage time 2-3 weeks at refrigerator temperature);
B - Homogenized, pasteurized, aseptically filled
(Storage time 1-2 months at refrigerator temperature);
C- Homogenized, UHT treated, aseptically filled
(Storage time several months at room temperature).



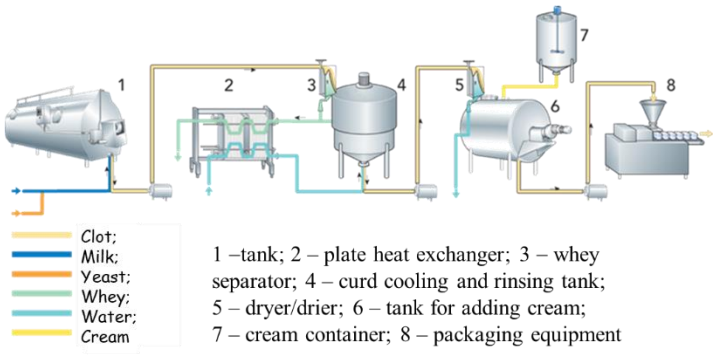
Yogurt
Cooling environment
Warming environment
Additives (fruits, berries, etc.)
Stabilizers

OR



OR

The technological scheme of making grainy cottage cheese, starting from sight



Flowchart for mechanized production of Cottage cheese.
https://dairyprocessinghandbook.com/chapter/cheese

Conclusions

During the practical activities, students acquire and strengthen knowledge and skills in the operation of equipment, as well as the understanding of equipment flow lines in the production of sour milk products. Students explain their work.

Approved by _____

(Name, surname, signature)

Date _____

Laboratory work

Study of whey separation influencing factors

1. Impact of pasteurisation regime

At the laboratory, the student takes two beakers with a clot. The day before, the milk was pasteurised in different conditions:

Unpasteurised

- 63 °C, 30 minutes;
- 72 °C, 20-25 seconds;
- 78 °C, 20-25 seconds;
- 80-85 °C, 20-25 seconds;
- 90-95 °C, 20-25 seconds.

After the heat treatment, the milk was cooled down to 30 °C, 5 mL of 40% $CaCl_2$ and starter culture (mesophile lactic starter) were added to it. The milk was fermented for 16 hours.

Weigh the beakers with clot and cut it with a knife into1-2 cm cubes. Then put the beaker into the water bath (45-50 °C) and heat it for 10-15 min. After it, pour the whole mass from the beaker through the flannel into a funnel located in the measuring cylinder.

Wait for whey to exude. After 1 min. set the amount of whey, and then after each 10 minutes set the amount of whey (for 1 h). After 1h, put 100g weight and extrude it for more 30 minutes. The retention rate (mL/h) is the amount of whey extruded after 1 hour, the total amount of whey will be extruded after 90 min.

The fat content (add 10 mL sulphuric acid to the butyrometer followed by 10.77 mL of well mixed whey. Avoid wetting the neck of the butyrometer. Next, add 1 mL of Amyl alcohol, insert a stopper and shake the butyrometer carefully until curd dissolves and no white particles can be seen. Place the butyrometer in the water bath at 65 °C and keep it there for more than 5 minutes. The butyrometer must be placed in the centrifuge with the stem (scale) pointing towards the centre of the centrifuge. Spin for 5 minutes, 1000 turnaround min^{-1}. Remove the butyrometer from the centrifuge. Put the butyrometer in a water bath maintained at 65 °C for 5 minutes before taking the reading. The fat column should be read from the lowest point of the meniscus of the interface of the acid-fat to the 0-mark of the scale and read the butterfat percentage. The butyrometer should be emptied into a special container for the corrosive liquid of acid-milk, and the butyrometers should be washed in warm water and dried before the next use.

The acidity of whey (10 mL of whey measured into the conical flask, 20 mL of distillate water, 2-3 drops of Phenolphthalein is added and then slowly from the burette 0.1 N Sodium hydroxide (NaOH) under continuous mixing, (until a faint pink colour appears) should be determined.

2. Impact of coagulation techniques

At the laboratory, the students takes two beakers with a clot. The Day before, the milk was pasteurised in different conditions:

Unpasteurised

- 63 °C, 30 minutes;
- 72 °C, 20-25 seconds;
- 78 °C, 20-25 seconds;
- 80-85 °C, 20-25 seconds;
- 90-95 °C, 20-25 seconds.

After heat treatment, the milk was cooled down to 30 °C, 5 mL of 40% $CaCl_2$, 1 mL of rennet and the starter culture (mesophile lactic starter) were added to it. The milk was fermented for 16 hours.

Weigh the beakers with clot, then cut it with a knife into 1-2 cm cubes. After it, pour the whole mass from the beaker through the flannel into a funnel located in the measuring cylinder. Wait for whey to exude. After 1 minute, set the amount of whey, and then after each 10 minutes set the amount of whey (for 1 h.). After 1hour put 100 g weight and extrude it for 30 more minutes. The retention rate (mL/h) is the amount of whey extruded after 1 hour, the total amount of whey will be extruded after 90 minutes. The content of the fat and acidity of whey should be determined as described previously.

The results are put into table 3.9.

Table 3.9.

Impact of milk pasteurisation regime and coagulation technique on the whey separation

Pasteurisation regime	Coagulation technique	The whey amount, mL							Retention rate (ml/h)	Total amount of whey, (mL)
		1	10	20	30	40	50	60		

3. Curd quality control

Determination of fat content

Use cream butyrometers. Weigh 5 g of cottage cheese in a butyrometer and add 5 mL of distilled water, 10 mL of H2SO4 (density=1.81-1.82) and 1 mL of isoamyl alcohol. The fat meters are closed with stoppers, shaken and placed in a water bath at 65-70 °C. During the heating, they are shaken

several times until all proteins are completely dissolved. The further course of determining the analysis is as for milk.

Determination of acidity

Weigh 5 g of cottage cheese in a porcelain bowl, add 30-40 mL of distilled water (35-40 °C) and crush the mixture well with a pestle. Add 2-3 drops of 1% phenolphthalein solution in alcohol and titrate with 0.1 M NaOH solution, stirring evenly with a glass stylus until the mixture develops a light pink (pink) colour that does not disappear within 2 minutes.

For the cottage cheese, the acidity in °T is calculated by multiplying the amount of NaOH (mL) used for titration by 20.

Determination of moisture content

Weigh two sheets of foil measuring 100 x 100 mm. Weigh 4 g of cottage cheese on one with an accuracy of 0.01 g, cover with a second sheet of foil, then set aside 10 mm wide edges. To increase the evaporation surface, the analysed sample is pressed down between two metal or wooden surfaces to a 0.8 - 0.9 mm thick layer (with a rolling pin, roll out the corresponding thickness, trying to achieve an even distribution of curd throughout the foil package).

After pressing, the package is opened and placed in a drying cabinet at 130 °C for 30 minutes. After 30 minutes, the package is removed, placed in a desiccator until it cools completely and weighed. The water content in the cottage cheese is calculated based on the formula:

$$M = \frac{(g - g_1)}{g - g_o} 100$$

where: M - curd moisture content, %;
g - foil mass together with cottage cheese until drying, g;
g1 - foil mass together with curd after drying, g;
go - foil mass, g.
The table summarises data only for the analysed curd sample.

Study of whey separation in different conditions

Table 3.10.

Impact of milk pasteurisation regime and coagulation technique on the whey separation

Pasteurisation regime	Coagulation technique	The whey amount, ml							Retention rate (mL/h)	Total amount of whey, (mL)
		1	10	20	30	40	50	60		

Sensory evaluation of cottage cheese

JAR (Just about Right) test

TRAY NO. **_____**

Select and write on the right-hand side of the scale the sensory properties that are specific to the cottage cheese.

Please, evaluate the sensory properties of the cottage cheese samples using the JAR (Just About Right) test.

Please, indicate your opinion about the cottage cheese samples sensory properties, marking the squared box that matches your preference and liking.

_____
sample code

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

_____
sample code

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

_____
sample code

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

_____
sample code

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

7-point Hedonic scale

TRAY NO. _____

Please evaluate the overall liking of the cottage cheese samples. Indicate how much you like or dislike each sample by checking (V or X) the appropriate phrase.

_____
sample code

like very much	like moderately	like slightly	neither like nor dislike	dislike slightly	dislike moderately	dislike very much

_____
sample code

like very much	like moderately	like slightly	neither like nor dislike	dislike slightly	dislike moderately	dislike very much

_____
sample code

like very much	like moderately	like slightly	neither like nor dislike	dislike slightly	dislike moderately	dislike very much

_____
sample code

like very much	like moderately	like slightly	neither like nor dislike	dislike slightly	dislike moderately	dislike very much

Conclusions

Approved by _____

(Name, surname, signature)

Date _____

Theme 4

Butter and ice cream: production technology and quality evaluation

Theoretical materials

Butter is a dairy product made from the churned cream, with a fat content of at least 80% and water content of no more than 16%. Butter should contain only dairy fats.

Table 4.1.

Butter and other similar products

Product	**Dairy fats, %**	**Other fats and oils, %**
Butter and other dairy products	100	-
Mixed fat products	15-80	20-85
Margarine and other similar products	>3	<97

Table 4.2.

Butter and other products with high fat content

Fat content, %	**Names**
80-95	butter
>62-<80	blended spread
60-62	reduced fat butter
>41-<60	reduced fat blended spread
39-41	low fat butter
<39	low fat blended spread

Fig. 4.1. Butter and other similar products[6]

Table 4.3

Butter quality parameters

Parameter	Content, %	
	Butter	Sour cream butter
Carbohydrates	1.23	1.33
Proteins	1.25	1.31
Non-fat dry matter	2.51	2.66
Acid number (mg/g fats)	1.22	1.77
Melting point (°C)	24.87	24.37
Diacetyl (mg $100g^{-1}$)	0.35 ± 0.2	2.20 ± 0.4

[6] Inga Ciproviča, lecture materials

Ice cream classification

- Ice cream made exclusively from milk products (milk, cream, butter, yogurt, whey ets.),
- Ice cream containing vegetable fat (olive, palm etc. oils),
- Sherbet ice cream made of fruit juice with added milk fat and milk solids-non-fat,
- Water ice cream made of water, sugar and fruit concentrate.

7 8 9 17 17 10

Fig.4.2. Types of ice creams

[7] https://www.frype.com/frozenyoggy/

[8] https://reitingi.lv/lv/news/komerczinas/121941-par-godu-latvijas-simtgadei-izn-cis-pa-s-ekselence-sald-jums-latvijas-karoga-kr-s-s.html

[9] https://pricer.lt/en/c/food/ice-cream-ice-cubes/tio-ice-cream

[10] https://www.rimi.lv/e-veikals/lv/produkti/saldetie-edieni/saldejums-un-ledus/saldetas-sulas-saldejumi/sulas-saldejums-jungle-pop-kolas-70ml-70g/p/987983

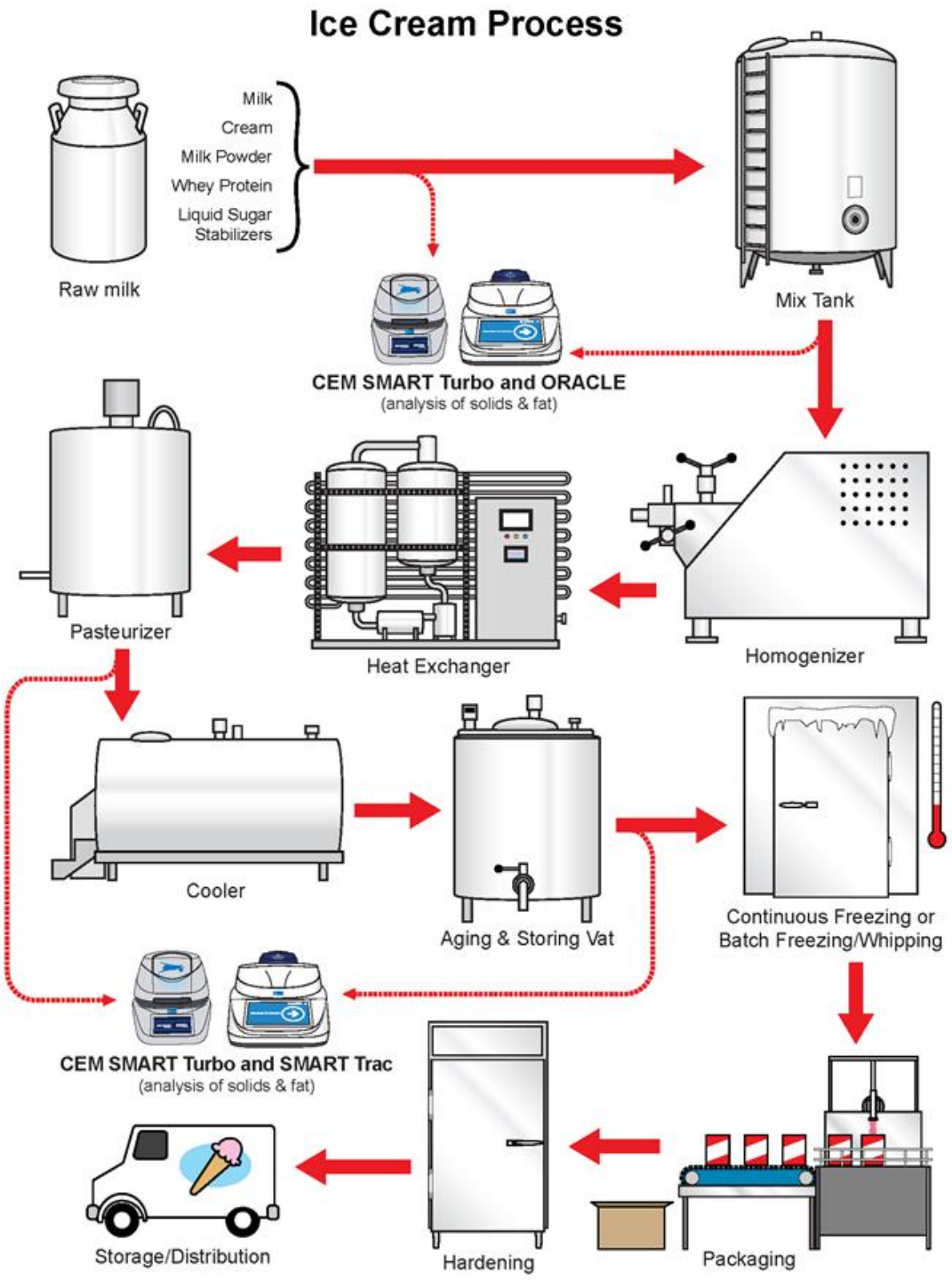


Fig.4.3. Ice cream production[11]

[11] https://cem.com/ice-cream-production-process

Laboratory work

Butter production and butter quality control

Task1. Butter production

Procedure

Students receive pasteurised and ripened sweet cream suitable for butter production. The students evaluate the cream's aroma and flavour, weigh the product, determine the fat content, temperature and acidity of the cream, and also analyse the weight of 100 mL cream prior to the churning process.

The cream plasma acidity is determined by calculation, knowing the cream fat content and acidity.

$$S_p = \frac{100 \cdot S_{kr}}{100 - T_{kr}},$$

where: *S_p – cream plasma acidity, °T;*
S_{kr} – cream acidity, °T;
T_{kr} – cream fat content, %.

Pour the cream into butter churn, put on a churning lid, verify the action of the butter churn and start the churning process.

The determination of cream volume changes during churning process and obtaining butter grains

The churning process continues for 15 minutes. After 1 minute of churning, the students stop the butter churn, open the lid and take a whipped cream sample (100 mL) and weigh it. The determination of the volume changes is done until the appearance of butter grain.

The churning process is stopped when the size of butter grain is 3-5 mm and the buttermilk is well extracted. The students pour the buttermilk, weigh it and determine the fat content, acidity and temperature of the product.

Determination of the buttermilk fat content. Carefully pipette or dispense 10 mL of sulphuric acid into the butyrometer. Carefully add 10.77 mL of milk to the butyrometer by letting it to flow slowly down the glass walls.

In order to not mix with the acid, pipette or dispense 1 mL of amyl alcohol. Clean the neck of the butyrometer. Close the butyrometer tightly using a clean, dry stopper. Shake and invert the butyrometer several times until the milk has been absorbed by the acid.

Place the butyrometer in a water bath at 65-75 °C for 5 minutes. Centrifuge for 5 minutes at 1200 rpm in the Gerber centrifuge. Remove the butyrometer from the centrifuge and adjust the meniscus to obtain a reading. The sample must be 65 °C when reading the fat percentage. If the centrifuge is not adjusted to the right temperature, the butyrometer must be heated in a water bath.

Adjust the bottom meniscus to zero on the butyrometer's scale using a stopper. Read out the fat content from the low part of the upper meniscus. Read the fat content result with an accuracy of

0.05%. The amount of fat varies from 0.4-0.7%. If the fat content is higher than 0.7%, the students will also know the factors influencing butter production in the laboratory and will be able to draw conclusions about the churning process and obtain results.

Determination of buttermilk acidity

Add to a conical flask 10 mL of milk and 20 mL of deionised water, 2-3 drops 1% phenolphthalein solution in alcohol, mix well and titrate with 0.1 M NaOH until a faint pink colour persists for 30 seconds. The acidity is expressed in °Th (Thorner degree). The acidity measured according to equation:

°Th= volume of used 0.1 M NaOH (counted in mL) × 10

The changes of cream volume during churning are calculated:

where: *V – changes of volume, %;*
m_{kr} *- 100 mL cream weight prior churning, g;*
m_{kr1}*- 100 mL cream weight after churning, g.*

Butter grains washing and butter treatment

The Students analyse the taste and smell of the butter grains and decide whether the butter grains need to be washed. If the students detect an untypical aroma or taste, they need carry out the grain washing procedure, but if the butter grains have a pleasant taste and smell such a procedure isn't necessary. Wash the grains with pasteurised water. The water temperature must be 1-2 ^{o}C below than analysed buttermilk temperature. If the grains are very soft and sticky, the water temperature decreases by 1-2 ^{o}C and hold grains 5 minutes in water prior to washing. If the grains are hard, the water temperature needs to be increased by 1-2 ^{o}C.

The washing process is as follows: add water, hold the grains for a few minutes and stir the grains with the water. Continue washing until no buttermilk is extracted and the water added is pure. After the washing, the butter grains are removed from the churn and treated with a spoon until the butter has the classical texture properties. Treat the curds until the structure of the butter is acceptable and drops of water or buttermilk can't be seen in the butter. Pack the butter, weigh it and put it in the fridge. Washing of butter churn

After the churning process, the churn needs to be washed with a cleaning solution. Carefully rinse and drain.
The students summarise the information about the churning process in the table.

Table 4.4.

Summary of butter production

No.	Indices	Parameters
1.	Cream: amount, kg temperature, °C fat content, % acidity, °T cream plasma acidity, % taste, smell, colour	
2.	100 mL cream weight, g	
3.	The changes of cream weight during churning, g: after 1 min after 2 min after 3 min after 4 min after 5 min	
4.	The changes of cream volume during churning, %: after 1 min after 2 min after 3 min after 4 min after 5 min	
5.	Buttermilk: amount, kg temperature, °C acidity, °T fat content, %	
6.	Butter outcome, kg	
7.	Water dispersion	
8.	Butter evaluation by score	

Task 2. Butter quality analyses

Procedure

Butter sensory evaluation

Students evaluate the sensory properties of the butter produced: aroma and taste, texture and body by scores according to the dairy products' sensory evaluation standard. Each student individually evaluates butter using a 5-point system, corresponding to explanations given in the table.

Table 4.5.

Butter evaluation by scores

Butter sample	Aroma and taste	Consistency	Texture (include also water dispersion evaluation)	Appearance

Explanations of the 5-point evaluation - see in table.

Table 4.6.

Evaluation of butter

Characteristics of evaluation	Reduction in points	Points
Excellent	0	5
Good	1	4
Satisfactory (small defects)	2	3
Poor (conspicuous defects)	3	2
Very poor (strong defects)	4	1

Note: if a student evaluates the sensory attributes of the butter scoring 3 or fewer points, the student must explain the assessment in mentioned defects.

Determination of water content

Weigh the vessel and weight 10 g of sand and add 5 g of butter. Carefully mix the content of the vessel and the students put the vessel into the oven at 102 °C for 2 hours. After 2 hours take the package from the oven, cool down and weigh it using balance. The moisture content is calculated using equation:

$$\bar{U} = \frac{(m_1 - m_2)}{m_1 - m_o} \cdot 100,$$

where: *Ū – water content in butter, %;*
mo – weight of vessel with sand, g;
m_1 – weight of vessel with sample prior to heating, g;
m2 – weight of vessel with sample after heating, g.

Determination of water dispersion

Using a sharp knife or other suitable technique, cut butter samples on two sides. Take a special indicator paper, put it on the surface of the cut butter. Take off the paper and evaluate water dispersion on 5-point system using the testing scale.

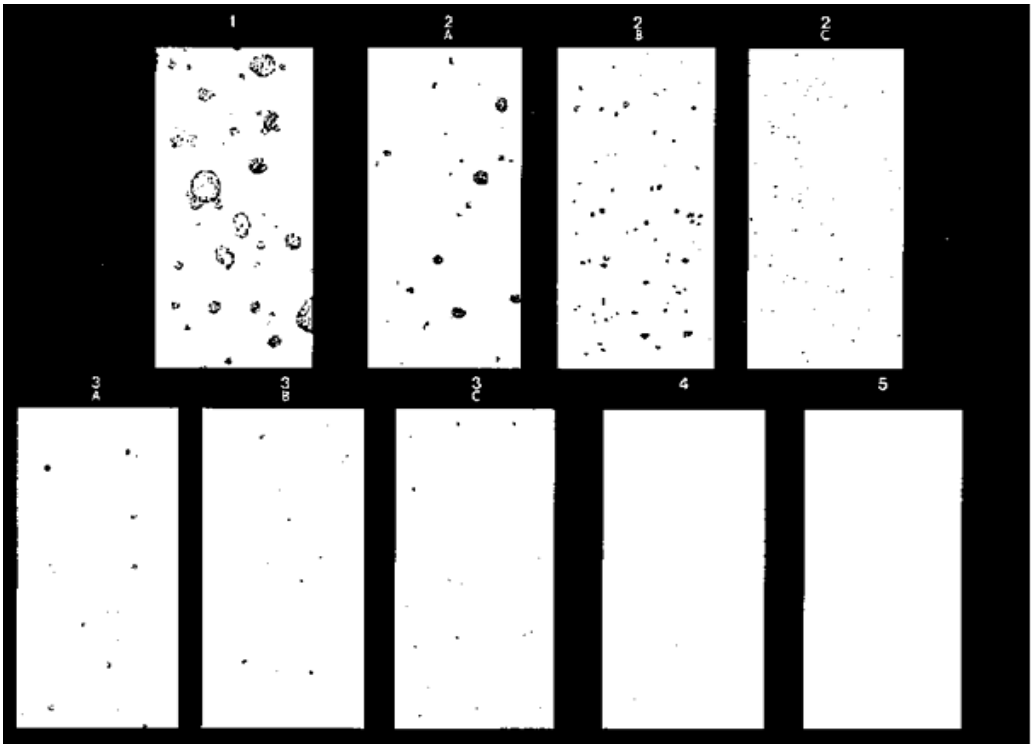


Fig.4.4. Water dispersion in butter[12]

Determination of solids-non-fat in butter

[12] Metodiskie norādījumi "Piens, tā pārstrāde", 2012 gads, Jelgava

Weigh a vessel with glass stick and filter paper. Take off the filter paper and weigh 5 g of butter into a vessel using a glass stick. Put the vessel into an oven at 102 °C for 30 minutes. After 30 minutes take out the vessel from the oven, cool down and add 20 mL ether or petrol, using a stick carefully mix the content of the vessel and hold for 3 minutes. Pour the fat-ether or fat-petrol solution until sediment level in the vessel and repeat procedure twice. After that weigh the vessel with filter paper and the glass stick.

$$BS = \frac{(g - g_1) \cdot 100}{g_o},$$

Where, BS – solids-non-fat content, %;
g – weight of vessel with sample after solvent evaporation, g;
g_1 – weight of vessel, filter paper and glass stick, g;
g_o – weight of butter, g.

2.5. Determination of fat content

The determination of butter fat content by a classical method (using extraction) is time consuming. In that case it is possible to make a calculation knowing the solids-non-fat and water content in butter using the following equations:

$$Ts = 100 - (\bar{U} + BS)$$

Where, T_s – fat content in butter, %;
$\bar{U}$ – water content, %.

Determination of plasma acidity

Weigh 100 g of butter into laboratory flask. Put the flask into a water bath at 55-60 °C temperature and hold until the butter completely melts. Take out the flask from the water bath and hold for 5 minutes at the room temperature. Carefully pour the layer of melted fats and lower the layer into the butyrometer and close it with a cork. Centrifuge for 5 minutes at 1200 rpm in the Gerber centrifuge. After centrifugation put the butyrometer into the glass with cold water and hold it till fat crystallisation occurs. Open the butyrometer and pour plasma into the flask. To 100 mL flask pour 5 mL of plasma, add 2-3 drops of 1% phenolphthalein solution in alcohol and titrate 0,1 M NaOH (sodium hydroxide) up to a pale pink colour.

Acidity is expressed in °Th (Thorner degree). The acidity is counted according to equation:

°Th= volume of used 0.1 M NaOH (counted in mL) × 20

Determination of peroxidase test

Measure 3-5 mL of butter plasma into a tube and add 2-3 mL of deionised water and 5 drops of KJ and 5 drops of 0.5% H_2O_2. Shake the tube and examine the colour of the tube. If the colour of the tube doesn't change, the sample is free from peroxidase. If the sample dyes dark blue to black, the sample contains peroxidase.

Conclusions

Approved by _____

(Name, surname, signature)

Date _____

Laboratory work

Ice cream preparation

Materials. Ice cream mixes were produced from the following ingredients: cream, condensed milk, sugar, milk and water.

Preparation of ice cream

The proportions of the main ingredients in the ice cream samples are according to table 4.7.

In the ice cream preparation, first, dry components were weighed and mixed, then liquid and dry components were combined into an ice cream mix. The obtained mix was pasteurised at 85 °C for 20 ± 5 seconds, then cooled down and maturated for 8 hours at 5 ± 1 °C. The main technological operation – freezing, when the ice cream mix was being frozen and whipped at the same time, the ice cream machine Taylor model 142 (Taylor, USA) at –8 ± 2 °C was used. Then the ice cream was placed into plastic containers (500 mL). The ice-cream was hardened at –20 ± 2 °C for 6 hours.

Table 4.7.

Recipe of ice creams

Raw materials	**Calculation for 1 kg of ice cream**			
	Cream ice cream	**Premium**	**Milk**	**Aromatised**
Milk with fat content 3.2%	500	450	730	500
Cream 40%	189	250	29.1	30
Butter	-	43.2	-	-
Condensed milk/milk powder*	219	56.0*	48.6*	49.6*
Stabiliser	3.0	3.0	3.0	15.0
Sugar	49	155	150	15.3
Jam				223.5

Water	40.00	42.8	39.3	146
Total	1000	1000	1000	1000

Table 4.8.

Calculations of ice cream formulation

Raw materials	**Calculation for 1 kg of ice cream**				
	g				
	Amount	**Fats**	**Non-fat solids**	**Sugars**	**Solids**
Milk with fat content of 3.2%, non-fat solids 8.00%	500				
Cream 40%, non-fat solids, 5.6%	189				
Condensed milk/milk powder*	219				
Stabiliser	3.0				
Sugar	49				
Water	40.00				
Total	1000				

Conclusions:

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(Name, surname, signature)

Date _____

Packaging materials, equipment and principles for dairy products (liquid and paste)

As you can see, the range of dairy products is wide and the packages are different. Therefore, different packaging materials and different packaging technologies are used in their packaging.

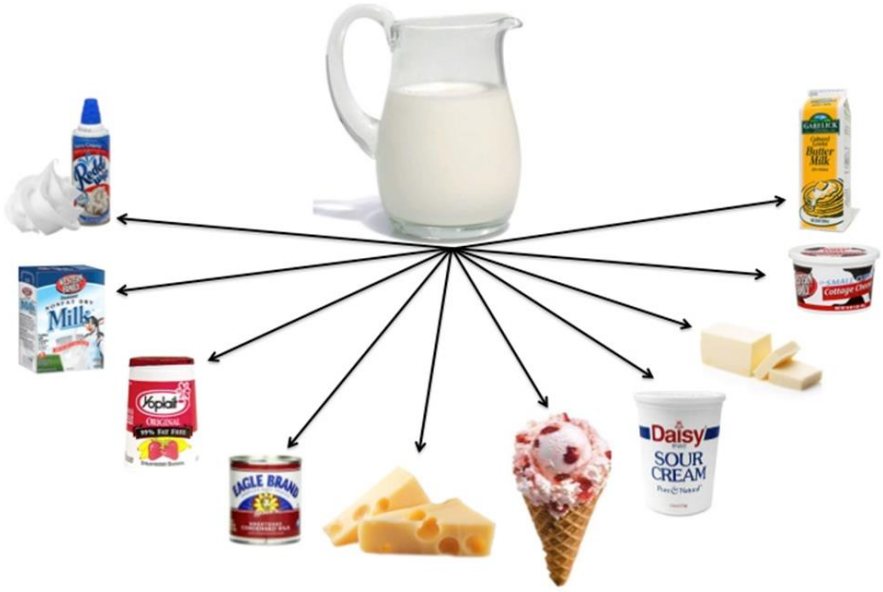

Fig. 4.5. Products produced from milk
https://newmexico.agclassroom.org/matrix/lesson/print/246/

Both single-layer and multi-layer packaging materials are used for packaging. If it is necessary to extend the shelf life, then multilayer packaging materials with high gas barrier properties are used, which allows products to be packed in vacuum (VP) and modified atmosphere packaging (MAP).

Fig. 4.6. The most typical packaging equipment used for products
https://gpnuy.com/project/tffs-spapor-bassa/

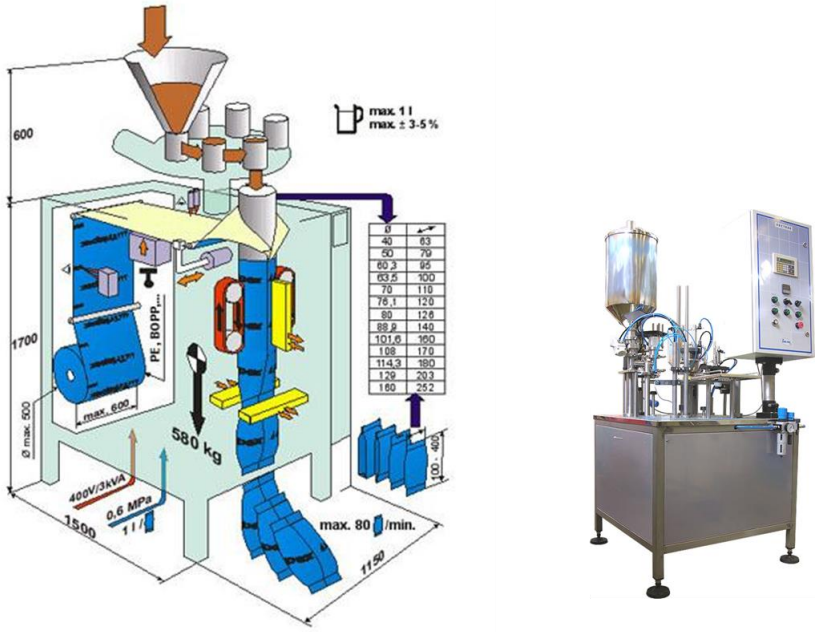

Fig. 4.7. The most typical packaging equipment used for products
https://www.triapex.cz/en/packaging-machines/hv4-14

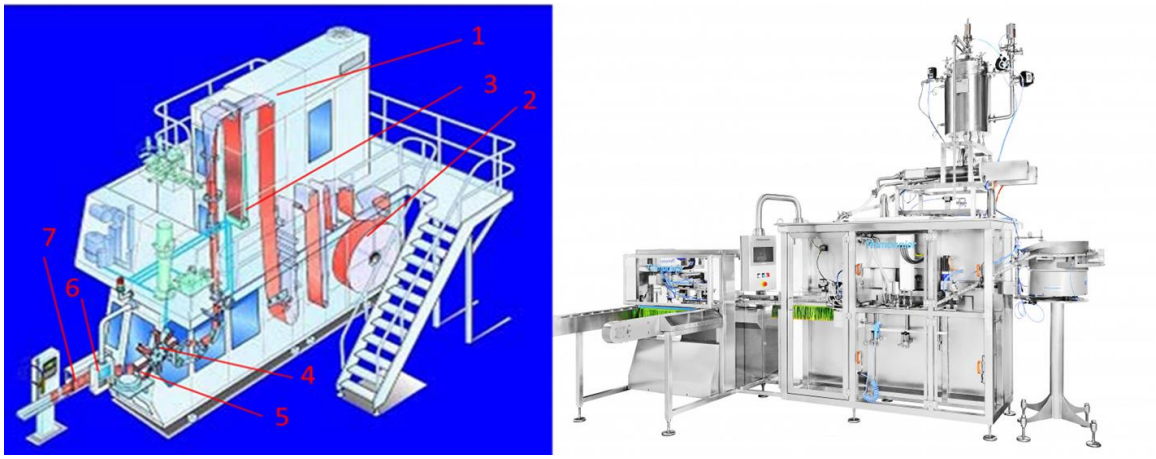

Fig. 4.8. The most typical packaging equipment used for products
https://www.researchgate.net/publication/228611726_Towards_Object-Oriented_Modeling_of_Complex_Mechatronic_Systems_for_the_Manufacturing_Industry/figures?lo=1
https://fud-tech.eu/portfolio-items/stavpaku-doypack-pouch-pilditaji/

Chamber type machines and tray sealers are usually used by smaller production companies, while flow-wrap and flow-packs (horizontal and vertical) as well as thermoforming machines are usually used by larger capacity companies because of the high output of these machines.

All packaging equipment and technologies have their pros and cons, therefore, when choosing equipment, some aspects should be evaluated.

PRACTICAL WORK

Selection and machinery of packaging materials for products

The aim of the workshop is to analyse the packaging as an added value to the product, because the packaging often plays an important role in the choice of a product. The group of students is divided into teams, and each team analyses products packaged using different packaging solutions, paying significant attention to packaging design.

Materials

In the seminar, we'll use either different prototypes of packaged products or photos found on Internet with different packaged products. Each group of students will analyses three different packages. And the characteristics are given in table 4.9.

Procedures and Results

The results obtained should be reflected in table 4.9.

Table 4.9.

Characteristic parameters	**Samples**		
	Product No. 1	Product No. 2	Product No. 3
Packaging material			
Packaging shape			
What information is printed on the package?			
Does the packaging contain information about the recyclability of the packaging?			
What can be done to make the packaging more attractive?			
Are there any flaws or gaps in the information printed on the package? If so, which ones?			

Conclusions:

After completing the table, different groups of students compare the results. If possible, each group presents and justifies its performance.

During the workshop, students acquire skills in characterising packages and analysing situations, as well as experience of working in groups.

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Date _____

Theme 5

Cheese: classification, production technology and quality assessment

Theoretical materials

Cheese classification criteria

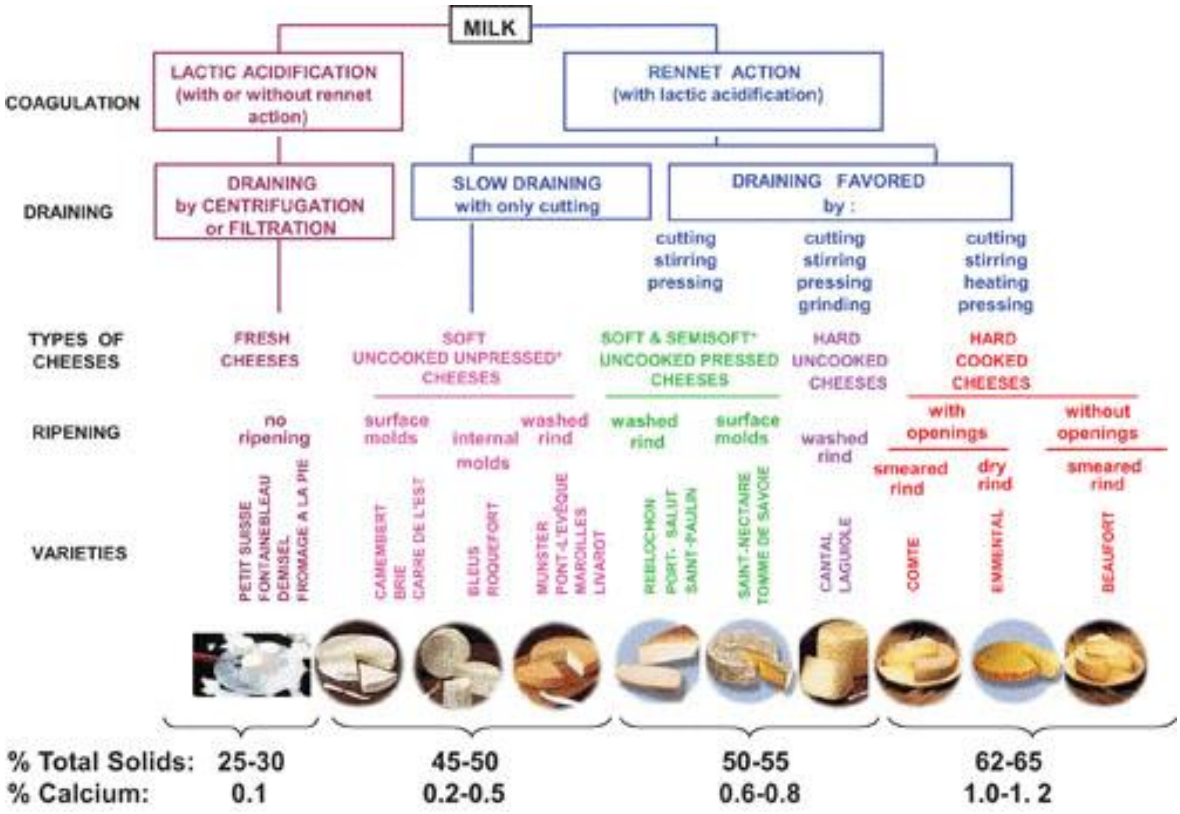

Fig. 5.1. Cheese classification criteria
https://journals.asm.org/doi/10.1128/microbiolspec.cm-0003-2012

Table 5.1.

Cheese classification according to fat and moisture content

Moisture content, %	Name	Fat content in dry basis, %	Name
< 41	Extra hard	> 60	High fat
49 – 56	Hard	45 – 60	Full fat
54 – 63	Semi-hard	25 – 45	Medium fat
61-69	Semi-soft	10-25	Low fat
>67	Soft	<10	Skim

Cheese production technology

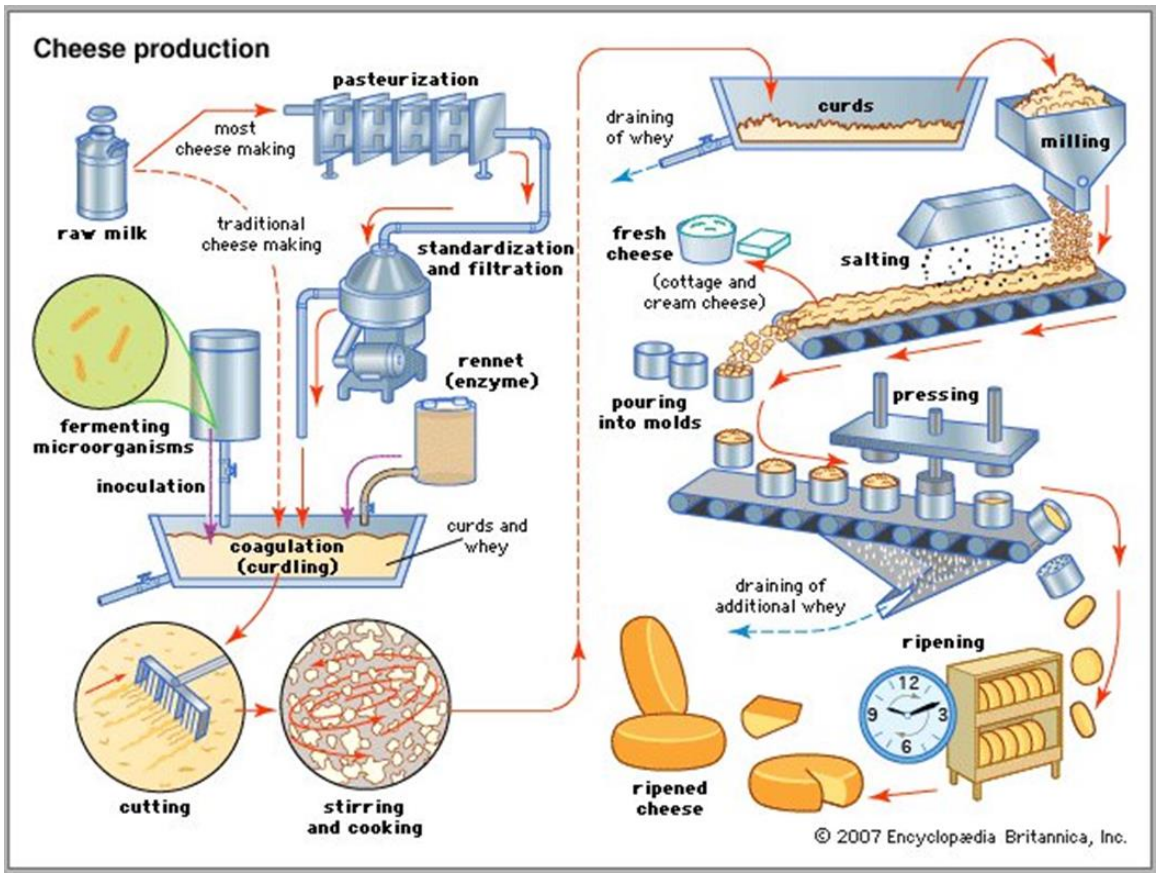

Fig. 5.2. Cheese production technology https://www.britannica.com/topic/cheese-making

Laboratory work Acid cheese production

Materials

Raw milk, rennet, CaCl2, starter, citric acid, etc.

Janu cheese

Fig. 5.3. Janu cheese
https://www.lsm.lv/raksts/dzive--stils/vecaki-un-berni/22.06.2023-klasiska-janu-siera-recepte-laiks-izmeginat.a282512/

Table 5.2.

Necessary ingredients for Janu cheese

Product	Amount	Unit
Milk	4	kg
Cottage cheese	1	kg
Eggs	4	pieces
Butter	0.2	kg
Salt	1.2	g
Cumin	20	g

Heat milk to 80 °C while continuously mixing it, then add cottage cheese, continue heating and mixing until the temperature reaches 80-85 °C, while green and clear whey are arising. The cheese mass with whey should be put into a pot with applied filter material, as a result the cheese mass and whey should be divided. The cheese mass is put into the pot where butter is melted. Then put whipped eggs, salt and cumin (which should be poured with hot water). The mass should be heated and intensively mixed till it is homogeneous and viscous. Then the hot mass should be put into a form

and weighted down. The prepared cheese should be sensory evaluated (taste, flavour, consistency, aroma).

Dessert cheese

Fig. 5.4. Dessert cheese
https://fondeco.ru/lv/chto-prigotovit-iz-suluguni-bystro-chto-prigotovit-s-syrom/

Table 5.3.

Necessary ingredients for dessert cheese

Product	Amount	Unit
Milk	2	kg
Lemon	4	pieces

Heat milk to 80 °C while continuously mixing it, then add juice of 4 lemons - add it very carefully in small amounts, continue heating and mixing till the green and clear whey are arising. The cheese mass with whey should be put into the pot with applied filter material, as a result the cheese mass and whey should be divided, but don't press on it. After 40 minutes, the cheese mass should be put into a form and weighted down. The prepared cheese should be sensory evaluated (taste, flavour, consistency, aroma).

Students' cheese

Fig. 5.5. Students' cheese
https://www.garsigalatvija.lv/page/25/?attachment_id

Table 5.4.

Necessary ingredients for Students' cheese

Product	Amount	Unit
Milk	**2**	**kg**
Vinegar	**10**	**mL**

Heat milk to 80 °C while continuously mixing it, then add vinegar (~10 mL), add it very carefully in small amounts, continue heating and mixing till the green and clear whey are arising. The cheese mass with whey should be put into the pot with applied filter material, as a result the cheese mass and whey should separate, don't press on it. After 40 minutes, the cheese mass should be put into a form and weighted down.

Soft cheese

Fig. 5.6. Soft cheese
https://skolenuekskursijas.lv/apskates-vieta/siera-razotne-sierstelle/

Table 5.5.

Necessary ingredients for soft cheese

Product	Amount	Unit
Milk	2	kg
Sour cream	500	mL

Heat milk to 80 °C while continuously mixing it, then add sour cream - add it very carefully in small amounts, continue heating and mixing till the green and clear whey are arising. The cheese mass with whey should be put into the pot with applied filter material, as a result the cheese mass and whey should separate, don't press on it. After 40 minutes, the cheese mass should be put into a form and weighted down.

Conclusions

Approved by _____

(Name, surname, signature)

Date _____

Laboratory work

Effect of different factors on milk clotting time

1. The influence of pH

Into 4 beakers, pour 50 mL of milk and add a different amount of 0,1 M H_2SO_4: 0; 1.0; 1.5; 2.0 mL; determine the pH and heat the samples in the water bath to 35 ^oC. Reaching the temperature, add 1 mL of 1% rennet solution to each beaker. Stir the content of the beaker gently for around 30 seconds and leave it to coagulate. Students measure the time necessary for the coagulation of the milk. The results are summarised in the table and the data are illustrated in a chart, too.

Table 5.6

The influence of pH on milk coagulation

Amount of 0,1 M H_2SO_4, mL	pH	Coagulation time, min
0		
1		
1.5		
2		

2. The influence of renneting temperature

Into 3 beakers pour 50 mL of milk and heat to 25, 35, 50 ^oC. Reaching the temperature, add 1 mL of 1% rennet solution to each beaker. Stir the content of the beaker gently for around 30 seconds and leave it to coagulate. Students measure the time necessary for the coagulation of the milk.

Results are summarised in the table and data are illustrated in a chart, too.

Table 5.7.

The influence of renneting temperature on coagulation time

Temperature, ^oC	Coagulation time, min
25	
35	
50	

3. The influence of calcium concentration

Into 4 beakers pour 50 mL of milk and add a different amount of 5% $CaCl_2$ solution - 0; 0.1; 0.2; 0.3 mL, which corresponds to $CaCl_2$ concentration - 0; 10; 20; 30 g/100 l of milk.

Heat the samples in the water bath to 35 ^oC. Reaching the temperature, 1 mL of 1% rennet solution is added to each beaker. Stir the content of the beaker gently for around 30 seconds and leave to coagulate. Students measure the time necessary for the milk coagulation. The results are summarised in the table and the data are illustrated in a chart too.

Table 5.8.

The influence of the amount of calcium chloride on coagulation time

$CaCl_2$, g/100 l milk	Coagulation time, min.
0	
10	
20	
30	

4. The influence of pasteurisation temperature

Without $CaCl_2$ addition

Into 3 beakers pour 50 mL milk. Each sample heats in the water bath to different temperatures: 72 ^oC, 80 ^oC and 90 ^oC. Reaching the temperature, hold samples for around 15 seconds. After pasteurisation, the samples cool down to renneting temperature (35 ^oC) and 1 mL of 1% rennet solution is added to each beaker. Stir the of content of the beaker gently for around 30 seconds and leave to coagulate at 35 ^oC. Students measure the time necessary for the milk to coagulate.

The obtained results are summarised in the table and the data are illustrated in a chart, too.

With $CaCl_2$ addition

Into 3 beakers pour 50 mL of milk. Each sample is heated in the water bath to different temperatures: 72 ^oC, 80 ^oC and 90 ^oC. Reaching the temperature, hold the samples for around 15 seconds. After pasteurisation, the samples cool down to renneting temperature (35 ^oC) and 0.2 mL of 5% $CaCl_2$ solution and 1 mL of 1% rennet solution is added to each beaker. Stir the content of the beaker gently for around 30 seconds and leave to coagulate at 35 ^oC. Students measure the time necessary for the milk to coagulate.

The obtained results are summarised in the table and the data are illustrated in a chart, too.

Table 5.9.

The influence of pasteurisation temperature on milk renneting

Pasteurisation temperature, ^oC	Renneting time, min.	
	Without $CaCl_2$	With $CaCl_2$
72 ^oC 15 s.		

80 °C 15 s.		
90 °C 15 s.		
unpasteurised milk		

Students collect results from all examinations and make conclusions about the influence of the pH, the amount of calcium chloride, the renneting temperature, and the pasteurisation temperature on coagulation time.

Conclusions

Approved by _____

(Name, surname, signature)

Date _____

Laboratory work

Semi – hard cheese production

Holandes cheese is the main representative of the class of semi - hard cheeses in the Baltic States and can be characterised by:

- the use of fresh pasteurised cow's milk, the milk normally being partly skimmed;
- milk clotting by means of rennet;
- the use of, preferably, mixed – strain starters consisting of mesophilic lactococci
- and usually leuconostics that generally produce CO_2;
- water content in the fat – free cheese below 63%;
- pressing the cheese to obtain a closed rind;
- acidification mainly in the curd block after separation of the whey during pressing, holding and the first hours of bringing;
- salting after pressing, usually in brine;
- absence of an essential surface flora;
- being at least somewhat matured (for 4 weeks) and thus undergone significant proteolysis.

Consequently, the cheese normally has a semi - hard consistency and a smooth texture, usually with small holes; the flavour intensity varies widely. After prolonged natural ripening, the consistency will be hard and the formation of amino acid crystals is common.

Procedure

Students receive pasteurised and ripened milk suitable for cheese production. The milk should be weighed and the acidity of milk should be detected. Pour 45 kg of milk into the cheese vat, stirring it constantly for even heat distribution.

The milk should be heated to 32 °C, then mixed – the starter culture should be added (the amount of the starter should be previously calculated taking into account the activity units of the starter). The starter should be dissolved in 100 mL of milk.

Then 40 % $CaCl_2$ should be added approximately 30 minutes before adding the rennet (coagulant), 30-40 g of dry $CaCl_2$ for 100 kg of milk. After adding the $CaCl_2$ solution, the milk should be well mixed.

Before coagulant/rennet is added, the milk acidity should be detected - it should be 19-20°T. For coagulation as dry as liquid rennet can be used, the amount of rennet depends on the rennet activity units. Rennet should be mixed with 50 ml of deionised water.

A good quality coagulum has been formed at 32-33 °C temperature after, 20-30 minutes. Renneting should be stopped when the rennet is firm, elastic, and the whey is clear. Cut the llot with special horizontal and vertical knives, continue stirring slowly. Cubes of 4-6 mm size should be formed during this process. Immediately after cutting, the curd grains are very sensitive to mechanical treatment, for this reason the stirring has to be gentle. It must, however, be fast enough to keep the grains suspended in the whey. Sedimentation of the curd in the bottom of the vat causes the formation of lumps. This puts a strain on the stirring mechanism, which must be very strong. The curd of low-fat

cheese has a strong tendency to sink to the bottom of the vat, which means that the stirring must be more intense than for the curd with high fat content. Lumps may influence the texture of the cheese as well as cause loss of casein in the whey.

The acidity of the whey should be detected. The grain formation time is 10-15 minutes.

After grain formation, 30-40% of the whey should be released from the cheese vat and continue to process the cheese grains for 20-35 minutes. The whey acidity, after clot cutting, should be 12-13°T, before the second heating - 13-15°T. The acidity of whey cannot decrease more than 2 °T from the clot cutting and the second heating time period. If the acidity of the milk increases more, the second heating should be shorter and 10-15% of 65-70 °C deionised water should be added to the cheese grains.

The acidity of whey should be detected before the second heating. The second heating regimes are 40 °C temperature and 10-15 minutes. To improve the cheese structure and increase in the water content, a salt solution (15%) could be added, previously discharge vat for 20-30% of the whey.

The grains should be mixed for 5-30 minutes. Normal grains are elastic. The total duration time of the curd and cheese grains processing is 60-70 minutes.

As soon as the required acidity and firmness of the curd have been attained – and checked by the producer – the residual whey is removed from the curd in various ways depending on the type of the cheese.

The curd was collected in cheese cloths while still in the whey and then transferred to a large mould on a special drainage material and pressed by weight of 1 kg per 1 kg of cheese. When the cheese is pressed, the whey is drained off. The cheese should be pressed for 15-20 minutes. At the end of pressing, the pressure should be increased to 4 kg per 1 kg of cheese. The amount of whey should be weighed.
The cheese is then placed into special equipment and pressed for 5-10 minutes. The cheese should be pressed for 90 minutes (45 min for one part, 45 for the other) with pressure of 20-30 kg per 1 kg of cheese.

Weigh the cheese and put into the refrigerator in brain (20-22%) for 24 hours. Following it, leave the cheese for 48-64 hours in a refrigerator, then it should be treated with disinfectant and packaged. The cheese should be ripened for 2 weeks at 10-12 °C.

All results should be summarised in the table 5.19.

Table 5.19.

The main parameters of cheese technological process

Title	Characteristic
Pasteurised milk amount, kg acidity, ^{o}T	
Starter amount, g/100 kg milk	
Added to milk $CaCl_2$, g/100 kg milk Coagulant/rennet, g/100 kg milk	
Renneting/Clot formation Acidity before renneting, ^{o}T temperature, ^{o}C time, min	
Clot and cheese grain processing Clot cutting and cheese making time, min Cheese grain processing before second heating, min	
Whey Acidity after clot cutting, ^{o}T Acidity before second heating, ^{o}T Acidity after second heating, ^{o}T Fat content (after second heating), % amount, kg, % from milk amount	
Second heating temperature, ^{o}C time, min amount of added water, kg	
Grain processing time after second heating, min	
Salt amount added to grains, g/100 kg milk	
Cheese formation time, min	
Cheese pressing time, min	
Brining/salting brine concentration, % temperature, ^{o}C time, h	
Cheese after salting/brining amount, kg	
Yield of cheese kg milk/ kg cheese after pressing	
Losses, kg, %	

Laboratory work

Evaluation of cheese quality

1. Chemical composition of cheese

Detection of fat content

Add 10 mL sulphuric acid (ρ-1.50-1.55 kg m^{-3}) to the milk butyrometer, then add 2 g of grated cheese followed by 10 mL of sulphuric acid (ρ-1.50-1.55 kg m^{-3}). Avoid wetting the neck of the butyrometer. Next, add 1 mL of Amyl alcohol, insert a stopper and shake the butyrometer carefully until the cheese dissolves and no white particles can be seen. Place the butyrometer in the water bath at 70 ºC and keep it there for ~1 hour until the cheese parts are dissolved. The butyrometer must be placed in the centrifuge with the stem (scale) pointing towards the centre of the centrifuge.
Spin for 5 min 1000 turnaround min^{-1}. Remove the butyrometers from the centrifuge. Put the butyrometers in a water bath maintained at 75 ºC for 5 minutes. before taking the reading. (Note: When transferring the butyrometers from the centrifuge into the water bath, make sure that the butyrometers are all the time held with the NECK POINTING UP).
The fat column should be read from the lowest point of the meniscus of the interface of the acid-fat to the 0-mark of the scale and read the butterfat percentage.
The butyrometers should be emptied into a special container for the very corrosive liquid of acid-milk, and the butyrometers should be washed in warm water and dried before the next use.

The fat content should be calculated according to the following equitation**:**

$$T = \frac{X \times 11}{m}$$

where: T – fat content in cheese, %;
X – reading of the butyrometer, %;
M – cheese weight, g;
11 – coefficient

The fat content in the cheese dry matter should be calculated according to the following equitation**:**

$$Ts = \frac{T \times 100}{100 - W}$$

where: T_s – fat content in dry matter;
W- water content in cheese, %.

Detection of moisture content

Weigh a 100*100 mm foil, then weigh 4 g of grated cheese (with an accuracy of 0.01 g), close with one foil and return the 10 mm edges, then, for smooth sample dispersion, press the cheese, then open the package and put it in the oven at 130 °C, after 40 min take out the package and put it into the desiccator.

The water content should be calculated according to the following equitation:

$$W = \frac{g - g1}{g - g0} \times 100$$

where: w – water content in cheese, %;
g – mass of foil and cheese before drying, g;
g_1 mass of foil and cheese after drying, g;
g_0 – mass of foil, g.

2 Sensory evaluations of cheese

Sensory evaluation of cheese

In each evaluation group - 4-5 experts; for each group - 4-5 cheese samples (one or two producers and differently prepared, for example sliced, and cubed). The cheese samples removed from original packaging and placed in transparent zip bags. Each sample is coded with three randomised numbers.

Table 5.20.

Cheese sensory evaluation table

Assessment	Points
Fits product type (very good)	5
Minimal defects (good)	4
Noticeable deviations from the specifications (minor defects)	3
Noticeable deviations (bad, visible defects)	2
Very pronounced deviations (very bad, severe defects)	1
Not suitable for human consumption	0

Defect
APPEARANCE
too flat
too high
deformed
puffed up
blowing
curved
stained
dirty
Top, bark
thick
plan
rough
colorless
cracked
dry
wet
rotten
greasy
stained
wrinkled
spotted
with mold spots
too thick a layer of paraffin
for a thin layer of paraffin
too little mold
uneven mold
wrong type of mold
holes
OVERALL SCORE **OUTER**APPEARANCE (max. 5 points)
INTERIOR APPEARANCE
A glance
there is no holes
too little holes
too much holes
too small
too big
atypical
distorted shapes
not equal
shiny
cracks
rotting spots
the presence of a foreign body
a lot of mesh at the top shell
Color
colorless

not the same
striped
marbled
spotted
spotty
whitish, grayish
faded in surface area
red color in the surface area
Structure
suffered
strict
perseveres
lumpy
soft
sticky
grainy
sandy
stretchy
fragile, crumbly
rubberized
layered
not the same
chalky
OVERALL SCORE **INTERIOR APPEARANCE**(max. 5 points)
SMELL and TASTE
dirty
inappropriate
rancid
greasy
soapy
rotting
ammonia
sharp
sweet
sour
bitter
salty
metallic
chemical
musty (stale taste)
yeast
butyric acid
fodder
fruit
pasteurization
burn
OVERALL SCORE **SMELL and TASTE**(max. 5 points)

COMMON ASSESSMENT 14-15 – very good quality 11-13 – good quality 9-10 – average quality less than 8 – inadequate quality

Please, evaluate given cheese samples and fill each expert group Table 5.21.

Table 5.21.

Cheese sensory evaluation summary

Sample code	Appearance	Interior appearance	Smell and taste	TOTAL

Conclusions

Approved by _____

(Name, surname, signature)

Date _____

Practical work

Packing, types, materials, equipment of preserved butter, cheese and milk

Multi-layer packaging materials are used for cheese packaging. If it is necessary to extend the shelf life, then multilayer packaging materials with high gas barrier properties are used, which allows products to be packed in vacuum (VP) and modified atmosphere packaging (MAP).

Three packaging technologies are mainly used for dairy products packaging: air, vacuum and MAP packaging. When packing products in an air environment, the packaging materials do not have specific characteristics. When packing in vacuum or MAP, it is important that the packaging materials have high gas barrier properties. Multi-layer films. Practically all the other films used for dairy products packaging are designed as strong oxygen and water-vapour barriers. In order to fully achieve these requirements, films with good barrier properties for oxygen and water vapour respectively are combined.

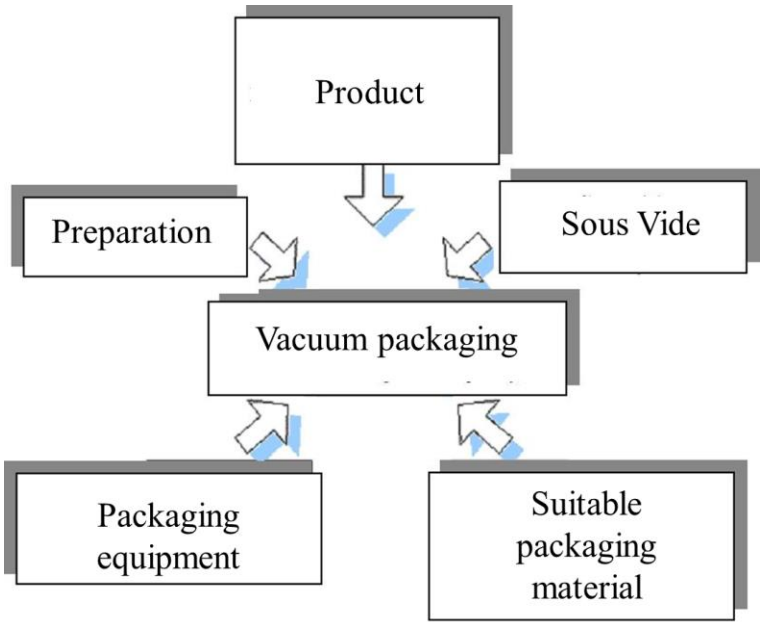

Fig. 5.7. The vacuum packaging process was influenced by these aspects

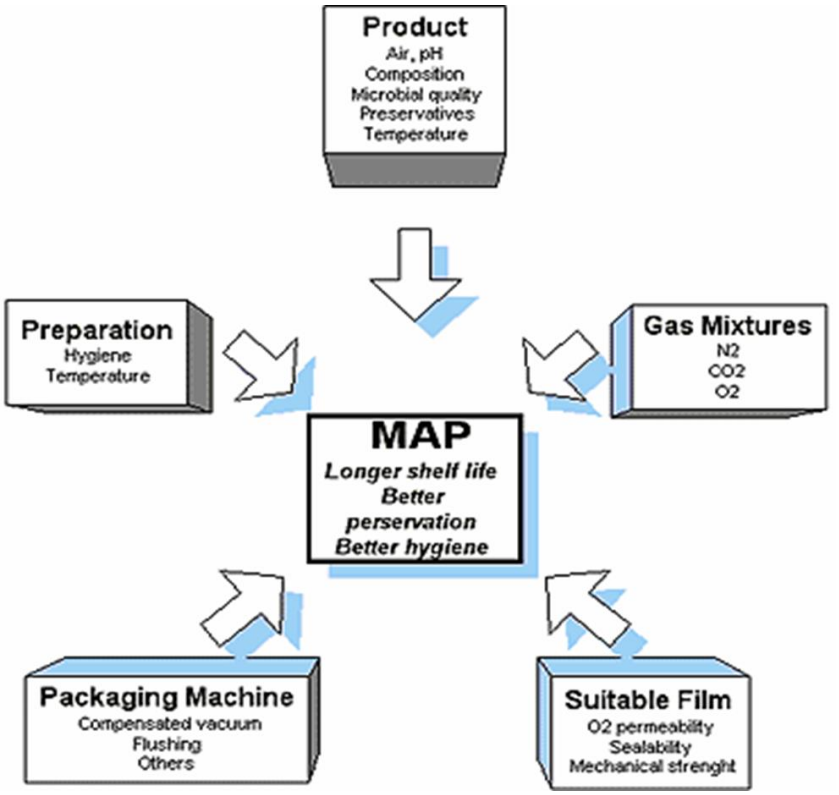

Fig. 5.8. MAP process was influenced by these aspects

Fig.5.9. The most typical packaging equipment used for products

Chamber type machines and tray sealers are usually used by smaller production companies, while flow-rap and flow-packs (horizontal and vertical) as well as thermoforming machines are usually used by larger capacity companies because of the high output of these machines.

All packaging equipment and technologies have their pros and cons, therefore, when choosing equipment, some aspects should be evaluated.

PRACTICAL WORK (package)

The aim of the work is to learn skills in cheese packaging using different packaging technologies (packaging in air, vacuum, modified gas composition (MAP)) with different packaging equipment using various packaging equipment (simple sealer and chamber-type vacuum packaging equipment etc.). Experiments with different vacuum depths were carried out during vacuum packing. The group of students is divided into teams and each team packs products using different solutions.

Materials

Products prepared in previous experiments or raw materials purchased at the discretion of the teacher.

Pulsed simple hermetically sealing equipment. Ready-made pillow packages made of multi-layer packaging material with high barrier properties.

Procedures and Results

The results obtained in the experiments should be reflected in table 5.22.

Table 5.22.

Parameters	packaging in AIR	packaging in vacuum	packaging in MAP
Characteristics of the multi-layer packaging material			
Which packaging solution is more suitable for packaging? Describe why?			
How well the sealing went (excellent, good, bad)			
What is this shape of packaging?			
What is the sealing time (sec.) and temperature of the package?			
Is it possible to close the package non-hermetically? Will it affect the expiration date?			
How eco-friendly is the chosen packaging? How sustainable is the chosen packaging?			

Conclusions

After packaging the products, different groups of students compare the results. If possible, each group packs 5 packages of each type, and then observes and determines the quality of the products during storage over the course of the study.

During practical operation, students learned the skills of working with packaging equipment and packaging technologies.

Approved by _____

(Name, surname, signature)

Date _____

Theme 6

Milk products with long shelf life

Theoretical materials

Increase of osmotic pressure	• Sweetened condensed milk and other products
Sterilization	• Condensed milk
Dehydrated products	• Milk, cream, skimmed milk and other

Fig. 6.1. Characteristics of dry dairy products

https://www.thespruceeats.com/homemade-condensed-milk-521028
https://www.biggerbolderbaking.com/how-to-make-condensed-milk/
https://konsonet.eu/milk-powder-full-cream-26-fat-25-protein/

Table 6.1.

Characteristics of milk powder

Parameters	Value				
	Milk (spray drying)		Skimmed milk		
	1	2	Milk (spray drying)		Roller drying
			1	2	2
Max water, %	4.0	4.0	4.0	5.0	5.0
Fat content, %	min. 25.0	min. 25.0	max 1.5	max 1.5	max 1.5
Min. protein content, %	-	-	32.0	-	-
Min. lactose content, %	-	-	50.00	-	-
Max solubility, cm^3					
premium	0.2	0.3	0.2	0.4	1.5
1st class	-	0.4	-	-	-
Max acidity, °T	20	21	20	21	21

Table 6.2.

Different dehydrated dairy products

cream	milk	skimmed milk	whey	whey proteins	lactose

https://www.adpi.org/ingredient-resource-center/cream-powder/
https://www.21food.com/products/skimmed-milk-powder-instant-fu-2199460.html
https://thewholesaler.in/products/milk-powder-skimmed-milk
https://www.food-safety.com/articles/6184-whey-powder-and-food-safety-risks-a-lesson-in-validation-and-verification
https://lifespa.com/health-topics/immune-support/the-benefits-of-undenatured-whey-protein-powder/
https://www.indiamart.com/proddetail/lactose-monohydrate-200-mesh-26216665112.html

Practical works

Equipment for the production of dry and canned milk

The aim of the work is to gain knowledge about milk products with long shelf life equipment. Compare the equipment used for the production of different types of products. The group of students is divided into teams, and each team analyses the set of equipment necessary for the production of specific milk products with long shelf life, and then presents it to the other groups.

Materials

Students, considering the information according to the production technology of milk products with long shelf life, try to find the equipment to achieve the required result. The students give a brief explanation of what each selected device provides.

Procedures and Results

As a result, it is necessary to draw a diagram (or assemble a diagram from equipment stencils, if such have been prepared) in order to create different production lines of milk products with long shelf life.

For example the following:

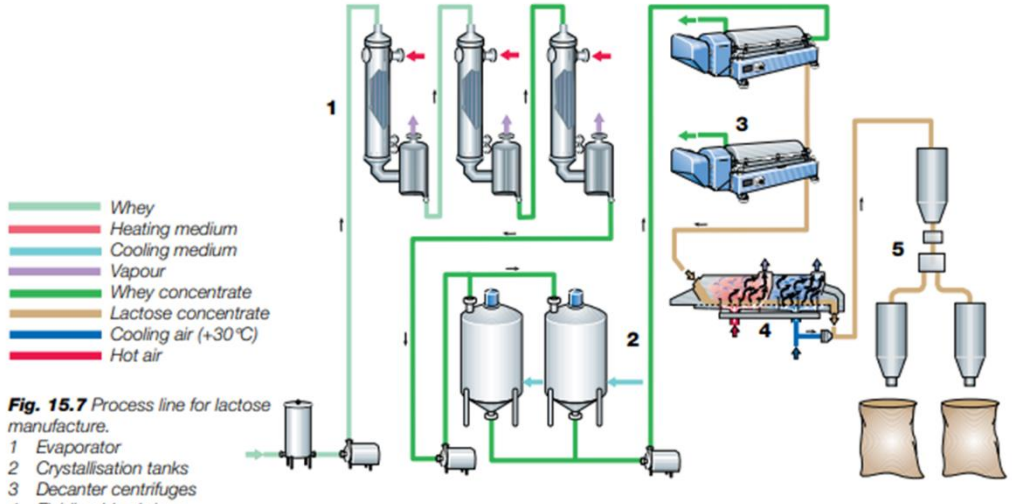

Fig. 15.7 *Process line for lactose manufacture.*
1 Evaporator
2 Crystallisation tanks
3 Decanter centrifuges
4 Fluidised-bed dryer
5 Packing

13

OR

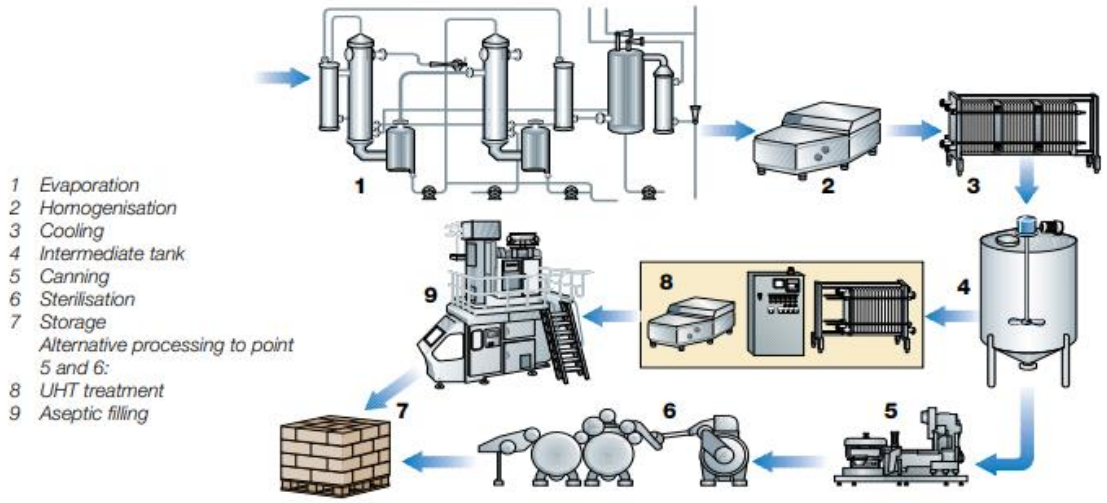

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Figure. Process line for unsweetened condensed milk

OR

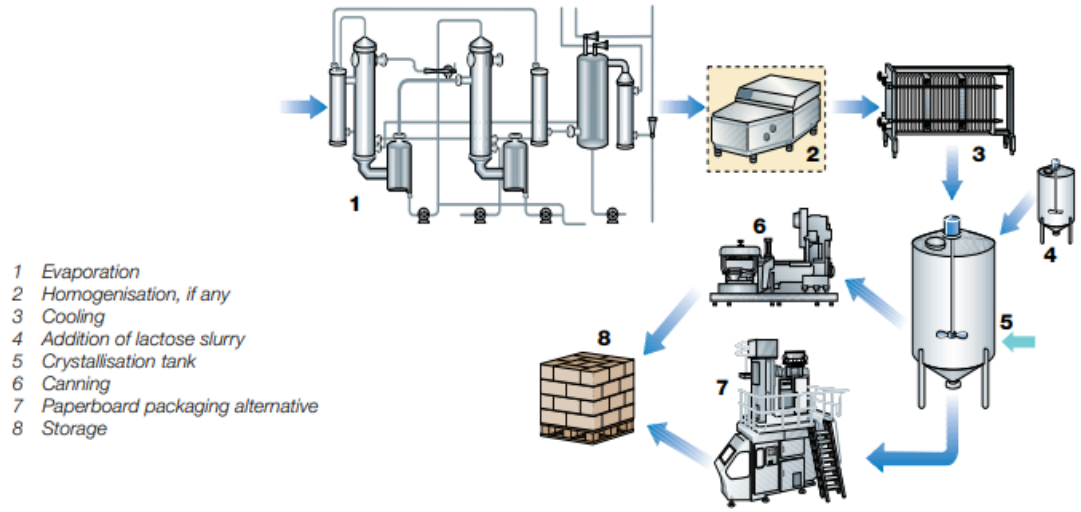

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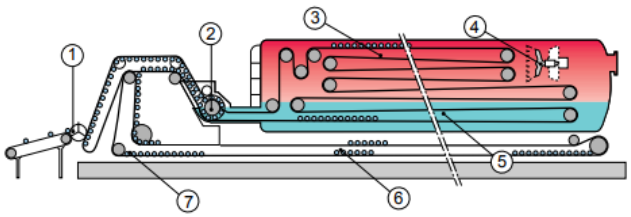
Fig 6.2.. Process line for sweetened condensed milk

Compare two types of sterilisation:



1. *Automatic loading of bottles or cans*
2. *Rotating valve simultaneously transports bottles into and out of pressure chamber*
3. *Sterilisation area*
4. *Ventilation fan*
5. *Pre-cooling area*
6. *Final cooling at atmospheric pressure*
7. *Unloading from conveyor chain*

Steam
Cooling water

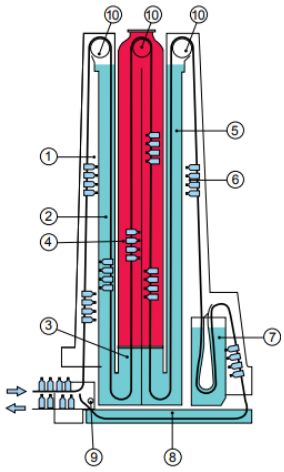


Fig. 9.10 *Hydrostatic vertical continuous bottle steriliser*
1. *1st heating stage*
2. *Water seal and 2nd heating stage*
3. *3rd heating stage*
4. *Sterilisation section*
5. *1st cooling stage*
6. *2nd cooling stage*
7. *3rd cooling stage*
8. *4th cooling stage*
9. *Final cooling stage*
10. *Upper shafts and wheels, individually driven*

Steam
Cooling water

13

Conclusions

During practical activities, students acquire and strengthen knowledge and skills in the operation of equipment, as well as understanding of equipment flow lines for the production of milk products with long shelf life. Students explain their work

Approved by _____

(Name, surname, signature)

Date _____

Laboratory work

Milk powder quality control

Materials

Milk, cream, whey powder

Methods and Procedures

The quality, chemical composition and stability analysis of reconstituted milk

1. Obtaining reconstituted milk

Students get 20 g of milk powder. Each student should prepare milk with solids non-fat 8.5%. The solid content of milk powder is 96%. Students should calculate the amount of water to dissolve 20 g of milk powder.

The calculated amount of water should be heated to 35-40 ^{0}C, then poured it into the measuring cylinder. Add milk powder and mix until it is fully dissolved (~20-25 min.).

2. The quality control of reconstituted milk. The following parameters should be controlled in the reconstructed milk:

Acidity

10 mL of milk is measured into a conical flask, 20 mL of distilled water, 2-3 drops of Phenopthalein is added. Titrate the solution from the burette using 0.1 N Sodium hydroxide (NaOH) continuously mixing, until a pink colour appears.

The number of mL of Sodium hydroxide solution multiplied by 10 expresses the acidity level of the milk in Thorner degree.

pH

Rinse the electrode in water. Remove water from electrodes. Place the electrode in your sample (50 mL), press Run, Enter and then Run, wait a while, and read pH from the display and record the result in a notebook.

Density

Mix the milk sample slowly and pour it gently into a measuring cylinder (300 mL). Let the aerometer sink slowly into the milk. Read and record the last aerometer degree (kg m^{-3}) just above the surface of the milk. If the temperature of the milk is different from the calibration temperature (Calibration temperature may be 20 ^{0}C) of the aerometer, calculate the temperature correction. Latvian standards expect milk to have a specific gravity of 1027 -1032 kg m^{-3} which implies an aerometer reading range of 27.0–32.0 ºA.

Freezing point

Put the milk sample with a pipette into the tube ~ 2.2 mL, then place the tube in the CrioStar socket. To begin the measurement, choose with an arrow “Start measurement” and press ENTER. The measurements will start, and values will change, the curve will be created. The temperature will be presented on the vertical axis, but time on the horizontal axis. To stop the measurement, press ENTER one more time. When a freezing point is detected, for example -0.557 °C, the CrioStar starts looking for a Plato regime.

The Alcohol Test

The test is done by mixing equal amounts of milk and ethanol solution in Petri plate. If the tested milk is of good quality, there will be no coagulation, clotting or precipitation, but it is necessary to look for small lumps. For routine testing, 2 mL milk is mixed with 2 mL of 68 % alcohol.

Presence of phosphatase in milk

Add 2 mL of milk and 1 mL of Na phenol phosphate in a tube, then close it with a cork and mix the solution. Mark the tube and put it into a water bath (40-45 °C temperature). Evaluate the colour of tube solution after 10 minutes and after 1 hour.

The pink or red colours indicate phosphatase presence in the milk, if the tube colour has not changed phosphatase is not present in the milk.

Detection of the undissolved amount reconstituted milk

Reconstituted milk (10 mL) is poured into the graduated tube. Put on the cover and place itin the water bath (35 °C) and heat for 10 minutes. Then put the tube to the centrifuge and centrifuge for 10 minutes. Following it, evaluate the amount of precipitate in the tube. The amount of the precipitate should be measured as 1 % of undissolved particles that is equal to 1 mL of precipitate. The acceptable amount of precipitate is 0.2%.

Table 6.3**.**

Milk powder characteristics

Sample	pH	Acidity, °T	Density, kg/m^3	Freezing point, °C	Thermostability	Presence of phosphatase	Amount of precipitate

Conclusions

Approved by _____

(Name, surname, signature)

Date _____

Theme 7

By-products: quality parameters, processing options

Theoretical materials

During cheese, butter, cottage cheese, casein production not all dry matter is used.

Some dry matter moves to the by-products:

- **Skimmed milk (70%),**
- **Buttermilk (70%),**
- **Whey (50%).**

Table 7.1.

By -products characterisation

Parameter	milk	skimmed milk	butter milk	whey
Dry matter	12.3	8.75	9.2	5.2-7.5
Proteins	3.2	3.2	3.2	0.8-0.9
Lactose	4.8	4.8	4.7	3.8-4.7
Fats	3.6	0.05	0.6	0.1-0.7
Minerals	0.7	0.7	0.7	0.5-0.7

Butter milk and skimmed milk are used for:

- Fat content regulation;
- Products and drinks;
- Canned food;
- Cheese;
- Cottage cheese and desert;
- Casein production.

Whey is used for:

- Whey cream;
- Whey drinks;
- Whey concentrate;
- Fraction products;
- Glucose-galactose syrup;
- Biologically active compounds.

Laboratory work

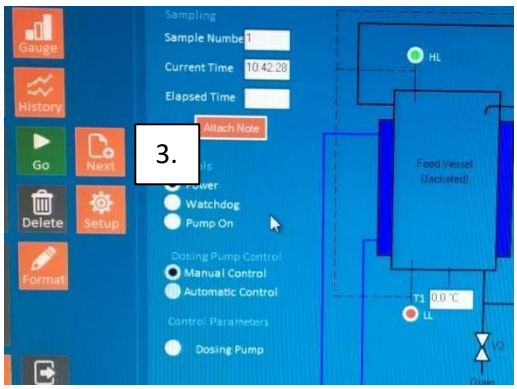
By-products processing and quality control

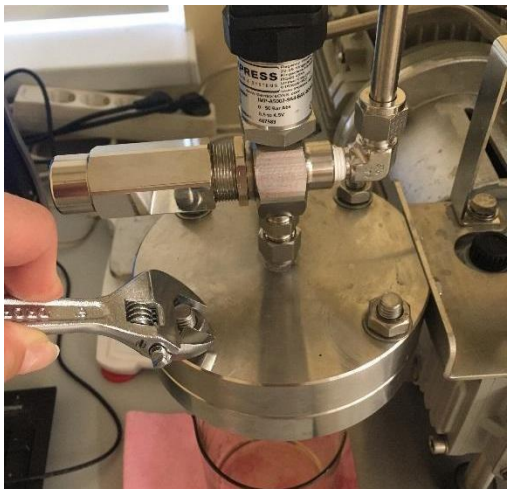
1. Ultrafiltration

1. Turn on the computer and equipment for UF and the cooler (shown in photos 1; 2).

2. Open the program SHORTCUT (Standard Unit) Authors photo

3. Turn on Power (3)

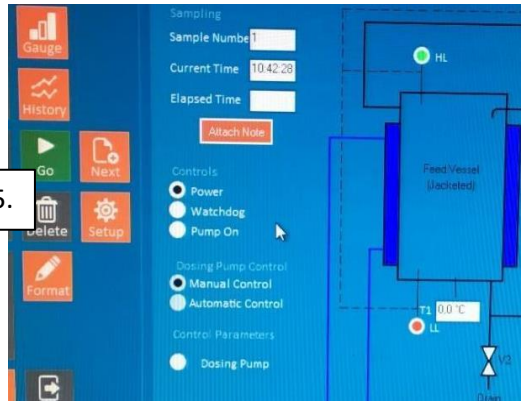




4. Fix (arrange) the filter (4)

Cleaning

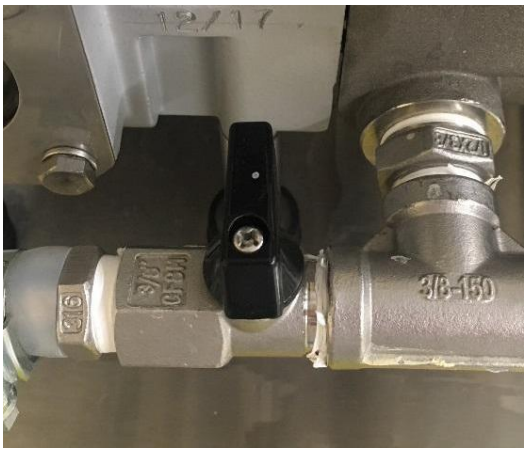
5. For cleaning: fill the container with distilled water (until green signal, otherwise the program will stop).
6. Pump for the cleaning process – 10



5.

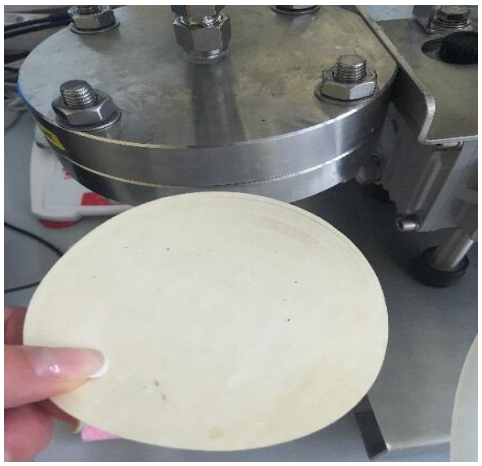
Turn Pump on (5)

7. After cleaning: take the water out of the system by opening the switch in the vertical position



Ultrafiltration

8. Open the filter and insert filter paper with the shiny side up and close it (picture 4). 1 filtration paper is valid for one filtration.



9. Based on the Instruction manual for Industrial Food Technology Equipment FT17, pressure should be regulated on the left-hand side of the equipment, for MF 0,3-14 (6). On the computer you can see the regulation of the pressure.

10. Turn on the pump – first 25 or less, optimum – 27, later you can use 40.
11. Turn the pump on (picture 5).
12. Stop the UF with the pump on (point out).

Cleaning

13. After UF/MF, open the filter, take out the filtration paper, fix the filter (step 4).
14. Cleaning in 3 steps:
    - distilled water (15 minutes),
    - 16% of NaOH (10 minutes),
    - distilled water (15-20 minutes).

After each cleaning, take the water out of the system by opening the switch in the vertical position. After turning the switch to the “close” horizontal position.

15. Switch off the equipment, cooler, programme, and the computer.

2. New type of product production from whey and butter milk

Students develop their one formulation and technology for new type of the product using by-products.

Conclusions

Approved by _____

(Name, surname, signature)

Date _____

Theme 8

HACCP in dairy processing companies

Theoretical materials

What is food safety?
Food safety is a scientific discipline describing handling, preparation, and storage of food in ways that prevent food borne illnesses. This includes a number of routines that should be followed to avoid potentially severe health hazards. In this way, food safety often overlaps with food defence to prevent harm to consumers.

As it is known since 1960s in EU each enterprise which works in Food segment must have a food safety system based on the 7 HACCP principles.

Seven basic principles are employed in the development of HACCP plans that meet the stated goal. These principles include hazard analysis, CCP identification, establishing critical limits, monitoring procedures, corrective actions, verification procedures, and record-keeping and documentation.
The Food Safety Plan - is not a stand-alone programme, but rather part of a larger food safety system. The foundational programmes that are part of the food safety system are frequently termed prerequisite programmes. The term was coined to indicate that they should be in place before HACCP based systems are implemented in order to effectively manage the risk of foodborne hazards. Good Manufacturing Practice (GMP) regulations address requirements for many prerequisite programmes. The conditions and practices that the regulated food industry must follow for processing safe food under sanitary conditions, including personnel, plant and grounds, sanitary operations, sanitary facilities and controls, equipment and utensils, processes and controls, warehousing and distribution, and action levels in case of potentially unsafe product.
The process flow of a food safety plan (HACCP or Preventive Controls) is the centre of a food product's food safety story. It tells how a company makes its products and also what hazards and controls are associated with each step.
Monitoring records and logs must include the actual values or observation that document the actual implementation of a Food Safety Plan. For example, if a temperature is being measured, the actual temperature must be recorded rather than a check mark indicating that the temperature complied with the critical limit. To comply with regulations, information must be recorded at the time it is observed.
Here are suggested record and log types to use:

- Customer Complaints,
- Corrective Action Forms,
- Employee Training,
- Food Safety Quarterly Audit,
- Food Safety Checklist,
- Raw Materials/Receiving Log,
- Worker Illness Log,
- Refrigerator Log,
- Assembly Log,

- Shipping Temperature Log,
- Suggested Supply Chain.

Documents

The safety of your product depends on much more than just what you control within your own facility. The use of an ingredient that has a history of association with a specific hazard may require a supply chain programme as a control within your food safety program. Companies may have extensive supplier programmes that encompass much more than food safety elements to manage their supplier expectations and performance.

Here is a list of suggested documents to obtain from your supply chain:

- Food Safety HACCP or Preventive Controls Plan for each product,
- Food Defence/Business Continuity Plan,
- Validation of each product and/or process and Ready-To-Eat statements (if applicable),
- Certificates of Analysis (COA),
- Third Party Audit Certificate, Report & Corrective Actions,
- Product Specification,
- Allergen management,
- Country of Origin,
- Potential Hazards,
- Biological hazards,

Microbiological Contamination – During Processing at Source of Origin – Supplier Management and HACCP in place and verified to eliminate and reduce potential presence of Microbiological contamination.

Microbiological Contamination for instance, Microbiological growth due to breakdown of refrigeration units.

Chemical

Chemical Contamination by pesticides at source of origin – chemical/pesticide used at source is verified to be compliant with regulations.

Chemical Contamination from machine oils or lubricants, as well as cleaning chemicals.

Microbiological / Physical / Chemical Contamination from – cross contamination or taint of finished product due to poor hygiene.

Physical

Physical Contamination – external contamination from rain water, bird droppings, vermin/rodents, and flying insects during the unloading process.

Glass Contamination – glass contamination from internal light sources. – pests/rodents and or flying insects due to poor hygiene/debris build up - physical risks from straps/thermocouples/staples/foreign bodies found on pallets on intake.

Physical Contamination –foreign bodies found within product and/or packaging from source of origin or during transportation.

Physical Contamination – physical contamination from warehouse operative, pests/rodents, and/or flying insects due to poor hygiene/debris build up – physical contamination from personnel, foreign body/dust contamination from production environment.

What are the 5 basic everyday food safety principles?

The core messages of the five key principles to safer food are: (1) keep clean; (2) separate raw and cooked; (3) cook thoroughly; (4) keep food at safe temperatures; and (5) use safe water and raw materials.

Table 8.1.

Five key every day food safety principles

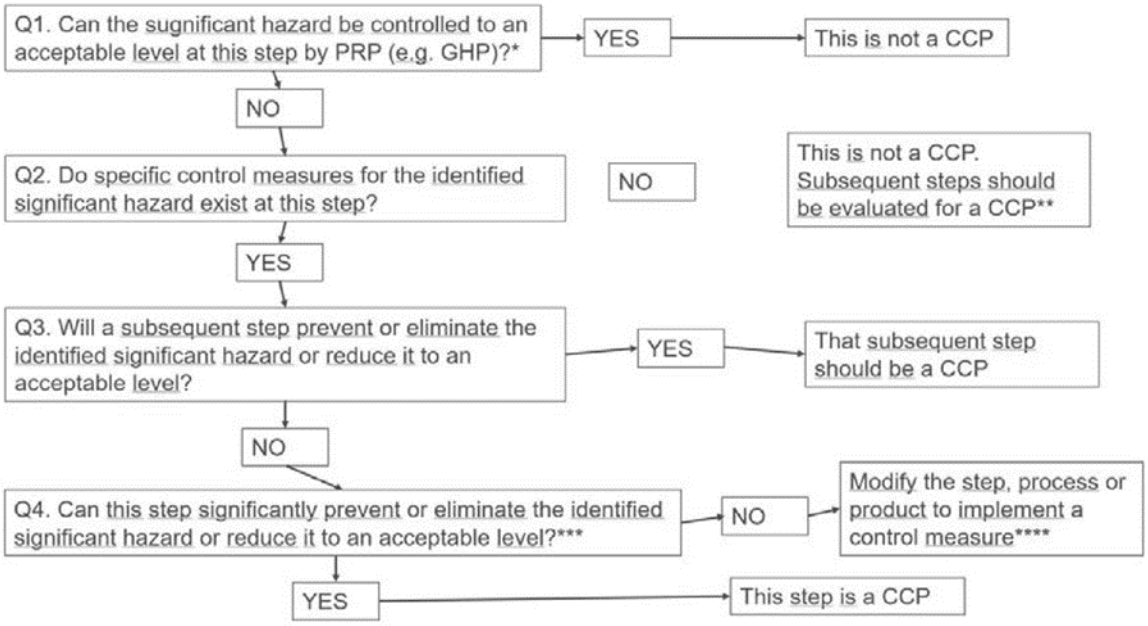
Likelihood	Severity
1 = Improbable event – once every five years	1 = Negligible – no impact or not detectable
2 = Remote possibility – once every year	2 = Marginal – only internal company target levels affected
3 = Occasional event – once per month	3 = Significant – Impact on critical limits
4 = Probable event – once per week	4 = Major – Impact on customers (may not be the public)
5 = Frequent event – once per day	5 = Critical – public health risk / public product recall

Likelihood	Severity				
	1	2	3	4	5
1	1	2	3	4	5
2	2	4	6	8	10
3	3	6	9	12	15
4	4	8	12	16	20
5	5	10	15	20	25

Severity of health effect	Can cause fatality	5	5	10	15	20	25
	Can lead to serious illness	4	4	8	12	14	20
	Can cause illness	3	3	6	9	12	15
	Can cause inconvenience	2	2	4	6	8	10
	Almost of no significance	1	1	2	3	4	5
			1	2	3	4	5
			Unlikely	Rare	Could occur	Likely	Frequent
			(<1/2 years)	(1 / year)	(1/6 month)	(1 / month)	(1 / week)
			Likelihood of occurrence				

Low risk hazards	Medium risk hazards	High risk hazards

Example of a decision tree to identify critical control points (CCP)


Q1. Can the sugnificant hazard be controlled to an acceptable level at this step by PRP (e.g. GHP)?*
YES
This is not a CCP
NO
Q2. Do specific control measures for the identified significant hazard exist at this step?
NO
This is not a CCP. Subsequent steps should be evaluated for a CCP**
YES
Q3. Will a subsequent step prevent or eliminate the identified significant hazard or reduce it to an acceptable level?
YES
That subsequent step should be a CCP
NO
Q4. Can this step significantly prevent or eliminate the identified significant hazard or reduce it to an acceptable level?***
NO
Modify the step, process or product to implement a control measure****
YES
This step is a CCP

Practical work

Assessment of potential hazards in milk processing

1. For a selected milk processing product, develop a product description, develop and draw a diagram of the process steps (flow diagram).

2. Identify potential hazards:

biological:

* pathogenic microorganisms;

chemical:

* agricultural chemicals;

physical:

*foreign objects typical for the product.

3. Evaluate the danger of the identified hazards using a risk matrix. Record the information in the hazard assessment table.

4. Complete the CCP identification table and the HACCP plan.

5. Write conclusions on determining the CCP using a risk matrix and a decision scheme/tree.

Results

Table 8.2.

Risk assessment table

Process stage	The identified hazard	Hazard assessment					Means of control
		Possibility	**The severity of the consequences**	**Risk level**	**Assessment**	**CCP**	

Table 8.3.

CCP identification table

Process stage	Process stage	Cause of risk	Description of the cause of the risk	Control actions	Answers to Decision Scheme questions				CCP yes/no
No.					1	2	3	4	

Table 8.4.

HACCP plan

In process	CCP / CP	Risk	Measurable	Monitoring procedures				Order-	Corrections
stage		the cause	critical limits of parameters	What?	How to?	How often?	What?	In what way?	events

Conclusions

Approved by _____

(Name, surname, signature)

Date _____

Co-funded by the European Union

OFINU

Open Food Innovation University (OFINU)

Study Module

"MEAT PROCESSING TECHNOLOGIES"

WORKBOOK

for students

2024

Summary

The workbook is elaborated within the project “Open Food Innovation University" (OFINU), being in implementation with support of the European Union Erasmus+ Programme.

Overall objective of the project - to modernise food innovation and technology related higher education in Uzbekistan and Tajikistan, thereby increasing the quality and ensuring relevance of the higher education to the needs of the socio-economic growth of the countries concerned and especially of their regions.

Full partners:
- Lead partner: Latvia University of Life Sciences and Technologies
- Uzbekistan: Samarkand Agro-innovations and Research University, Andijan Institute of Agriculture and Agro-technologies
- Tajikistan: Technological University of Tajikistan, Kulob Institute of Technology and Innovation Management, Isfara Branch of the Technological University of Tajikistan
- Slovakia: Slovak University of Agriculture in Nitra

Associated partners in Uzbekistan:
- A group of companies "AGROMIR"
- "Navigul" MCHJ QK
- “Samarqand don mahsulotlari” JC (Samarkand grain products)

Associated partners in Tajikistan:
- CJSC “Combinati Shiri Dushanbe”
- LTD "Orion Rustam"
- Association of Entrepreneurs of Khatlon

The project implementation period: 01/02/2024 - 31/01/2027.

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Partner universities and their academic staff, involved in the development of the study course:

P1 LBTU. Latvia University of Life Sciences and Technologies

Ilze Gramatina - meat processing technologies, ilze.gramatina@lbtu.lv
Sandra Muizniece-Brasava - packaging of meat and meat products, sandra.muizniece@lbtu.lv
Normunds Puzulis - meat processing equipment, normunds.puzulis@inbox.lv
Evita Straumite - sensory evaluation of meat and meat products, evita.starumite@lbtu.lv
Egija Sproge - HACCAP, egita.sproge.egita@gmail.com

P2 SAMARU. Samarkand Agroinnovations and Research University

Elnara Devletshaeva - technology of storage and processing of livestock products, elnaradevletshayeva@gmail.com
RahmatilloTashmanov - technology of storage and processing of agricultural products, tashmanovraxmatillo@gmail.com

P3 AIAA. Andijan Institute of Agriculture and Agro-technologies

Rakhim Mirzaev - technology of storage and processing of agricultural products, r.mirzayev0406@gmail.com
Kholdarov Shukhratjon - technology of storage and processing of agricultural products, shuhratxoldarov7777@gmail.com

P5 KITIM. Kulob Institute of Technology and Innovation Management

Amrudin Rustamov - technology of meat and meat products, rustamovamridin423@gmail.com
Safar Odinaev - technology of meat and meat products, odinaevsafar35@gmail.com

P7 SUA. Slovak University of Agriculture in Nitra

Miroslava Kačániová - microbiologist, miroslava.kacaniova@gmail.com

https://www.dreamstime.com/food-collage-various-fresh-meat-chicken-top-view-image119436719

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Theme of the study course

The “Meat processing technologies” study module covers the following topics: technological process and equipment, packaging material and equipment, raw materials and product quality evaluation, including sensory evaluation and quality management assurance in the meat processing. A lecturer with knowledge in the specific field is involved in the implementation of each section in order to achieve the goal of the study module.

Learning methods

An innovative teaching method is used in the “Meat Processing Technologies” study module. The novelty for the Central Asian (CA) universities was: a) illustration of theory with practical examples; b) online classes, methods and tools used for their delivery; c) application of interactive methods, such as seminars; d) methods used for delivery of laboratory and practical work (individually, group work, discussions, retraining). All of the above helped to absorb new thematic knowledge.

The main pedagogical methods taught are as follows: learner centred approach, competence-based approach, experiential learning, cooperative learning, and interactive learning. The training includes practicing of methods, as well as an introduction to modern learning analytics, to be used to support the student engagement and responsibility, and to support assessment.

Highly appreciated are the knowledge and skills to produce and deliver classes and lectures in distance learning format, because the application of this method broadens availability of the experts and worldwide knowledge (inviting entrepreneurs, foreign academic staff etc. as lecturers), can be applied in the case of double diploma studies, provides an opportunity to study for persons having limited possibilities to take part in full time studies (young mothers, students with disabilities). Distance learning is very effective for specific courses when participation of lecturers from foreign partner universities is crucial and discussions with students with diverse experiences and visions are needed to explain and demonstrate possibilities and various solutions and options. The first feedback from the academic staff who has introduced the new methods has demonstrated positive impacts, such as:

1) transformation to teaching approaches in faculties;

2) the learner-centred approach has empowered students to take charge of their own learning, leading to increased engagement and motivation;

3) students have become more proactive in seeking knowledge and are more participative in class discussions;

4) the use of digital tools for interactive learning has made classes more dynamic and accessible - students can access learning materials from anywhere, leading to increased flexibility and convenience;

5) the collaborative nature of some of these methods has also led to increased interaction and rapport between faculty and students.

Open lectures discussions, involving internal and external stakeholders, is a new form of teaching and communication of higher education to the society, adopted at the participating UZ universities during the implementation of the project.

Course Schedule

Thematic Study Plan for module "Meat Processing Technologies"

Date, Time	Study form	Theme	Lecturer
Theme 1. Meat and its general characteristics, and quality			
1st day	Lecture (1h)	Introductory lecture in the study course.	I. Gramatina
	Lecture (3h)	Morphological structure of meat (***Technology)***.	I. Gramatina
		Meat quality, chemical composition and nutritional value (***Technology)***.	I. Gramatina
	Lecture (1h)	The most suitable packaging materials for fresh meat (***Packaging***).	S. Muizniece-Brasava
	Lecture (1h)	Meat safety and risk assessment (***Quality***).	E. Sproge
2nd day	Laboratory work (8h)	**1st Laboratory work** – evaluation of the chemical composition of meat using physico-chemical quality analysis methods (***Technology***).	I. Gramatina
Theme 2. Biochemical and microbiological processes in meat			
3rd day	Lecture (2h)	Biochemistry and microbiological developments in meat. Meat rigor-mortis, maturation and breaking down (***Technology***).	I. Gramatina
	Lectures (2h)	Characteristics of main technological equipment (***Equipment***).	
	Lecture (3h)	Intensification of the maturation process. Meat maturation, PSE and DFD defective meat (***Technology***).	I. Gramatina
	Lecture (1h)	Contamination, safety and risk assessment (***Microbiology***).	M. Kačániová

4th day	Laboratory work (8h)	**2nd Laboratory work** – assessment of meat freshness using sensory, physic-chemical and microbiological quality analysis methods (***Technology***).	I. Gramatina
Theme 3. The slaughter process of animals and birds			
5th day	Laboratory work (1h)	Microbiological testing of chilled meat (***Microbiology***).	M. Kačániova
	Lecture (3h)	Preparation of animals, birds for processing, and slaughtering. Animals and birds carcass division. (***Technology***).	I. Gramatina
	Lecture (1h)	By-products, use and processing (***Technology***).	I. Gramatina
		Intestinal structure and treatment. (***Technology***).	I. Gramatina
6th day	Laboratory work (8h)	**3rd Laboratory work** – evaluating the quality of food fat by analysing changes in the sensory and physico-chemical quality indices (***Technology***).	I. Gramatina
Theme 4. Meat preservation methods			
7th day	Lecture (2h)	Meat preservation methods. Chilling and storage of meat (***Technology***).	I. Gramatina
	Lecture (1h)	Quality indicators of meat (***Sensory evaluation***).	E. Straumite
	Seminar (2h)	Sensory evaluation of meat (***Sensory evaluation***).	E. Straumite
	Lecture (1h)	Chilled and frozen meat safety and risk assessment (***Quality***).	E. Sproģe
8th day	Lecture (2h)	Meat freezing, changes in quality indicators during storage. (***Technology***).	I. Gramatina
	Lecture (2h)	Characteristics of equipment (***Equipment)***.	I. Gramatina

	Lecture (1h)	Package selection for preserved meat (***Packaging***).	S. Muizniece-Brasava
	Practical work (3h)	Safety and risk assessment of meat (***Quality***).	E. Sproge
9th day	Lecture (2h)	Meat salting types, storage and characterisation of quality indicators (***Technology***).	I. Gramatina
	Lecture (1h)	Contamination risks of preserved meat (***Microbiology***).	M. Kačániová
	Laboratory work (2h)	Microbiological testing of semi-finished meat products (***Microbiology***).	M. Kačániová
	Practical work (2h)	Mechanical equipment for meat processing (***Equipment***).	I. Gramatina
10th day	Lecture (2h)	Meat smoking, smoking methods, changes in quality indicators (***Technology***).	I. Gramatina
	Lecture (2h)	Meat product drying methods, quality indicators and their changes (***Technology***).	I. Gramatina
	Lecture (1h)	Optimal packaging solutions for preserved meat products (***Packaging***).	S. Muizniece-Brasava
11th day	Lecture (1h)	Security and risks of salted, smoked and dried products (***Quality***).	E. Sproge
	Seminar (3h)	Optimal packaging solutions for preserved meat products (***Packaging***).	S. Muizniece-Brasava
Theme 5. Meat products			
12th day	Lecture (2h)	Classification of semi-finished meat products (***Technology***).	I. Gramatina
	Lecture (3h)	The main raw materials for meat products production and their characterisation (***Technology).***	I. Gramatina

	Lecture (1h)	Sensory quality indicators of meat products and their changes during storage (***Sensory evaluation***).	E. Straumite
13th day	Laboratory wok (8h)	**4th Laboratory work** – preparation of semi-dry and cooked sausages, determination and analysis of sensory, physico-chemical, microbiological quality indicators (***Technology***).	I. Gramatina
14th day	Lecture (2h)	Characteristics of the main equipment used in the processing of meat products (***Equipment***).	I. Gramatina
	Laboratory work (2h)	Microbiological evaluation of processed meat products (***Microbiology***).	M. Kačániová
	Lecture (4h)	Meat cooking technologies (***Technology***).	I. Gramatina
15th day	Seminar (3h)	Sensory evaluation of meat products (***Sensory evaluation***).	E. Straumite
	Lecture (1h)	Microbiological quality indicators of meat products and their changes during storage (***Microbiology***).	M. Kačániová
	Lecture (1h)	Meat product safety and risks (***Quality***).	E. Sproge
16th day	Laboratory works (8h)	**5th Laboratory work** – preparation of semi-finished products and liver pate or liver sausages, determination and analysis of sensory, physico-chemical, and microbiological quality indicators (***Technology***).	I. Gramatina
17th day	Lecture (3h)	Most important meat products sensory, physico-chemical, microbiological methods of analysis and equipment (***Technology***).	I. Gramatina
	Seminar (3h)	Sensory evaluation of meat products (***Sensory evaluation***).	E. Straumite
	Lecture (1h)	Meat product safety and risk assessment (***Quality***).	E. Sproge

	Laboratory work (1h)	Microbiological evaluation of meat processing products (***Microbiology***).	M. Kačániová
Theme 6. Canned meat products			
18th day	Lecture (3h)	Canned meat technology. Changes during heat treatment, and quality indicators (***Technology***).	I. Gramatina
	Lecture (1h)	Meat products contamination risks (***Microbiology***).	M. Kačániová
	Lecture (1h)	Most value packaging types and materials for canned meat products (***Packaging***).	S. Muizniece-Brasava
19th day	Seminar (3h)	Package as added value of meat products (***Package***).	S. Muizniece-Brasava
	Practical work (3h)	Meat product safety and risk assessment (***Quality***).	E. Sproge
	Practical work (2h)	Thermal equipment for meat processing (***Equipment***).	I. Gramatina

Theme 1
Meat and its general characteristics and quality

Theoretical materials

Meat quality has become a more demanding issue due to consumer awareness of eating quality meat and its nutritional value. The sensory qualities of meat also have great importance in terms of consumer preference. At the purchasing stage, consumers generally evaluate the colour and oiliness of raw meat as quality criteria. The flavour of the meat consumed is linked to its softness, juiciness, aroma, and taste. Quality meat should be soft, high in moisture, contain more muscle fibres than connective tissue, pink in colour, and have an appropriate aroma.

Table 1.1.

Chemical composition of meat

Meat	***Water***	***Proteins***	***Fats***	***Ash***
Cattle	58.5-74.0	15.6-21.1	3.8-22.9	0.8-1.1
Sheep	48.0-72.2	13.3-20.9	8.9-35.1	0.7-1.0
Poultry	58.4-68.3	18.5-21.5	9.3-22.5	0.9-1.1
Turkey	55.5-73.5	20.6-22.5	4.8-22.9	1.0-1.1
Duck	48.2-61.2	17.8-18.5	19.0-33.0	1.0-1.1
Goose	38.0-53.4	15.9-16.5	29.0-45.6	0.8-1.1
Rabbit	66.8-73.8	20.4-21.7	3.3-9.7	1.0-1.1

Moisture, protein, fat, and ash ratio constitute the chemical composition of meat. It is varied according to the species of animal, genotype, sex, age, body condition score, nutritional status, and muscle structure of the animal.

Water has the highest proportional value in the composition of meat. Muscle contains approximately 75 per cent water (ranging from 65 to 80%) by weight. Water is the principal constituent of the extracellular fluid and numerous chemical constituents are dissolved or suspended in it. Because of this, it serves as a medium for the transport of substances between the vascular bed and the muscle fibres. Water is an important thermoregulator and solvent, and plays an important role in cell and organ metabolism and the transport of metabolites and wastes. The water holding capacity of meat is an important factor affecting the appearance, colour, tenderness, taste, and aroma of the meat. The amount of water in the meat is an important factor affecting the profitability in terms of weight loss during the meat waiting processes (resting, packaging, freezing, transportation). At the same time, meat that does not lose its water as a result of the cooking methods and is able to keep its content is considered to be quality meat.

Meat ***proteins*** are superior to plant proteins because meat contains high biological value proteins in a concentrated form. Muscle proteins are broadly divided into following three categories: soluble in water or dilute salt solutions (the sarcoplasmic proteins), soluble in concentrated salt solutions (myofibrillar proteins), insoluble in salt solution at low temperature (proteins of connective tissue and other

formed structures). Myoglobin, hemoglobin and various enzymes constitute sarcoplasmic protein, whereas, myofibrillar proteins are actin, myosin, tropomyosin, troponin, α, β and ɣ-actinin, C-proteins, M-proteins etc. Major connective tissue proteins are collagen, elastin and reticulin. Fat (%) We have already studied that proteins are made up of amino acid chains and 20 amino acids are very common. Animals can not synthesize amino groups which form amino acids. Therefore, proteins must be provided in the diet of animals so that they can synthesize their own amino acids. Meat proteins are a rich source of essential amino acids viz., phenylalanine, valine, tryptophan, threonine, methionine, leucine, isoleucine and lysine which are very much essential for humans. Generally, proteins are very much susceptible to denaturation at their isoelectric point (i.e., the point at which electrical charges on their amino and carboxyl groups exactly cancel one another), at relatively low temperature and on exposure to acid conditions. Denatured meat becomes insoluble in aqueous solution and this property affects the structure and characteristics of meat, its appearance and ability to hold or bind water. This is very important for comminuted meat products where meat is mixed with other components to form gels and emulsions.

Since proteins are the basic building blocks of the organism, they are key elements that should be included in diets. Proteins are essential nutrients that enable the development of muscles and organs in young people and direct the body in adults. An adult person needs about 70-80 g of protein per day. About half of this value should be of animal origin. Protein content in meat is under the influence of many factors such as species, genotype, age, gender, and ration composition. Animals with the same genotype may have different nutrient contents. In human nutrition, proteins of animal origin have an important place in terms of the essential amino acids and fatty acids they contain. It is generally desirable to have a higher protein content in meat products.

The ***fat*** content of meat varies greatly from species to species (ranging approximately 1.5 to 3 per cent). Fat is found in the meat as intracellular deposits or marbling, or intramuscularly in the adipose tissue deposits associated with the loose connective tissue septa between the bundles. Meat fats are generally simple triglycerides in nature, but beef and mutton have mixed triglycerides. The caloric value of fat depends on the fatty acid composition. Meat mainly contains saturated and monounsaturated fatty acids. Commonly occurring saturated fatty acids in meat are palmitic acid and stearic acid. Oleic, linoleic and linolenic acids are the major unsaturated fatty acids in meat.

Polyunsaturated fatty acids (PUFA) play a very important role in meat fat. Nowadays, people are very health conscious and think that meat fat is dangerous to health without knowing the scientific explanation behind this. In the case of PUFA, if the first double bond occurs three carbon atoms away from the methyl end of the molecule then it is called an omega-3 fatty acid and similarly, PUFA with that bond at six carbon atoms away from the methyl end, then it is called an omega-6 fatty acid. Linoleic acid is an omega-6 fatty acid and linolenic acid is an omega-3 fatty acid. For men, a dietary ratio of 4 or 5:1 for n-6; n-3 PUFA is desirable. The ratio of omega-3 fatty acids is important in relation to the incidence of cardiovascular disease. For example, omega-3 fatty acids reduce blood clotting and omega-6 fatty acids counteract this

effect. Animals synthesise arachidonic acid from linoleic acid and use linolenic acid to synthesise eicosapentaenoic (EPA) and docosahexaenoic (DHA) acids. A diet rich in linoleic acid leads to deficiency of EPA and DHA. EPA and DHA can reduce the incidence of disease significantly. Scientists are trying to increase the proportion of polyunsaturated fatty acids to saturated fatty acids (P:S ratio) in meat considering their effects on human health. In non-ruminants such as pigs and poultry, the body fat closely reflects the characteristics of the dietary fat. Thus, it is not difficult to get the desirable P:S ratio in pork or chicken. But, this is not possible in beef or mutton, as a major part of unsaturated fat supplied through the diet of cattle and sheep (i.e. ruminants) is saturated through the process of hydrogenation by rumen microorganisms. Most animal fats are solid at room temperature because the triglycerides of animal fat 1 contain mainly saturated fatty acids. Pig fat is called lard which is soft in nature due to the higher ratio of unsaturated to saturated fatty acids. Beef fat is harder than pork fat because beef fat contains up to 25% stearic acid i.e. saturated fatty acid. The saturation of lamb or mutton fat may explain the 'greasy' mouthfeel associated with eating it as the melting point of this fat is often above the temperature of the mouth.

Fats are associated with tenderness, flavour, and aroma of meat products. In terms of human health, unsaturated fatty acids should be higher in the composition of the fatty acid profile of meat and saturated fatty acids should be lower. It is important for meat products to have a lower fat content in the diets of individuals with cardiovascular problems or obesity. The fat ratio in the meat composition differs depending on various factors. Since the muscle development is higher in male animals, the protein ratio is proportionally higher, and the fat content is lower. Carcass score is also one of the parameters to be taken into account as it affects fatness.

Although ***carbohydrate*** is a minor component of animal tissues in terms of the overall composition, it plays a very important role in conversion of muscle to meat. The main carbohydrate in meat is glycogen which is a polymer of glucose. It is found particularly in muscle and organ meat like liver. In well fed animals, the liver contains 50 mg glycogen per grammme of liver tissue. Generally 10-20 mg of glycogen is present in 1 grammme of muscle. In the fasting stage of an animal before the slaughter, the liver glycogen is converted into glucose in order to maintain blood glucose concentration at a constant level. In anaerobic conditions, muscle glycogen is used to produce energy for contraction and is then broken down into lactic acid. The post-mortem changes and the onset and completion of rigor mortis greatly depend on glycogen reserve in the muscle. We have studied this in the previous unit i.e. the conversion of muscle to meat. Other carbohydrates present in the meat are mucopolysaccharides associated with the connective tissue, glucose and intermediates of glycolytic metabolism such as lactic acid, acetoacetic acid etc.

Ash is the mineral substance of the meat and is very important for human health. It is generally stored in teeth and bones (calcium, phosphate, magnesium). Apart from this, there are also mineral substances stored in body fluids (iron, sodium, and potassium), enzymes (zinc), and nucleotides (phosphorus). Because mineral deficiencies cause significant discomfort in the body, it is very important to get them from food sources.

Generally lean meat is an excellent source of B-complex group of ***vitamins*** but is a poor source of fat soluble vitamins like vitamin A, D, E and K and water soluble vitamin C. Meat fats provide these fat soluble vitamins to some extent. Certain organ meats contain vitamin C in minor quantities. All of the B-complex vitamins are present in meat and in a concentrated form in the liver. Contents of the B-complex vitamins group vary among different types of meat. Pork is superior to beef, veal, lamb or poultry meat in terms of containing B-complex vitamins. Thiamin content in pork is 8 to 10 times higher than in other meats, but its vitamin B content is lower than in other meats. The liver of any animal is a good source of vitamin B, i.e. thiamin. During cooking, some of these water soluble vitamins are lost. Generally, 100 grammes of cooked meat supplies 25-60 per cent of the recommended (RDA) B-complex vitamins.

Table 1.2.

Chemical composition of typical adult mammalian muscle
http://www.ifrj.upm.edu.my/18%20(03)%202011/4)IFRJ-2010-227.pdf

Component	% weight
Water	75
Protein	19
Myofibrillar (11.5) - myosin, actin, connectin (titin), N2 line protein (nebulin), tropomyosins, troponins, actinins (α, β and γ), myomesin, desmin, filamin, vinculin, talin, etc.	
Sarcoplasmic (5.5) - glyceraldehyde phosphate dehydrogenase, aldolase, creatine kinase, glycolytic enzymes (such as phosphorylase), myoglobin, haemoglobin etc	
Connective tissue and organelle (2.0) - collagen, elastin, mitoehondrial, cytochrome c and insoluble enzymes	
Lipid - neutral lipid, phospholipids, fatty acids, fat-soluble substances	2.5
Carbohydrate - lactic acid, glucose-6-phosphate, glycogen, glucose, - traces of other glycolytic intermediates	1.2
Miscellaneous Soluble Non-Protein Substances	2.3
Nitrogenous (1.65) - creatinine, inosine monophosphate, di- and tri-phosphopyridine nucleotides, amino acids, carnosine, anserine	
Inorganic (0.65) - total soluble phosphorus, potassium, sodium, magnesium, calcium, zinc, trace metals	
Vitamins - various fat- and water-soluble vitamins	qm

The most sustainable packaging materials for fresh meat

When packaging fresh meat, it is important to choose packaging materials and packaging technologies that not only contain the meat and meat products, but also extend the delivery time as much as possible.

Both single-layer and multi-layer packaging materials are used for packaging. If it is necessary to extend the shelf-life, then multilayer packaging materials with high gas barrier properties are used, which allows products to be packaged in vacuum (VP) and modified atmosphere packaging (MAP).

Table 1.3.

The most commonly used packaging shapes for packaging of fresh meat

Illustration	***Package shape***	***Description***
	Wrapped in cling film	Meat/meat products, which are expected to have a short period of sale, are usually wrapped in food film.
	Pillow pouches	Usually produced in-house in horizontal flow-pack equipment. Or purchased packaging in the form of ready-made packages with three fused seams.
	Doypack	Usually produced in-house in horizontal flow-pack equipment. Or purchased packaging in the form of ready-made packages with three fused seams.
	Trays	Usually, companies already receive ready-made containers, which are hermetically sealed after placing the products.

	Thermoformed packages	These packages are usually made in-house from a roll of packaging.
	SKIN package	As a rule, companies use a packaging tray on which, after placing the product on it, the upper film is fused to the base of the package

These three packaging technologies are mainly used for fresh meat packaging: air, vacuum and MAP packaging. When packaging products in an air environment, the packaging materials do not have specific characteristics. When packaging products in vacuum or MAP, it is important that the packaging materials have high gas barrier properties.

Multi-layer films. Practically all the other films used for meat packaging are designed to be strong oxygen and water vapour barriers. In order to fully achieve these requirements, films with good oxygen and water vapour barrier properties are combined.

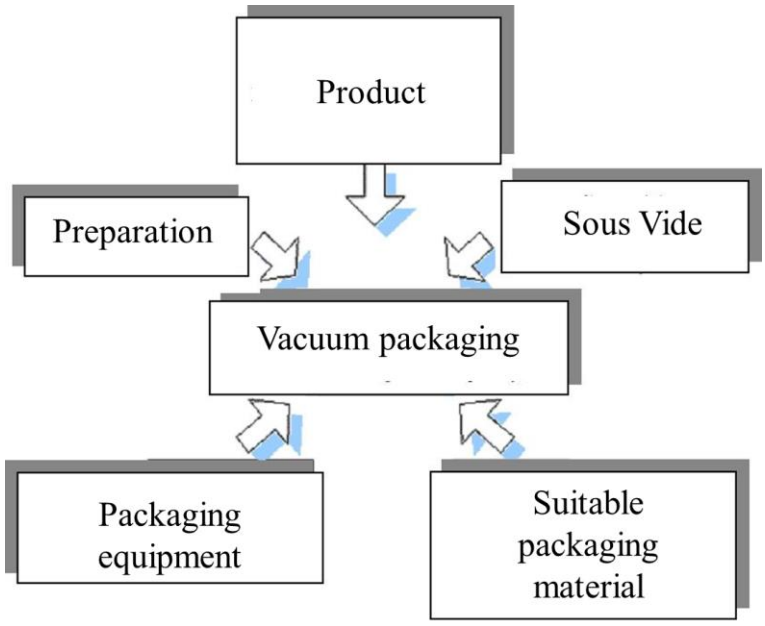


Figure 1.1. The vacuum packaging process was influenced by these aspects

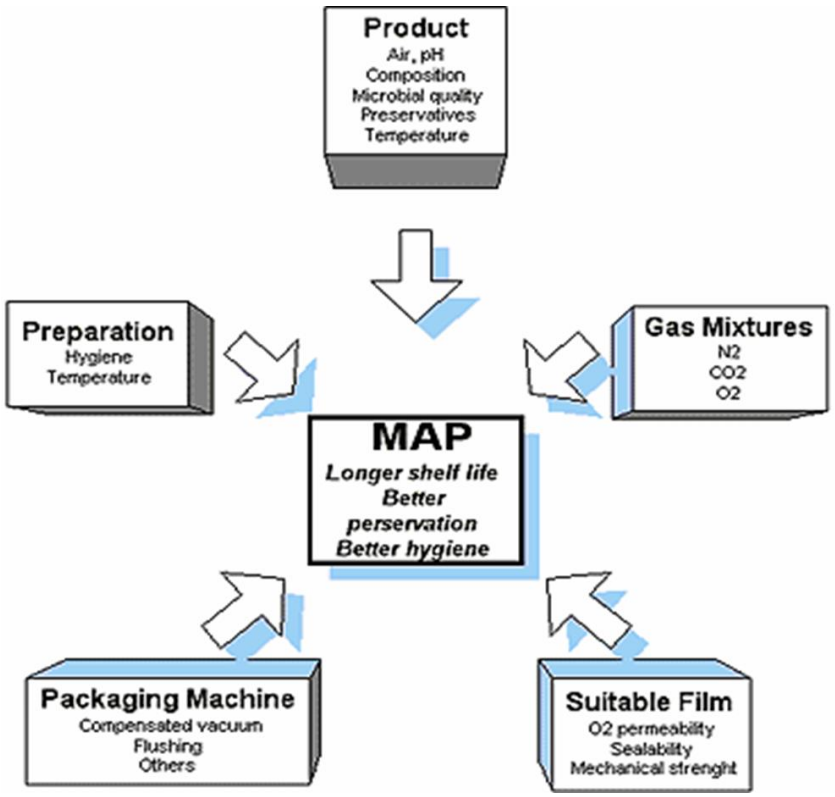


Figure 1.2. MAP process was influenced by these aspects

Figure 1.3. The most typical packaging equipment used for packaging meat / meat products

Chamber type machines and tray sealers are usually used by smaller production companies, while flow-wrap and flow-packs (horizontal and vertical) as well as thermoforming machines are usually used by larger capacity companies because of the high output of these machines.

All packaging equipment and technologies have their pros and cons, therefore, when choosing the equipment, some aspects should be evaluated.

Laboratory work

Evaluation of the chemical composition of meat using physico-chemical quality analysis methods

Materials

Different types of minced meat samples, an oven for drying at 150 ± 2 ºC temperature, scales with a precision of 0.01 gramme, prepared and preheated sands, metal crucible with lid and glass stick, porcelain bowl, H_2SO_4 of 1.5 density solution, butyrometer, sulfuric acid solution, water bath for heating samples at 70 to 75 °C temperature, centrifuge with 800 to 1 000 rpm, preheated porcelain crucibles, muffle for heating samples at 600 to 800 °C temperature, scales with a precision of 0.0001 gramme, Kjeldahl apparatus (mineralisation block and distillation unit), 250 mL mineralisation tubes, pipettes, cylinders, Kjeltabs tablets Cu/3.5 (3.5 g K_2SO_4, 0.4 g $CuSO_4$ per tablet), concentrated sulfuric acid solution, H_2O_2 (30 to 35% concentration) solution, distilled water, 4% boric acid solution, 40% NaOH solution, 0,1 n HCl solution.

Methods and Procedures

Task 1. Moisture content in meat

The moisture content of the meat determines its stability during storage (as the moisture content increases, oxidation processes intensify, and favourable conditions for the development of microorganisms are created). The moisture content of the meat and meat products is determined by drying in an oven at 150 ± 2 ºC;

Rationale for the method

To speed up the drying process, the meat sample is mixed with sand, which loosens the product, creates a larger evaporation surface, and prevents the formation of a drying layer. Before use, sift the sand through a sieve with holes 1-3 mm in diameter and wash, while stirring with water, to remove clay particles. When the water is no longer cloudy, drain it, add 1:1 diluted hydrochloric acid to the sand, mix and stand for one day. The sand is then rinsed in running water while stirring until neutral, then rinsed in distilled water. Dry and heat in a muffle oven. Store sand in a closed container. To determine the moisture, grind the meat sample twice in a meat mincer (meat grinder) with a sieve-hole diameter of 3 to 4 mm, mixing the resulting mass thoroughly each time. Determine the moisture content by drying the samples at 150 ± 2 ºC.

Procedure

Pour the heated sand into the metal crucible, which is 2-3 times the weight of the meat sample, put the lid on and weigh, for example 3 g of meat with 9 g of sand.

Weigh into a metal crucible about 3 g of the meat sample, weigh, mix thoroughly with sand using a glass stick and dry in an open oven at 150 ± 2 ºC for 1 hour, then place the lid on the metal crucibles, cool in a desiccator to room temperature and only then weigh it.

The moisture content in % is calculated according to the formula:

$$X = \frac{(m_1 - m_2) \cdot 100}{m_1 - m_0},$$

where: m_1 – mass of metal crucible with lid, sands, glass stick and sample before drying, g;

m_2 – mass of metal crucible with lid, sands, glass stick and sample after drying, g;

m_0 – mass of metal crucible with lid, sand and glass stick, g.

Task 2. Determination of fat content with a fat meter (butyrometer)

Background

The method for determining the fat content is based on treating the product with concentrated sulfuric acid solution, separating the fat with isoamyl alcohol, and further separating by centrifugation. Sulfuric acid breaks down proteins and separates fats easily. Further addition of isoamyl alcohol forms an isoamyl alcohol sulfuric acid ether, which reduces the surface tension of the fat globulesand promotes their adhesion. The formation of a fat layer is accelerated by heating and centrifuging the solution. During centrifugation, the fat, as the lightest component under the influence of centrifugal force, is concentrated closer to the centre on the scale of the fat gauge.

Procedure

Weigh 1 to 3 g (±0.01g as near as possible, you need to be extremely close) of the prepared sample, place in a porcelain bowl, add 5 mL of H_2SO_4 of 1.5 density, mix with a glass rod and heat (do not boil) for 5 to 10 minutes until a homogeneous mass is obtained. If the globules do not break, add another 2-3 mL of acid, reheat. Pour the resulting solution through a funnel into a butyrometer previously filled with 5 mL of sulfuric acid, rinsing the residue from the dish with small portions of sulfuric acid. Then pour 2-4 mL of isoamyl alcohol into the fat meter, close the fat meter with a rubber stopper and mix by inverting the butyrometer 2-3 times. The butyrometer is then placed with the stopper down in a water bath at 70 to 75 °C for 10 minutes and then centrifuged for 15 minutes at 800 to 1 000 rpm.

After centrifugation, place the butyrometer again in a water bath at 60 to 75 °C and after 5 minutes read the number of graduations taken up by the fat on the butyrometer scale.

The fat content in % is calculated according to the formula:

$$X = \frac{0{,}01133 \cdot a}{b} \cdot 100,$$

where: 0.01133 – the quantity of fat corresponding to one part by mass of the fat meter, g;

a – is the number of small sections of the fat-gauge occupied by the fat column;

b – product weight, g.

Task 3. Determination of ash content

Background

When organic compounds are heated, they decompose into carbon dioxide, water, ammonia and minerals, which remain ash. The amount and composition of ash in animal products depends on the chemical composition of the feed, the animal species, etc.. The physiological and technological value of the product can be judged by the composition and quantity of the ash.

During the ashing process, the mineral content of the product under investigation can be converted into volatile products, therefore ashing should be performed at a temperature of 550 ºC - 600 ºC. If the meat product contains a lot of moisture, the sample is first dried in an oven. To determine the ash content of meat with a high fat content, as well as the fat itself, the weight is first burned in a crucible containing ashless filter paper. Relationship between the glow colour and temperature: dark red onset - 525 ºC; dark red - 700 ºC; beginning of cherry colour - 800 ºC; cherry colour - 900 ºC; light cherry colour - 1000 ºC; dark orange - 1100 ºC; light orange - 1200 ºC; white - 1300 ºC; bright white - 1400 ºC; silvery white - above 1500 ºC.

Procedure.

Heat a clean porcelain crucible (approximately 1 hour) in a muffle furnace at 600 ºC, cool it in a desiccator and weigh, then heat, cool and weigh to constant weight. Repeat the weighing every 30 minutes. The mass is considered constant until the difference between the two weights is not more than 0.0002 g.

Weigh, to the nearest 0.0002 g, 2 to 5 g of the sample into the heated crucible. Initially, the incineration is carried out at a lower temperature (on an electric hob) to avoid weight loss. The combustion is carried out in a fume cupboard until the intense smoke is eliminated. Then place the crucible in a muffle furnace and continue incinerating at 600 to 800 °C for 1 to 2 hours.

If the residue is incomplete (dark ash with carbon particles), cool the crucible, moisten the ash with water, saturated ammonium nitrate or 30 drops of 30% hydrogen peroxide solution and continue to ash. This process is completed when the ash is white, yellowish or brownish. Ashing is carried out to a constant weight.

The ash content in % is calculated according to the formula:

$$X = \frac{(m_2 - m_0)}{(m_1 - m_0)} \times 100,$$

where: m_0 – empty crucible, g;
m_1 – crucible with the sample, g;
m_2 – crucible with the ash, g.

Task 4. Determination of protein content

The amount of protein in a product is judged by the amount of nitrogen in it. The total nitrogen content of the product can be determined by the Kjeldahl method

Background

A food is digested with a strong acid so that it releases nitrogen which can be determined by a suitable titration technique. The amount of protein present is then calculated from the nitrogen concentration in the food. The same basic approach is still used today, although several improvements have been made to speed up the process and to obtain more accurate measurements. It is usually considered to be the standard method of determining protein concentration. Because the Kjeldahl method does not measure the protein content directly, a conversion factor (F) is needed to convert the measured nitrogen concentration to a protein concentration. A conversion factor of 6.25 (equivalent to 0.16 g nitrogen per grammme of protein) is used for many applications, however, this is only an average value, and each protein has a different conversion factor depending on its amino-acid composition. The Kjeldahl method can conveniently be divided into three steps: digestion, neutralisation and titration.

Digestion. The food sample to be analysed is weighed into a digestion flask and then digested by heating it in the presence of sulfuric acid (an oxidizing agent which digests the food), anhydrous sodium sulphate (to speed up the reaction by raising the boiling point) and a catalyst, such as copper, selenium, titanium, or mercury (to speed up the reaction). Digestion converts any nitrogen in the food (other than that which is in the form of nitrates or nitrites) into ammonia, and other organic matter to CO_2 and H_2O. Ammonia gas is not freed in an acid solution because the ammonia is in the form of the ammonium ion (NH_4^+) which binds to the sulphate ion (SO_4^{2-}) and thus remains in solution:

$$\text{N (food)} \rightarrow (NH_4)_2SO_4$$

Neutralisation. After the digestion has been completed the digestion flask is connected to a receiving flask by a tube. The solution in the digestion flask is then made alkaline by the addition of sodium hydroxide, which converts the ammonium sulphate into ammonia gas:

$$(NH_4)_2SO_4 + 2\ NaOH \rightarrow 2NH_3 + 2H_2O + Na_2SO_4$$

The ammonia gas that is formed is freed from the solution and moves out of the digestion flask and into the receiving flask – which contains an excess of boric acid. The low pH of the solution in the receiving flask, converts the ammonia gas into the ammonium ion, and simultaneously converts the boric acid to the borate ion:

$$NH_3 + H_3BO_3 \text{ (boric acid)} \rightarrow NH_4^+ + H_2BO_3^- \text{ (borate ion)}$$

Titration. The nitrogen content is then estimated by titration of the ammonium borate formed with standard sulfuric or hydrochloric acid, using a suitable indicator to determine the end point of the reaction.

$$H_2BO_3^- + H^+ \rightarrow H_3BO_3$$

The concentration of hydrogen ions (in moles) required to reach the end-point is equivalent to the concentration of nitrogen that was in the original food. The following equation can be used to determine the nitrogen concentration of a sample that weighs milligrams using a 0,1 M HCl acid solution for the titration.

Procedure

Use nitrogen-free weighing paper to facilitate weighing of the samples. Weigh, to the nearest ± 0,1 mg, 0.5 g of the sample into a 250 mL mineralisation tube. Add 2 Kjeltabs tablets Cu/3.5 (3.5 g K_2SO_4, 0.4 g $CuSO_4$ per tablet) to the mineralisation tube and, depending on the contents of the sample, add 12 to 15 mL of concentrated sulfuric acid. Shake it gently to soak the entire sample. When the paper used for weighing the sample has dissolved, add 5 mL of H_2O_2 (30 to 35% concentration). Place the tubes in a mineraliser heated to 420 ºC and place the hood on the tubes, and switch on the water aspirator.

Mineralise for 60 minutes until the contents of the tube are clear, greenish blue. Then remove the tubes from the mineraliser without removing the hood and cool the tubes in a fume hood for at least 15 minutes. Add 80 mL of distilled water to each chilled mineralisation tube and place in a distillation apparatus. Pour 25 to 30 mL of the receiving solution (boric acid solution) into a 250 mL conical flask which is placed in the distillation apparatus so that the end of the exhaust pipe is below the surface of the boric acid solution. Add 50 mL of 40% NaOH by distillation apparatus automatically. The distillation unit is operated according to the user manual. During the distillation process, the steam "transfers" the ammonia to the receiving flask. Distillation is continued for 5 minutes.

Titrate the trapped ammonia with 0,1 n HCl until the solution changes from green to pink, recording the acid consumption.

The protein content is calculated according to the formula:

$$\text{Nitrogen} = \frac{(T - B) \cdot N \cdot 14.007 \cdot 100}{m},$$

where: N – normality of the acid solution, 0.1;

B – the quantity in mL of 0.1 N HCl used to titrate the control sample;

T – the quantity in mL of 0.1 N HCl used to titrate the sample;

m – the weight of the sample, mg.

% Protein = Nitrogen content (%) × F

F = protein factor = 6.25 for meat and meat products.

The carbohydrate content in % can be calculated using the following formula:

$$C = S - (O + T + P),$$

where: S – dry matter content, g;

O – protein content, g;

T – fat content, g;

P – ash content, g.

Results

Draw conclusions, and compare the obtained results with the information available in the literature and scientific publications.

Conclusion

1.
2.
3.

Approved by _____

Name, Surname, signature

Date _____

Theme 2

Biochemical and microbiological developments in meat

Theoretical materials

Meat is defined as "the edible part of the skeletal muscle of an animal that was healthy at the time of slaughter". Chemically, meat is composed of four major components including water, protein, lipid, carbohydrate and many other minor components such as vitamins, enzymes, pigments and flavour compounds. The relative proportions of all these constituents give meat its particular structure, texture, flavour, colour and nutritive value. However, because of its unique biological and chemical nature, meat undergoes progressive deterioration from the time of slaughter until consumption. Meat is a nutritious, protein-rich food which is highly perishable and has a short shelf-life unless preservation methods are used. Shelf life and maintenance of the meat quality are influenced by a number of interrelated factors, including holding temperature, which can result in detrimental changes to the quality attributes of meat.

Biochemical changes in meat during *post mortem*. In the living animal, aerobic metabolism is used to obtain energy. After slaughter, aerobic metabolism begins to fail due to the stored oxygen supply being depleted. After exsanguination, cessation of blood circulation shifts muscle metabolism from aerobic to anaerobic. It has been reported that when muscle contracts in an anaerobic environment, glycogen disappears and lactic acid becomes the principal end product of glycolysis; whereas under aerobic conditions, lactic acid does not accumulate as it is oxidised to CO_2 and water. One molecule of glucose will generate 3 moles of ATP via anaerobic glycolysis providing the high-energy phosphates necessary for post mortem (anaerobic) muscle contraction. Creatine phosphate is rapidly depleted as a result of post-mortem metabolism, yet ATP may be maintained for several hours from anaerobic glycolysis. Accumulation of lactic acid in post-mortem muscle reduces the localised pH and muscle is converted to meat. The conversion of glycogen to lactic acid will continue to lower the muscle pH until the glycogen (or ATP stores) are depleted or until the contractile proteins cease to function as a result of the low intramuscular pH. The sequence of chemical steps by which glycogen is converted to lactic acid is essentially the same post-mortem as in vivo when the oxygen supply may become temporarily inadequate for the provision of energy in the muscle; but it proceeds further. Except when inanition or exercise immediately pre-slaughter has appreciably diminished the reserves of glycogen in muscle, the conversion of glycogen to lactic acid will continue until a pH is reached when the enzymes affecting the breakdown become inactivated. In typical mammalian muscles this pH is about 5.4–5.5. An initial level of 600 mg glycogen/100 g muscle is required to attain this pH. Muscles that have an ultimate pH of 5.4–5.5 after post mortem glycolysis may still contain some residual glycogen, even though it is generally considered that there will be no residual glycogen if the pH fails to fall to 5.4–5.5 during post-mortem glycolysis. The final pH attained, whether through the lack of glycogen, inactivation of the

glycolytic enzymes or because the glycogen is insensitive (or inaccessible) to attack, is referred to as the ultimate pH; this is generally about 5.5, which is the iso-electric point of many muscle proteins. Both the rate and the extent of the post-mortem pH fall are influenced by intrinsic factors such as species, muscle type and variability between animals; and by extrinsic factors such as the administration of drugs pre slaughter and the ambient temperature; pre slaughter exercise is also a known factor which produces dry firm dark (DFD) meat which has a pH of around 7.0 (http://www.ifrj.upm.edu.my/18%20(03)%202011/4)IFRJ-2010-227.pdf).

Meat is a complex of muscle, fatty, connective and bone tissue, the quality of which is determined by the quantitative proportions of its components. Morphological composition of meat depends on animal species, age, sex, fattening, technological processing. Meat quality is also influenced by transport, pre-slaughter holding, and slaughter method of animals. Meat quality mostly depends on its storing conditions.

External appearance. External appearance is characterised by the overall appearance of a product or carcass meat; attention is paid to presence of mould on the surface, extraneous inserts and drawing of a cut (of products), drying of carcass meat. Bruising, clots, residues of skin and the internal organs not only impairs commercial appearance of meat but also decreases its durability for storing.

Meat colour. It is one of the main quality characteristics evaluated by a consumer first: based on this characteristic, an opinion about the commercial appearance of meat is formed. Meat colour depends on various factors: firstly, on the muscle tissue pigments haemoglobin and myoglobin as well as the amount of their compounds; also on pH, quantitative proportion of fatty and connective tissue, mode of technological processing, storage conditions, etc.

Odour and flavour. These are also important quality characteristics which are determined by the chemical compounds characteristic to a product. Meat odour and flavour depends on the animal age, sex, the amount of fatty tissue and the nature of its distribution. Meat from a previously sick, scraggy animal will always taste worse. The flavour of fresh meat is specific, somewhat sweetish. Meat from goats does not have a strong taste or smell, whereas meat from cattle has a stronger specific smell and a less pleasant taste.

Consistence. It is one of the most important quality characteristics of meat and meat products which is evaluated quite strictly by a consumer. The concept of consistency is rather wide and difficult to define. When evaluating meat consistency, its softness, tenderness, juiciness, etc. is evaluated. Meat consistency is highly dependent on the condition of the myofibril proteins, the ratio of fatty and connective tissue, the pH of the muscle tissue, the level of hydration of the muscle proteins and other meat characteristics. The consistency of meat changes when stored in refrigerated conditions, when corned, and after thermal processing. When storing meat, its quality characteristics change; the intensity and character of the change depends on the storing conditions and mode, also on the composition and characteristics of the meat.

Putrefaction of meat. It is the main and most frequent type of meat deterioration. Putrefaction of meat is caused by proteolytic microorganisms, growth of which requires proteins or products of partial protein hydrolysis. This process can take place under

both aerobic and anaerobic conditions, and its progress depends on the following factors:

1. Type of meat;
2. Initial microbial contamination and micro flora composition;
3. Meat pH;
4. Water content in the upper layers of meat or water activity;
5. Destructive properties of proteins;
6. External environmental factors (storing conditions).

Usually, putrefaction processes begin on the surface of meat when aerobic microorganisms from the environment start acting.

The first sign of aerobic putrefaction is the formation of mucus on the surface of the meat. At the initial stage of putrefaction, the previously red colour of meat gradually turns grey. At the deep stage of putrefaction, the colour of meat turns greenish. In the event of the aerobic decomposition, the meat pH is between 7.0 and 8.0, the meat has an unpleasant smell, however less strong than that of aerobic putrefaction.

Anaerobic putrefaction of meat begins in thick muscle layers, near bones, and joints. During this process, organic compounds are discharged which accumulate among muscle plates, the structure of the meat becomes porous, an unpleasant smell is present, the colour of the meat changes to blue-red or grey-green. Alkaline pH values ($8.0 < pH > 9.0$) are typical for such meat.

When carrying out sensory evaluation of raw material (meat), it must be ensured that: 1) The raw material was obtained from animals corresponding to the health requirements established in the EU legislative acts; 2) The raw material was obtained from enterprises following HACCP or the principles of good hygiene practices; 3) The raw material was transported using vehicles that meet the requirements applicable to such raw material; 4) The raw material has received a veterinary certificate with a health mark or other identification mark in accordance with the requirements provided for in the legislative acts; 5) The raw material is fresh.

When the compliance of documents received with raw material is assessed, the most important thing is to determine whether the raw material (meat) is fresh.

Contamination, safety and risk assessment of meat

Food safety is becoming a global problem, leading governments and public health organizations in many nations to search for more effective methods of production chain monitoring. As part of a comprehensive strategy for managing food hygiene, providing food hygiene training to all individuals who handle food could potentially lower the prevalence of food-borne illnesses. When food hygiene instruction is founded on an appropriate constellation of strategies created in accordance with successful health education theories and models, its efficacy could be significantly increased. These models could aid in the creation of strategies that take into account the social and environmental aspects that affect food safety in addition to the information that aims

to change attitudes and behaviours. It is commonly known that the HACCP system is a management technique that can guarantee food safety. Food safety experts have understood the value of HACCP principles for reducing the risk factors that directly cause foodborne illness since the 1960s. However, according to European Union (EU) Directive 93/43/ EEC and Regulation 852/2004/EC, the application of HACCP principles is required at all stages of the food chain. Analysis of Hazards Crucial Control Point - the well-proven HACCP management system gives customers assurance about the safety of their food. The system is built on focused control at operation points, which could be essential to food safety. By promoting involvement in a system that guarantees the control of risk factors for foodborne illness, the principles of HACCP exemplify the idea of active managerial control. The fundamental idea behind the HACCP method is that dangerous or potentially harmful practices can be identified early in the food processing process. In the case of meat hygiene, the qualitative recognition of unseen microbiological and chemical contamination, rather than grossly-apparent abnormalities are now the most important sources of hazards to human health which has led to increasing demands for a more systematic regulatory approach to combat these hazards.

Food safety based on HACCP

Throughout the food supply chain, HACCP is a risk management method that finds, assesses, and controls hazards connected to food safety. It is commonly known that the hazard analysis and critical control point system is a management technique that can guarantee food safety. The system's main phrase is "prevention," which refers to identifying potential contaminants before they happen and defining control measures as maximising food safety at every stage of the procedure. Throughout the operation, the HACCP program can be used to manage chemical, biological, and physical risks. Customers and regulatory agencies can be assured by the plan that you are taking all necessary precautions to ensure food safety. It also aids in improving the design of new food products and lowering contamination linked to food losses. The ISO 9001 quality management system (QMS) and ISO 22000 food safety management systems (FSMS) are displayed in Fig. 2.1.

Figure 2.1. Food safety and customer satisfaction (Quality Resource Corporation)

ISO 22000:

According to Quality Resource Corporation, the ISO 22000 standards systematise and include the 12 phases and 7 HACCP principles. This is a requirement for Food Safety Management Systems (FSMS), which aims to provide security in all food chain industries. In order to guarantee food safety throughout the food chain up to the point of final consumption, ISO 22000 specifies the standards for an FSMS that incorporates the following widely acknowledged essential elements:

a) Interactive communication,
b) System management,
c) Prerequisite programs,
d) HACCP principles.

The organisation shall establish, document, implement and maintain an effective food safety management system and update it when necessary in accordance with the requirements of ISO22000 System.

ISO 9001:

Quality Resource Corporation (2009) defined ISO 9001 as the benchmark for customer satisfaction since it ensures the security of customers purchasing goods or receiving services by verifying and approving a business's Quality Management System. Building this system within your business also offers a significant benefit in terms of boosting constitutional improvement, consumer confidence, and other factors. In compliance with the ISO 9001 Standard, the business must create, record, implement, and maintain a quality management system and continuously enhance its efficacy. The company will:

a) Determine the processes needed for the quality management system and their application throughout the organization,

b) Determine the sequence and interaction of these processes,

c) Determine criteria and methods needed to ensure that both the operation and control of these processes are effective,

d) Ensure the availability of resources and information necessary to support the operation and monitoring of these processes,

e) Monitor, measure where applicable, and analyse these processes, and

f) Implement actions necessary to achieve planned results and continual improvement of these processes.

HACCP plan principles

Basic HACCP principles are as:

a) Identification of food hazards and the necessary risk control measures,
b) Identification of the food safety Critical Control Points (CCPs),
c) Determination of the critical limits for each CCP,
d) Establish monitoring procedures for CCPs,
e) Plan and take corrective action when critical limits are exceeded,
f) Establish verification procedures for the HACCP FSMS system,
g) Establish documentation and record keeping for the HACCP FSMS system.

Requirements for the HACCP plan to be completed: To guarantee fundamental hygienic conditions in the processing plant, a few "prerequisite programs," such as good manufacturing practices and cleaning protocols, should be set up prior to the implementation of HACCP principles. Good manufacturing practices and sanitation standard operating procedures are the primary preparatory programs. The physical layout and upkeep of the facility, the water supply, the health and personal hygiene of the handlers, pest control, equipment sanitisation, instrument calibration, quality control of raw materials and ingredients, recall procedures, and consumer complaint handling are all included in these programs. The fundamental requirements for HACCP implementation in the food sector are depicted in Figure 2.2.

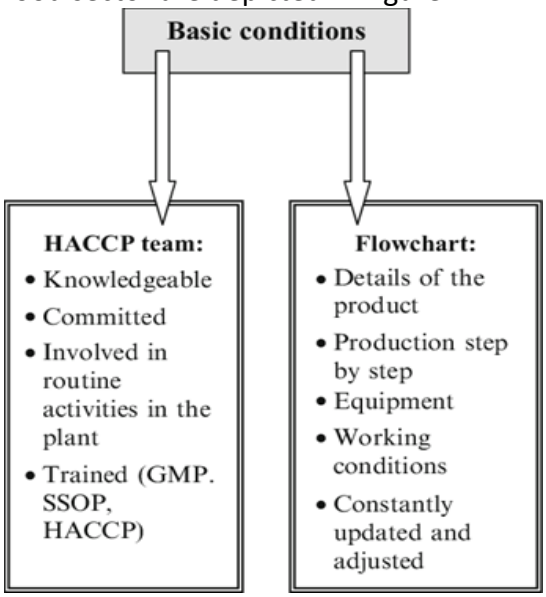


Figure 2.2. Basic conditions for HACCP implementation in the food industry

Impact of HACCP for Food Safety: The growing recognition of HACCP as the most economical approach to managing food-borne illnesses and the consequent spread of HACCP implementation have underscored the necessity of unambiguous directives regarding the training prerequisites essential for successful HACCP execution. Significant developments in food production over the past few decades, including improved manufacturing techniques, shorter time frames between production and consumption, longer product shelf lives, and a rise in the presence of some bacteria, have made the pursuit of safety more difficult.

HACCP is a crucial instrument for contemporary quality control in the food business, guaranteeing product integrity, avoiding FBDs, and safeguarding consumer health. Only until its principles are correctly and widely implemented at every stage of the food supply chain will HACCP become effective. The frequency of foodborne illness (FBD) outbreaks has increased recently, and some of the reasons for this could be attributed to low adoption rates of HACCP in developing nations—where the majority of FBD outbreaks occur—final consumer ignorance perpetuating inadequate food handling practices, and inadequate application or implementation of HACCP, particularly in small businesses.

HACCP application in the meat industry

All links in the food chain are covered under the Food Safety Act of 1990, which also makes it possible to enact laws like the Meat Products (Hygiene) Regulations of 1994. Since a significant amount of meat products are traded internationally, the meat sector places a high value on HACCP acceptance. The supplier of raw beef products will benefit from an HACCP program to monitor the microbiological condition of items entering the processing plant.

A person who works in the meat sector would be acquainted with the butchery and slaughterhouse procedures. In order to learn about the agricultural methods used from the time an animal is born until it arrives at the slaughterhouse, they should also get in touch with the farmers. Since the animal is a source of pathogenic and spoilage organisms, adopting HACCP should be used to manage every important control point at every stage of the animal's slaughter. Employees in the meat and poultry industries should also strive to protect themselves by donning a variety of safety gear and other items.

The organism has the potential to contaminate the carcass during the slaughter process. A 0.2% incidence of *E. coli* 0159:H7 was found on raw beef carcasses according to the USDA's statewide beef microbiological baseline collection program for steers and heifers (no *E. coli* 0157:H7 was observed on pork carcasses in the market hog study). Although there have been cases of cross-contamination from animal food to other foods, *E. coli* 0157:H7 contamination in foods is typically linked to animal goods, particularly ground beef. The pathogen *E. coli* 0157:h6 is resistant to freezing and refrigeration. If the bacteria is present, it can grow extremely slowly at 6 °C and could show up in a fermented product since it can endure for extended periods of time in an environment with a pH of 3.6 to 7.0, barring destruction by heat or other processes. The precise methods to be employed in order to destroy E. coli 0157:H7 frequently involve a mix of temperature, pH, Aw control, and microbiological controls in raw materials. Figure 3 illustrates how people usually wear a variety of safety and other equipment to help protect themselves from sickness and harm.

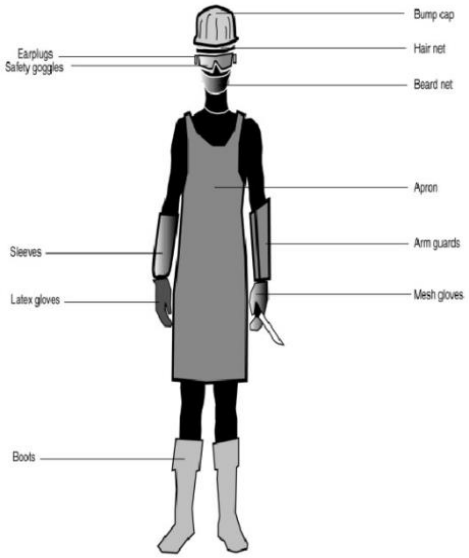


Figure 2.3. Safety and other equipment worn by meat and poultry production workers

Using HACCP in meat processing: To ensure the safety of the product generated by a processing system, both individual processors and processors working under the control system must establish a high degree of qualified potency. Generally speaking, the processing of meat involves implementing HACCP to prevent and decrease hazards to safe levels. The first step is to identify the many risks—such as microbiological, chemical, and physical risks that are connected to raw meat. Microbiological risks are the primary ones connected to raw meat, and they are managed both in farms and at abattoirs. Starter culture and the addition of curing salt are other essential control points. These components must be of the highest calibre to stop additional contamination and to work well to create the ideal environment for the development of beneficial bacteria utilised in fermented goods. Because the pH value drops quickly during the fermentation stage, most harmful microbes are inhibited from growing, making it another crucial CCP. The steps of heating and drying may cause a decrease in the number of organisms and growth inhibition. Raw fermented meat production is depicted in Fig. 4. Assemble the evolution of a HACCP plan for refrigerated beef ravioli in order to facilitate the HACCP discussion.

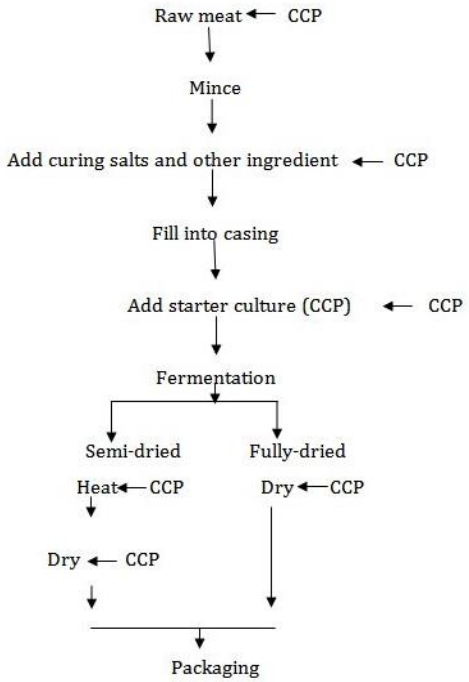


Figure 2.4. Flow diagram for the production of raw fermented meat

Control of meat and poultry products linked to microbiological hazards:

Because red meat and poultry are products of warm-blooded animals, their microbial flora is diverse and includes both mesophilic and psychrotropic bacteria. These bacteria include pathogenic species that come from the animal itself,

environmental sources, and bacterial species that are added during raw product processing and slaughter. The pH range of 5-7 and aw>0.09 found in raw meat and poultry provide the ideal conditions for microbial development. When processing meat and poultry, a variety of control procedures are needed. Additives including sugars, nitrates, and salt are used in the cooking and smoking processes of cured meats and some sausage products. Bacterial biota may be limited to salt-tolerant species by salt. Numerous vegetative cells will be destroyed by cooking and smoking. It is important to take into account the possibility of introducing microorganisms, including pathogens, into packaged products due to factors such as product handling, processing environment, and packaging. Products made from meat and poultry have a long history of meeting requirements. Apart from the aforementioned requirements, specific combinations of pH, aw, and other variables can be employed to inhibit the growth of pathogens, which would otherwise escalate when meat products are stored at room temperature. Retail-processed goods, which are exempt from the HACCP regulation, should adhere to this recommendation and keep records regarding the management of risks.

Good manufacturing practices

Programs known as good manufacturing practices (GMPs) are made up of fundamental, universal actions and procedures that regulate working conditions in businesses and guarantee ideal circumstances for the production of safe food. The control factors known as GMPs are not process-specific; rather, they pertain to the entire operation. Programmes including pest control, recall protocols, building and maintenance, and cleanliness are examples of GMPs. To guarantee that GMPs are followed, there are detailed instructions that tell people what, how, and when to do the duties necessary to meet GMP requirements. The microbiological conditions of the product are given particular consideration in order to prioritise the safety and quality of processed goods.

Food safety hazard

The goals for food safety that regulatory bodies are currently adopting purport to take into account the idea that resources should be distributed in a way that minimises costs in order to identify and control the hazards that are most important to public health. Any biological, chemical, or physical substance, or food condition, that has the potential to hurt or negatively impact one's health when consumed, is considered a food safety hazard. Food safety risks are categorised as follows:

a) Biological such as microorganisms,
b) Chemical such as chemicals, pesticides, cleaning agents and allergens,
c) Physical foreign objects that are not supposed to be in the food, such as timber, glass, packaging material and naturally occurring objects – bones, dust and grit.

Any business should aim to reduce the risk of these hazards in its food processing and service ensuring the food is safe to consume. A food safety programme outlines the systems in place to keep food safe and procedures which reduce the risk of the hazards which may occur in the food production and service business.

Physical hazards:

Physical hazards which can be found in food include:

a) Objects naturally present in the food (animal hair, bone chips, leaves, etc.),
b) Objects occurring in agriculture (dirt, manure, leaves, etc.),
c) Objects added during processing (glass, plastic, hair, metal, etc.).

Reducing physical hazards is relatively simple in most hospitality businesses as they are physically visible in the food. They are normally controlled by procedures such as a visual inspection of food and good kitchen procedures such as no wood or glass policy, and keeping the food covered.

Chemical hazard:

Chemical hazards which can be found in food include:

a) Naturally occurring poisonous chemicals (poisonous plants such as rhubarb leaves and mushrooms, poisonous animals such as puffer fish, algal blooms, mould toxins, etc.),
b) Chemicals added via water, agricultural chemicals from soils, plants and animals (pesticides, antibiotics, dips, heavy metals, etc.),
c) Chemicals added during food processing (additives, cleaners, etc.).

Some people have an allergic reaction to certain ingredients or parts of food. Common allergens include: soybeans and their products, seams, cereals containing gluten, milk and milk products, sulphites, egg and egg products, peanuts and their products, fish and fish products.

Chemical hazards in foods can be controlled by:

a) Purchasing from an approved supplier,
b) Covering food and protecting it from contamination,
c) Having an allergen awareness, and strategies to prevent cross contamination from allergens,
d) Separate chemical storage area, away from food,
e) Use of food safe chemicals within the food preparation areas,
f) Correct cleaning procedures.

Biological hazards:

Hazards that are present in foods and can come from multiple sources. These microorganisms (commonly called “germs”) are so small they can only be seen under a microscope. Not all microorganisms are harmful to humans. Pathogens are the microorganisms which cause harm to humans, when they reach a high level in food. Some examples are:

a) Bacteria e.g., *Salmonella*, *Staphylococcus aureus*, *Bacillus cereus,*
b) Viruses e.g., hepatitis A, influenza,
c) Yeasts,
d) Moulds,
e) Protozoa e.g., Guardia.

Most food poisoning is the result of these microorganisms growing in food. When food is in moist and warm conditions, they multiply to an “infective dose” which makes a person ill. Most food poisoning occurs due to the continued growth to dangerous levels of microorganisms, particularly bacteria, in food. Food handlers should know about food poisoning bacteria and the conditions they require for growth, to ensure food borne illness is avoided. It is important to be aware of the different types of food safety hazards which may pose a significant risk to the safety of your customers. Situations when food safety hazards are likely to pose a significant risk are:

a) Handling “potentially hazardous foods” which are susceptible to microorganism’s contamination and growth. These are low acid, high protein foods such as meat, eggs, poultry, seafood and dairy items,
b) Handling raw food and fresh foods - handling food with your hands, rather than using equipment; cooking food - food needs to be cooked thoroughly to kill microorganisms,
c) Chilling food - food needs to be chilled quickly to reduce the growth of microorganisms,
d) Defrosting foods,
e) Reheating foods,
f) Displaying food on buffets or self-service.

Laboratory work Assessment of meat freshness using sensory, physic-chemical and microbiological quality analysis methods

Materials

Different types of meat samples, but for bouillon preparation the same minced meat samples, a knife, conical flasks from 100 to 250 mL capacity, distilled water, thermometer, scales with an accuracy of 0.01 grammes, scales with a accuracy of 0.0001 grammes, cylinders, pipettes, water bath for samples heating at 100 °C temperature, glass test tubes for chemical evaluation of meat freshness, 5% $CuSO_4$, Nessler reagent (double salt of mercury iodide and potassium iodide, melted in potassium hydroxide), 0.2% benzidine spirituous (96%) solution, 1% fresh H_2O_2 solution, 1% phenolphthalein spirituous solution, 0.1 n NaOH solution, 0.1 n $KMnO_4$ solution, 0.4 n H_2SO_4 solution, pH-meter, funnels, filter paper, 100 mL graduated flask, 10% aluminium alum [$AlK(SO_4)_2 \cdot 12H_2O$] solution, saturated $Ba(OH)_2$ solution, formalin (titrated till neutral reaction with indicators No. 1), indicators No. 1. (equally mixed 0.1 % neutral red and methylene blue spirituous solutions), indicators No. 2. (1 part of 0.1 proc. thimolium blue mixed with 3 parts of 1 % phenolphtalein, dissolved at 50 % of spirit).

Methods and Procedures

Task 1. Sensory evaluation of raw meat

Evaluating freshness of raw material (meat)

When determining the freshness of meat by means of sensory method, the following characteristics are determined: external appearance, colour, structure, aroma of meat, condition of fat and tendons, broth transparency as well as condition of broth fats.

External appearance is evaluated by observing the surface and deeper layers. A dry surface of the meat indicates long term storage. Appearance and colour of muscles is viewed at the fresh cut of muscles. Moreover, when the appearance of meat is evaluated, the structure of the meat is evaluated by pressing the sample with your finger. The freshness of the meat is evaluated by placing filter paper on the meat sample. If the meat is fresh, no moisture is transferred onto the filter paper, i.e. no wet stain appears on it. *Evaluation of meat color*. The colour is determined by observing the whole carcass of meat upon taking a sample. When the colour of the meat is evaluated, attention is paid to the fact whether the colour is typical for that type of meat. The colour of meat depends on the changes of the pigments – haemoglobin and myoglobin. The colour of the meat surface (up to 3 cm deep) is determined by the pigment oxymyoglobin. The colour of deeper layers of meat depends on the purple-red myoglobin. As microorganisms develop, the colour of the meat gets darker (sometimes it turns green) as the pigments react with various compounds formed in meat. Therefore, various pigment derivatives are formed: metmyoglobin, methaemoglobin, sulphohaemoglobin.

Under the effect of hydrogen peroxide (which is formed due to microorganism activities), myoglobin can decompose to yellow or green pigments. The colour of meat can also change due to blue-green and pink pigments which are discharged by various types of microorganisms, for example, some mould can colour meat black, white or blue-green. The colour of the muscles of fresh meat has to correspond to the type of meat, i. e. pork – from pale pink to red; beef – from pale to dark red, etc.

Determining consistency. The consistency is determined at the fresh cut of meat by gently pressing it with a finger and observing the pit equilibrating: the cut of fresh meat is firm and elastic, the pit equilibrates quickly (up to 1 minute). When the meat deteriorates, its consistency becomes soft (as opposed to firm).

Determining odor. Firstly, the smell of the surface of the carcass or a sample taken from it is determined. Then, a cut is made with a clean knife and the smell of deeper layers is determined immediately. Special attention is paid to the smell of connective tissue which is around the bones. The smell has to be specific, typical for a particular type of meat. Changes of the smell of meat appear in great part due to aromatic and of sulfur-containing amino acids decomposition, when aromatic compounds of unpleasant smell are formed (anaerobic putrefaction). The sensory characteristics of meat freshness are shown in Table 2.1.

Table 2.1.

Sensory characteristics of meat freshness

Indexes	Meat		
	Fresh	Doubtful freshness	Not fresh
Surface appearance and colour	Meat is encrusted with bright red dry film	Surface is wet, sticky, darkened	The surface is very dry, encrusted with gray-brown mucus or molds
Muscle incision	Slightly wet, but wet trace is not left on filtered paper, color is typical for animal species	Wet (wet filter paper), slightly sticky, dark red color	Wet (wet filter paper), sticky, red-brown color
Consistency	Firm at the incision, with finger pressed pit equilibrates soon	Not so firm at the incision as fresh meat; with finger pressed pit equilibrates slowly (within 1 min.)	Tumbled at the incision; with finger pressed pit doesn't equilibrates
Odour	Specific, typical for fresh meat	Slightly acidic or tainted	Sour, tainted or weak decay
Fat	Cattle - white, yellowish or yellow, hard, crumble under pressure; Swine - white or slightly pink, soft, smooth; Sheep - white, solid.	Dull greyish, slightly sticky, may have rancidity odour	Gray mat, spotting consistency. Swine - sometimes encrusted with mold, have rancidity odour.
Condition of tendons and joints	Tendons are elastic, resilient. Articular surface is smooth, glossy	Tendons are little soft, opaque, white. Articular surface is slightly slimy	Tendons are soft, grayish color. Articular surface is mucous.

Determining the transparency and aroma of bouillon. The bouillon has to be transparent and fragrant. Bouillon turbidity is caused by primary products of protein degradation dissolving in the hot water.

Meat boiling test. The meat sample is minced. Place 20 g of minced meat into 150-200 mL capacity flask, add 60 mL of distilled water, mix the content well and, after closing it with a clock glass, it is kept in boiling water for 10 minutes. When the meat sample heats to 80-85 °C, its odour is evaluated. The meat sample is filtered through a dense layer of cotton wool into a large tube and placed in cold water.

The quality of the meat bouillon obtained is determined by its aroma and colour. Pour into a cylinder (25 mL content and 20 mm diameter) 20 mL of meat bouillon and visually evaluate its lucidity (against white background).

Meat bouillon of healthy animals is lucid and aromatic. Bouillon of sick animals' meat and of meat from animals slaughtered in agony, is muddy, with flakes, and can have an odour, which is unrepresentative of the meat.

Cold-processed meat is tested when defrosted. If there's any doubt as to the freshness of the meat, chemical tests and tests for microbiological contamination are carried out. Meat has to be clean, without any visible additives, without extraneous smells, bruising, or blood residues.

The prepared bouillon is used to further determine the freshness of the meat by chemical methods!

Task 2. Chemical evaluation of meat freshness

2.1. Evaluation of primary protein degradation products in bouillon (copper sulphate reaction).

Background

The method is based on copper ion reaction with protein primary interaction products, forming insoluble compounds of copper sulphate.

Procedure

2 mL of meat bouillon is poured into the test-tube and 3 drops of 5% $CuSO_4$ solution are added. The tube is shaken 2 or 3 times and placed in the rack. After 5 minutes, analysis results are set.

Reaction with copper sulphate in bouillon:

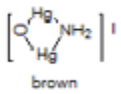
a) Fresh meat - bouillon is clear or slightly cloudy,
b) Doubtful meat - bouillon with flakes,
c) Not fresh meat - bouillon with bluish or greenish flakes and sediments.

2.2. Evaluation of ammonia and ammonium salts.

Background

Ammonia and ammonium salts reacting with the Nessler reagent (double salt of mercury iodide and potassium iodide, melted in potassium hydroxide) form mercuramony iodide – a substance of yellow-brown colour.

$$NH_4^+ + 2\,[HgI_4]^{2-} + 4\,OH^- \rightarrow HgO{\cdot}Hg(NH_2)I + 7\,I^- + 3\,H_2O$$



Procedure

In a test tube 1 mL of meat bouillon and 1-10 drops of Nessler reagent are added. The substance is mixed and the changes in colour and lucidity are observed.

Table 2.2.

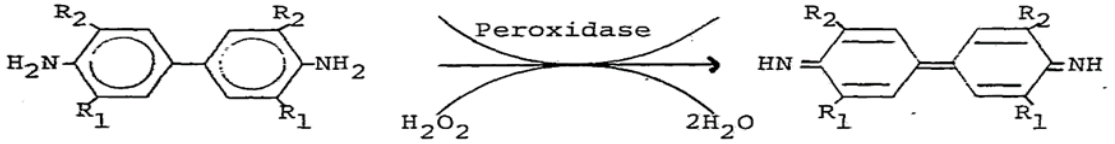
Amount of NH_3 according to Nessler reagent drops

Drops of Nessler reagent	*Colour of meat bouillon*	*Amount of NH_3 (mg %)*	*Evaluation of meat*
10	Without changes	Less than 16	Fresh meat
10	Transparent yellow colour or slight yellow opacity	16-30	The meat must be used immediately
6	The yellow clouds are clearly visible	31-45	Only to be used after pre-treatment (cleaning, washing, etc.)
10	A slight yellow precipitate which disappears after 30 min.)	31-45	Only use after pre-treatment
1-5	Lots of yellow or orange precipitate	46 and more	Meat is inedible

2.3. Peroxidase (benzidine) reaction.

Background

Activity of peroxidase enzyme depends on pH and oxidizing substances content in the extract of meat or meat bouillon. If the pH of the meat aqueous extract (1:4) or meat bouillon is less than 6.0, the peroxidase reaction is mostly positive, if the pH is 6.1-6.2 the reaction is suspicious, and if the pH is more than 6.2 it is negative. The reaction is based on the fact that, under the action of peroxidase, oxygen separates from hydrogen peroxide, which oxidises indicator benzidine and forms parachinon diamid, which, in responding to unoxidised benzinine, forms a coloured compound coloured extract blue-greenish, later changing to brown.



Procedure

2 mL of the tested meat bouillon are added to a test tube, later 5 drops of 0.2% benzidine spirituous (96%) solution are added and everything is mixed. Then 2 drops of

1% fresh hydrogen peroxide solution are dripped and the reaction is being observed. The filtrate of healthy animal meat within 1-2 minutes becomes blue greenish, then gets to brown (if peroxidase reaction is positive); meat filtrate of sick, weary during transport or slaughtered in agony animals turns blue green, soon changing to brown or very quickly becomes brown (negative reaction).

Peroxidase reaction can be carried out in an accelerated (express) method. On the fresh meat slices, 2 drops of 1% hydrogen peroxide solution and 5 drops of 0.2% benzidine are dropped. The reaction is considered positive if, in the place where the reagent has been applied, there appears a blue-green colour spot, which later becomes brown; if the reaction is negative, the blue-green colour spot does not form.

2.4. Evaluation of acidity-oxidation coefficient.

Background

Titratable acidity of healthy animals' meat and its extract significantly increases because of accumulation of milk, and ortho-phosphoric and other acids. Titratable acidity of sick animals' meat increases slightly. Meat's oxidation depends on the amount of microorganisms and organic matter degradation products (reducing substances). Reducing matters or reducers are substances thatreduce oxidation (potassium permanganate). In turn, potassium permanganate oxidises reducers to colourless oxidation products, while reducing agents reduce potassium permanganate to colourless materials: manganese (II) sulphate, potassium sulphate and water. In meat of sick animals, titratable acidity increases slightly during the same period (24 h), while reducing material content is significantly higher than in healthy animals. Thus, there are less reducers in fresh meat of healthy animals. Characteristics of the meat titratable acidity and reducing material size vary in opposite directions. The acidity-oxidation coefficient of healthy animal's chilled meat is generally 2-3 times greater than that of the sick animals. When the meat starts to spoil, this ratio decreases.

Procedure

Evaluation of titratable acidity. 10 mL of a meat bouillon are poured into the flask No. 1 and it is diluted with 40 mL of distilled water, later 3 drops of phenolphthalein spirituous 1% solution are added and are titrated with 0.1 n of sodium hydroxide until a slightly pink colour appears and the amount of 0.1 n NaOH (mL) used for titrating is recorded.

Evaluation of reducing substances amount (oxydation). In an acidic environment, potassium permanganate oxidises organic substances which are in the tested meat extract to colourless oxidation products. Thus, the amount of potassium permanganate (oxydants) describes the amount of organic reducing substances in the meat extract. To the flask No. 2, add 50 mL of distilled water, 5 mL of 0.4n sulphuric acid solution and 1-2 drops of 0.1 n potassium permanganate solution until a slightly pink colour appears. The contents of the flask are heated to 40-50 °C (after heating if the colour disappears add an additional 1-2 drops of potassium permanganate solution). 2 mL of meat bouillon are poured into a warm flask and immediately filtered with 0.1n potassium permanganate solution till a slightly pink colour appears, not disappearing for 0.5 min. 0.1 n $KMnO_4$ solution (mL) consumed for flask No. 2 content titration is

converted to 10 mL of extract, while 2 mL of meat extract were taken for analysis. Therefore, the amount of this solution, used for titrating of flask No. 2, is multiplied by 5.

Acidity-oxidation coefficient (AOC) is calculated using formula:

AOC = A/B

A – the amount of 0.1n NaOH solution (mL) consumed for flask No.1 content neutralisation (titration);

B – the amount of 0.1n KMnO4 solution (mL) consumed for titration of 10 mL of flask No.2 content.

Evaluation: AOC of fresh not chilled meat is 0.15-0.2. AOC of healthy animal mature meat is 0.4-0.6. AOC of sick animals' meat and meat of doubtful freshness is 0.2-0.4. The AOC of spoiled meat is from 0.05 to 0.2.

Example of calculation. For titration of 10 mL of extract in the flask No.1, 3 mL of 0.1 n NaOH solution was used, and for titration of 5 mL of extract in the flask No.2 1.4 mL of 0.1 n KMnO4 solution was used. The amount of 0.1 n KMnO4 solution (mL) used for flask No 2 content titration is converted to 10 mL of extract. In this case, the amount of this solution used for the titration of flask No.2 is multiplied by 5:

1.4 mL of 0.1 n $KMnO_4$ x5 = 7 mL 0.1 n $KMnO_4$ solution; AOC = 3/7 = 0.43

2.5. Evaluation of meat pH.

Background

Partly matured meat is used for testing, which means that the time after slaughter of the animal is not less than 20-24 hours. Soon after the slaughter of the animal, the meat pH is neutral or slightly alkaline (pH 7.0-7.2). After some hours after the animal slaughter, because of glycolytic processes in the meat, lactic acid starts to concentrate and the meat becomes acidic (pH 6.2-6.4), after 24-48 hours the pH drops to 5.8-6.0. Such pH stays for a longer time. But if the animal was sick, thin or in agony before slaughter, there is little glycogen in the muscles and the activity of muscle enzymes is reduced. During the maturation of such animal meat, the amount of concentrated lactic acid is low and the meat does not become significantly acidic. The pH measures are made using colorimetric or potentiometric methods. The colorimetric method is based on indicators that change colour depending on the concentration of hydrogen ions. Most indicators are selective and change colour only in margins of particular pH intervals. Liquid indicators or indicatory papers are used. Depending on the indicator and pH, the colour of the meat extract changes. Different indicators can be used to measure the pH of meat and meat products (see in Table 2.3.).

Table 2.3.

Indicators for meat extract pH measuring

Name	pH range	Colour of indicator
Methilenum red	4.2-6.2	red-yellow
Bromcresolum purple	5.2-6.8	yellow-purple-violet
Bromothimolum blue	6.0-7.6	yellow-blue
Phenol red	6.8-8.4	yellow-red
Universal indicator	4.0-11.0	red-yellow-green-blue-violet

Procedure

For measuring the pH of meat and meat products, water extract 1:10 is prepared. The preparation of meat-water extract: 5 g of minced meat are weighed to an accuracy of 0.01 g and put into a conical flask of 100 mL capacity, where 50 mL of distilled water is poured. Periodically stirring, the content of the flask is stored for 30 min. Then it is filtered. The measuring of meat pH by potentiometric method and preparation of the pH-meter for work is done according to instructions.

2.6. Determination of amino-ammonium nitrogen content

Background

The method is based on the reaction of ammonia and amino groups with formalin. The total amount in the meat extract is equivalent to amount of 0,1 mol/l sodium hydroxide and is evaluated titrating.

The breakdown of meat proteins by the breakdown process breaks down the peptide bonds (-CO-NH-) of the protein molecules, resulting in an increase in the number of free amino and carboxyl groups.

Simultaneous deamination of amino acids is associated with the accumulation of ammonia compounds. Accordingly, the amount of nitrogen amino groups and nitrogen ammonium (amino-ammonium nitrogen) in meat increases, according to which the degree of the process of spoilage of meat can be judged.

The method for the determination of amino-nitrogen is based on the titration of the free carboxyl groups with alkali after blocking the amino groups with formalin, assuming that the number of carboxyl groups titrated is equal to the number of amino groups blocked and that the amount of alkali used is equivalent to the number of nitrogen amino groups. Amino group blocking is necessary to exclude the interaction of amino and carboxyl groups.

When titrating with alkali, ammonia is also blocked in the presence of formaldehyde, which is displaced by the alkali from the ammonia compounds, while the released acid values are titrated with alkali. This part of the alkali, which is equivalent to the amount of ammonia displaced, will correspond to the amount of ammonia in the nitrogen.

In this way, the total amount of alkali used for the titration will be equivalent to the total amount of nitrogen amino groups and ammonia.

Amino-ammonium nitrogen content: for fresh meat - up to 80 mg%; suspected of deterioration - from 80 to 130 mg%; for spoiled meat - more than 130 mg%.

Procedure

Preparation of meat extract

Weigh 25 g of minced meat into a 250 mL conical flask. Pour 100 mL of distilled water on top of the weighted sample. Using a glass rod, mix the sample with the water until slurry is obtained. Put the stopper on the conical flask and rinse for 3 minutes; allow it to stand for a further 2 minutes, then filter the contents of the conical flask through a triple gauze.

Preparation of meat filtrate

Weigh 40 mL of the meat extract obtained into a 100 mL graduated flask. To precipitation the protein, add to the meat extract accurately measured solutions of aluminium alum and barium hydroxide ($Ba(OH)_2$ in a total volume equal to or slightly greater than 40 mL).

To determine this ratio, pour 10 mL of 10% aluminium alum solution into a beaker, add 5 drops of 1% phenolphthalein solution and titrate with saturated (($Ba(OH)_2$ solution) until the reaction is neutral. If 8 mL of saturated (($Ba(OH)_2$) is used to neutralize 10 mL of 10% aluminium alum, take 25 mL of 10% aluminium alum and 20 mL of $Ba(OH)_2$.

Add to the graduated flask the calculated quantities of 10% aluminium alum and saturated $Ba(OH)_2$ (successively, aluminium alum solution first), top up to the mark with distilled water and allow to stand for 10 minutes, then filter the contents of the flask through a filter paper.

In parallel, top up to the mark with distilled water in the second flask, making up to volume with the calculated solutions of aluminium alum and $Ba(OH)_2$. Allow to stand for 10 minutes and filter through a filter paper. Determine the amount of amino-ammoniacal nitrogen in both filtrates.

Determination of amino - ammoniacal nitrogen

Weigh 20 mL of meat filtrate into a conical flask, add 0.3 mL of indicator No. 1 and titrate with 0.1 n NaOH until neutral, i.e. until the filtrate changes colour from purple to green.

Then add 10 mL of formalin, previously titrated to indicator No. 1, in the same flask, add 0.5 mL of indicator No. 2. The contents of the flask turn blue-purple. Titrate this solution with 0.1 n NaOH, which turns bright green at first and purple on further titration. Stop the titration when the colour changes from bright green to purple. Titrate analogously with 20 mL of control solution.

The amount of amino - ammonium nitrogen (mg%) is calculated using formula:

$$X=\frac{1.4\times100\times100\times(V-V_1)\times100}{25\times40\times20}=70\times(V-V_1),$$

where: 1.4 – the amount of nitrogen in mg, equivalent to the amount of NaOH in 1 mL of 0.1n NaOH in 1 mL of 0.1 n NaOH solution,

100 – dilution of the meat sample with water, mL,

100 – dilution of the extract, mL,

V – amount of 0.1 n NaOH consumed for titration of the sample extract, mL,

V1 – amount of 0.1 n NaOH consumed for titration of the control test, mL,

100 – for conversion to 100 g of sample, g,

25 – sample weight, g,

40 – amount of extract taken to prepare the filtrate, mL,

20 – amount of filtrate taken for titration, mL.

Results

Draw conclusions and compare the obtained results with the information available in the literature and scientific publications.

Conclusion

1.
2.
3.

Approved by _____

Name, Surname, signature

Date _____

Theme 3

The slaughter process of animals and birds

Theoretical materials

Veterinary and sanitary control is divided into pre-slaughter and post-slaughter.

Pre-slaughter control: only healthy animals are allowed to slaughter. It is also permitted to slaughter animals that are sick or suspected of having a disease if the meat, after appropriate processing, is suitable for human consumption. The slaughter of such animals is carried out on specially designated sanitary days either at the end of the working day or at a sanitary slaughterhouse. The slaughter of these animals is carried out in strict compliance with the rules in a sanitary slaughterhouse. Such conditionally suitable animals for slaughter include animals susceptible to tuberculosis, brucellosis, as well as foot-and-mouth disease, leukaemia, leptospirosis, colibacillosis, dysentery, and bronchopneumonia.

Animals that are in a state of agony (which can only be determined by a veterinarian or paramedic) cannot be killed for meat, regardless of the reasons that caused this state. In addition, animals vaccinated against anthrax and rabies within the first 14 days should not be killed. Animals younger than 14 days old and animals within 3 days if they have been treated with antibiotics are not allowed to be slaughtered.

Pre-slaughter control begins with measuring of the temperature of the entire population of cattle and horses, and selectively of pigs and sheep. Pre-slaughter holding of all horses, donkeys and mules in a meat processing plant must in all cases be at least 24 hours (until the results of malleinization). Animals that have a positive and questionable reaction to mallein are subject to destruction in accordance with the established procedure.

Preparing animals for slaughter. Preparation of animals for processing begins upon arrival at the stockyards and during the reception process, when they are sorted into homogeneous groups according to fatness, sex, age and health status. Usually the same groups of animals are sent for slaughter. The preparation for slaughter of livestock and poultry has a great influence on the quality of the resulting meat and facilitates primary processing. For this purpose, animals are sent to pens for pre-slaughter holding. Cattle and small cattle are kept for 24 hours, pigs - 12 hours, calves - 6 hours. During this time, the animals are not fed, but the supply of water is not limited, stopping it 2 hours before slaughter.

Pre-slaughter holding helps to clear the contents of the gastrointestinal tract and allows animals to rest. The quality of the meat largely depends on the condition in which the animals were sent to slaughter. Animals must not be beaten. Excitement, fear and pain cause increased blood flow to the muscles, trapping the blood in the vessels, so that the bleeding during slaughter is not complete. Poorly bled meat has a dark colour with a bluish tinge, is moist, of low quality, serves as a good breeding ground for various microflora, and therefore doesn't store well. Blows inflicted on animals cause bruises

and injuries, which also deteriorates the quality of the meat and its presentation. During veterinary examination, the tissue around bruises and wounds is carefully cleaned and removed, which leads to significant meat losses, and the quality of the hides is also reduced.

To move animals, it is recommended to use a firecracker or electric prod. The voltage in the electric drive should not be higher than 25 V.

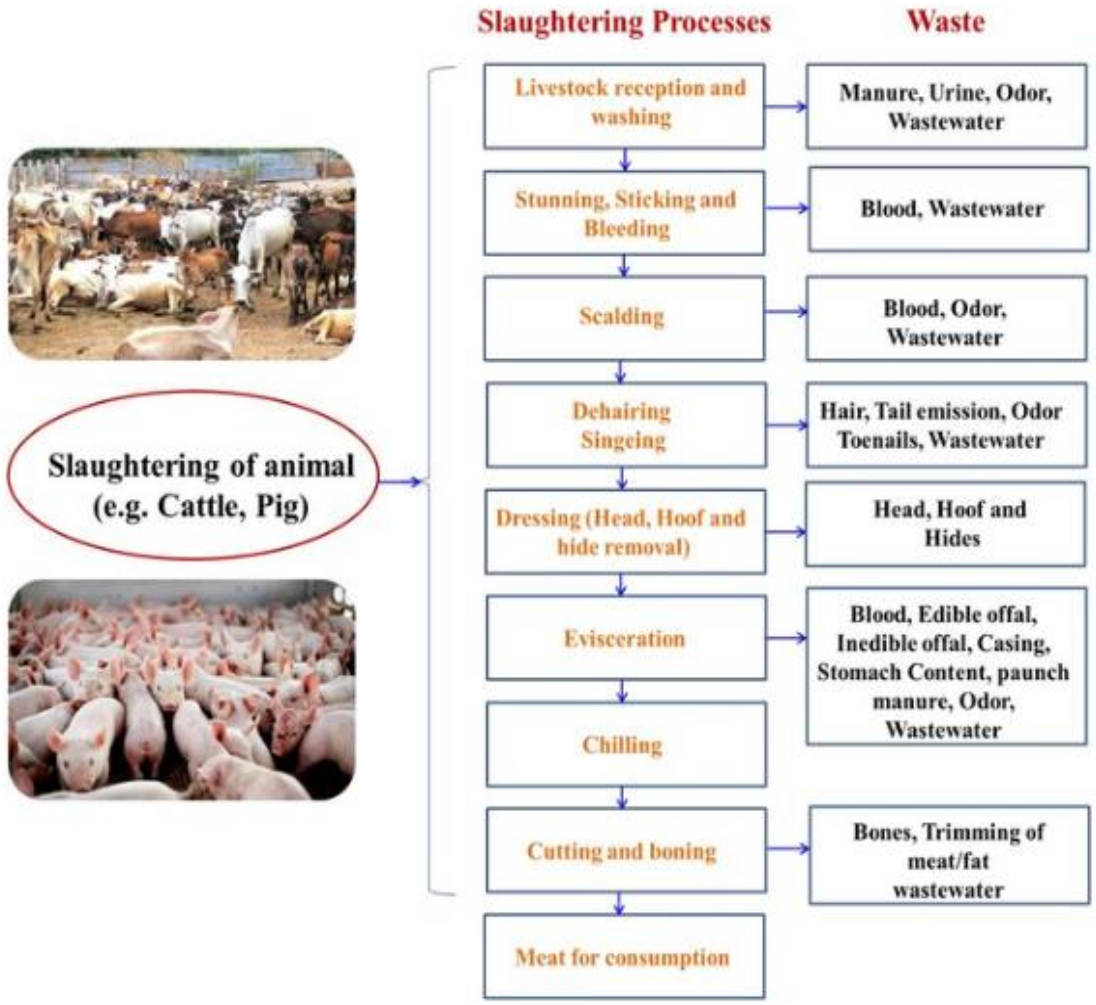


Figure 3.1. Flow chart diagram of slaughtering process and the waste generation
(https://www.researchgate.net/publication/358497457_Slaughterhouse_and_poultry_wastes_management_practices_feedstocks_for_renewable_energy_production_and_recovery_of_value_added_products/figures)

Cattle slaughter technology.

On the cattle slaughter conveyor line, the following operations are carried out sequentially.

Immobilisation of animals. Cattle are stunned before slaughter, firstly, due to humane considerations in relation to the animals, and secondly, to ensure the safety of the operators when applying fetlock chains to the hind legs of the animals when lifting them into the path of bleeding. A stunned animal loses the ability to move, the activity of its higher nerve centres stops, but the heart continues to work.

To immobilise cattle in a low-power enterprise, it is advisable to use devices in the form of pistols, stilettos and special mobile shooting devices. When stunning with a stylet, the blow is delivered to the medulla oblongata at a time when the animal's head is tilted down and fixed. When stunning, the blow is directed into the gap between the first occipital vertebrae and the occipital bone. With the help of pistols and shooting devices, a blow (cartridges, bullets, rods) is applied to the upper part of the frontal bone above eye level. The operation of stunning livestock should only be performed by qualified workers with extensive practical skills.

In addition to mechanical stunning methods, it is possible to use electrical stunning. A pointed electric glass is inserted into the occipital part of the head in the region of the medulla oblongata, piercing the skin to a shallow depth. Current voltage 127-220 V, duration of action 8-15 s. Electrical stunning can be carried out through the limbs with a three-phase current applied to the floor of the box. Voltage is applied until the animal stops moving (15-25 s). Electrical stunning is safe for operating personnel, but additional stunning is required, and the floors of the box are de-energised. The above method is widely used in meat processing plants of medium and high capacity.

To properly stun an animal, it must be in a certain position. For this purpose, it is introduced into a special chamber-box or tied to a ring embedded in the floor. The use of boxes ensures the safety of jammer workers.

Once stunned, the animal usually falls to the floor. Standing to the side of the stunned animal, a worker wraps a chain around the animal's hind legs. At one end of this chain there is a hook, the other is tightly attached to the roller on which the carcass will move along the suspended path. The chain is placed around the fetlock joint. Fetlock chains with lengths of 2, 1, 0.9, 0.6 m are used. Different lengths of chains make it possible to hang carcasses so that the head of each animal, regardless of its size, is approximately at the same height from the floor. This makes subsequent carcass processing operations easier. To lift carcasses onto the bleeding path, lifting mechanisms of various designs are used. The most widely used is the electric winch, which lifts the load and automatically installs the roller on the overhead track. It takes up little space and is reliable in operation; it is usually mounted above the box.

Stunning with electric current is carried out in a special chamber (box) to improve performance and better bleeding of the carcass. Stunning mode: current 1-1.5 A, voltage (depending on the age of the animal) 70-220 V when the stack comes into contact with the animal's body for 6-20 s. Electronarcosis ensures immobility of the animal for 5-10 minutes.

Slaughter and bleeding. In workshops equipped with overhead tracks, the slaughter and bleeding are usually carried out in a vertical position. In this position, blood flows out more completely and acceptable sanitary conditions are created for its collection. The complete bleeding of animals helps to obtain well-preserved meat.

Before bleeding, a ligature is placed on the esophagus to prevent the contents of the animal’s stomach from entering the bloodstream. To apply a ligature, it is necessary, holding a knife in your right hand with the blade up, to make a longitudinal incision in the skin of the neck along the midline, starting slightly above the middle of it and leading the incision to the junction of the neck with the body. The length of the incision is usually

30-50 cm. Having exposed the trachea, the esophagus is separated and tied with twine (or a spiral clamp is applied).

After applying a ligature to the esophagus, the worker proceeds to perform operations related to slaughter. Depending on the further use of the blood, the performance of these operations is not identical.

When collecting blood for technical purposes, the worker inserts a knife into the chest cavity of the animal at the junction of the neck with the body and by turning the knife transversely, he cuts the plexus of large blood vessels in the neck (carotid artery and jugular vein). For slaughter, a regular knife with a handle 15-20 cm long is used. The handle has a protrusion at the blade that protects the hand from cuts. For more complete bleeding, the worker, removing the knife from the wound, lengthens the cut, and the blood flows into the gutter. The duration of bleeding for cattle is 6-8 minutes.

Blood for food purposes is collected using a hollow knife. The blood flows through a hose into a vessel designed to collect blood.

A hollow knife is inserted into the animal's neck from the right side of the trachea and guided from the bottom up until it enters the right atrium, where blood flows through the systemic circulation from the entire animal's body. When the copious flow of blood stops, the hollow knife is removed from the carcass and the neck blood vessels are additionally cut to allow the remaining blood used for technical purposes to flow out.

When collecting edible blood, equipment, instruments and containers must always be clean. They must be washed after each use until all traces of blood are completely removed, and then disinfected with an antiseptic solution. After disinfection, equipment should be rinsed with hot water. It is recommended to use a solution of bleach or chloramine as an antiseptic.

During horizontal bleeding of a stunned animal laid on its right side, the worker uses a knife, holding it with the blade upward, to make a longitudinal incision in the skin on the neck along the midline, starting from the sternum up to the lower jaw. Through the incision, he inserts a knife into the junction of the neck and torso towards the chest cavity and cuts the neck veins and arteries. Blood flowing from the wound can be collected in basins. Bleeding lasts 8-10 minutes and is considered complete when the blood stops flowing out in streams. After bleeding, the head is separated from the carcass and the skin is removed from the head.

It is advisable to use the obtained blood (at low-power enterprises) in the future for the production of blood and culinary products. To prevent blood clotting, it is advisable to add a stabiliser solution to the vessels where the blood flows. As stabilisers, you can use pure table salt (3% of the blood weight), tripolyphosphate solution (15-20 mL per 1 litre of blood), 10% sodium pyrophosphate solution in the amount of 25 mL per 1 litre of blood.

Cutting the carcass. Cutting a carcass includes a number of technological operations that include removing the skin, removing internal organs, sawing, stripping the carcass, etc.

Skinning is carried out by combining manual techniques with a knife (whitening) with a mechanized operation for the final removal of the skin. First of all, the ears are

removed and the skin is removed from the head; for this, a cut is made with a knife from one horn to the other, the skin is separated in the frontal, occipital, cheek, jaw parts and on the neck so that the skin of the head is integral with the skin of the body. The head is separated at the atlanto-occipital joint and hung on hooks for veterinary examination.

The pelvic and thoracic limbs are whitened after ring-shaped skin incisions at the level of the fetlock joints and cut along the inner surface of the pelvic limbs to the anus and further along the white line of the abdomen to the chest and neck. The skin is manually separated with a knife from the pelvic limbs, abdomen, chest and neck parts of the body, from approximately 35% of the surface of the carcass. The shooting is completed using mechanised units or skinning units.

The manual method of skinning. Cattle skins are removed on corrugated plates or special spreaders in three successive positions of the carcasses: horizontal, semi-vertical and vertical. After separating the head, the carcass is lowered to the floor by a winch, laid on its back towards the winch spreader and strengthened in a horizontal position with special support pads.

First, the worker skins the front and hind limbs, then breaks them at the carpal and fetlock joints; whitens the skin in the area of the udder or scrotum and groin, cuts along the white line of the abdomen (without damaging the abdominal muscles) and at the same time separates the left edge of the skin (from the left side) from the muscles to a width of 4-5 cm along the entire length of the cut. The worker then removes the skin from the sides until the longitudinal muscles (magpie meat) on the inside of the groin and thigh are completely exposed.

The worker removes the skin from the neck: inserts a knife under the skin in the forearm area and leads towards the shoulder, separates the skin from the forearm, then from the front of the chest and from the neck to its upper part at the withers.

Next, he incises the muscles along the midline of the sternum and cartilage and, following the incision made, starting from the crown, saws (or cuts) the sternum with a saw (or cleaver). The cutting line (cut) must pass exactly along the midline of the sternum, without violating the integrity of the internal organs.

Upon completion of whitening and sawing of the sternum, the carcass is winched to a semi-vertical position for subsequent operations.

Having pulled the skin away from the hock, the worker inserts the knife with the tip down and moves it from top to bottom towards the ridge, separating the skin from the upper part of the thigh, then from the thigh to the foot. It is necessary to ensure that the film from the thigh does not separate along with the skin. Next, he separates the skin from the side of the abdomen and the upper part of the back (sacrum). To do this, the worker pulls the skin upward, inserts the knife with the tip upward and leads it towards the root of the tail, separating the skin from the side of the abdomen and back to the spinal column. The skin from the sides up to half of the carcass (up to the lumbar vertebrae) begins to be removed from the foot the knife is inserted between the skin and the film and moved towards the shoulder blade.

When sealing the tail, the worker makes a longitudinal cut in the skin along the underside of the tail to its root, seals the skin around the root of the tail, and then with

a sharp jerk pulls the tail out of the skin. Then he cuts the passage with a crown to a width of 4-5 cm from the walls of the pelvic bone, while cuts to the bladder and passage are not allowed.

The carcass is raised to its full height and the skin is torn off from the carcass, cutting off the fastening ligaments.

Workers engaged in whitening and skinning operations must sanitise tools, hands and clothing during work, for which workplaces must be equipped with hot and cold water devices.

Removing the entrails (gutting) requires preparatory operations (removing the genitals, udders in cows, ligating the rectum, cutting the pubic bones, sawing the sternum, etc.). The organs of the abdominal and thoracic cavities are removed almost simultaneously using special techniques through an incision in the abdominal wall along the white line of the abdomen, and the liver is removed through the hole formed after the incision of the sternum and the incision of the diaphragm.

Sawing up carcasses. Carcasses are sawn down the spine into two longitudinal halves. Sawing is necessary for rapid cooling of carcasses and the ease of transportation.

Before sawing along the spine, a deep incision is made into the muscles with a knife, capturing the muscles of the thoracic and cervical vertebrae. The spine is cut along the incision so that the vertebral bodies are divided in half; the cut should pass along the very edge of the spinal canal, without touching the brain, approximately 7 - 8 mm to the right from the midline of the spine. First, the sacrum is sawed, then the lumbar, thoracic and cervical vertebrae. The pressure on the saw blade should be moderate and uniform in order to prevent a zigzag cut.

Cleaning carcasses. To give the half-carcasses a marketable appearance, cleaning is carried out. When dry stripping, the following operations are performed: remove possible abscesses and bruises from half-carcasses; the meat and bone tail is separated; collect internal and kidney fat (together with the kidneys); the spinal cord is removed.

If necessary, the carcass is washed. After washing, the half-carcasses are placed in special chambers for drying at a temperature of 4 C.

Carcasses with trimmings and subcutaneous fat stripping of more than 15% of the entire surface are classified as non-standard, they cannot be sold, and they are processed in the workshops of the enterprise.

Branding of carcasses. After completing all the technological operations associated with the production of half-carcasses, the final stage is the commercial assessment of the resulting products. The commodity assessment involves branding the carcasses and weighing them. The carcass branding is carried out in accordance with the current regulations. After branding, the carcasses are weighed to determine pair weight. Next, a plumb invoice is printed, which is the main document in the relationship between the receiver and the livestock deliverer.

Figure 3.2. Beef meat production process stages https://www.alamy.com/beef-production-on-meat-factory-infographic-process-vector-illustration-cartoon-info-education-poster-with-automated-processing-line-from-cutting-sorting-packaging-farm-meat-products-technology-image389015426.html

Pig slaughter technology

Stunning pigs with electric shock. Pigs are stunned with high or industrial frequency electric current. Before stunning, they are fixed on special conveyors or using other devices. Boxes are also used.

Pigs are stunned with industrial frequency current using a single-horn stack, which is placed on the back of the head. The second contact is the floor. Electric current voltage is 65-100 V, frequency 50 Hz, duration of exposure 6-8 s.

In low-power meat processing plants, it is advisable to stun pigs using a special electric needle mounted together with a 24 V power source. The needle is inserted into the muscles behind the ear and is not removed until food blood has been completely collected. The duration of the process is 45 s. To prevent convulsive muscle contractions and, as a result, haemorrhages in the tissues, high-frequency current is used using the ФЭОС-У4 apparatus, voltage 200-250 V, frequency 2400 Hz, duration of exposure from 8 to 12 s.

At medium-power enterprises, electrical stunning of pigs is carried out in a carousel-type box. The pigs are driven with an electric drive into the compartment, which is located at an angle to the box, and then directly into the box, where they are picked up by the rotating floor and the inner wall and fed under the panels with electrodes. The electrodes have a free swing and are connected to the ФЭОС-У4 installation, which is mounted next to the drive on the ceiling of the box.

Stunning pigs with a gas mixture. The gas mixture consists of 65% carbon dioxide and 35% air. Stunning with a gas mixture is carried out in a sealed chamber for 45 s. Animals fall into deep sleep and remain motionless and relaxed for 1-3 minutes. During

this time, they are lifted onto the overhead track, slaughtered and bled. Stunning with carbon dioxide prevents muscle and pulmonary haemorrhages and makes it easier to scald and remove hair from pig carcasses. The use of CO_2 for stunning pigs ensures a high degree of bleeding of carcasses. The blood yield during gas anaesthesia is 0.4% higher than during electrical stunning. Carbon dioxide consumption is 80 g per head.

Processing of pigs with skinning. Skinning pig carcasses is a more labour-intensive and complex operation than skinning other species.

A high-quality pork carcass is characterised by a relatively smooth surface, without fat snags formed when skinning. Snatches, which deteriorate the quality and presentation of carcasses, are formed in most cases on the loin and flank, less often in the lumbar region and ham. The area of the grabs is regulated by the standard.

The reason for the large number of fat snatches on carcasses of the fatty category is the low strength properties of fat. The subcutaneous tissue of pigs is of considerable thickness and filled with fatty deposits, so when harvesting, the skin must be separated directly from the subcutaneous fat. Fat cuts on the skin also remain because this is facilitated by the very structure of the inner layers of the dermis, which have many depressions filled with fat, which cannot be separated from the dermis.

The quality of skinning from pig carcasses is greatly influenced by the structure of subcutaneous fat, which depends on the breed of pigs, the nature of fattening and other characteristics of the animals.

The fat slits in the whitening area are usually 2-3 times larger than in the mechanical shooting area, so reducing the whitening area when removing skins from pork carcasses will help reduce fat loss in the form of slits and improve the marketable appearance of the carcasses. When removing skins, it is necessary to improve the quality of manual whitening, preventing fat from cutting into the skin.

Blowing carcasses with compressed air. Before skinning, carcasses are blown with compressed air. At the same time, the carcass swells, the skin stretches, and the folds straighten. This helps to reduce the loss of fat and meat from the carcass, damage to the skins, and facilitates the work of workers due to the weakening of the connection of the skin with the surface layer of the carcass.

Processing of pork carcasses with skin. Pork carcasses are lifted onto the bleeding path, washed, some of the side and back bristles are removed manually or using electric shearing machines and sent for scalding.

When scalding carcasses by immersion, the lungs fill with water, their volume increases, the colour changes, as a result of which their quality, as well as the quality of the carcasses, decreases. Microbial contamination of pork carcasses through scalding water can be significant. This is avoided by packing or ligating the windpipe. Ligation of the trachea of adult pigs is difficult due to the fact that the cartilaginous rings of the windpipe become rigid with age. A rubber stopper on an aluminium base is also used for tamponing. The stopper is inserted into the windpipe before the carcass is immersed in the scalding vat, which prevents water from entering the lungs. At the end of the scalding, the cork is removed and used again.

To prevent hot water from entering the lungs, the method of filling the chest cavity with compressed air before scalding is used. It is advisable to frequently (at least once per shift) replace the water in the steaming tank, or clean it.

The main importance for the quality of scalding and subsequent cleaning of pork carcasses on a scraping machine is compliance with scalding regimes - temperature and duration.

Pork carcasses are scalded at a water temperature of 63-65 °C for 3-5 minutes, depending on the pig breed, weight, type of fattening, age and other factors. When scalded, the top layer of the skin (epidermis) softens and the bristle bulb comes out of the hair follicle more easily.

Processing of pork carcasses using the cutting method.

Cropping is a combined method of processing pork carcasses, when the most valuable part of the skin (removed from the dorsal and side surface of the carcass) is used in tanning. The skin remains on the rest of the carcass; bristles, small hair, fluff and epidermis are removed from it.

Preparing pork carcasses for scalding. After washing, to prevent contamination of the lungs with water from the scalding vat, compressed air is blown into the chest cavity of the pork carcasses.

For pressurisation, compressed air with a pressure of 0.3-0.5 MPa is used from a centralised system or obtained at an individual installation and purified using oil filters.

Compressed air is pumped into the chest cavity immediately before lowering the carcasses into the scalding vat, for which the wall of the chest cavity is pierced with a needle between the 5th and 6th rib at the junction of them with the sternum, without violating the integrity of the internal organs. To prevent air from entering the muscle tissue, the shut-off valve is opened only after the needle is completely inserted into the chest cavity.

The blowing operation is performed with the carcasses in a vertical or horizontal position (depending on the organisation of workplaces). The carcasses are blown through for 5-7 s (until the feeling of the needle being pushed out appears). The air consumption for blowing 100 pork carcasses is 2.8-3.8 m^3.

Pork carcasses prepared in this way are served along a suspended path to the table near the scalding vat and placed with the abdominal part into conveyor cradles immersed in water.

Scalding the belly of pork carcasses and removing bristles. Depending on the weight of the carcasses, the water level in the scalding tank is adjusted so that the abdominal part of the carcass is immersed in water to a depth of 15-20 cm from the nipple line. In this case, the croupon is not scalded. Heads are scalded under a shower mounted along the entire length of the vat. The scalding of carcasses and heads is carried out at a temperature of 63-65 °C for 3-5 minutes. The scalding process is considered complete when the bristles are easily pulled out by hand. The water in the steaming vat is changed as it gets dirty, at least once or twice a shift.

After scalding is completed, the carcasses are unloaded from the vat by conveyor into a scraper machine to clean the scalded areas from bristles. During the cleaning

process in a scraper machine, the carcass is irrigated with water at a temperature of 30-45 °C. The duration of carcass processing is 25-30 s.

After unloading from the scraping machine, the carcasses are inspected. If necessary, they are additionally cleaned on the table manually with a knife. If scratches are found on the carcass, stop the scraping machine and eliminate the causes of their formation.

On the table before the scraper on the hind limbs of pork carcasses, a through puncture is made with a knife between the tibia bones and the common calcaneal (Achilles) tendon, the hooks of a spreader or trolley are inserted into the incision and the carcass is lifted by an elevator or winch onto a suspended track.

Shooting close-ups. Before shooting the croupon, it is isolated on the carcass by cutting the skin with a knife with a shortened blade (3-4 mm) along the following lines: on the sides of the carcass - along the boundaries between the scalded peritoneum and unscaled dorsal-side parts and across the carcass - at the base of the tail and at base of the head (at the junction of the occipital bone with 1 cervical vertebrae - the atlas and at the base of the ears).

After this, the neck part of the carcass is whitened so that the skin can be grabbed with a clamp or chain. Whitening of carcasses must be carried out without damaging the subcutaneous layer of adipose tissue and without causing cuts to the skins.

Removing internal organs from pig carcasses. After skinning the carcasses, or processing the carcasses in the skin, or removing the croup, the head is prepared for a veterinary examination, for which the head is semi-severed with an incision passing through the junction of the occipital bone with 1 cervical vertebra at the base of the ear and then along an oblique line at the level of the lower third jaws. The head is left with the carcass until a full veterinary examination of the carcass and all organs is carried out and is separated in such a way that the back part of the external masticatory muscles is exposed.

The parotid and submandibular lymph nodes of the carcass prepared for veterinary examination are examined and the carcass is sent for further cutting.

Before removing the internal organs, preparatory operations are performed: the breast bone is separated with an electric saw or knife; the genitals are separated from the carcasses of males (after cutting off the layer of fat covering them) and sent to the feed and technical products workshop; cut the abdominal muscles along the white line from the pubis to the sternum.

After the preparatory operations, the momentum is removed from the carcass, and then the intestines with the stomach and spleen are removed and placed on the evisceration conveyor or a special table. Then the liver is removed along with the tongue. The edges of the diaphragm are trimmed at the chest walls. Pulling the liver from the chest cavity, trim the muscles of the pharynx with a circular movement of the knife until the root of the tongue is completely separated from the adjacent tissues. The liver with tongue extracted from the carcasses is placed on a conveyor belt containing the gastrointestinal tract or hung on a hook. It is allowed to extract the liver without the tongue.

After removing the internal organs, pork carcasses are divided into half-carcasses, carcasses and half-carcasses are stripped, veterinary and sanitary examination, quality assessment, branding and weighting are carried out.

Sawing and cleaning pork carcasses. Longitudinal division of carcasses is carried out in the middle of the vertebrae without crushing them or adding whole vertebrae to one half-carcass.

For this purpose, the hind limbs of the carcass are pre-stretched to a distance of 600 mm using a special device or conveyor pushers. Carcasses are separated with a power saw or cleaver. When dividing the carcass into legs, 1 cervical vertebra is left whole and separated in the refrigerator.

After dry stripping, the half-carcasses are washed from the inside with warm (25-38 °C) or cold tap water using shower brushes or a hose to remove bruises and other contaminants. In case of surface contamination of the carcass, only the contaminated areas are washed, excess moisture is removed with the blunt side of a knife or by drying the surface of the carcass with a clean towel, blowing with air, etc. When washing carcasses with a hose, a stream of water is directed at an acute angle to the surface of the carcass to avoid damaging the integrity of the outer layer of muscle and adipose tissue.

After dry and wet stripping, pork half-carcasses should not have any remaining bristles, internal organs, blood clots, fringes of muscle and fatty tissue, dirt, and bruises.

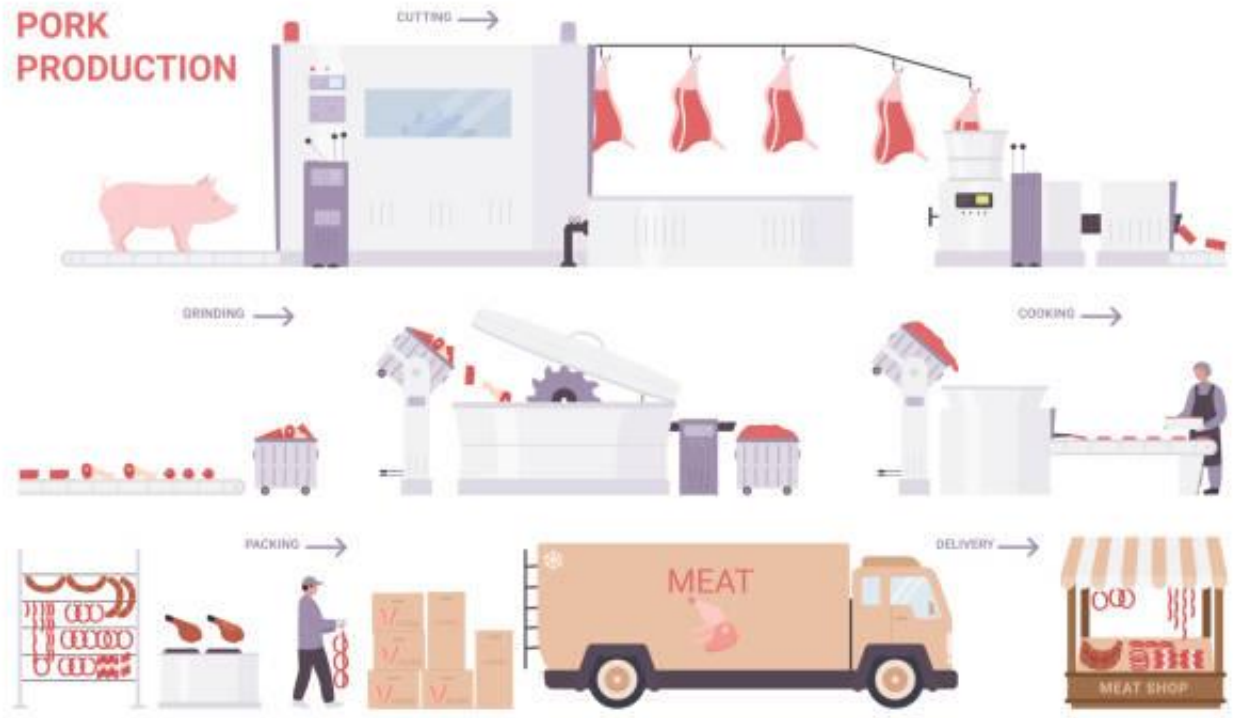


Figure 3.3. Pork meat production process stages https://stock.adobe.com/images/beef-production-on-meat-factory-infographic-process-vector-illustration-cartoon-info-education-poster-with-automated-processing-line-from-cutting-sorting-packaging-farm-meat-products-technology/398243773?asset_id=39978906

Laboratory work

Evaluating the quality of food fat by analysing changes in sensory and physico-chemical quality parameters

Materials

Different types of fat samples, glass test tubes, glass capillary, thermometers, scales with an accuracy of 0.01 gramme, scales with a accuracy of 0.0001 gramme, water bath for samples heating, prepared and preheated sand, metal crucible with lid and glass stick, porcelain bowl, 96% ethyl alcohol, conical flasks from 100 to 250 mL capacity, 0.2 n spirituous iodine solution, pipettes, distilled water, cylinders, 1% starch solution, 0.1 n $Na_2S_2O_3$ solution, neutral mix (1:2) of ethyl (96%) and ether solutions, 1% phenolphthalein spirituous solution, 0.1 n NaOH or KOH solutions, chloroform, icy acetic acid solution, fresh prepared saturated KJ solution, 0.01 n $Na_2S_2O_3$ solution, neutral red solution (fresh prepared aquatic 0.01 % solution of neutral red, 7,0 ≤ pH ≥ 7,2, is can be used for some hours).

Methods and Procedures

Task 1. Sensory evaluation of fat

Analysis is processed at a temperature of 15-20 °C.

Evaluation of colour. Melted fats are poured into a dry colourless glass test-tube. The test-tube is put in a glass with cold water for 1-2 hours. Fat colour and shades are evaluated in day light.

Evaluation of lucidity. Melted at a water bath, the fat is poured into dry colourless test-tube and its lucidity is evaluated in day light.

Evaluation of smell and flavor. A thin layer of melted fat is spread on objective glass and the smell is evaluated. For evaluation of flavour, a little piece of fat is tasted.

Table 3.1.

Sensory characteristics of fat

Index (18-20) ^{0} C	Sort of melted fat	
	The highest	I
Colour	cattle – from light yellow to yellow; swine – white; sheep – from white to light yellow; hens – from white to yellow, gees – white or light yellow, greyish shade is allowed	cattle – from light yellow to yellow; swine – white, light yellow or greyish shade is allowed; sheep, hens – from white to yellow; ducks – white or light yellow, greyish shade is allowed
Odour	Typical for fat, melted from fresh fat stock, without outside taste and odour	Typical for fat, melted from fresh fat stock, light frying odour and taste is allowed
	In birds – typical for species and melting way, without outside taste and odour, soft frying odour and taste is allowed	
Lucidity	lucid	
Consistence	Cattle fat – stiff or solid, swine fat – soft or sticky, hens, gees and ducks fat – liquid, sticky	

Task 2. Evaluation of fat physical and chemical characteristic

Fat consists of fatty acids mixed with different molecular mass, physical and chemical characteristics. Therefore, they melt and stiffen at certain temperature interval, while separate components of fatty acids mix, melt or stiffen.

2.1. Evaluation of fat melting temperature.

Background

A fat melting temperature is such temperature, at which the fat changes from a solid to a liquid and lucid state. Before analysis, the fat is melted and filtered through a dry paper filter to eliminate moisture which increases the melting temperature.

Procedure

The melted fat is drawn into the capillary at a height of 10 mm. Wipe the outside of the capillary with a moisture absorbent material and for 10 min. and leave it on ice surface (refrigerator freezer compartment) or leave it for 24 hours at room temperature. After the capillary is connected to the thermometer so that the fat bar should be in the one level with the thermometer mercury column. Then place the capillary thermometer in a glass with water at a depth of 3 to 4 cm so that no water flows into the open end of the capillary. The water onset temperature is 15-18 ° C. The glass with water is heated, stirring continuously.

The melting point of fat is considered to be the point at which the fat begins to move upward in the capillary. The melting point of the fat is determined twice by taking the average of the two measurements, which must not differ by more than 0.5 °C.

Melting temperature can be measured in capillary (see Figure 3.4.).

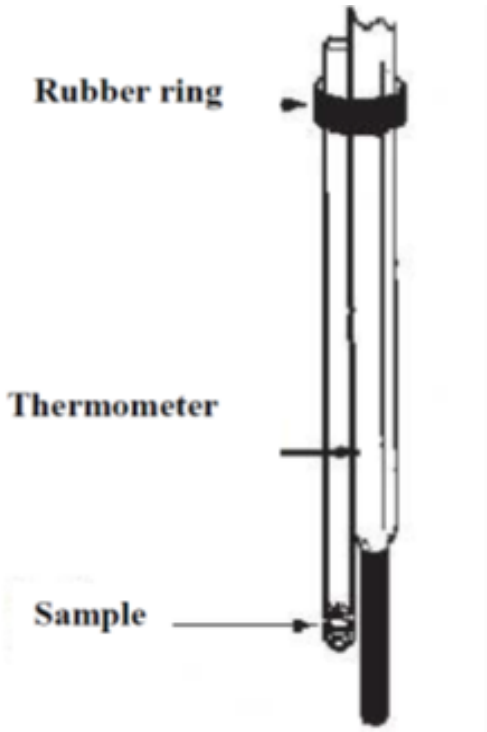


Figure 3.4Capillary tubes with thermometer for measuring fat melting temperature

Table 3.2.

Fat melting temperature of different animals and birds

Animal	Melting t-re (°C)	Animal	Melting t-re (°C)	Animal	Melting t-re(°C)
Bovine	45-50	Dog	30-39	Elk	46-48
Sheep	44-55	Cat	39	Whale	50
Goat	48-50	Rabbit	42.3	Hen	34
Deer	48-52	Hare	45.5	Goose	32.2
Pig	36-46	Bear	39.15	Turkey	35.5
Horse	28-32	Badger	31.33	Partridge	31.9

2.2. Evaluation of fat stiffening temperature

Background

According to the composition of the fatty acids and glycerides, different kinetic curves (which depend on crystallisation of different components) of fat stiffening can be seen. When cooling melted fats, at first a significant fall of temperature is seen, then, when the crystallisation begins, the temperature decreases more quickly or sometimes even increases because of the latent crystallization warmth. After crystallisation, the fat temperature decreases again.

At the stiffening temperature (Figure 3.5, a), solidification of fat takes place, but the temperature drop is delayed by the heat of crystallisation released.

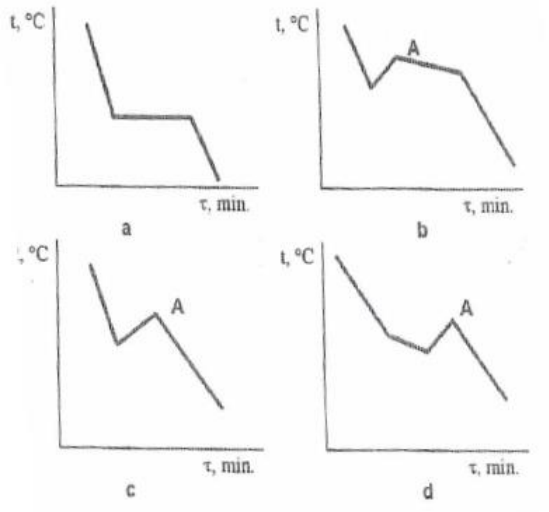


Figure 3.5. Curves of fat stiffening temperatures

Procedure

Put the fats in a porcelain bowl and then melt the sample in a water bath. When the temperature of the melted fat becomes about 15 °C higher than the expected fat stiffening temperature, they are poured into the dish, leaving 2 cm above. A thermometer is fixed in such a way that the end of the hydrargyrum column would be at the centre of the fat column. First, the liquid fat is mixed using a thermometer. Starting the thickening process, the fat stiffening temperature is checked. The thermometer is fixed every minute. According to the analysed data, the fat stiffening curve is drawn, at x axis marking time of the analysis (min), at y axis – showings temperature (in degrees).

2.3. Evaluation of fat moisture

Procedure

At an accuracy of 0.0002, 2-3 g of fat is weighed in a pre-heated metal crucible and dried in a drying fire (at 102-105 °C temperature) to fixed mass. First time, the sample is weighed after 1 val. Later weightings are repeated every 30 min. Before weightings, the dishes are cooled in a desiccator.

Amount of moisture (%) is calculated using formula:

$$X = \frac{(m_1 - m_2) \cdot 100}{m_1 - m_0},$$

where: m_0 – mass of metal crucible with lid, sand and glass stick, g;

m_1 – mass of metal crucible with lid, sand, glass stick and sample before drying, g;

m_2 – mass of metal crucible with lid, sand, glass stick and sample after drying, g.

The results are of accuracy of 0.1 %. The results of parallel analysis should differ no more than 0.05%. During drying, the fat oxidation can occur, which increases the

sample mass, therefore the calculation is made according to the smaller dried sample mass.

2.4. Evaluation of fat iodine number

Background

The iodine number describes the amount of unsaturated fatty acids in fat. Unsaturated fatty acids, affected with halogens, easily attach themselves at the places of double joints. From the amount of attached halogens, it is decided about composition of fatty acids and nature of fat. According to the iodine number and other indices there is a possibility to decide about the clarity of the fat. The iodine number is its amount in grammes which 100 g of fat attach at the place of a double bond. A quicker method of the iodine amount evaluation is based on spirituous iodine reaction with joints of unsaturated fatty acids, participating sodium thiosulphate.

Procedure

0.3-0.4 g of fat is weighted into a cone flask at accuracy 0.0001 g and 30-40 mL of 96% ethyl alcohol is poured. The flask is covered with a plug which has a glass tube (30-50 cm of length) and is left at 40-50 °C temperature water bath, till the fat melts. The mixture is cooled to the ambient temperature, then 25 mL of 0.2 n spirituous iodine solution is dripped with a pipette and 50 mL of distilled water is poured. The flask is plugged again and the mix is shaken well. After 5 min. 0.5 mL 1% starch solution is poured and it is titrated with 0.1n $Na_2S_2O_3$, till a blue colour disappears. The parallel control analysis is made, using the same amount of water instead of fat.

Iodine number (%) is calculated using formula:

$$X=0.01269\ (a-b)\cdot 100/\ m$$

where: 0.01269 – amount of iodine, corresponded to 1 mL of 0,1 n $Na_2S_2O_3$ solution, g/mL;

a – amount of 0,1 n $Na_2S_2O_3$ solution (mL), used to titrate control sample;

b – amount of 0,1 n $Na_2S_2O_3$ solution (mL), used to titrate analysed sample;

m – fat amount, g

2.5. Evaluation of the number of fatty acids

Background

The acid number is one of the most important indicators of fat quality. In fat processing, this index describes the stickiness of hydrolytic fat spoilage, and analysing the quality of keeping fat shows oxidative spoilage (together with other more important indices). The method is based on titration of fatty acids, which are in a fat-spirituous-ether solution with an aquatic hydroxide solution. Ether is used as fat solvent and ethanol homogenizes fat and aquatic hydroxide systems, formed during titrating. If spirit isn't used, the reaction takes place only at the surface of the phase connection, therefore the system must be homogenised by mixing ethanol with water and organic solvents.

Procedure

3-5 g of fat is weighed into a 250 mL conus flask at accuracy 0.01 g. The fat is melted in a water bath. 50 mL of neutral mix (1:2) of ethyl and ether, which is neutralised in advance with 0.1n of hydroxide solution to pink colour using phenolphthalein, is poured into the flask. The solution is mixed in the flask, 2-3 drops of 1% phenolphthalein are added and immediately titrated with 0.1n NaOH (KOH) till a pink colour appears. If the solution in the flask becomes muddy, 5-10 mL of ethyl alcohol and ether mix are added. If the feculence doesn't disappear, the flask is slightly warmed in the water bath and is titrated after cooling.

The number of fatty acids, described as KOH or NOH amount, used for neutralisation of free fatty acids in 1 g of fat.

Number of fatty acids (mg) is calculated using formula:

$$X = \frac{5{,}61 \times V \times K}{m},$$

where: 5,61 – KOH (NaOH) amount (mg) which is in 1 mL of solution,

V – titrated amount (mL) of 0.1n KOH (NaOH) solution,

K – re-counting coefficient to straight 0.1n KOH (NaOH) solution,

m – fat amount, g.

Acid value in fresh fats is from 1.2 to 2.2 mg NaOH or KOH/g.

2.6. Evaluation of oxidative fat spoilage

One kind of fat spoilage is oxidation with air oxygen. Hydroperoxides are primary products of oxidation. Formed peroxides later take part in various chemical reactions, during which the secondary fat spoilage products form: aldehydes, ketones, little molecular mass acids, alcohols. Some of these products have an unpleasant odour and taste, and are toxic. The degree of oxidative spoilage is established using Table 3.3.

Table 3.3.

Indices, characterising oxidative fat spoilage

Reaction with solution of neutral red		
Colour		**Evaluation of fat condition**
Swine or sheep fat	From yellow with green shade to yellow From dark yellow to brown From brown to pink From pink to red	fresh fresh but not for storage doubtful freshness spoiled
Cattle fat	From yellow to brown From brown to browny pink From browny pink to pink From pink to red	fresh fresh but not for storage doubtful freshness spoiled
Number of peroxides, % of iodine		
to 0.03 from 0.03 to 0.06 from 0.06 to 0.10 more than 0.10		fresh fresh but not for storage doubtful freshness spoiled

2.6.1. Evaluation of peroxides number

Background

During fat processing or storing unmelted fat stock for a long time, the influence of air oxygen, light, high temperature and other peroxides can form. The number of peroxides is related to sensory fat indices: worse fat taste and odour are typical for fats with high peroxides number (Table 3).

The number of peroxides, expressed as the amount of iodine (g), that the peroxides present in 100 g of fat will separate from potassium iodine in an acidic environment. The method is based on the interaction of the peroxides or hydroperoxide active oxygen with iodic acid (HJ) in the presence of acetic acid.

$$KJ + CH_3COOH \rightarrow HJ + CH_3COOK$$

$$CH_3(CH_2)_6HOO\text{-}CH\text{-}CH{=}CH(CH_2)_7COOH + 2\ HJ \rightarrow$$
$$CH_3(CH_2)_6HO\text{-}CH\text{-}CH{=}CH(CH_2)_7COOH + H_2O + J_2$$

The liberated iodine is titrated with sodium thiosulphate.

$$J_2 + 2\ Na_2S_2O_3 \rightarrow 2\ NaJ + Na_2S_4O_6$$

Procedure

1 g of fats are weighted with an accuracy of 0.002 g into cone flasks with a polished plug and are melted in a water bath. From the measuring cylinder along the flask wall, 10 mL of chloroform, 10 mL of icy acetic acid and 0.5 mL of fresh prepared saturated solution of KJ are poured, and the attached fat parts would be washed. The flask is plugged, and the solution is mixed accurately and left for 5 min. in a cool and dark place. Then, 100 mL of distilled water and 1 mL of 1 % starch are poured, mixed and separated iodine is titrated with 0.01n $Na_2S_2O_3$ solution till a blue colour disappears. The control analysis is made in parallel. Reagents are right for analysis if for titration of control samples no more than 0.07 mL of 0.01n $Na_2S_2O_3$ solution are used.

Number of peroxides (%) is calculated using formula:

$$X = \frac{0{,}001269 \times (V - V_1) \times K \times 100}{m},$$

where: V – amount of 0,01n $Na_2S_2O_3$ solution (mL), used for titration of analysed sample,

V_1 – amount of 0,01n $Na_2S_2O_3$ solution (mL), used for titration of control sample,

K – re-counting coefficient to straight 0,01n $Na_2S_2O_3$ solution,

m – amount of fat in extract, g.

2.6.2. Reaction with solution of neutral red

Procedure

0.5-1.0 g. of melted fat is put into a porcelain plate and a solution of neutral red is poured (a freshly prepared aquatic 0.01 % solution of neutral red, 7,0 ≤ pH ≥ 7,2, is used. The solution can be used for a few hours). Using a porcelain pistil, the fat and solution of neutral red are rubbed for 1 min.

Then the solution is poured out and fat colour is observed. The degree of oxidation spoilage is assessed using Table 3.

Results

Draw conclusions and compare the obtained results with the information available in the literature and scientific publications.

Conclusion

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Laboratory work
Microbiological testing of chilled meat

Total Viable Count

Total Viable Counting is a laboratory technique used to count all the microorganisms in food. It is sometimes referred to as Standard Plate Counting (SPC) and Aerobic Plate Counting (APC). TVC, as the name suggests, is a quantitative analysis that provides the number of microorganisms that are viable and thrive on microbiological media for food and environment. The food industry has made extensive use of them to assess the efficacy of cleanliness programs, processing conditions, food quality, and food safety. The conditions under which food is processed have a big impact on the microorganism populations found in it. The microbiota is made up of a variety of microorganisms that are typically found in raw and uncooked foods. The majority of vegetative germs will die when exposed to heat, although certain heat-resistant spores will survive. The microorganisms may also develop spores or go into a viable but non-culturable (VBNC) condition as a result of additional non-thermal processing. A low TVC count does not always indicate that there are no pathogens in the meal; bacteria can still cause infection at low concentrations.

TVC has a number of limitations, including the inability to distinguish between different types of microorganisms and the inability to estimate microbial cells that do not develop on plates, such as anaerobic bacteria or bacteria that have formed spores. To ensure food safety, TVC is therefore more helpful in microbial food quality assessment than in food pathogen assessment.

Learning Outcomes. Learn microbiological skills such as pipetting, performing serial dilutions, preparing spread plates for a viable plate count, and performing a colony count.

Estimate the number of microbes in a sample using serial dilution techniques, including:

a) correctly choosing and using pipettes and pipetting devices,
b) correctly spreading diluted samples for counting,
c) estimating appropriate dilutions,
d) extrapolating plate counts to obtain the correct CFU in the starting sample.

Students work in a group; students receive raw meat obtained from the meat processing plant or market. Five grams of meat for 1 sample, for 1 student.

Materials

Prepare samples: 25 g of chilled meat sample + 225 mL 0.98 % physiological solution

Media: dilution tubes of sterile water

Supplies: nutrient agar plates, P-1000 Pipetman, sterile tips, sterile L-shaped blue cell spreaders ("hockey stick" or "spreader")

Methods and Procedure

A. Sample dilution and spread plating

1. Label one a plate on the bottom for each of the following dilutions: 10^{-2}-10^{-8}. The dilution depends on the meat contamination.

2. Label the dilution tubes as follows: label the two tubes (navy blue caps) containing 9.9 mL sterile water as 10^{-2} and 10^{-4}; label the four tubes (green caps) containing 9.0 mL sterile water as 10^{-5}, 10^{-6}, 10^{-7}, and 10^{-8}.

3. Carefully and aseptically remove 0.1 mL (100 µL) of the sample and pipette it into the tube marked 10^{-2}. Mix the tube completely, being careful not to spill any of the contents. The vortex mixer will help you mix the contents of the tube.

• You have now prepared a 10^{-2} (1/100) dilution. Why is it 10^{-2}? Because 0.1 mL of undiluted culture was diluted into 9.9 mL of water, giving a total volume of 10.0 mL in the dilution tube. That makes this a 10^{-2} dilution (0.1/0.1 + 9.9 = 0.1/10.0= 1/100= 10^{-2}).

4. Change the pipette tip, and take 100µL (0.1 mL) from the 10^{-3} dilution and pipette it into the next 9.9 mL dilution tube marked 10^{-4}. Mix well. You have now prepared a successive 1/100 dilution, resulting in 10^{-4} dilution of the original culture (1/100 multiplied by 1/100 = 1/10,000 = 10^{-4}, which is the same as 10^{-2} x 10^{-2} = 10^{-4}).

5. Change your pipette tip again.

• Why keep changing pipettes? Because any fluid left in the pipette tip from the previous dilution will contain many more cells per mL than any subsequent dilution and, if used, will grossly distort the final results by indicating a higher number of cells than were actually present in the original sample.

Now we will start doing a series of 1/10 dilutions. Set your Pipetman to 1,000µL and remove a 1,000 µL (1.0 mL) aliquot from the 10^{-4} dilution tube. Transfer it to the 9.0 mL dilution tube marked 10^{-5} and mix well. The original culture has now been diluted 1/100,000, or 10^{-5} (10^{-4} x 10^{-1} = 10^{-5}).

Continue your dilution series, as indicated in Figure 3.6., through to the 10^{-8} dilution tube.

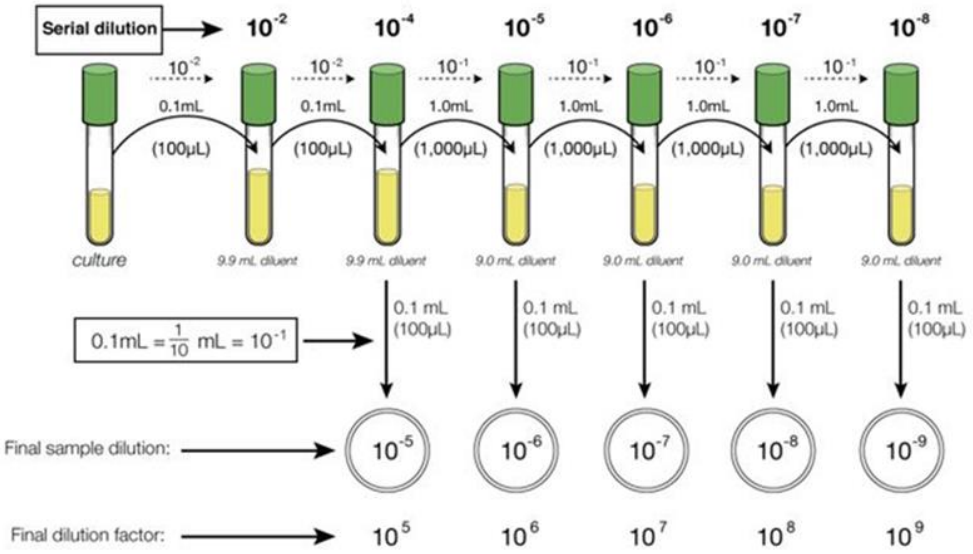

Figure 3.6. Serial dilution and plating

6. Using a new pipette tip, transfer 100 µL (0.1 mL) of the 10^{-8} dilution onto the centre of the agar surface of the plate marked 10^{-X}.

Consider why this is a 10^{-X} plate after you put 100uL (0.1 mL) of inoculum from the 10^{-X} dilution tube on it. Remember that you are trying to determine the number of viable cells in each 1.0 mL aliquot of the sample, and you only put 10% of 1.0 mL (0.1 mL) on the plate count agar (PCA).

Repeat with the rest of the dilutions, transferring 100µL (0.1 mL) from each dilution tube onto the appropriate agar surface, using a new pipette tip between each dilution tube.

7. Spread the plates: Using good aseptic technique, take one sterile blue L-shaped cell spreader out of the bag and reseal the bag. Starting with the plate marked 10^{-x}, using the spreader, gently push the liquid inoculum applied to the centre of the plate, two or three times clockwise around the dish, then several times anticlockwise, turning the plate on the turntable as needed to obtain *complete* coverage.

Continue with the rest of the spread plates *using the same* cell spreader. Make sure you are continuing to work *backwards* (from 10^{-2} to 10^{-x} etc.) from the most dilute suspension to the most concentrated suspension to minimise the amount of carryover from plate to plate. Again, use good aseptic technique, work quickly, do not touch the cell spreader on surfaces other than the agar plate you are using. If you accidentally "contaminate" the spreader by touching a surface (table or other), then dispose of it and get a new spreader. We are trying to minimise the use of the spreaders to reduce waste, but if it gets compromised, then replace it with a new sterile spreader.

Dispose of the cell spreader in the small orange biohazard bin on your bench when you are done with your spread plates.

Remember that the plates should be labelled as a ten-fold higher dilution than the dilution tube of the 0.1 mL sample being plated. For example, 0.1 mL of the 10^{-2} dilution tube should be plated on the agar plate marked 10^{-3}.

It is generally desirable to make duplicate *or* triplicate plantings of each dilution and to average the resulting counts. However, since your lab sample comes from the same stock culture, the class average should give an accurate enumeration of the original stock culture.

8. After the spread plating, leave plates agar side down for at least 30 min in order for the inoculum to absorb onto the agar, then invert the plates and incubate at 30 °C.

B: Counting colonies on plates

1. Looking at the dilution plates you prepared last time, choose the plates that have from 30-300 colonies on them. As this might take some practice in plate counting, you might need to choose all plates with what looks like a reasonable number of colonies to count.

a) those plates that have no microbial growth can be recorded as 0 or NG, No Growth.
b) those plates on which colonies are not individually distinct (their edges run together) can be recorded as TNTC, Too Numerous To Count.
c) those plates on which you cannot distinguish any individual colonies, the entire surface is covered with microbial growth, can be recorded as *confluent*.

2. Count each colony to give a total colony count for each plate chosen. You will avoid counting a colony twice by marking off the colonies on the bottom of the plate as you count them. This requires, of course, that the plate be upside down. Be sure to count any small colonies. Record your results on the report sheet.

C: Calculation of number viable cells/mL in the original sample

• Choose the plate containing between 30 and 300 colonies.

• Multiply the *number of colonies on the plate* by *the final dilution factor.* This gives the total viable cells/mL in the original sample.

• Calculate the colony-forming units, CFU, per mL for the *sample*.

Watch Video 1: Dilutions and Plating at NC State Microbiology labs. URL: https://youtu.be/IJcw4fRsYnU

Enumeration of Bacteria

Often one needs to determine the number of organisms in a sample of material, for example, in water, foods, or a bacterial culture. For example, bacterial pathogens can be introduced into foods at any stage: during growth/production at the farm, during processing, during handling and packaging, and when the food is prepared in the kitchen. In general, small numbers of pathogenic bacteria are not dangerous, but improper storage and/or cooking conditions can allow these bacteria to multiply to dangerous levels.

Faecal contamination of water is another one of the ways in which pathogens can be introduced. Coliform bacteria are Gram-negative non-spore forming bacteria that are capable of fermenting lactose to produce acid and gas. A subset of these bacteria are the faecal coliforms, which are found at high levels in human and animal intestines.

Faecal coliform bacteria such as *E. coli*, are often used as indicator species, as they are not commonly found growing in nature in the absence of faecal contamination. The presence of *E. coli* suggests faeces are present, indicating that serious pathogens, such as *Salmonella* species and *Campylobacter* species, could also be present.

For the enumeration colony forming units for the meat samples we use violet red bile agar with lactose

Methods of Enumeration

Many approaches are commonly employed for enumerating bacteria, including measurements of the *direct microscopic count, culture turbidity, dry weight of cells,* etc. In a microbiology lab, we frequently determine the total viable count in a bacterial culture.

The most common method of measuring viable bacterial cell numbers is the *standard or viable plate count or colony count.* This is a viable count, NOT a total cell count. It reveals information related only to *viable or live* bacteria. Using this method, a small volume (0.1 - 1.0 mL) of liquid containing an unknown number of bacteria is spread over the surface of an agar plate, creating a "spread plate." The spread plates are incubated for 24-36 hours. During that time, each individual viable bacterial cell multiplies to form a readily visible colony. The number of colonies is then counted and this number should equal the number of viable bacterial cells in the original volume of sample, which was applied to the plate.

For accurate information, it is critical that each colony comes from only one cell, so chains and clumps of cells must be broken apart. However, many bacterial species grow in pairs, chains, or clusters or they may have sticky capsules or slime layers, which cause them to clump together. It is sometimes difficult to separate these into single cells, which in turn makes it difficult to obtain an accurate count of the original cell numbers. Therefore, the total number of viable cells obtained from this procedure is usually reported as the number *of colony-forming units (CFUs).*

A bacterial culture and many other samples usually contain too many cells to be counted directly. Thus, in order to obtain plates, which are not hopelessly overgrown with colonies, it is often necessary to *dilute* the sample and spread measured amounts of the diluted sample on plates. Dilutions are performed by careful aseptic pipetting of a known volume of sample into a known volume of a sterile buffer or sterile water. This is mixed well and can be used for plating and/or further dilution. If the number of cells in the original sample is unknown, then a wide range of dilutions are usually prepared and plated. The preparation of dilutions and the calculation and use of dilution factors to obtain the number of microorganisms present in a sample are important basic techniques in microbiology.

Method and Procedures

Aliquots from a stepwise or *serial dilution* of the original sample are spread on plates. Only a few of the plates following incubation will contain a suitable number of colonies to count; those plated from low dilutions may contain too many colonies to count easily while those plated from high dilutions may contain too few colonies or

none at all. Ideally plates containing 30-300 colonies per plate should be counted. At this colony number, the number counted is high enough to have statistical accuracy, yet low enough to avoid mistakes due to overlapping colonies.

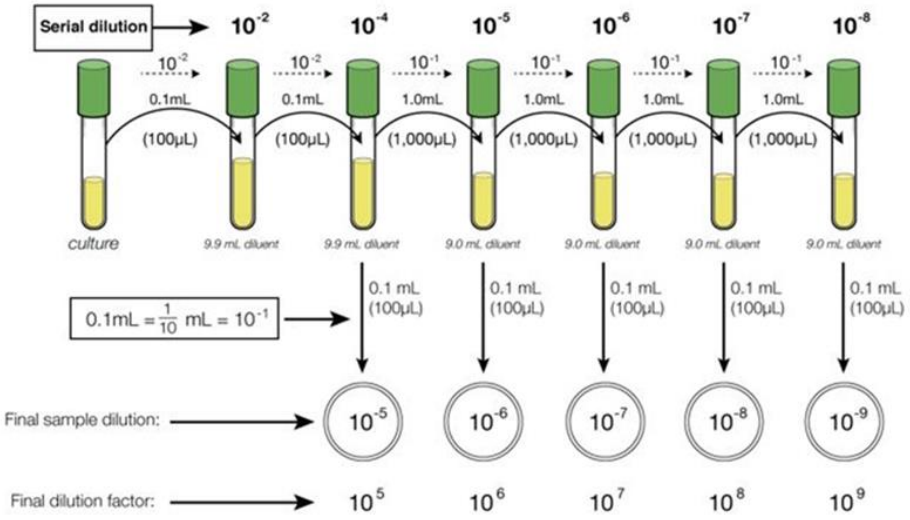

Figure 3.7. Serial dilution series and plating

A wide series of dilutions (e.g. 10^{-2} to 10^{-x}) is normally performed on the sample culture and spread plates created from the dilutions. A number of spread plates are needed because the exact number of live bacteria in the sample is usually unknown. Greater accuracy can be achieved by plating duplicates or triplicates of each dilution.

Figure 3.8. The series of dilutions

Results

Draw conclusions and compare the obtained results with the information available in the literature and scientific publications.

Conclusion

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Theme 4
Meat preservation methods

Theoretical materials

Refrigeration as a method of preserving meat. Classification of meat by thermal condition.

Refrigeration processing of meat and meat products and their storage at appropriate low temperatures is one of the most modern methods of preventing or slowing down the spoilage of these products. During the refrigeration, the best preservation of the original native properties of meat and offal is achieved.

Cold storage ensures minimal changes in the nutritional value and taste of meat. Cold treatment suppresses the vital activity of microorganisms, and slows down the chemical and biochemical processes occurring in the product under the influence of its own enzymes, atmospheric oxygen, heat and light.

Depending on the expected shelf life, there are:

1. Storage at a temperature above the freezing point of tissue fluid, but close to it (0–4 °C); possible shelf life is 7–10 days, and under particularly favourable sanitary conditions – up to 3–4 weeks.

2. Storage at a temperature below the freezing point, but close to it, possible storage period up to 2–3 weeks.

3. Storage at temperatures well below freezing; Shelf life is 6–12 months, and under favourable conditions even longer.

Accordingly, the meat is cooled, i.e. its temperature is reduced close to the freezing point, or it is frozen, bringing its temperature to the one at which storage is proposed.

In technological practice, depending on the nature of refrigeration treatment, meat is classified as follows:

1. The meat is hot-steamed, that is, it has not lost animal heat with a temperature of at least 36–38 °C.

2. The meat has cooled down and has a temperature no higher than 12 °C.

3. Chilled meat, having a core temperature no higher than 4 °C after cooling under regulated conditions.

4. Frozen meat, having a temperature of –2-(–3) °C.

5. Meat frozen with a temperature not higher than –8 °C.

6. Frozen meat, the temperature of which, under certain conditions, is brought in thickness to 1 °C.

The original, natural properties of meat are most fully preserved in chilled meat, which is superior in quality to frozen meat.

Cooling meat to the freezing point of tissue fluid slows down the vital activity of microorganisms and also introduces a qualitative change in the composition of the microflora. The proportion of thermophiles and mesophiles decreases to 2–5% of the total. During freezing, the decrease in temperature and the removal of moisture as a

result of crystal formation leads to the cessation of the vital activity of microorganisms. Psychrophilic bacteria lose their ability to reproduce at temperatures below –5 °C, psychrophilic yeast at –10 °C. At –18 °C and below, frozen meat cannot be spoiled as a result of the development of microorganisms.

Various spoilage agents, moulds, and yeasts cease their activity at temperatures below –10 °C. Moulds are the most resistant to low temperatures, including those that cause the formation of mucus on the surface of meat.

The high viability of microorganisms is due to the fact that the most important factor in their development is water, without which metabolism in microorganisms is impossible. When meat and offal are frozen, the water in the tissue fluid turns to ice. Complete freezing of tissue fluid occurs in meat at a temperature of –55 - (–65) °C. If the freezing temperature is not low enough, water remains in the meat, therefore, the most important conditions for the life of microorganisms remain. When food is frozen, along with the slowing down or cessation of the vital activity of microorganisms, their death also occurs. The death of microorganisms during freezing is caused by a significant metabolic disorder due to freezing of moisture and significant damage to the cell structure.

The maximum degree of damage to microbial cells is observed when meat is slowly frozen to a temperature of –6 - (–12) °C. When frozen very quickly, about 10% of the cells remain alive. This is explained by the formation of a large number of tiny ice crystals and, as a result, less damage to the cell structure. However, the processes of refrigeration processing of meat and offal should be carried out at an accelerated pace, since the faster the temperature of the product decreases, the faster the vital activity of microorganisms and the activity of enzymes are suppressed, and the slower the structural and chemical changes in the product occur.

Package selection for preserved meat

The choice of packaging for preserved meat has significantly expanded over the last few years – the possibilities for products in different types of packaging. As with fresh meat, processed meat is often packaged in a modified gas environment. Packaging solutions are very similar to fresh packaged meat. For hermetically sealed packages, it is essential that the packaging materials have high barrier properties

Table 4.1.

The most commonly used packages shapes for packing of fresh meat

Illustration	***Package shape***	***Description***

	Shrink package	More often, they are used for packaging various pickled baked goods.
	Pillow pouch	Usually produced in-house in horizontal flow-pack equipment. Or purchased packaging in the form of ready-made packages with fused three seams. This type of packaging is also common for packaging different types of sausages, as well as for packaging frozen meat.
	Doypack	Usually produced in-company in horizontal flow-pack equipment. Or purchased packaging in the form of ready-made packages with fused three seams.
	Trays	Usually, companies already receive ready-made containers, which are hermetically sealed after placing the products.
	Thermoformed packages	These packages are usually made in-house from a roll of packaging.

	Plastic buckets/containers	This type of packaging is often used for packaging marinated meat.
	Glass and/or plastic (PET) jars	Often used for packing pickled products.

For the packaging of this type of products, both air, vacuum and MAP technologies are used. The technological process is the same as for fresh meat.

However, it should be noted that when packing MAP it is important to know and observe the appropriate gas composition inside the package above the product. A mixture of CO_2 gas and N_2 gas is usually used as the shielding gas environment.

Gases. Oxygen helps to keep the fresh and natural colour of food products, prevents the growth of anaerobic bacteria (present in certain types of fish and vegetables) and allows fresh fruit and vegetables to breathe. In the case of fruit and vegetables, the absence of O_2 can lead to anaerobic respiration in the package which accelerates senescence and spoilage. Levels of O_2 that are too high do not retard respiration significantly and it is around 12% of O_2 where the respiration rate starts to decrease. So oxygen is used at low levels (3-5%) for positive effect.

When packaging meat and fish, for example, the high CO_2-levels are effective bacterial and fungal growth inhibitors. In the case of vegetables and fruits, CO_2 is not a major factor since CO_2-levels above 10% are needed to suppress fungal growth significantly. Unfortunately higher levels than 10% of CO_2 are working phytotoxic for fruit & vegetables.

Nitrogen, for example, is used as a filler gas since it neither encourages nor discourages bacterial growth and it prevents the oxidative rancidity caused by the presence of oxygen in packaged snacks and dried products.

In recent years, there has been a debate regarding the use of carbon monoxide (CO) in the packaging of red meat. While no risk was found in the use of low levels of CO, the fact that CO maintains the colour of the meat, and can hide visual evidence of spoilage, was raised.

When solving packaging issues, it is important to remember that meat and meat products are perishable products, therefore, not only the packaging, but the combination of the packaging material with the storage temperature is a very important factor.

It is also important that if the meat products are packed in different packages, it is possible to create a packaging system that combines all packaging processes in the company.

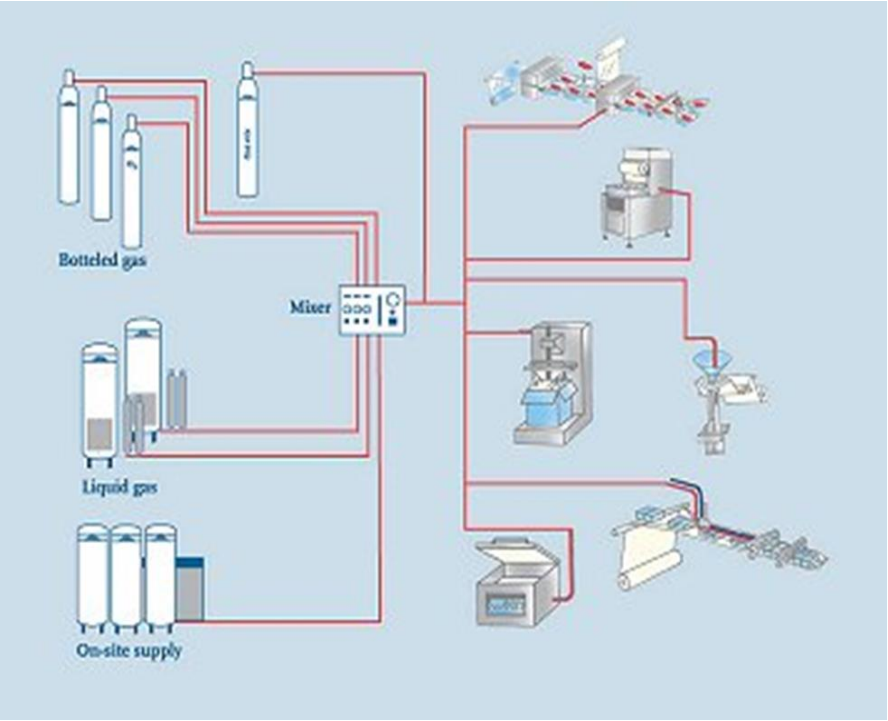

Figure 4.1. In protective uses of packaging systems

Contamination risks of preserved meat

Any meat that has been preserved through smoking, curing, salting, or the use of chemical preservatives is considered processed meat; examples of this type of meat include sausages, bacon, salami, hot dogs, processed deli meats, and luncheon meats. Meat products are the most consumed and highly appreciated food items globally. These meat products retain at least half of their original meat integrity after processing (i.e. the original meat qualities have reduced by half when a meat is processed into meat products). Food processing and supply businesses have been captivated by the prevalence of harmful microbes and spoilage, making safe food supply a global concern. The obstacles to the hygienic processing of meat have included the lack of centralised harvest facilities, the small amount of retail business (i.e. the retail enterprise is typically a small market), prohibitive capital expenses on mechanised, infrastructural, and recurring expenditures.

The main goal in trying to extend the shelf life of products is to reduce the initial bacterial load in meat. Meat products' shelf life is influenced by a number of variables, the most significant of which is their microbiological quality. Numerous research investigations have demonstrated a correlation between the consumption of meat and meat products and the occurrence of foodborne illness outbreaks. The primary causes of disease and mortality in developing nations are foodborne pathogens, which have a billion-dollar impact on societal and medical expenses. The failure or incapacity to

control microorganisms at one or more stages of the food chain, from raw material consumption to end product consumption, leads to foodborne illness and microbial food spoilage. Events leading to outbreaks of food poisoning or food spoiling can have serious ramifications for food manufacturers, distributors, buyers, and government agencies.

One of the key elements influencing meat product quality during storage is microbial development, which can result in contamination, spoiling, and financial loss. Microbiological standards ought to consider any organisms that might be found in the beef product. When items are maintained properly, they should remain safe and wholesome until the end of their shelf life, even after allowing for the predicted growth of these organisms. This is because tolerance thresholds should be applied at the time of manufacture.

Animal-derived food safety for human consumption is now a crucial topic of discussion in public health discussions. Therefore, the environment, the type of meat and raw materials, the equipment, the handling procedures, the processing, the packaging, and the temperature of storage will all have a major impact on the microbial ecology of meat products.

Historically, microbiological testing of samples at different phases of manufacturing, including the finished product, has been used to demonstrate control of bacteria in food. The type of bacteria present and their capacity to proliferate to a point of concern under the storage circumstances used during the product shelf life determine the potential for growth and/or toxin production of residual microbial population in completed products.

Sources of Microbial Contaminants in Meat Products

During the manufacturing, packing, and marketing processes, meat handlers who are infected with harmful germs might contaminate meat products. The working habits of food handlers and disease-causing microorganisms on or in the food handler's body that are then transferred from the food handler to the food throughout the handling process are two of the main causes of food contamination hazards. Because humans are a primary source of contamination that can result in food poisoning from Staphylococcus aureus, personal cleanliness is crucial when handling food. Inadequate personal hygiene habits, such as failing to wash hands after using the restroom, can cause food workers to have up to 10^7 CFU (colony-forming units) ml 1 pathogens under their fingernails.

Spices can harbour germs, moulds, or yeasts and play a significant role in meat products. Spice variety, processing technique, granule size, and moisture level all affect the microbiological load of the spice. When making sausages, minced meat and spice mixture have been found to be the main causes of contamination. The most likely cause of the increased microbial load in minced meat is the unclean nature of the raw flesh. The microbiological quality of raw meat and non-meat materials influences the finished product's quality. Another contributing source of contamination in processed beef products is the degree of sophistication and hygienic state of the harvesting and processing machinery. Research has indicated that as harvest facilities became more

sophisticated, the amount of bacteria contaminating meat was reduced. Furthermore, different parts of the carcasses from which processed meat is extracted may have varying incidences of different foodborne pathogens; for example, research has indicated that, regardless of the processing conditions, thigh muscles were much more likely to become contaminated than breast muscles.

Some Microbial Contaminants of Processed Meat

In the right circumstances, a wide variety of bacteria may contribute to meat deterioration. Because of this, the microbial ecology of damaged meat products is extremely complicated, making it very challenging to stop the spoiling process. Numerous investigations have established the existence of foodborne pathogens, including *Clostridium perfringens, Salmonella* spp., *Escherichia coli, S. aureus*, and *Listeria monocytogenes*, in pork products.

Listeria monocytogenes is a facultative anaerobic gram-positive rod-type bacteria that does not form spores and is extremely mobile. It may thrive in a broad variety of pH and temperature ranges. The organism is widely distributed in the environment and is capable of withstanding nitrite and salt.

One of the most frequent culprits in bacterial food poisoning epidemics is *Staphylococcus aureus*, which is also a key pathogen responsible for the development of clinical or subclinical mastitis in dairy domestic ruminants. Milk and milk products, meat, poultry, and egg products have all been identified as common foods that can result in staphylococcal food poisoning. Because *Staphylococcus aureus* can create a wide variety of exotoxins and other virulence factors, it is one of the most common etiological agents of bacterial illnesses globally. Of them, the majority of common foodborne intoxications are caused by staphylococcal enterotoxins, which are produced by certain strains of *S. aureus*. Both staphylococcal food poisoning and toxin-1, which causes toxic shock syndrome, are the causes of staphylococcal scarlet fever.

Intervention against Microbial Contaminants of Processed Meat

Cooking can quickly deactivate the majority of microbial vegetative cells and hazardous products since they are susceptible to heat treatment. Consequently, the primary problem when packaging is post-cooking recontamination. Common strategies to manage microbiological contaminants in processed meat include post-package decontamination techniques such in-package thermal pasteurization and irradiation, as well as designing meat products with antimicrobial compounds. As a result, the producer has the advantage of taking action to lessen food contamination.

Irradiation

Exposure of items to radiant energy is the process that results in ionizing radiation. X-rays, electron beams, and gamma rays are examples of ionizing radiation. It has been observed that e-beam irradiation is superior to gamma-ray irradiation in terms of reducing *Bacillus cereus* and *E. coli* O157:H7, but not *L. monocytogenes*. Low-dose (0.75–0.90 kGy) radiation lowered L. monocytogenes by 42 log in cooked pork chops and hams infected with the pathogen. Compared to vacuum or modified

environment packing settings, aerobic packaging resulted in significantly higher mortality rates from radiation treatments. The use of modified environment packaging in irradiated meat or poultry raises the possibility that pathogens will proliferate and/or develop poisons due to a lack of competing organisms. If spoiling is suppressed and does not give the typical warning signals, then this is even more of a concern. The impacts of temperature must be carefully taken into account because lower radiation temperatures generate fewer detrimental alterations to the sensory qualities of meat and poultry products. Nonetheless, higher radiation doses are needed in colder temperatures to render foodborne bacteria inactive. Another influence is the rate of radiation exposure since, at low doses, microbial enzymes may have more time to repair cell damage, leading to increased resistance. Because product compositions and irradiation circumstances might impact the effectiveness of irradiation, generalising about its effects can be deceptive.

Food Preservatives

Chemical antimicrobials: Due to its advantageous effects on meat quality when administered at the right concentrations, salt of lactate (SL) is widely utilised as an antimicrobial in meat products. There is a good chance that the shelf life of food products with a neutral pH can be extended by adding lactate. Under ideal growth circumstances (pH 6.5, 20 °C), Gram-positive bacteria were often more sensitive to lactate than Gram-negative bacteria. It has been shown that applying lactate and diacetate together has a synergistic inhibitory effect that inhibits the growth of harmful organisms in meat products. It has been demonstrated that a chemically produced short-chain peptide with six leucine and eight lysine residues is biocidal against a variety of foodborne pathogens, including *L. monocytogenes* suspended in phosphate buffer at doses ranging from five to fifty mg/ml. Meat exudate contained both aerobic and anaerobic microorganisms that were suppressed by peptide doses of 100 mg/ml. *L. monocytogenes* was successfully eradicated by the use of peroxyacetic acid, sodium hypochlorite, and quaternary ammonium compound as sanitizers in meat processing facilities.

Probiotic bacteria, bacteriocins, and lactobacilli: Using different lactic acid bacteria strains for biopreservation is a good substitute for chemical preservatives. Both naturally and artificially contaminated salami demonstrated the potent antibacterial activity of a bacteriocin-producing *Lactobacillus plantarum* MCS strain against *L. monocytogenes*. Therefore, adding *Lactobacillus, Pediococcus*, and enterococci to starter cultures could pose an extra barrier against pathogens in meat products that have undergone fermentation. It is also possible to employ lactic acid bacteria to stop bacterial contamination from growing in non-fermented foods. In the initial days following manufacturing, the addition of *Lactobacillus sakei* Lb 706 inhibited the growth of *L. monocytogenes* in pasteurised minced meat and comminuted cured raw pork. When a cocktail of three rifampicin-resistant mutant L. monocytogenes strains was added to cooked items at a concentration of 10^5 - 10^6 CFU/g right before slicing and vacuum packaging, the growth of those strains was reduced at both 8 °C and 4 °C. Bacteriocins are polypeptides that bacteria create through ribosome synthesis that

have the power to either kill or stop the growth of related bacterial strains. Because of its comparatively lengthy history of safe usage, nisin is the most significant bacteriocin in terms of commerce. Approximately fifty nations currently recognize it as a safe food preservative.

Plant extracts: Plant extracts have a wide range of antibacterial action against numerous genera of bacteria and fungi because of their antioxidant and antimicrobial properties. Pine bark extract and eugenol (clove extract) have been shown to strongly suppress the growth of *L. monocytogenes* and *Aeromonas hydrophila* inoculated in cooked beef slices. After nine days of refrigeration, the treated raw ground beef with 1 % pine bark extract as an antibiotic showed a decrease in the quantity of *E. coli* O157:H7, *L. monocytogenes*, and *S. typhimurium*. These findings imply that using natural plant extracts in conjunction with other preservation techniques may help lower the pathogen content of processed beef.

In-Package Thermal Pasteurisation

When exposed to an 85 °C water bath for 10 seconds (a 46-log reduction), all of the *L. monocytogenes* cells were destroyed; however, viable cells were still detectable after up to 10 minutes of heating at 61 °C (a 0.6-log reduction). These findings were related to the effects of surface pasteurisation temperatures on the survival of *L. monocytogenes* in low-fat turkey bologna. The size of the packaging and the roughness of the product surface affected how well in-package pasteurisation inactivated pathogenic germs. The efficiency of heat pasteurisation is also influenced by the strains of bacteria. Prior to heat treatment, cells grown at 42.8 °C showed greater thermo-tolerance than those grown at 37 °C. *L. monocytogenes* thermo-tolerance was raised by heating at gradually rising temperatures (0.7 °C/min), and the organism's heat resistance in broth was increased by starving it in phosphate-buffered saline pH 7 for six hours at 30 °C.

High-Pressure Processing

Food is processed using a revolutionary non-thermal technique called high-pressure processing (HPP), in which it is heated to high pressures either with or without the input of heat. Microorganisms can be rendered inactive by HPP without causing noticeable alterations to the food's nutritional content, texture, or colour. HPP is a potent instrument for managing pathogenic organisms, but it also works well against viruses and spores. In addition, a number of other variables, including pressure, temperature of treatment, duration of exposure, pH, water activity, and food composition, affect how effective HPP is at decontaminating. Numerous investigations have demonstrated that HPP was somewhat less efficient at ambient temperature than it was when chilled. Moreover, the presence of oil decreased the efficiency of high pressure in eliminating *L. monocytogenes*, and the shape of the cell also affected HPP, with bacilli being more pressurised-sensitive than cocci. Because HPP causes sublethal damage to living cells, the death rate increases when mixed with antimicrobials such as bacteriocins.

Combination Therapy Technology

Combination treatment technology is based on the application of many preservative elements to ensure food stability and microbiological safety. Temperature, water activity, acidity, redox potential, antimicrobials, and competitive microbes are the most significant barriers utilised in food preservation. If obstacles strike at different times and disrupt the equilibrium of the microbes found in food, a synergistic effect can result. The most often used barriers for beef products include nitrite, vacuum packing, thermal processing, and chilled storage. These obstacles, however, don't seem to be enough for *L. monocytogenes* because of its widespread distribution, capacity to grow in anaerobic environments and at cold temperatures, and resistance to nitrite and salt.

Microbial Contamination Intervention and Processed Meat Quality

Interventions produce free radicals that can lead to lipid peroxidation and other chemical changes that affect the quality of processed meat, even if they are particularly successful at controlling food-borne pathogens in meat. Meat items exposed to radiation may take on a distinct smell that has been called "bloody sweet" or "barbecued corn-like." According to sensory analysis, the irradiation dose rose with the sulfur odour. Irradiation significantly boosted other volatiles in the beef products in addition to sulfur compounds. Depending on the radiation dose, animal species, muscle type, pH, meat reduction potential, and packaging style, radiation can cause a wide range of colour changes. The formation of carbon monoxide during irradiation is linked to the colour change caused by radiation and is correlated with the enhanced redness of irradiated meat. Carbon monoxide-myoglobin (CO-Mb) is the pigment that gives irradiated turkey flesh its pink colour.

It has also been observed that radiation causes substantial yields of side-chain hydroperoxides, which are linked to the oxidation of lipids and proteins, which in turn causes the oxidation of amino acids. When cooked and vacuum-packed beef top rounds were injected with SL, the cooked beef produced larger cooking yields and a deeper, redder colour with less grey surface area. The addition of SL improved the flavour notes associated with fresh beef and reduced flavour deterioration during storage. In Chinese-style sausage, the addition of 3 % SL resulted in better quality regarding physicochemical characteristics. Research reports have shown that SL added to fresh pork sausage did not affect the internal lean colour but resulted in more rapid surface discoloration, and that 2 % potassium lactate had no effect on quality and sensory properties of low-fat pork sausage or lean colour during refrigerated aerobic storage. Adding 2 % SL to turkey breast rolls resulted in lower colour values, but increased hardness, springiness, cohesiveness, chewiness, and resilience of turkey breast rolls. Including 3.3 % commercial SL in frankfurter formulation did not affect the textural profile of sausage. The texture of products was unaffected by the addition of up to 0.1% potassium sorbate or up to 0.1% sodium benzoate in the product composition. These findings imply that the degree of SL and the kinds of items influence how SL affects product quality. The flavour of ham products is adversely affected by excessive sodium

diacetate (SDA) concentrations. Nevertheless, SDA has no effect on the quality of meat products at lower concentrations (0.1%). Benzene level in the volatiles of irradiated RTE turkey ham and breast rolls significantly increased with the addition of potassium benzoate, indicating that benzoate salt is not a suitable antibacterial to be utilised in goods for irradiation. Nonetheless, there is no denying that HPP alters the quality of meat. While certain modifications, like colour and lipid oxidation, are undesirable, other changes, like pressure tenderisation and pressure-assisted gelation, are advantageous.

Conclusion

At several points during the meat processing process, microbial contamination can happen and can be minimised. The most significant indicator species that are frequently employed to guarantee food safety are coliform bacteria, faecal coliform bacteria, *Escherichia coli,* total *Enterococcus spp.*, and aerobic plate count, as demonstrated by experiments. Counting yeast on samples taken during processing in small firms to confirm appropriate manufacturing methods is beneficial in certain cases. It was discovered that this monitoring-based verification was a more appealing option than having the final items examined. Before entering the processing facility, raw meat and additives must be examined to guarantee the microbiological quality of the finished goods. It is necessary to choose certified vendors. For suppliers of raw meat, strict standards for hygienic quality must be established. The materials and uncooked meat must be kept in the right storage conditions until used. Processing plant cleaning and sanitation procedures need to be done well. Employees should adhere to basic hygiene protocols, and their health should be routinely monitored. Lastly, the right time and temperature settings for processing meat should be chosen.

HACCP (Hazard analysis and critical control points)

Food safety is a scientific discipline describing handling, preparation, and storage of food in ways that prevent food borne spoiling. This includes a number of routines that should be followed to avoid potentially severe health hazards. In this way food safety often overlaps with food defence to prevent harm to consumers.

As it is known since the 1960s in the EU each enterprise that works in the Food segment must have a food safety system that is based on 7 HACCP principles. Seven basic principles are employed in the development of HACCP plans that meet the stated goal. These principles include hazard analysis, CCP identification, establishing critical limits, monitoring procedures, corrective actions, verification procedures, and record-keeping and documentation.

The Food Safety Plan - is not a stand-alone programme, but rather part of a larger food safety system. The foundational programmes that are part of the food safety system are frequently termed prerequisite programmes. The term was coined to indicate that they should be in place before HACCP based systems are implemented in order to effectively manage risk from foodborne hazards. Good Manufacturing Practice (GMP) regulations address requirements for many prerequisite programs. The conditions and practices the regulated food industry must follow for processing safe

food under sanitary conditions, including personnel, plant and grounds, sanitary operations, sanitary facilities and controls, equipment and utensils, processes and controls, warehousing and distribution, and action levels in case with potentially unsafe product.

The process flow of a food safety plan (HACCP or Preventive Controls) is the centre of the food safety story of a food product. It tells how a company makes its products and also what hazards and controls are associated with each step.

Monitoring records and logs must include the actual values or observations that document the actual implementation of a Food Safety Plan. For example, if a temperature is being measured, the actual temperature must be recorded rather than a check mark indicating that the temperature complied with the critical limit. To comply with regulations, the information must be recorded at the time it is observed.

Here are suggested record and log types to use:

- Customer complaints,
- Corrective action forms,
- Employee training,
- Food safety quarterly audit,
- Food safety checklist,
- Raw materials/receiving log,
- Worker illness og,
- Refrigerator .og,
- Assembly log,
- Shipping Temperature og,
- Suggested supply chain.

Documents. The safety of your product depends on much more than just what you control within your own facility. Using an ingredient that has a history of association with a specific hazard may require a supply chain programme as a control within your food safety programme. Companies may have extensive supplier programmes that encompass much more than food safety elements to manage their supplier expectations and performance.

Here is a list of suggested documents to obtain from your supply chain:

- Food safety HACCP or preventive controls plan for each product,
- Food defence/ business continuity plan,
- Validation of each product and/or process and Ready-to-Eat statements (if applicable),
- Certificates of Analysis (COA),
- Third party audit certificate, report & corrective actions,
- Product specification,
- Allergen management,
- Country of origin,
- Potential hazards.

Biological hazards. Microbiological contamination – during processing at source of origin – supplier management and HACCP are in place and verified to eliminate and reduce the potential presence of microbiological contamination.

Microbiological contamination, for instance microbiological growth due to breakdown of refrigeration units.

Chemical hazards. Chemical contamination by pesticides at source of origin – chemical/pesticide used at source is verified to be compliant with regulations.

Chemical contamination from machine oils or lubricants, as well as cleaning chemicals.

Microbiological/ physical/ chemical contamination from – cross contamination or taint of finished product due to poor hygiene.

Physical hazards. Physical contamination – external contamination from rainwater, bird droppings, vermin/ rodents, and flying insects during the unloading process.

Glass contamination from internal light sources – pests/rodents and/or flying insects due to poor hygiene/debris build up - physical risks from straps/thermocouples/staples/foreign bodies found on pallets on intake.

Physical contamination from: 1) company quality inspectors – foreign bodies found within product and/or packaging from source of origin or during transportation; 2) warehouse operatives, pests/rodents, and/or flying insects due to poor hygiene/debris build up; 3) personnel foreign body/dust contamination from production environment.

The core messages of the Five Keys to Safer Food are: (1) keep clean; (2) separate raw and cooked; (3) cook thoroughly; (4) keep food at safe temperatures; and (5) use safe water and raw materials.

Recall plan. According to the Food Safety Modernisations Acts, Preventive Controls for Human food regulation requires the development of a written recall plan when a hazard analysis identifies a hazard requiring preventive control. Recalls are actions taken by an establishment to remove an adulterated, misbranded or violative product from the market. In other words, a product for which FDA or a state could take legal action against the company would be subject to recall.

Verification is an important component of supply chain, sanitation, allergen and critical controls. It confirms that the Food Safety Plan is operating as intended. Validation confirms the effectiveness of the Food Safety Plan in controlling food safety hazards. The purpose of verification is to provide a level of confidence that the Food Safety Plan is: 1) based on solid scientific principles that are adequate to control the hazards associated with the products and process, and 2) that the plan is being followed correctly every day of operation.

Risk assessment Matrix:

Likelihood	Severity
1 = Improbable event – once every five years	1 = Negligible – no impact or not detectable
2 = Remote possibility – once every year	2 = Marginal – only internal company target levels affected
3 = Occasional event – once per month	3 = Significant – Impact on critical limits
4 = Probable event – once per week	4 = Major – Impact on customers (may not be the public)
5 = Frequent event – once per day	5 = Critical – public health risk / public product recall

Likelihood	Severity				
	1	2	3	4	5
1	1	2	3	4	5
2	2	4	6	8	10
3	3	6	9	12	15
4	4	8	12	16	20
5	5	10	15	20	25

Severity of health effect							
	Can cause fatality	5	5	10	15	20	25
	Can lead to serious illness	4	4	8	12	14	20
	Can cause illness	3	3	6	9	12	15
	Can cause inconvenience	2	2	4	6	8	10
	Almost of no significance	1	1	2	3	4	5
			1	2	3	4	5
			Unlikely	Rare	Could occur	Likely	Frequent
			(<1/2 years)	(1 / year)	(1/6 month)	(1 / month)	(1 / week)
			Likelihood of occurrence				

Low risk hazards	Medium risk hazards	High risk hazards

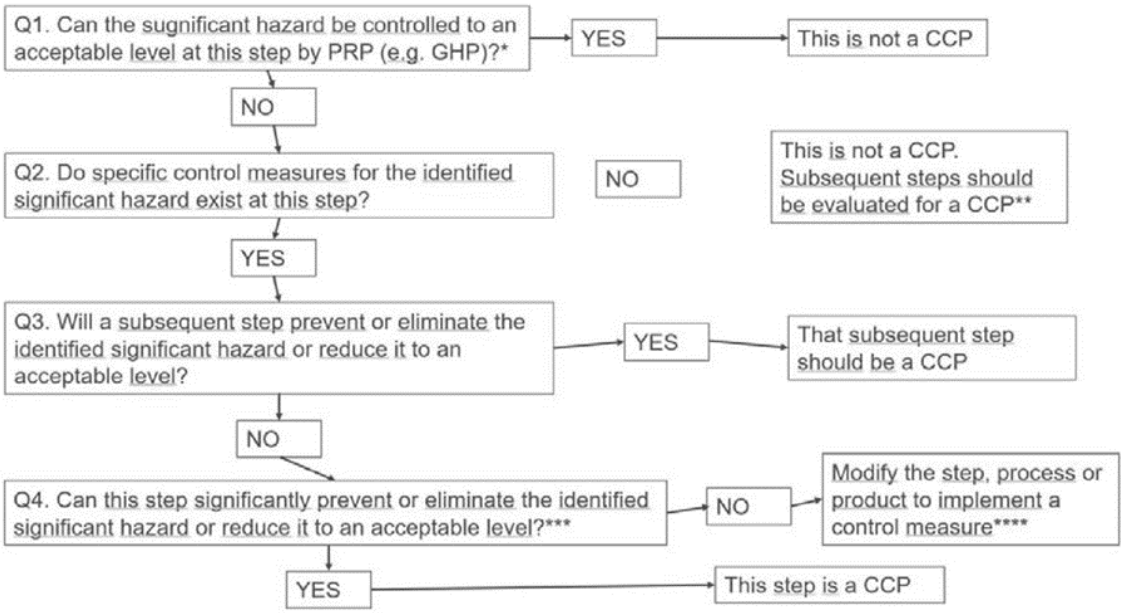

Figure 4.2. Example of a decision tree to identify critical control points (CCP)

Laboratory work
Sensory evaluation of meat

Materials
Different types of fresh meat samples (max. 7) for each panellist.

Methods and Procedures
Fresh meat samples need to be evaluated for appearance, structure and aroma. Mark the characteristics of each meat sample in the Table 4.2.

Table 4.2.

Sensory evaluation of meat

Sensory property	**SAMPLE CODE**						
Appearance							
Structure							
Aroma							

Results
After samples sensory evaluation and completing the table, students compare the results and draw the main conclusions.

Conclusion
1.
2.
3.

Approved by _____

Name, Surname, signature

Date _____

Practical work

Safety risk assessment of meat

Materials

Theoretical materials

Methods and Procedures:

The following tasks must be completed in the practical part of the work:

1. For a selected meat, develop a product description, and draw a diagram of the process steps.
2. Identify potential hazards:
   - biological – pathogenic microorganisms,
   - chemical – agricultural chemicals,
   - physical – foreign objects atypical for the product.
3. Evaluate the danger of the identified hazards using a risk matrix.
   1. Record the information in the hazard assessment table.
   2. Complete the CCP identification table and the HACCP plan.
   3. Write conclusions on determining CCP using a risk matrix and a decision scheme.

Results

Table 4.3.

Risk assessment table

Process stage	The identified hazard	Hazard assessment					Means of control
		Possibility	The severity of the consequences	Risk level	Assessment	CCP	

Table 4.4.

CCP identification table

Process stage No.	Process stage	Cause of risk	Description of the cause of the risk	Control actions	Answers to Decision Scheme questions				CCP yes/no
					1	2	3	4	

Table 4.5.

HACCP plan

In process stage	CCP/ CP	Risk the cause	Measurable critical limits of parameters	Monitoring procedures				Order-	Corrections events
				What?	How to?	How often?	What?		

Conclusion

1.
2.
3.

Approved by _____

Name, Surname, signature

Date _____

Laboratory work

Microbiological testing of semi-finished meat products

Total Viable Count

Total Viable Counting is a laboratory technique used to count all the microorganisms in food. It is sometimes referred to as Standard Plate Counting (SPC) and Aerobic Plate Counting (APC). TVC, as its name suggests, is a quantitative analysis that provides the number of microorganisms that are viable and thrive on microbiological media for food and environment. The food industry has made extensive use of them to assess the efficacy of cleanliness programs, processing conditions, food quality, and food safety. The conditions under which food is processed have a big impact on the microorganism populations found in it. The microbiota is made up of a variety of microorganisms that are typically found in raw and uncooked foods. The majority of vegetative germs will die when exposed to heat, although certain heat-resistant spores will survive. The microbe may also develop spores or go into a viable but non-culturable (VBNC) condition as a result of additional non-thermal processing. A low TVC count does not always indicate that there are no pathogens in the meal; bacteria can still cause infection at low concentrations.

TVC has a number of limitations, including the inability to distinguish between different types of microorganisms and the inability to estimate microbial cells that do not develop on plates, such as anaerobic bacteria or bacteria that have formed spores. To ensure food safety, TVC is therefore more helpful in microbial food quality assessment than in food pathogen assessment.

Learning Outcomes. Learn microbiological skills such as pipetting, performing serial dilutions, preparing spread plates for a viable plate count, and performing a colony count. Estimate the number of microbes in a sample using serial dilution techniques, including:

- correctly choosing and using pipettes and pipetting devices,
- correctly spreading diluted samples for counting,
- estimating appropriate dilutions,
- extrapolating plate counts to obtain the correct CFU in the starting sample.

Materials

Cultures: stationary phase broth culture of *Serratia marcescens*

Media: dilution tubes of sterile water

Supplies: nutrient agar plates, P-1000 Pipetman, sterile tips, Sterile L-shaped blue cell spreaders ("hockey stick" or spreader")

Methods and Procedures

A. Sample dilution and spread plating

1. Label one plate on the bottom for each of the following dilutions: 10^{-5},10^{-6}, 10^{-7}, 10^{-8}, and 10^{-9}. See Figure 4.3.

2. Label the dilution tubes as follows: label the two tubes (navy blue caps) containing 9.9 mL sterile water as 10^{-2} and 10^{-4}; label the four tubes (green caps) containing 9.0 mL sterile water as 10^{-5}, 10^{-6}, 10^{-7}, and 10^{-8}.

3. Carefully and aseptically remove 0.1 mL (100 µL) of the *Serratia marcescens* culture and pipette it into the tube marked 10^{-2}. Mix the tube completely, being careful not to spill any of the contents. The vortex mixer will help you mix the contents of the tube.

• You have now prepared a 10^{-2} (1/100) dilution. Why is it 10^{-2}? Because 0.1 mL of undiluted culture was diluted into 9.9 mL of water, giving a total volume of 10.0 mL in the dilution tube. That makes this a 10^{-2} dilution ($0.1/0.1+9.9=0.1/10.0=1/100=10^{-2}$).

4. Change the pipette tip, and take 100µL (0.1 mL) from the 10^{-2} dilution and pipette it into the next 9.9 mL dilution tube marked 10^{-4}. Mix well. You have now prepared a successive 1/100 dilution, resulting in 10^{-4} dilution of the original culture (1/100 multiplied by 1/100 = 1/10,000 = 10^{-4}, which is the same as $10^{-2} \times 10^{-2}=10^{-4}$).

5. Change your pipette tip again.

• Why keep changing pipettes? Because any fluid left in the pipette tip from the previous dilution will contain many more cells per mL than any subsequent dilution and, if used, will grossly distort the final results by indicating a higher number of cells than were actually present in the original sample.

Now we will start doing a series of 1/10 dilutions. Set your Pipetman to 1,000 µL and remove a 1,000 µL (1.0 mL) aliquot from the 10-4 dilution tube. Transfer it to the 9.0 mL dilution tube marked 10^{-5} and mix well. The original culture has now been diluted 1/100,000, or 10^{-5} ($10^{-4} \times 10^{-1} = 10^{-5}$),

You have just prepared a 10^{-1} (1/10) dilution of the previously diluted culture. Why is it 10^{-1}? Because 1.0 mL of diluted culture was further diluted into 9.0 mL of water, giving a total volume of 10.0 mL in the dilution tube. ($1.0/1.0 + 9.0 = 1.0/10.0 = 1/10 = 10^{-1}$). Now you know why these series of dilutions are referred to as serial dilutions.

Continue your dilution series, as indicated in Figure 4.3., through to the 10^{-8} dilution tube.

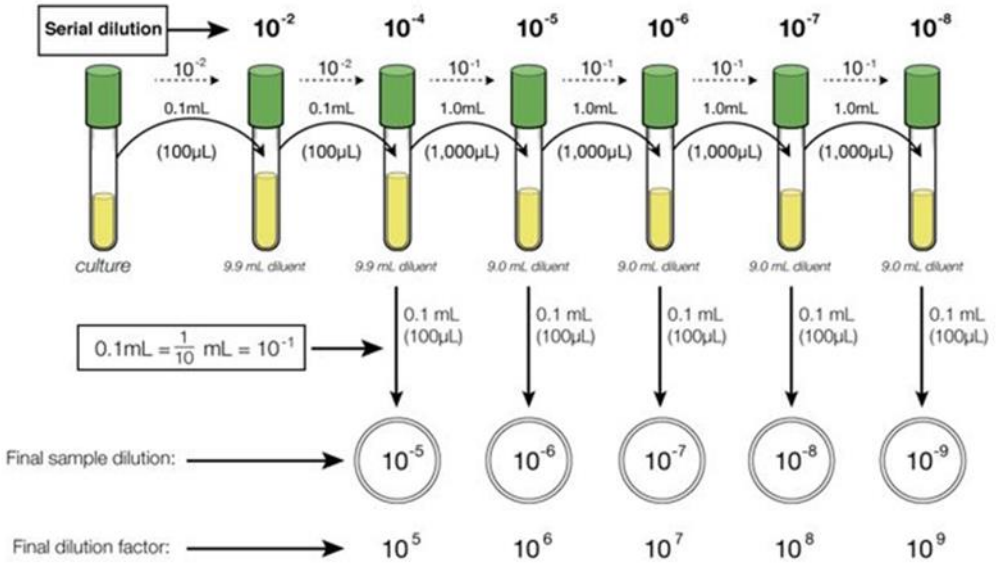

Figure 4.3. Serial dilution and plating

6. *Using a new pipette tip,* transfer 100 µL (0.1 mL) of the 10^{-8} dilution onto the centre of the agar surface of the plate marked 10^{-9}. Consider why this is a 10^{-9} plate after you put 100 µL (0.1 mL) of inoculum from the 10^{-8} dilution tube on it. Remember that you are trying to determine the number of viable cells in each 1.0 mL aliquot of the original *Serratia marcescens* sample, and you only put 10% of 1.0 mL (0.1 mL) on the nutrient agar plate.

Repeat with the rest of the dilutions, transferring 100 µL (0.1 mL) of each dilution tube onto the appropriate agar surface, using a new pipette tip between each dilution tube.

7. Spread plates: using good aseptic technique, take one sterile blue L-shaped cell spreader out of the bag and reseal the bag. Starting with the plate marked 10^{-9}, using the spreader, gently push the liquid inoculum applied to the centre of the plate, two or three times clockwise around the dish, then several times anticlockwise, turning the plate on the turntable as needed to obtain *complete* coverage.

Continue with the rest of the spread plates *using the same* cell spreader. Make sure you are continuing to work *backwards* (from 10^{-9}, then 10^{-8}, then 10^{-7} then 10^{-6} etc.) from the most dilute suspension to the most concentrated suspension to minimise the amount of carryover from plate to plate. Again, use good aseptic technique, work quickly, do not touch the cell spreader on surfaces other than the agar plate you are using. If you accidentally "contaminate" the spreader by touching a surface (table or other), then dispose of it and get a new spreader. We are trying to minimise the use of the spreaders to reduce waste, but if it gets compromised, then replace it with a new sterile spreader.

Dispose of the cell spreader in the small orange biohazard bin on your bench when you are done with your spread plates.

Remember that the plates should be labelled as a ten-fold higher dilution than the dilution tube of the 0.1 mL sample being plated. For example, 0.1 mL of the 10^{-6}

dilution tube should be plated on the agar plate marked 10^{-7}. Again, if you need help visualising this, see Figure 4.3.

It is generally desirable to make duplicate *or* triplicate plantings of each dilution and to average the resulting counts. However, since your lab sample comes from the same stock culture, the class average should give an accurate enumeration of the original stock culture.

8. After the spread plating, leave plates agar side down for at least 30 min in order for the inoculum to absorb onto the agar, then invert the plates and incubate at 30 °C.

B. Counting colonies on plates

1. Looking at your dilution plates prepared last period, choose the plates that have from 30-300 colonies on them. As this might take some practice in plate counting, you might need to choose all plates with what looks like a reasonable number of colonies to count.

a. Those plates that have no microbial growth can be recorded as 0 or NG, No Growth.

b. Those plates on which colonies are not individually distinct (their edges run together) can be recorded as TNTC, Too Numerous To Count.

c. Those plates on which you cannot distinguish any individual colonies, the entire surface is covered with microbial growth, can be recorded as *confluent*.

2. Count each colony to give a total colony count for each plate chosen. You will avoid counting a colony twice by marking off the colonies on the bottom of the plate as you count them. This requires, of course, that the plate be upside down. Be sure to count any small colonies. Record your results on the report sheet.

Results

Draw conclusions and compare the obtained results with the information available in the literature and scientific publications.

C. Calculation of number viable cells/mL in the original sample

- Choose the plate containing between 30 and 300 colonies.
- Multiply the *number of colonies on the plate* by *the final dilution factor.* This gives the total viable cells/mL in the original sample.
- Calculate the colony-forming units, CFU, per mL for the *Serratia marcescens* culture. Watch Video 1: Dilutions and Plating at NC State Microbiology labs. URL: https://youtu.be/IJcw4fRsYnU

Conclusion

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3.

Approved by _____

Name, Surname, signature

Date _____

Laboratory work

Mechanical equipment for meat processing

Materials

Different types of meat samples ground with different mesh sizes of grinder.

Methods and Procedures

According to the flow chart (see below in Figure 4.4.), students prepare hamburgers. In the meat grinding process use different mesh sizes of grinder.

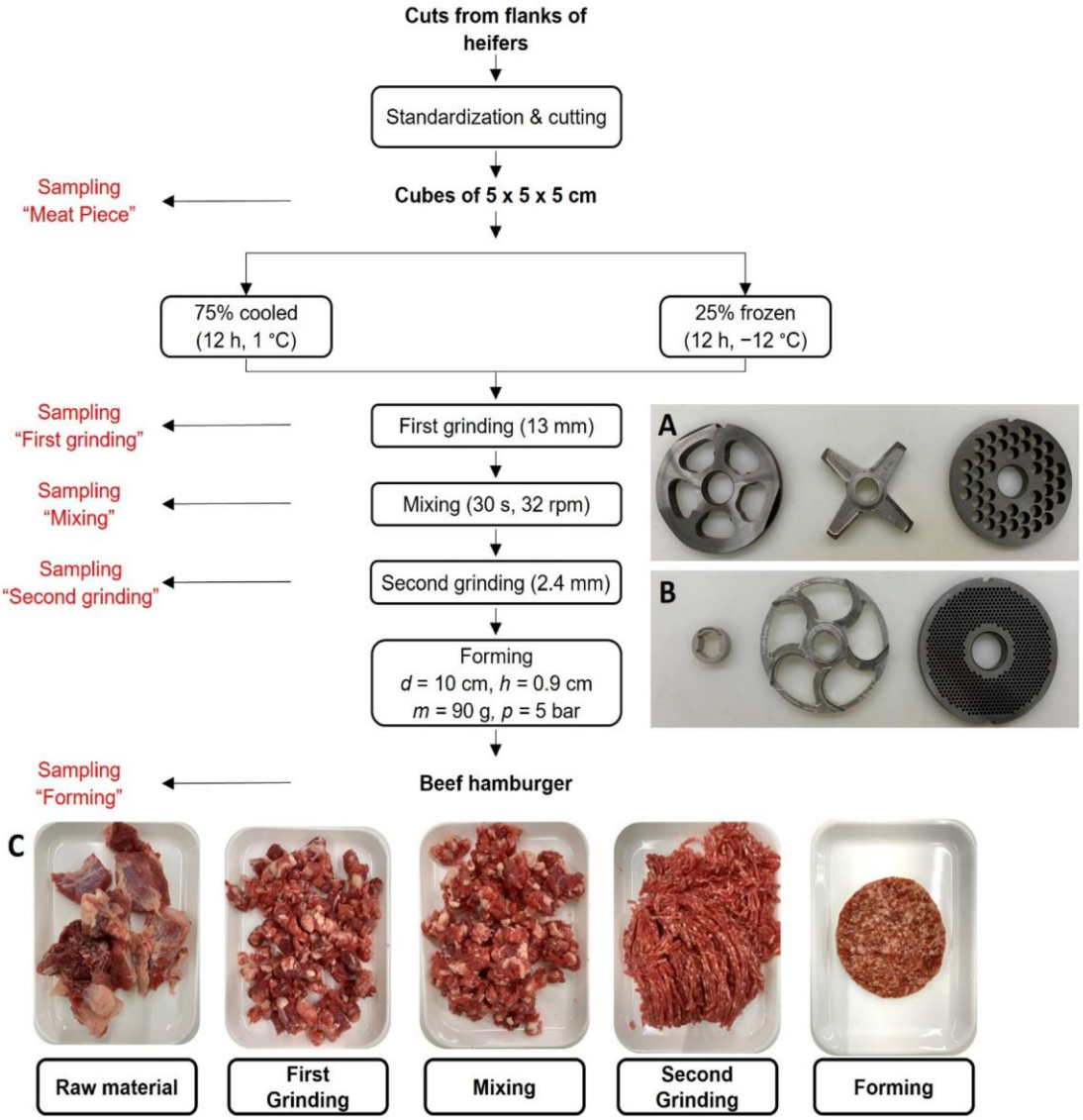

Figure 4.4. Flow chart of the hamburger manufacturing with different points of sampling, cutting set composition of (A) first grinding step (3-part cutting system:

pre-cutter, 4-bladed knife, 13 mm inclined perforated disc) **and (B) second grinding step** (3-part cutting set: spacer, 5-bladed sickle knife, 2.4 mm inclined perforated disc) **and photographs of the samples (C)** (https://www.mdpi.com/2076-3417/12/15/7377#)

RESULTS

Draw conclusions and compare the obtained results with the information available in the literature and scientific publications.

Conclusion

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Seminar

Optimal packaging solutions for preserved meat products

The optimal packaging solution includes the correct selection of packaging materials, packaging gas environment, packaging equipment and technological processes.

A = 100% CO_2 / *1 °C*
B = 10–30% CO_2, 90–70% N_2 / *1 °C*
C = vacuum / *1°C*

D = 100% CO_2 / *4–6 °C*
E = vacuum / *4–6 °C*
F = 10–30% CO_2, 90–70% N_2 / *4–6 °C*

G = air/ *1 °C*
H = air / *4–6 °C*

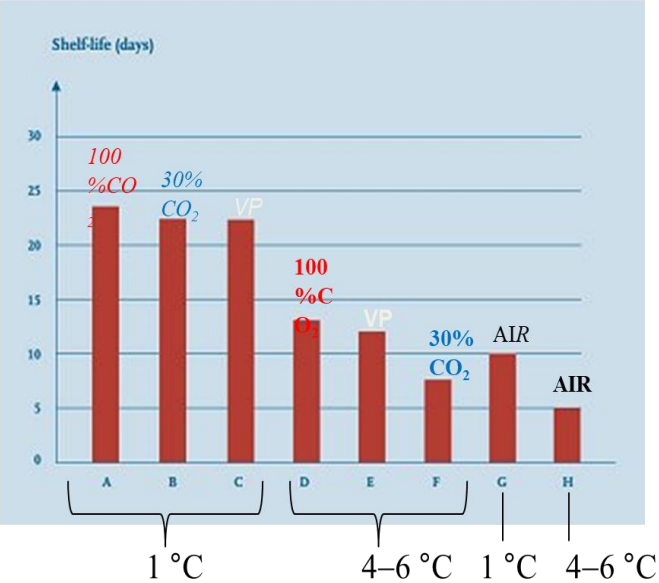


Figure 4.5. Gas composition and temperature influence on meat storage time

VIDEO: packaging process: (11.4 min):
https://www.youtube.com/watch?v=nqcwpa7aAV0&nohtml5=False

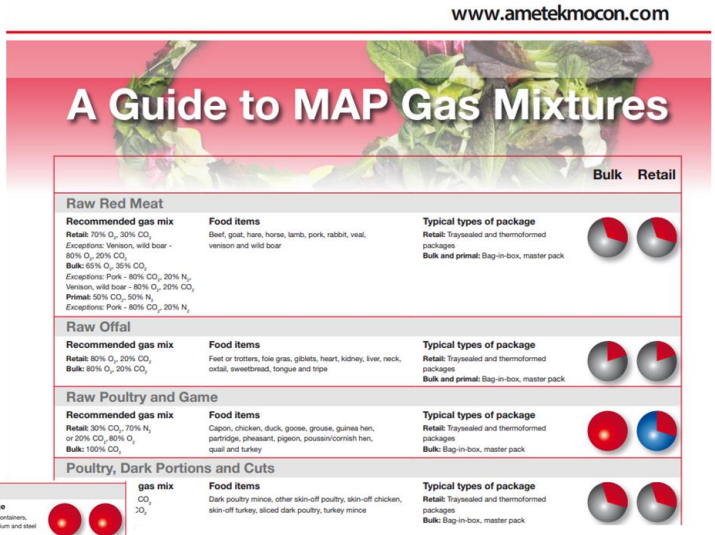
Vacuum Sealer Operation Techniques

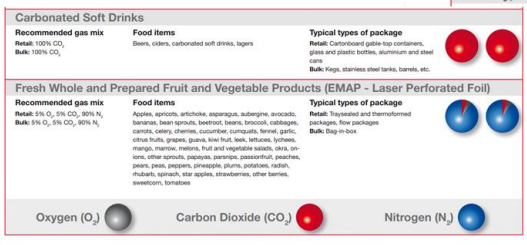
When packaging products in a gas environment, it is essential to choose the most appropriate composition of gasses, which can extend the time of shelf life.

A guide of MAP gas mixtures:

http://modifiedatmospherepackaging.com/~/media/Modifiedatmospherepackaging/Brochures/MAP-Poster-Guide-2014.ashx

file:///C:/Users/Lietotajs/Desktop/Packaging_ERASMUS_EN_2022/dansensor-map-gases-guide-poster_2019_web.pdf





The issue of not only packaging products in such a way that they have a longer shelf life, but also how to optimise the packaging in the direction of sustainability is becoming more and more urgent.

The aim of the seminar is to gain knowledge and acquire skills in the packaging of preserved meat products using different packaging equipment, and different packaging

materials. The group of students is divided into teams and each team analyses products packaged using different packaging solutions.

Materials

Different prototypes of packaged products, or photos found on the Internet of different packaged products.

Methods and Procedures

Each group of students analyses three different packages. And the characteristics are given in Table 4.6.

Results

The results obtained should be reflected in Table 4.6.

After completing the table, different groups of students compare the results. If possible, each group presents and justifies its performance.

During the exercise, the students acquire skills in characterising packages and analysing situations, as well as experience in working in groups.

Table 4.6.

Packages characterisation

Characteristic parameters	**Samples**		
	Product No. 1	Product No. 2	Product No. 3
Packaging material			
Packaging shape			
Is gas environment used in the package, if yes, what is its composition?			
What equipment can be used for this packaging process?			
What information is printed on the package?			
Does the packaging contain information about the recyclability of the packaging?			

Conclusion

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Date _____

Theme 5

Meat products

Theoretical materials

Sausage classification

Sausage type:

- fresh sausages,
- cooked and smoked sausages,
- uncooked, smoked sausages,
- dry or fermented sausages,
- fermented sausages,
- semi-dry sausages,
- mould-ripened sausages.

Fresh sausage:

- fresh sausage is made from coarse or finely ground meat,
- it is mixed with seasonings and can be stuffed into casings, wrapped as a bulk package, or pressed into patty form,
- this type must be refrigerated and thoroughly cooked before eating,
- fresh sausage is typically prepared from one or more kinds of meats, but not from meat by-products (heart, kidney, or liver, for example),
- it may contain water (not exceeding 3 percent of the total ingredients in the product), binders and extenders (for example, wheat flour and non-fat dry milk),
- examples include fresh pork breakfast sausage, Italian sausage, bulk pork sausage, and most bratwurst.

Figure 5.1. Fresh sausages - examples

https://www.stoysichonline.com/product-page/fresh-sausage
https://www.5280.com/stuff-it-try-western-daughters-sausage-101-class/

Cooked and smoked sausages:

- cooked and smoked sausages are made from meats that are ground, seasoned, stuffed into casings, and fully cooked (to a min. internal temperature of 72 °C) and smoked during processing,
- cooked sausages, like frankfurters or bologna, are made from fresh or frozen meats that are cured during processing, fully cooked and/or smoked, then packaged as ready-to eat products,
- cooked sausages are perishable and will last approximately seven to 14 days under refrigerated conditions,
- these sausages must be refrigerated all the time, up until time of consumption,
- since most processors prefer to vacuum-pack these sausages, consumers should pay attention to storage-life and reheating conditions,
- cooked and smoked sausages develop some additional flavours through the addition of nitrates and during the cooking and smoking processes,
- examples of cooked and smoked sausages are wieners, bologna, Berliner, cotto salami, frankfurters, and red hots.

Figure 5.2. Cooked sausages - examples

https://www.rgk.lv/b/raznas-doktordesa-1
https://gpu.lv/produkti/cisini-un-sardeles/sardeles-premium/
https://www.prasuma.com/product/chicken-frankfurters

Uncooked, smoked sausages:

- uncooked, smoked sausages are manufactured from ground meat, seasoned, stuffed in casings, and smoked,
- these sausages are smoked for flavour development; they MUST be fully cooked before eating,
- uncooked, smoked sausages must be stored under refrigerated conditions or can be frozen for longer storage,
- uncooked, smoked sausages are NOT ready to eat. “Uncooked”, “Ready-to-cook”, “Cook-before eating”, “Cook and serve”, or “Needs to be fully-cooked” should be stated on the label,
- the product should display cooking directions that are sufficient for the intended user to prepare it properly.

Dry or fermented sausages:

- the lactic acid is produced by microbial fermentation of the sugars, and the addition of salt often provides a distinctive and enticing aroma, flavour, and a characteristic “bite”,
- sausages are dried for varying lengths of time during processing and smoking, depending on the sausage type,
- fermentation and drying are the oldest way of preserving meat and meat products. The drying is accomplished by adding salt to meat to prevent spoilage,
- they are also referred to as “summer sausages” and eaten cold,
- some examples are summer sausage, Italian salami, German salami, Lebanon bologna, Genoa salami, thuringer, cervelat, and pepperoni,
- fermented sausages are prepared from chopped or ground meat products that, as a result of microbial fermentation of a sugar, reach a pH range of 4.6–5.3 (pH of 4.6– 5.0 is more typical) and have undergone a drying or aging process to remove 15–25 per cent of the moisture,
- these products are typically cured, but not necessarily cooked or smoked,
- dry- and semi-dry sausages are considered shelf stable due to low water activity (aw), and may be sold and consumed without further cooking or heat treatment,
- sausage products must have an aw below 0.85 and a pH under 5.3 to be shelf stable,
- examples are pepperoni and salami(s).

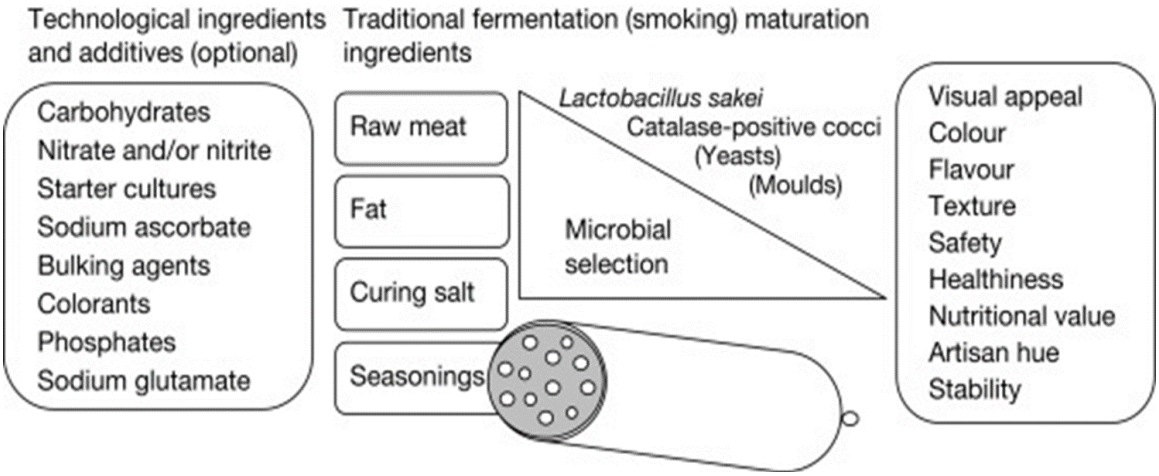

Figure 5.3. The main ingredients of fermented sausages

Figure 5.4. Fermented sausages - examples

https://www.labmanager.com/how-microbes-in-starter-cultures-make-fermented-sausage-tasty-23481
https://www.dekeysermeatproducts.com/products/salami-and-fermented-meat-products

Semi-dry sausages:

- semi-dry sausages differ greatly from dry sausages due to their pronounced tangy flavour,
- these products are generally stuffed in medium- to large-diameter natural casings, and the length of fermentation, drying, and/or smoking depends on their type,
- the final pH of semi-dry sausages varies from 4.7 to 5.4, but their moisture content is typically 35 percent or higher,
- semi-dry sausages may be smoked and slightly cooked in the smokehouse and after smoking, or these sausages may be air dried for a relatively short time,
- compared with dry sausages, semi-dry products have higher water activity (aw) values (greater than 0.90 up to 0.91),
- the main difference with semi-dry fermented sausages is the long maturing and drying process.

Figure 5.5. Semi dry sausages - examples

https://wolt.com/en/lva/cesis/venue/ama/items/puszavetas-desas-8
https://wolt.com/en/lva/cesis/venue/ama/mednieku-desinas-itemid-65d34bda8c8ca5597d264df6

Mould-ripened sausages:

- ❖ mould-ripened sausages are raw, fermented products usually with a longer ripening and drying time,
- ❖ mould-ripened sausages can be classified as very similar to fermented sausages,
- ❖ mould growth requires time and a supporting environment with adequate temperature and relative humidity,
- ❖ the starter culture can be the mould present either as native flora or added as an artificial inoculum,
- ❖ mould growth and changes in ripening conditions are the basic differences between sausages with and without mould.

Figure 5.6. Mould-ripened sausages examples

https://startercultures.eu/product/sausages-and-charcuterie/starter-cultures-for-sausage-making/molds/bactorferm-600/

Meat products and contamination risks

Ham

To a certain degree, microorganisms can enhance the quality of meat products. They have the ability to increase the nutritious content of meat products in addition to accelerating the breakdown of fat and protein and enhancing the creation of flavouring compounds. In addition, they can lessen the amount of salt used in meat products, enhance their flavour, lower the amount of nitrite and BAs, stop the growth and reproduction of dangerous bacteria, and increase the safety of meat products.

Fresh (frozen) pig hind legs are the main raw material used to make ham, which is a non-ready-to-eat pork product that is further enhanced by other ingredients after curing, washing, desalting, air-drying, fermenting, and other procedures. The staphylococci and the aldehyde compounds that are generated as hexanal, nonanal, benzaldehyde, and phenylacetaldehyde have a close link that suggests their roles in the development of distinctive flavour compounds in Jinhua dry-cured ham. Moulds and yeasts were mostly found on the outside of the ham, whereas cocci and yeasts were mostly found on the inside. The amount of microorganisms within the Jinhua ham reduced to 2.0×10^3 CFU/g throughout the maturation stage, from 1.39×10^6 CFU/g during the dehydration of the ham. The two main types of bacteria found in Jinhua ham are lactic acid bacteria and staphylococci. Primarily, *Pediococcus urinaeequi (P. urinaeequi), Pediococcus pentosaceus,* and *Lactiplantibacillus pentosus* have been identified as the lactic acid bacteria. *Staphylococcus xylosus, Staphylococcus equus*, and *Staphylococcus gallinarum* are the three main species of staphylococci.

Moulds, staphylococci, and micrococci were the most common microorganisms in ham; their counts above 10^2 CFU/g internally and over 10^6 CFU/g on the surface. The ham was found to contain 27 fungi according to PCR-DGGE analysis. The main species were *Candida glucosophila, Yamadazyma triangularis, Aspergillus pseudoglaucus, Phialosimplex caninus,* and *Aspergillus penicillioides. Aspergillus pseudoglaucus* was the most common species. Ham has a higher diversity and abundance of bacteria than fungi. At the phylum level, ten bacterial phyla were identified, with Firmicutes and Proteobacteria being the most prevalent. At the genus level, 154 different bacterial genera were found, with *Psychrobacter, Acinetobacter, Ochrobactrum, Staphylococcus*, and *Micrococcus* being the most prevalent genera. At the phylum level, four fungal phyla were identified, with Ascomycota being the most prevalent fungi. At the genus level, 51 fungal genera were identified, with *Debaryomyces, Aspergillus, Yamadazyma, Candida*, and *Penicillium* emerging as the most prevalent fungi. Ten strains in all were obtained after the dominant microorganisms in ham were isolated and purified. These strains included four strains of *S. equinosus*, two strains of *S. xylosus*, two strains of *Lactococcus lactis*, one strain of *Candida metapsilosis*, one strain of *Candida parapsilosis*, and two strains of *S. equinosus*.

Sausage

A variety of non-ready-to-eat meat products, such as sausage, are created by cutting (or mincing), stirring, curing, filling (or shaping), baking (or air-drying in the shade), smoking (or not smoking), and other procedures from fresh (frozen) livestock and poultry meat and other auxiliary materials. Sausage was shown to include Bacteroidetes, Proteobacteria, Firmicutes, and Actinobacteria at the phylum level. The two most common phyla were Firmicutes (85.65-93.96%) and Proteobacteria (5.59-13.95%). At the genus level, *Lactobacillus, Weissella, Brochothrix, Pediococcus,* and *Staphylococcus* were found. The two most common genera among them were Lactobacillus (63.14%) and *Weissella* (26.74%). Ninety percent of sausages contained unclassified fungi; only Ascomycota and Bangiales accounted for more than 0.1% of the total fungi. At the genus level, *Porphyra* accounted for 10.75%, whereas *Debaryomyces* and *Saccharomyces* contributed less than 1 percent.

Sausages were used to isolate 12 strains of lactic acid bacteria and 19 strains of staphylococci. *S. epidermidis, Staphylococcus cohnii, Lactococcus garvieae*, and *Bacillus* spp. were the secondary dominant bacteria, according to PCR-DGGE identification. The primary dominant bacteria were *Staphylococcus saprophyticus (S. saprophyticus), S. xylosus*, and *Lactobacillus*. Sausages were found to include the following phyla: Firmicutes (57.01%), Proteobacteria (30.43%), Cyanobacteria (7.67%), Bacteroidetes (2.63%), and Actinobacteria (2.01%), with Firmicutes and Proteobacteria being the two most prevalent phyla. Among the genera that were discovered, *Brochothrix* accounted for 38.34 percent, followed by *Staphylococcus* (9.79%), *Psychrobacter* (7.55%), *Photobacterium* (5.90%), *Pseudomonas* (4.82%), *Lactobacillus* (2.80%), *Leuconostoc* (2.29%), and *Acinetobacter* (2.19%).

In most sausages, the main phylum is Firmicutes. Furthermore, the most common genera were *Pseudomonas, Tetragenococcus, Psychrobacter, Lactobacillus*, and *Micrococcus*. The Ascomycota was the most common phylum of fungi. Research has indicated that in five different varieties of sausage, *Lactobacillus, Staphylococcus, Leuconostoc, Lactococcus*, and *Weissella* are the predominant genera, and Firmicutes and Proteobacteria are the major phyla. *S. xylosus, Leuconostoc citreum, Lactococcus raffinolactis, W. hellenica, L. sakei*, and *L. plantarum* are the dominant species.

Preserved meat

A variety of non-ready-to-eat meat products, such as preserved meat, are created using fresh (frozen) cattle meat as the main ingredient and other ingredients through curing, baking, smoking, air-drying in the shade, or drying by other methods. The main flavouring agents in preserved meat were hexanal, 3-methyl butyraldehyde, 3-methyl valeraldehyde, (E)-2-octenal, octanal, linalool, nonanal, hexanoic acid, ethyl hexanoate, anisole, and acetone.

Traditional preserved meat contains microorganisms belonging to the phylum Firmicutes, Proteobacteria, Actinobacteria, Cyanobacteria, and Bacteroidetes, with Firmicutes being the most prevalent phylum. Staphylococcus was the most common genus among the bacteria, with *Micrococcus, Acinetobacter, Psychrobacter, Pseudomonas, Brochothrix, Cupriavidus, Citrobacter*, and *Enterobacter* being the other genus.

Traditional preserved meat contains *Ascomycota, Basidiomycota, Glomeromycota*, and *Rozellomycota* among other fungi, with Ascomycota being the most prevalent phylum. At the genus level, the dominating fungi were *Aspergillus*, followed *by Debaryomyces, Candida, Wallemia, Penicillium, Malassezia*, and *Didymella*. *Staphylococcus* and *Micrococcus* were the most common microbes during the preserved meat's shelf life, followed by *Lactobacillus*. Firmicutes (54.05%) and Proteobacteria (44.28%) were the two most common phylum-level microorganisms found in preserved meat. *Pseudoalteromonas* (9.37%), *Brochothrix* (8.53%), *Cobetia* (4.71%), and *Acinetobacter* (2.31%) were the most common genus-level microorganisms. 2.6×10^7 CFU/g of yeasts and moulds were found in the conserved beef. Staphylococci and micrococci were counted at 3.7×10^6 CFU/g. Lactic acid bacteria

were detected at 2.4×10^6 CFU/g, while heat-resistant microorganisms were found at 3.5×10^3 CFU/g.

According to a study on the microbial diversity in preserved meats, there were about 20 different phyla present, with Firmicutes, Proteobacteria, Cyanobacteria, and Actinobacteria being the most common. Furthermore, over ten different bacteria taxa were identified, with the most prevalent ones being *Staphylococcus, Sphingomonas, Pseudomonas, Enterobacter, and Leuconostoc. Lactobacillus curvatus (L. curvatus), Latilactobacillus sakei, Companilactobacillus alimentarius (C. alimentarius), P. pentosaceus*, and *Leuconostoc mesenteroides (L. mesenteroides)* were among the lactic acid bacteria found in preserved meat. Among these, *L. plantarum* exhibited a robust acid production capacity and demonstrated a high degree of tolerance towards sodium chloride and sodium nitrite.

In preserved beef, the total quantity of microorganisms was 2.863×10^7 CFU/g. Prior to air drying, the most common microbes at the genus level were *Halospirulina, Acinetobacter*, and *Bacillus*. Following a week of air drying, *Pseudomonas, Acinetobacter, Psychrobacter*, and *Halospirulina* were the most prevalent microbes. Following two weeks of air drying, *Erwinia, Halospirulina, Enterobacter*, and *Acinetobacter* were the most prevalent microbes. Following three weeks of air drying, *Bacillus, Halospirulina, Enterobacter*, and *Erwinia* were the most prevalent microbes. Following four weeks of air drying, *Halospirulina, Acinetobacter, Enterobacter*, and Microbacteriaceae were the most prevalent microbes.

Pressed salted duck

Duck is used as the raw material for pressed salted duck, a non-ready-to-eat meat product that is prepared through the following steps: slaughter, hair removal, evisceration, cleaning and curing, shape, and air drying. A specialty of the southwest is pressed salted duck, which is one of their most well-known goods. The main flavouring ingredients in pressed salted duck are benzoaldehyde and - 2.4-nonadienal. The main substances influencing the flavuor variations in crushed salted ducks from various places were hexanal, nonanal, naphthalene, (Z)-2-heptenal, (E)-2-octenal, (E)-2-kunienal, 1-octene-3-ol, 2-n-pentylfuran, and linalool. In air-dried ducks, there were 4.692×10^3 CFU/g of microbial colonies overall, with *Neisseria, Micrococcus*, and *Staphylococcus* being the three main dominating species.

Yeasts, moulds, micrococci, lactic acid bacteria, and staphylococci are the main helpful microorganisms found in pressed salted duck. *S. carnosus, S. simulans, and S. xylosus* are among the staphylococci. *Lactobacillus: Lactobacillus plantarum, L. sakei, Lactobacillus acidophilus, Lactobacillus lactis, Lacticaseibacillus casei, L. curvatus, Limosilactobacillus fermentum, Loigolactobacillus bifermentans, Levilactobacillus brevis, Lentilactobacillus buchneri* subsp. *buchneri, Lactobacillus helveticus*, and *Lactobacillus delbrueckii* subsp*. bulgaricus* are among the lactic acid bacteria, and *Pediococcus: Pediococcus cerevisiae*, and *Pediococcus acidilactici. Macrococcus auterisiae, Micrococcus candidus, Micrococcus varians, Micrococcus roseus, Micrococcus epidermidis*, and *Micrococcus luteus* are among the micrococci. At the end of the duck's shelf life, *Brochothrix thermosphacta* and lactic acid bacteria were the

main spoilage bacteria in water-cooked salted duck; enterobacteriaceae, micrococci, yeasts, and moulds were the minor components.

Air-dried meat

Meat that has been air dried is kept at low temperatures. To create a product that can be eaten right away, the meat is chopped into thin strips, spiced, pickled, hung in the shade, and allowed to naturally air dry for about three months. Acids, aldehydes, ketones, alcohols, alkenes, sulfur-containing compounds, and heterocyclic compounds are among the volatile taste compounds found in air-dried meat. The main contributors include heptanal, 1-octene-3-ol, cyclopentanol, 3-hydroxy-2-heptanone, and 6-methyl-5-heptene-2-ketone. During the air-drying phase of the beef, micrococci, staphylococci, and lactic acid bacteria were the most common microbes.

The total number of microorganisms was 8.0×10^8 CFU/g, 1.48×10^7 CFU/g of lactic acid bacteria, 4.40×10^8 CFU/g of staphylococci and micrococci, approximately 10^2 CFU/g of *Enterobacteria*, less than 10^5 CFU/g of enterococci, and approximately 1.50×10^4 CFU/g of yeasts and moulds. The air-dried beef included 36% *Enterobacteria*, 33% yeasts, 16% pseudomonades, 10% cocci, and 5% lactic acid bacteria. Twenty-one microbial phyla and two hundred and forty species were found in naturally fermented air-dried beef; the three most common phyla were Firmicutes (39%), Proteobacteria (40%), and Bacteroidetes (14%).

Conclusion

The study of meat products mostly focuses on their microbial variety, the ways in which particular bacteria affect the product's quality, its distinctive flavour, and its manufacturing process. Numerous studies have demonstrated that microbes can enhance the flavour of meat products and prevent the production of nitrosamines, biogenic amines, and other hazardous compounds in fermented meat products; however, the precise mechanisms underlying these effects have not been thoroughly documented.

Microbiological quality indicators of meat products and its change during storage

Spoilage microbial diversity

Major types of spoilage microorganisms in livestock meat

Specific spoilage organisms (SSOs) are a limited initial group of microorganisms found in meat that are responsible for food spoiling; not all bacteria produce this. SSO metabolises available substrates in meat products during preservation, changing the flavour and quality of the meat.

According to a study, *Klebsiella* (46.05%) and *Escherichia* (39.96%) were the most common bacteria in the meatballs of the blown pack spoilage (BPS) group packed with 71.85% CO_2. Because it could pack edema, *Klebsiella pneumoniae* was the primary strain responsible for BPS in meatballs. Both culture-dependent and non-culture-dependent techniques identified Proteobacteria, Firmicutes, *Pseudomonas* spp., *Acinetobacter*

spp., *Pantoea* spp., *Brochothrix* spp., and *Raoultella* spp. as the primary pathogenic and spoilage bacteria in chilled pork. Pork preserved between −2 °C and 4 °C exhibited a highly comparable microbial composition, with the predominant species being *Pseudomonas* and *Brochothrix*. The indicators of damaged pork meat kept at 25°C were *Acinetobacter* spp., *Myroides* spp., and *Kurthia* spp. The current research findings indicate that while the primary putrefactive microorganisms of different types of ham vary, the aberrant growth of lactic acid bacteria, Micrococcaceae, Enterobacteriaceae, yeast, and mould plays a major role in the formation of dry cured ham odour problems. *Aspergillus* (84.27%) was the most common fungus genus in ham, whereas *Clostridium*_sensu_stricto_2 (92.01%) was the most common bacterial genus.

In comparison to normal ham, the amount of Enterobacteriaceae and *Enterococcus* in the degraded ham was much higher. The aberrant growth of Enterobacteriaceae and *Enterococcus* in degraded ham is caused by high water content and low salt content. The three predominant ham spoiling bacteria were *B. cereus* ATCC 14579, *E. faecalis* ATCC 19433, and *C. farmei* CDC 2991–81. The most prevalent *Clostridium* species found in vacuum-packed beef and other raw meats linked to BPS was found to be *C. sestertheticum*. Meat surfaces that were dry-aged for 19 days showed higher levels of Lactobacillus (3.20 log CFU/cm^2) and total viable bacteria (8.75 log CFU/cm^2).

Pseudomonas and *Enterobacteriaceae*, which are thought to be the main spoilers in dry-aged beef, are present in the microbial communities of all the samples examined in dry-aged beef. In a different study, the most common type of *Clostridium* was discovered to be psychrophilic Clostridium spp. after samples of beef and lamb from Europe, North and South America, and Oceania were examined.

Major types of spoilage microorganisms in poultry meat

Poultry meat demand and consumption have been rising steadily on a global scale. Processed chicken meat accounts for over 75% of all poultry meat consumed, with turkey and duck meat following closely behind with roughly 25% each of the total. *Salmonella* and *Campylobacter* are among the pathogenic organisms found in poultry flesh. In cold meat and poultry packed under aerobic conditions, *Pseudomonas* spp., *Bacillus* spp., *Crude Typhimurium* spp., *Schwartzella* spp., and *Aeromonas* spp. are typically considered the dominant communities when defining the dominant spoilage bacteria in the meat product spoilage process based on the number of bacteria. Meat from poultry degrades easily, even when refrigerated.

Clostridium perfringens was shown to have significantly increased with time in nearly all poultry samples that were kept aerobically under various chilling conditions. Poultry flesh kept at 8 °C for four days deteriorates due to *Pseudomonas fluorescens, Aeromonas salmonicida*, and *Serratia liquefaciens*. In poultry products, a number of novel enterococci or lactic acid bacteria have also been discovered, including Heterofermentative lactic acid bacteria, *Seigonensis enterococcus*, and *Viikkiensis enterococcus*. With the advancement of MS investigations, evaluating the spoiling capacity of bacterial isolates cultured in situ is a more suitable method for identifying the predominant spoiling organism.

Pseudomonas fragilis, Pseudomonas lundengensis, and *Pseudomonas fluorescens* are the most prevalent pseudomonas in chicken flesh. During storage, *Pseudomonas aeruginosa*, *Pseudomonas fragilis*, and *Pseudomonas fluorescens* generated slime on meat and its by-products. Pseudomonas aeruginosa secretes extracellular enzymes that exhibit potent protease activity directed against myogenic fibronectin and myxomatosis protein. This facilitates the entry of microorganisms into the meat to find fresh nutrition sources, which increases mucus production and softens the flesh. In addition, during microbial spoilage (MS), the generation and softening of slime were linked to *Serratia* spp., *Micrococcus* spp., *Serratia* spp., and *Brucella* spp.

Common control approaches

Packaging methods

Both intrinsic (natural and added components, pH, redox potential, and water activity) and extrinsic (storage temperature and packing techniques) factors can influence the proliferation of microbes in meat.

A study on modified atmospheric packaging (MAP) found that it could prolong the frozen meat's shelf life. Research has shown that when fresh turkey sausage was combined with MAP (50% CO_2 -50% N_2), a 2% (w/w) lactic acid formulation greatly decreased acidification, off-flavours, and prevented the sausage from turning brown or dark grey. MAP (70% O_2-30% CO_2) modestly lessens the sense of off-flavour in pig sausages. Meat quality decreases during storage due to bacterial metabolism activity as well as bacterial population density. The free amino acids that proteases generate can be further processed by bacteria, giving rise to the mucus and bad flavours linked to spoiling.

Frozen chicken can have its shelf life increased by using a gas mixture of 30% CO_2 and 70% N_2 for MAP, according to earlier research. Compared to storage in the air, meat under this MAP has fewer Pseudomonas species and is less likely to deteriorate. Thus, MAP might have an impact on both bacterial growth and metabolism. Microorganism development and carp shelf life are impacted by various packaging circumstances.

At4 °C, the air-packed (AP) and vacuum-packed (VP) filets had respective shelf lives of 8 and 12 days. The AP sample contains the greatest concentration of *Pseudomonas aeruginosa*, while the VP sample has a comparatively high concentration of lactic acid bacteria (LAB). VP delays the increase in biogenic amine content compared to AP.

The growth of common meat spoilage and dangerous bacteria was examined in relation to innovative antimicrobial packaging materials that contained poly-[2-(tertbutylamino) methylstyrene] (poly-TBAMS). The findings demonstrated that the antibacterial activity increased with a rise in the amount of poly (TBAMS) in the base polymer and that Gram-positive bacteria were more vulnerable to poly (TBAMS) foil than Gram-negative bacteria. A novel hybrid packing pad with antibacterial properties was created using biodegradable polyurethane. It was discovered that this kind of packing material exhibited strong antibacterial activity against *Salmonella typhimurium* and *Staphylococcus aureus*.

TiO_2 nanocomposites and 3kGy radiation were found to prolong the shelf life of fish filets in cold storage by maintaining their chemical, microbiological, and sensory qualities for longer periods of time. Research shown that TiO_2 nanoparticle-containing antibacterial polyvinyl alcohol coatings inhibited *Pseudomonas putida, Aeromonas hydrophila*, and *Shewanella* spp. in addition to extending the shelf life of macroscopic rotenone by one to two days.

Addition of antibacterial substances

Recently, there has been a hunt for new natural product alternatives due to the negative impacts of synthetic preservatives. Commercially available polyphenols minimise the destruction of salt-soluble myogenic fibrin and sulfhydryl groups, inhibit lipoxygenase activity, increase meat colour stability, and slow down the growth of germs. They also lower levels of primary and secondary lipid peroxidation. The plant families *Asteraceae, Lamiaceae, Lauraceae, Myrtaceae, Rutaceae, Umbelliferae, and Zingiberaceae* are among those from which essential oils (EOs) are derived, which are a complex blend of volatile, low molecular weight substances. The bark, flowers, fruits, leaves, roots, and stem of the plant are among the sections that might yield these useful chemicals.

Staphylococcus aureus, Pseudomonas aeruginosa, and *Bacillus cereus* are all inhibited by thymol and carvacrol. On the other hand, it has been noted that Gram-negative bacteria are strongly inhibited by the free terpenes that are frequently present in essential oils. In meat products utilised as fresh pig sausages, sage essential oil (EO) was shown to have the ability to reduce aerobic thermophilic bacterial counts (4.8–7.3%) at the end of the storage period. *Satureja montana* L. EO's antibacterial ability in fresh pork sausage was assessed. When *Satureja montana* L. EO is added to sausage, it can decrease the overall amount of Enterobacteriaceae (7.1-19.6%) and thermophilic aerobic bacteria (4.9-10.9%) compared to the control group. The growth of cryophilic, Enterobacteriaceae, and thermophilic bacteria, as well as *Staphylococcus aureus* and *Escherichia coli* O157:H7, was found to be significantly impacted by both lactobacillus peptides and essential oils in raw beef patties. The samples treated with 0.2% essential oil + 500 IU/g lactobacillus peptide showed the fastest reduction in the number of tested microorganisms.

MAP conditions encourage the growth of anaerobic bacteria, which can create toxins, in fish meat. Consequently, to increase the potency of natural preservatives, they are frequently used in conjunction with other modalities (MAP, edible coatings and films, non-thermal sterilisation, etc.). Black spot shrimp treated with chitosan coating in conjunction with pomegranate peel extract (PPE) showed reduced total volatile alkaline nitrogen and total aerobic colony values than shrimp treated with chitosan coating or PPE alone, suggesting a synergistic effect between the two treatments.

It was discovered that using vacuum packaging with natural antioxidants including rosemary, sage, thyme, and clove essential oils might increase the shelf life of smoked rainbow trout by 6-7 weeks. A prior study examined the impact of commercial oil-based (sunflower, canola, corn, olive, soybean, and hazelnut oils)- nanoemulsions on the fatty acid contents of farmed sea bass kept at 2 ± 2 °C. According to the findings, at the end

of the storage period, the hazelnut group had the greatest polyunsaturated fatty acid concentration, followed by canola and soybean. These oils may be suggested for use in fish nanoemulsions as a preservative.

Sterilization with plasma

Different microbicidal mechanisms are used by reactive oxygen species (ROS) in atmospheric pressure cold plasma (APCP) to affect both Gram-positive and Gram-negative bacteria. Prolonged exposure to APCP raises intracellular ROS levels in Listeria monocytogenes and *Staphylococcus aureus* without significantly harming their cell walls. Staphylococcus aureus and Listeria monocytogenes shrink when exposed to APCP, although the cell wall is not significantly harmed. In addition, it has been demonstrated that the duration of APCP exposure raises the intracellular ROS levels of *Staphylococcus aureus* and *Listeria monocytogenes*. The plasma from dielectric barrier discharge (DBD) sources produces reactive oxygen species (ROS) that can pierce cell membranes, and induce death by damaging intracellular DNA. According to earlier research, DBD treatment decreased the amount of *Listeria monocytogenes* in inoculated meat and meat products by 0.59–6.52 Log CFU/g.

Sterilization of bacteriophages

Phages are thought to be a promising new class of bioretention agents due to their ability to lyse specific and efficient targets of bacteria. Three phage cocktails considerably raised the pH, total volatile basic nitrogen, and organoleptic value indices of catfish filets while also substantially suppressing the growth of *Shiva* in the filets.

Low-level radiotherapy

Low-level radiation is thought to be a typical method for preserving the freshness of fish meat. Sous-vide filets can withstand up to eight weeks of refrigeration by being irradiated (5.0 kGy) without compromising their organoleptic and physicochemical qualities.

Conclusion

Meat microbial contamination, which accounts for about 21% of all food losses, is the primary cause of losses during manufacturing, storage, and distribution. We discuss steps to avoid MS and evaluate recent developments in studies on the microbial variety causing deterioration of animal, poultry, and fish meat. However, more thorough and accurate data on the make-up of microbial communities and the dynamic processes of their metabolism must be obtained in order to achieve more precise and successful control of spoilage microorganisms in meat. Through the identification of distinct interplays among diverse spoilage phenotypes during MS, we could attain manageable product quality throughout the meat production, transportation, marketing, and storage processes.

Laboratory work

Preparation of fresh, semi-dry or cooked sausages, determination and analysis of sensory, physico-chemical, and microbiological quality indicators

Materials

Different types of meat, spices or spice mixtures and other ingredients according to recipes. Students can find in literature or internet sources and choose their favourite fresh, semi-dry or cooked sausages recipe.

Methods and Procedures

Fresh sausages - these products are meat mixtures composed of comminuted muscle meat, with varying quantities of animal fat. These products are only salted, and curing is not practiced.

Non-meat ingredients are added in smaller quantities to improve the flavour and aid binding; in low-cost versions larger quantities are added for volume extension. All meat and non-meat ingredients are added fresh (raw). Heat treatment (frying or cooking) is applied immediately prior to consumption to make the products palatable.

Ingredients: (https://www.simplyrecipes.com/recipes/how_to_make_homemade_sausage/)**:**

- *1.8 kg shoulder* of *beef or sheep meat*
- *450 g beef or sheep fat*
- *40 g salt*
- *35 g sugar*
- *20 g toasted fennel seeds*
- *6 g cracked black pepper*
- *4 g ground nutmeg*
- *1 cup chopped fresh parsley*
- *1 bulb of garlic, peeled and chopped*
- *178 g dry sherry*
- *59 g sherry vinegar*

Additional steps for making sausage mass:

1. Start with very cold ingredients and equipment: make sure your ingredients are laid out, and the meat and fat are very cold (fat can be completely frozen), before you begin (put the meat and fat in a freezer for 2 hours). Put bowls and grinder in the freezer or refrigerator for an hour before using them.

2. Cut the fat and meat into chunks and keep cold in a bowl over ice: prepare a large bowl of ice and put a medium metal bowl on top of it. Slice your meat and fat into chunks between an inch and two inches across. Cut your fat a little smaller than your

meat. To keep your ingredients cold, put your cut meat and fat into the bowl set into a larger bowl filled with ice.

Figure 5.7. Cutting the fat and meat into chunks
https://www.simplyrecipes.com/recipes/how_to_make_homemade_sausage/

3. Mix the meat and fat, add most of the spices and chill: When the meat and fat are cut, mix them quickly. Add in most of your spices; I leave out a tablespoon or two of fennel seeds and a tablespoon of black pepper for later. Mix quickly. Add the salt and sugar and mix one more time.

Figure 5.8. Meat and fat mixing

Place into a covered container or top the bowl with plastic wrap and put the sausage mixture into the freezer for at least 30 minutes but not more than an hour. Now you can call back whoever might have bothered you when you started this process.

4. Mix the sherry vinegar and the dry sherry and chill: I know that sherry is not traditional in Italian sausage. You can use white wine and white wine vinegar if like (I save red wine and red wine vinegar for the hot sausages).

5. Immerse the casings in warm water: if you plan on stuffing your sausage, take out some of the casings and immerse them in warm water. (If you are not planning on stuffing the sausage, you can skip this step.)

Figure 5.9. Casings preparation

6. Set up the grinder: after your sausage mixture has chilled, remove your grinder from the freezer and set it up. I use the coarse die for Italian sausage, but you could use either. Do not use a very fine die, because to do this properly you typically need to grind the meat coarse first, then re-chill it, then grind it again with the fine die. Besides, an Italian sausage is supposed to be rustic.

7. Push the mixture through grinder and chill: push the sausage mixture through the grinder, working quickly. If you use the KitchenAid attachment, use it on level 4. Make sure the ground meat falls into a cold bowl. When all the meat is ground, put it back in the freezer and clean up the grinder and the work area.

8. Add the remaining spices and sherry mixture: when you've cleaned up, take the mixture back out and add the remaining spices and the sherry-sherry vinegar mixture. Using the paddle attachment to a stand mixer (or a stout wooden spoon, or your very clean hands), mix the sausage well. With a stand mixer set on level 1, let this go for 90 seconds. It might take a little longer with the spoon or hands. You want the mixture to get a little sticky and begin to bind to itself — it is a lot like what happens when you knead bread.

When this is done, you have sausage. You are done if you are not making links. To cook, take a scoop and form into a ball with your hands. Flatten out a bit. Cook on medium low heat in a skillet for 5 to 10 minutes each side until browned and cooked through.

Figure 5.10. Meat mass mixing

Additional steps for making sausages:

1. Chill the sausage mixture: put the mixture back in the freezer so it's chilled for stuffing in the casings.

2. Run warm water through the casings and set up sausage stuffer: bring out your sausage stuffer, which should have been in the freezer or refrigerator. Run warm water through your sausage casings. This makes them easier to put on the stuffer tube and lets you know if there are any holes in the casings. Be sure to lay one edge of the flushed casings over the edge of the bowl of warm water they were in; this helps you grab them easily when you need them.

3. Slip a casing onto the stuffing tube: Leave a “tail” of at least 6 inches off the end of the tube: You need this to tie off later.

Figure 5.11. Casing slipping onto the stuffing tube

4. Add the meat to the stuffer and start cranking the stuffer: take the meat from the freezer one last time and stuff it into the stuffer. If all the meat will not fit, keep it in a bowl over another bowl filled with ice, or in the fridge while you stuff in batches. Start cranking the stuffer down. Air should be the first thing that emerges — this is why you do not tie off the casing right off the bat.

5. Let the sausage come out in one long coil and then tie-off: when the meat starts to come out, use one hand to regulate how fast the casing slips off the tube; it’s a little tricky at first, but you will get the hang of it. Let the sausage come out in one long coil; you will make links later. Remember to leave 6 to 10 inches of “tail” at the other end of the casing. Sometimes one really long hog casing is all you need for a 5-pound batch. When the sausage is all in the casings, tie off the one end in a double knot. You could also use fine butcher’s twine.

Figure 5.12. Meat stuffing into casings

6. Pinch and spin the links: With two hands, pinch off what will become two links. Work the links so they are pretty tight: You want any air bubbles to force their way to the edge of the sausage. Then spin the link you have between your fingers away from you several times. Repeat this process down the coil, only on this next link, spin it towards you several times. Continue this way, alternating, until you get to the end of the coil. Tie off the other end.

Figure 5.13. Sausages formation

7. Hang the sausages and prick air bubbles with sterilised needle: almost done. Time to hang your sausages. Hang them on the rack so they don't touch (too much), and find yourself a needle. Sterilise it by putting into a gas flame or some such, then look for air bubbles in the links. Prick them with the needle, and in most cases the casing will flatten itself against the link.

Figure 5.14. Sausages hanging

8. Let dry for an hour or two and then chill: let these dry for an hour or two, then put them in a large container in the fridge overnight, with paper towels underneath. Package them up or eat them the next day. They will keep for a week, but freeze those that will not be used by then.

Results

Sensory evaluation of all prepared fresh, semi-dry and cooked sausages. Compare the samples and choose the best one. Analysis of the physico-chemical, microbiological quality indicators as described above.

Conclusion

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Approved by _____

Name, Surname, signature

Date _____

Laboratory work

Microbiological evaluation of processed meat products

Enumeration of Bacteria

Often one needs to determine the number of organisms in a sample of material, for example, in water, foods, or a bacterial culture. For example, bacterial pathogens can be introduced into foods at any stage: during growth/production at the farm, during processing, during handling and packaging, and when the food is prepared in the kitchen. In general, small numbers of pathogenic bacteria are not dangerous, but improper storage and/or cooking conditions can allow these bacteria to multiply to dangerous levels. Faecal contamination of water is another one of the ways in which pathogens can be introduced (1). Coliform bacteria are Gram-negative non-spore forming bacteria that are capable of fermenting lactose to produce acid and gas. A subset of these bacteria are the faecal coliforms, which are found at high levels in human and animal intestines. Faecal coliform bacteria such as *Esherichia coli*, are often used as indicator species, as they are not commonly found growing in nature in the absence of faecal contamination. The presence of *Eschericia coli* suggests faeces are present, indicating that serious pathogens, such as *Salmonella* species and *Campylobacter* species, could also be present.

Methods of Enumeration

Many approaches are commonly employed for enumerating bacteria, including measurements of the *direct microscopic count, culture turbidity, dry weight of cells,* etc. In a microbiology lab, we frequently determine the total viable count in a bacterial culture. The most common method of measuring viable bacterial cell numbers is the *standard or viable plate count or colony count.* This is a viable count, NOT a total cell count. It reveals information related only to *viable or live* bacteria. Using this method, a small volume (0.1-1.0 mL) of liquid containing an unknown number of bacteria is spread over the surface of an agar plate, creating a "spread plate." The spread plates are incubated for 24-36 hours. During that time, each individual viable bacterial cell multiplies to form a readily visible colony. The number of colonies is then counted and this number should equal the number of viable bacterial cells in the original volume of sample, which was applied to the plate.

For accurate information, it is critical that each colony comes from only one cell, so chains and clumps of cells must be broken apart. However, many bacterial species grow in pairs, chains, or clusters or they may have sticky capsules or slime layers, which cause them to clump together. It is sometimes difficult to separate these into single cells, which in turn makes it difficult to obtain an accurate count of the original cell numbers. Therefore, the total number of viable cells obtained from this procedure is usually reported as the number *of colony-forming units (CFUs).*

A bacterial culture and many other samples usually contain too many cells to be counted directly. Thus, in order to obtain plates, which are not hopelessly overgrown

with colonies, it is often necessary to *dilute* the sample and spread measured amounts of the diluted sample on plates. Dilutions are performed by careful aseptic pipetting of a known volume of sample into a known volume of a sterile buffer or sterile water. This is mixed well and can be used for plating and/or further dilution. If the number of cells in the original sample is unknown, then a wide range of dilutions are usually prepared and plated. The preparation of dilutions and the calculation and use of dilution factors to obtain the number of microorganisms present in a sample are important basic techniques in microbiology.

Materials

Cultures: stationary phase broth culture of *Serratia marcescens*

Media: dilution tubes of sterile water

Supplies: nutrient agar plates, P-1000 Pipetman, sterile tips, Sterile L-shaped blue cell spreaders ("hockey stick" or spreader")

Methods and Procedures

Aliquots from a stepwise or *serial dilution* of the original sample are spread on plates. Only a few of the plates following incubation will contain a suitable number of colonies to count; those plated from low dilutions may contain too many colonies to count easily while those plated from high dilutions may contain too few colonies or none at all. Ideally plates containing 30-300 colonies per plate should be counted. At this colony number, the number counted is high enough to have statistical accuracy, yet low enough to avoid mistakes due to overlapping colonies.

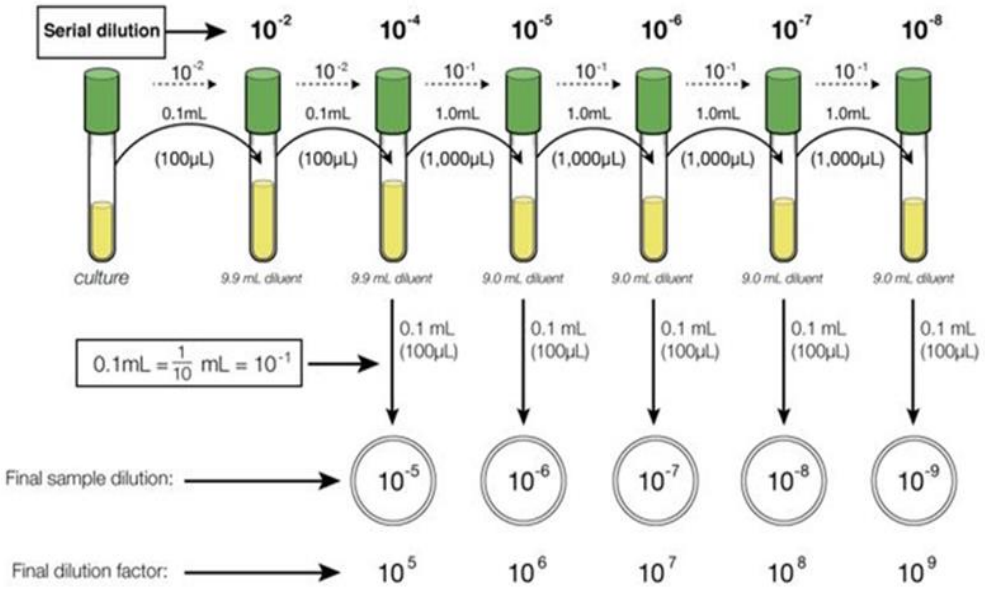

Figure 5.15. Serial dilution series and plating

A wide series of dilutions (e.g. 10^{-2} to 10^{-8}) is normally performed on the sample culture and spread plates created from the dilutions. A number of spread plates are needed because the exact number of live bacteria in the sample is usually unknown. Greater accuracy can be achieved by plating duplicates or triplicates of each dilution.

Figure 5.16. The series of dilutions

B. Counting colonies on plates

1. Looking at your dilution plates prepared last period, choose the plates that have from 30-300 colonies on them. As this might take some practice in plate counting, you might need to choose all plates with what looks like a reasonable number of colonies to count.

a. Those plates that have no microbial growth can be recorded as 0 or NG, No Growth.

b. Those plates on which colonies are not individually distinct (their edges run together) can be recorded as TNTC, Too Numerous To Count.

c. Those plates on which you cannot distinguish any individual colonies, the entire surface is covered with microbial growth, can be recorded as *confluent*.

2. Count each colony to give a total colony count for each plate chosen. You will avoid counting a colony twice by marking off the colonies on the bottom of the plate as you count them. This requires, of course, that the plate be upside down. Be sure to count any small colonies. Record your results on the report sheet.

Results

C. Calculation of number viable cells/mL in the original sample

• Choose the plate containing between 30 and 300 colonies.

• Multiply the *number of colonies on the plate* by *the final dilution factor.* This gives the total viable cells/mL in the original sample.

• Calculate the colony-forming units, CFU, per mL for the *Serratia marcescens* culture. Watch Video 1: Dilutions and Plating at NC State Microbiology labs. URL: https://youtu.be/IJcw4fRsYnU

Draw conclusions and compare the obtained results with the information available in the literature and scientific publications.

Conclusion

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3.

Approved by _____

Name, Surname, signature

Date _____

Laboratory work

Sensory evaluation of meat products

Materials

A total of five sausage samples are used for the sensory evaluation – four from previously prepared samples and one from the store, already available in the market. The sausage samples are served in containers coded with three randomised numbers. Sample size – approximately 25-30 g to each panellist.
To clean your mouth between samples - warm black tea and / or Maca bread.

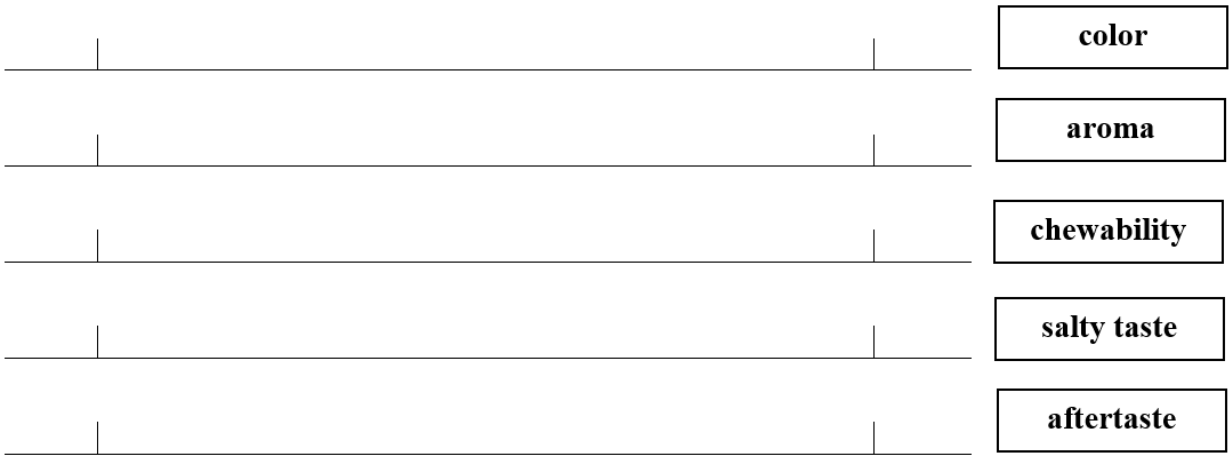
Methods and Procedures

Task – to evaluate the intensity of sensory properties (colour, aroma, chewability, salty taste and aftertaste) for sausage samples.

12 cm Line scale

TRAY NO. _____

Please mark the intensities of the presented product samples on the Line scale and write the sample number below the marking.



Results

After samples sensory evaluation and completing the line scales, students compare the results and draw the main conclusions.

Conclusion

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Approved by _____

Name, Surname, signature

Date _____

Laboratory work

Preparation of semi-finished and liver pate or liver sausages. Determination and analysis of sensory, physico-chemical and microbiological quality indicators

Materials

Fresh chicken meat, beef livers and other ingredients according to recipes. Students can find in literature or internet sources and choose their favourite pâté recipe.

Methods and Procedures

Chicken liver pate I

Figure 5.17. Chicken liver pate I

https://www.delfi.lv/tasty/45833919/recepsu-kolekcijas/51875043/majas-gatavota-aknu-pastete-17-receptes-un-specialistu-padomi

https://www.santa.lv/raksts/ievasreceptes_/receptes/pamatsastavdalas/vistas-galas-edieni/vistu-aknu-pastete-ar-brendija-piedevu-11191/

Ingredients:

- *1 kg of chicken liver*
- *2 carrots*
- *1 celery stalk*
- *2 onions*
- *2 cloves of garlic*
- *Thyme*
- *1 bay leaf*
- *300 g of whipping cream (35% fat)*

- *150 g melted butter*
- *Frying oil*
- *Salt, pepper*
- *Nutmeg*

1. Chicken livers are washed, dried, cleaned of films, tendons, blood vessels and cut into small pieces.

Figure 5.18 Chicken livers cutting

2. Chop carrot, celery stalk, onions and garlic into small pieces. Heat 25 g of butter in a pan, add a little oil and fry the liver quickly. Add sliced vegetables, thyme and bay leaf. Allow it to fry a little.

3. Add whipping cream, salt and pepper, boil and simmer for 5-6 minutes, remove from heat and cool slightly.

Figure 5.19. Chicken liver frying with vegetables, spices and whipping cream

4. The thyme twigs and bay leaf are removed, the liver and vegetables are finely blended or ground several times in a meat grinder.

5. Mix the rest of the butter, add nutmeg, add salt and pepper to taste, reheat and whisk well.

Figure 5.20. Chicken liver pate mixing

6. Finished pate is filled into dishes, decorated and cooled.

Chicken liver pate II

Figure 5.21. Chicken liver pate II

https://www.delfi.lv/tasty/45833919/recepsu-kolekcijas/51875043/majas-gatavota-aknu-pastete-17-receptes-un-specialistu-padomi

https://www.piegalda.lv/receptes/garda-aknu-pastete/

Ingredients:

- *1 kg of fresh chicken liver*
- *2 small onions*
- *3-4 cloves of garlic*
- *1 carrot*
- *100 g of melted butter*
- *4 tablespoons oil*
- *2 hard boiled eggs*
- *2 large sweet and sour apples*
- *300 g of whipping cream*

- *Glass of milk*
- *Freshly ground black pepper*
- *Salt*

1. The liver is washed under running water and cleaned of films with a knife. Then put the liver in a bowl, pour cold milk and leave to soak for approx. 2 hours. Milk removes liver acuity. If you need to hurry, the liver can also be cooked unabsorbed.

Figure 5.22. Chicken liver soaking in cold milk

2. The eggs are peeled and chopped, the apples are peeled and cut into slices. Onions and garlic are cleaned and finely chopped, peeled carrots are finely cut or grated on a coarse grater. Heat 1 tablespoon of oil and 50 g of butter in a pan. Lightly brown the onions, garlic and carrots.

3. The liver is removed from the milk. Heat the remaining oil and butter in a pan and fry the liver on both sides. The liver should not be overcooked – it should be slightly pink inside. When the liver is browned on both sides, add the already fried onions and carrots, as well as the sliced apples and add half a glass of water. Put the lid on the pan and cook for 10-15 minutes.

Figure 5.23. Prepared vegetables and chicken liver frying with vegetables and spices

4. Transfer the liver to a large bowl, add the chopped eggs, add whipping cream and grind into a homogeneous, slightly airy mass. Finely chopped sage leaves can also be added to enrich the taste. Add salt and freshly ground black pepper and mix.

Figure 5.24. Chicken liver pate preparation

5. Put the pate in bowls, melted butter can be poured on top so that the pate does not dry out. When the pate has cooled, it is left to stand in the refrigerator until it is completely cold.

Beef liver pate

Figure 5.25. Beef liver pate

https://flavorfulhome.com/recipes/beef-liver-pate-recipe/

Ingredients:

- *1 kg of fresh beef liver*
- *2 small onions*
- *6 cloves of garlic*
- *1/2 cup olive oil (+ 2 tablespoons for frying)*
- *1 1/2 tablespoons salt*
- *1/2 tablespoon black pepper*
- *1 tablespoon vinegar (or lemon juice for candida diet + AIP)*
- *4 sprigs fresh thyme*

- *2 sprigs fresh rosemary*

1. Start by slicing up your onions and garlic and set them aside in a small bowl.
2. Remove the stems from your fresh herbs and set aside in a small bowl.
3. Next, cut your beef liver into thin slices. Optionally, you can transfer your liver slices over to a plate lined with paper towels to soak up the excess blood.

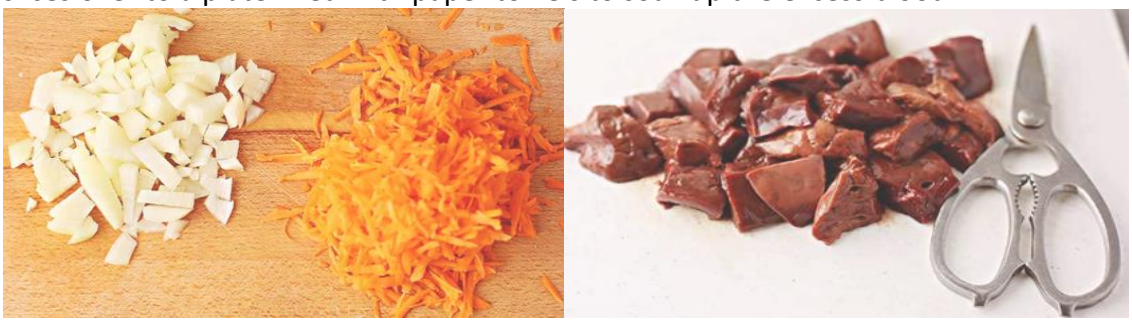

Figure 5.26. Cutting of vegetables and beef livers

4. Heat your frying pan to medium heat, and then add your 2 tablespoons of olive oil, sliced onions and garlic.
5. Sauté your onions and garlic until they start to brown, and then add your liver pieces and your fresh herbs.
6. Fry everything until your liver has cooked through completely.

Figure 5.27. Beef liver and onions frying

7. Turn your stove off and let your cooked liver mixture cool completely.
8. Once it has cooled, transfer the mixture over into your food processor and then add all the remaining ingredients including the 1/2 cup oil, 1 tablespoon vinegar, salt and pepper.
9. Blend in a food processor on high until your pate is smooth and has no remaining clumps.

Figure 5.28. Beef liver pate mixing

10. Serve your pate in small ramekins surrounded by your favourite bread and/or crackers. If you are making it ahead of time, make sure to store it in a sealed container in the fridge (or covered in plastic wrap) until you are ready to serve it.

Figure 5.29. Ready pate product

Results

Carry out sensory evaluation of all prepared liver pate product; compare the samples and chooses the best one. Perform analysis of the physico-chemical, microbiological quality indicators as described above.

Conclusion

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Name, Surname, signature

Date _____

Laboratory work Sensory evaluation of meat products

Materials

A total of five liver pate samples are used for the sensory evaluation – three from previously prepared samples and two from the store, already available in the market. The liver pate samples are served in containers coded with three randomised numbers. Sample size - approximately 20 g to each panellist.
To clean your mouth between samples - warm black tea and / or Maca bread.

Methods and Procedures

Task: to evaluate the liking of liver pate sensory properties - aroma, structure and taste, using a 5-point Hedonic scale.

5-point Hedonic scale

TRAY NO. _____

Please evaluate the liking of the liver pate samples sensory properties. Indicate how much you like or dislike each sample by checking (V or X) the appropriate phrase.

_____
sample code

color

___ like very much
___ like slightly
___ neither like nor dislike
___ dislike slightly
___ dislike very much

aroma

___ like very much
___ like slightly
___ neither like nor dislike
___ dislike slightly
___ dislike very much

consistency

___ like very much
___ like slightly
___ neither like nor dislike
___ dislike slightly
___ dislike very much

salty taste

___ like very much
___ like slightly
___ neither like nor dislike
___ dislike slightly
___ dislike very much

aftertaste

___ like very much
___ like slightly
___ neither like nor dislike
___ dislike slightly
___ dislike very much

_____
sample code

color

___ like very much
___ like slightly
___neither like nor dislike
___ dislike slightly
___ dislike very much

aroma

___ like very much
___ like slightly
___neither like nor dislike
___ dislike slightly
___ dislike very much

consistency

___ like very much
___ like slightly
___neither like nor dislike
___ dislike slightly
___ dislike very much

salty taste

___ like very much
___ like slightly
___neither like nor dislike
___ dislike slightly
___ dislike very much

aftertaste

___ like very much
___ like slightly
___neither like nor dislike
___ dislike slightly
___ dislike very much

_____
sample code

color

___ like very much
___ like slightly
___neither like nor dislike
___ dislike slightly
___ dislike very much

aroma

___ like very much
___ like slightly
___neither like nor dislike
___ dislike slightly
___ dislike very much

consistency

___ like very much
___ like slightly
___neither like nor dislike
___ dislike slightly
___ dislike very much

salty taste

___ like very much
___ like slightly
___neither like nor dislike
___ dislike slightly
___ dislike very much

aftertaste

___ like very much
___ like slightly
___neither like nor dislike
___ dislike slightly
___ dislike very much

_____
sample code

color

___ like very much
___ like slightly
___neither like nor dislike
___ dislike slightly
___ dislike very much

aroma

___ like very much
___ like slightly
___neither like nor dislike
___ dislike slightly
___ dislike very much

consistency

___ like very much
___ like slightly
___neither like nor dislike
___ dislike slightly
___ dislike very much

salty taste

___ like very much
___ like slightly
___neither like nor dislike
___ dislike slightly
___ dislike very much

aftertaste

___ like very much
___ like slightly
___neither like nor dislike
___ dislike slightly
___ dislike very much

_____
sample code

color	**aroma**	**consistency**
___ like very much	___ like very much	___ like very much
___ like slightly	___ like slightly	___ like slightly
___neither like nor dislike	___neither like nor dislike	___neither like nor dislike
___ dislike slightly	___ dislike slightly	___ dislike slightly
___ dislike very much	___ dislike very much	___ dislike very much

salty taste	**aftertaste**
___ like very much	___ like very much
___ like slightly	___ like slightly
___neither like nor dislike	___neither like nor dislike
___ dislike slightly	___ dislike slightly
___ dislike very much	___ dislike very much

Results

After the liver pate sensory evaluation and completing the 5 point Hedonic scales, the students compare the results and draw the main conclusions.

Conclusion

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Name, Surname, signature

Date _____

Laboratory work

Microbiological evaluation of meat processing products

Materials

Cultures: stationary phase broth culture of *Serratia marcescens*
Media: dilution tubes of sterile water
Supplies: nutrient agar plates, P-1000 Pipetman, sterile tips, Sterile L-shaped blue cell spreaders ("hockey stick" or "spreader")

Methods and Procedures

Aliquots from a stepwise or *serial dilution* of the original sample are spread on plates. Only a few of the plates following incubation will contain a suitable number of colonies to count; those plated from low dilutions may contain too many colonies to count easily while those plated from high dilutions may contain too few colonies or none at all. Ideally plates containing 30-300 colonies per plate should be counted. At this colony number, the number counted is high enough to have statistical accuracy, yet low enough to avoid mistakes due to overlapping colonies.

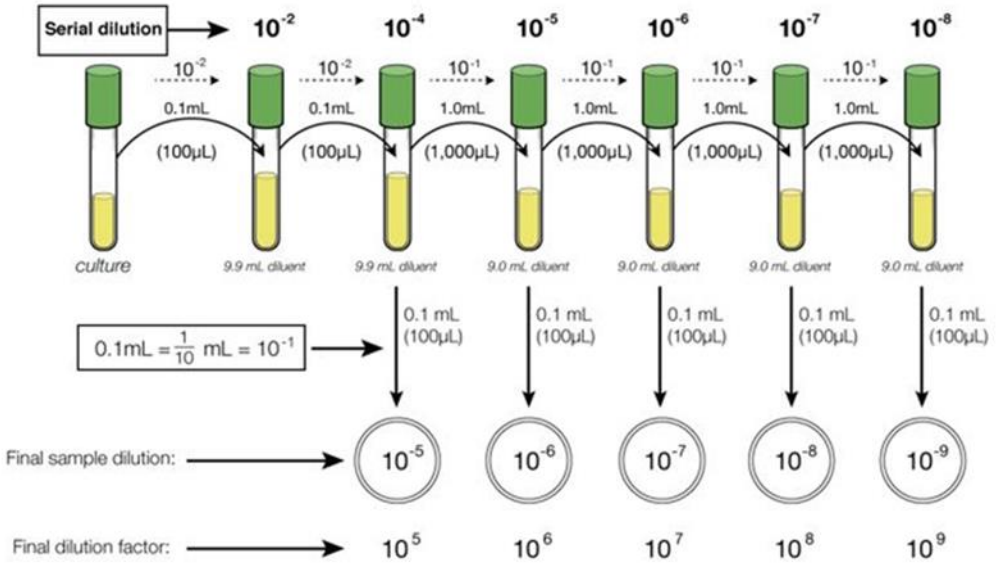

Figure 5.30. Serial dilution series and plating

A wide series of dilutions (e.g. 10^{-2} to 10^{-8}) is normally performed on the sample culture and spread plates created from the dilutions. A number of spread plates are needed because the exact number of live bacteria in the sample is usually unknown. Greater accuracy can be achieved by plating duplicates or triplicates of each dilution.

Figure 5.31. The series of dilutions

B. Counting colonies on plates

1. Looking at your dilution plates prepared last time, choose the plates that have from 30-300 colonies on them. As this might take some practice in plate counting, you might need to choose all plates with what looks like a reasonable number of colonies to count.

a. Those plates that have no microbial growth can be recorded as 0 or NG, No Growth.

b. Those plates on which colonies are not individually distinct (their edges run together) can be recorded as TNTC, Too Numerous To Count.

c. Those plates on which you cannot distinguish any individual colonies, the entire surface is covered with microbial growth, can be recorded as *confluent*.

2. Count each colony to give a total colony count for each plate chosen. You will avoid counting a colony twice by marking off the colonies on the bottom of the plate as you count them. This requires, of course, that the plate be upside down. Be sure to count any small colonies. Record your results on the report sheet.

Results

C. Calculation of number viable cells/mL in the original sample

• Choose the plate containing between 30 and 300 colonies.

• Multiply the *number of colonies on the plate* by *the final dilution factor.* This gives the total viable cells/mL in the original sample.

• Calculate the colony-forming units, CFU, per mL for the *Serratia marcescens* culture. Watch Video 1: Dilutions and Plating at NC State Microbiology labs. URL: https://youtu.be/IJcw4fRsYnU

Draw conclusions and compare the obtained results with the information available in the literature and scientific publications.

Conclusion

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THEME 6

Canned meat products

Theoretical materials

Heating is probably the cheapest and most efficient method of preserving meat; its main objective is to ensure the destruction of most pathogens and spoilage microorganisms and to inactivate enzymes, in such a way as to prevent spoilage reactions and proliferation of undesirable microflora. Depending on the expected shelf life, a specific food is subjected to a set of conditions, of varying intensity. If food is cooked, only partial elimination of spoilage microorganisms and enzymes takes place, but additional preservation methods are necessary; conversely, canning allows the destruction of virtually all microorganisms and their spores, able to proliferate and/or produce toxins, specially *Clostridium botulinum*, as well as spoilage microorganisms. The result of some thermal-processing methods, such as canning, is the production of self-stable foods, with a considerably long shelf life, without the need of applying and other special storage conditions. However, thermal processing usually alters sensory and physical characteristics; in some cases, changes in physical structure are highly desirable, and are even part of the process itself, as is the case of luncheon meat where an emulsion system changes to a gel as a result of thermal processing.

Therefore, a compromise must be reached between food safety and the desirable, or minimum, sensory and physical properties alteration. When a thermal process is applied for the first time, it is calculated taking as the basis the destruction of the most harmful or the most abundant microorganism present, or the enzyme or enzymes that need to be inactivated to prevent spoilage for a reasonably long time. Usually, C. botulinum destruction is taken as a calculation basis, although other bacteria can be considered for meat processing, such as *Staphylococcus aureus* or *Streptococcus thermophilus*, depending if an uncooked or processed meat is processed.

Microorganisms in meat. Microbial populations in foods are not static; as these are heterogeneous substrates, a given microbial population is established depending on nutrient availability. This is even more noticeable when a food material is processed and its chemical and physical characteristics change. In cured meats, considerable microbial reduction is obtained due to the action of nitrites and salt on aw and pH. However, these products require further processing or refrigeration to extend their shelf life. Microbial contamination can occur during meat fabrication; the populations present can be *Enterobacteria*, *Clostridium spp.*, some psychorphiles such as *Lactobacillus viridescens* and *Leuconostoc*.

There is a specific association in refrigerated meats of nonfermentative Gram-negatives belonging to genera *Pseudomonas, Alcaligens, Flavobacterium, Shewella,* and *Moraxella*. The addition of salt, nitrates, and nitrites and phosphates during curing

completely changes the microbial association to Gram positives, such as *Micrococcus*, *Lactobacillus*, *Carnobacterium*, and *Brochothrix*.

Although the striated muscle of a healthy animal is considered sterile, meat microbial contamination starts from a number of sources: water, skin, viscera, and workers' clothing and handling. It is mainly composed by yeasts, bacilli, and bacteria such as *Moraxella, Acinetobacter, Flavobacteria, Enterobacteriaceae*, *Escherichia coli*, *Salmonella spp., Shewanella putrefaciens*, and *Listeria spp*. After prolonged refrigerated storage, psychrophiles are the main responsible of meat spoilage, mainly by *Brochothrix thermosphacta, Carnobacterium spp., Lactobacillus spp., Leuconostoc spp., Weissella spp., Pseudomonas spp., Acinetobacter,* and *Psychrobacter inmobilis*. In poorly refrigerated meats, *Clostridium perfringens* and *Enterobacteriaceae* are present.

In general, no signs of deterioration become evident in meats contaminated with pathogens. There are few exceptions, such as contamination with proteoytic strains of *Clostridium botulinum*, causing off-odours although not intense enough to be taken as a pathogen indicator. Some of the most important microorganisms causing food poisoning, involving meat and meat products are *Salmonella spp., Escherichia coli* O157:H7, *Yersinia enterocolítica, Campylobacter jejuni*, *Staphylococcus aureus, Listeria monocytogenes*, *Clostridium perfringes, Clostridium botulinum, Bacillus cereus,* and *Staphylococcus aureus*.

The thermal destruction of microorganisms is calculated from the point of view of sanitation as well as extending food shelf life. Vegetative cells are destroyed at temperatures slightly higher than their maximum temperature to grow, whereas spores can survive much higher temperatures. Two principles must be taken into consideration:

1. All microbial cells and spores, able to grow and/or to produce toxins, must be eliminated.
2. Spoilage microorganisms must be reduced to a safe lowest limit.

From the commercial point of view, a food is commercially sterile if it is free from *Bacillus stearothermophilus* or *Clostridium perfringens*. Sporulated thermophiles are important only if food is to be stored at high temperatures. Thermal processes that eliminate *Clostridium botulinum* and *Clostridium sporogenes* produce a thermostable food of long shelf life, without the need of other preservation methods.

Heat transfer mechanisms. Process calculations consider vegetative cell destruction following the ratio:

$$\frac{dc}{dt} = kc$$

That is, cell concentration (dc) decreases with time (dt) in a direct proportion to viable cell concentration (c). This is a logarithmic destruction, decreasing one long cycle (for instance, 10^3–10^2) as time linearly increases. This calculation has the advantage of allowing death rate comparison among microbial populations, as all microorganisms follow a log destruction pattern.

In all heat transfer operations, it is necessary to know the amount of heat to be transferred. This allows calculating the transport parameters in the system. As this is a dynamic process, heat flow is proportional to the driving force and inverse to the resistance to flow. The heat transfer mechanisms are conduction, convection, and radiation.

Thermal technologies. Heat transfer is a phenomenon directed by energy interchange; as a material is heated, molecules move faster; the kinetic energy increases the absorbed caloric energy. Heat capacity (Cp, p means that it occurs at constant pressure) defines the amount of caloric energy necessary to increase the temperature to a given mass unit. As mentioned before, the application of a given thermal treatment intensity depends on the required shelf life. It can be as mild as cooking where only few vegetative cells and enzymes are inactivated, to sterilisation where practically all the microorganisms are destroyed. Canning, a treatment at intermediate severity, can range from semi-preserves to tropical preserves with shelf life from 6 months at < 5 °C up to 1 year at 40 °C, respectively. Mild heat treatments, however, need an extra preservation method, such as refrigeration for cooked meats to prevent proliferation of spoilage microorganisms and pathogens as well as toxin production, in some cases. Even Though, heat transfer principles are the same for all thermal technologies, each one has a different aim. Depending on the treatment severity, they can be divided into scalding, cooking, pasteurisation, and sterilisation.

Sterilisation. In a sterile product, no viable microorganism is present. However, the term "sterile" is not suitable for food processing, as the sterility criterion for food is the growth inhibition of vegetative cells and spores in normal storage conditions. Therefore, in foods, the term used is "commercial sterility," "bacteriologically inactive," or "partially sterile." These foods have a considerably extended shelf life without any other preservation method. Usually *Clostridium botulinum* and *Clostridium sporogenes* are used as indicators for meats, and process calculations are based on the destruction of these bacteria.

Process calculations. In order to establish the thermal process severity, calculations require two types of basic information: 1) heat resistance of a given microorganism taken as process indicator, usually *Clostridium botulinum* or *Clostridium perfringens*; 2) previous handling of the products: for meats, post-mortem handling, sanitation, etc. It is also necessary to define the expected shelf life of the product and thermal sensitivity of the product (possible alterations in colour, flavour, odour, texture, etc.). Several inactivation parameters are usually calculated:

D-value: it is the time interval, at a given temperature, necessary to destroy 90% of a given microbial population. This value varies among microorganisms, and allows comparing thermal destruction among populations. For instance:

- At 110 °C, 90% *Clostridium sporogenes* population (10^5–10^4) is reduced if heating is kept for 10 min ($D_{110\,°C}$ = 10 min),
- At 115 °C, the necessary time for the same reduction is 3 min ($D_{115\,°C}$ = 3 min),
- At 120 °C, only 1 min is necessary ($D_{120\,°C}$ = 1 min).

On the other hand, at different heating times, the destroyed population increases with time of the exposure.

Z-values: it is the temperature necessary for reducing D values in 1/10. For example: if Z = 10 °C; D-value at 100 °C is 50 min; at 110 °C is 5 min; at 120 °C is 0.5 min.

F-values: it is a calculation of the overall process efficiency. Total F-value of a given process is the sum of lethality efficiency of every part of the process (heating, holding, and cooling). F-values are used to compare severity of different thermal treatments, according to microbial resistance to process conditions. F and D values are related by the following equation:

$$F = D(\log a - \log b)$$

where: a - initial cell load

b - final cell load

Process lethality is calculated by the equation: log (t/F) = (250 − T)/Z. In fact, total process lethality is the sum of the lethality calculated for every minute of the entire process, resulting in a process curve; the area under the curve represents total lethality. Low acidity foods, such as meats, are heated at temperature that ensure reduction of *Clostridium botulinum* spores in 12 log cycles, or 12D, with a final contamination of one *Clostridium botulinum* spore per g, an extremely low probability of finding a spore, or $1/10^{12}$. In order to reach this reduction, heating must be 12 times more severe than D_{121} = 0.2 min, therefore, the meat must be processed for 2.52 min at 120 °C. The process lethality is F = 2.5, known as botulinum cooking.

https://www.researchgate.net/profile/Abdelkader-Bouaziz/post/Can-we-increase-the-oxidative-stability-of-meat-and-meat-products-and-if-possible-how-is-it-done/attachment/5eb934f8f155db0001faf18d/AS%3A889966779457543%401589196023464/download/Handbook+of+Meat+and+Meat+Processing+(2nd+Est).pdf

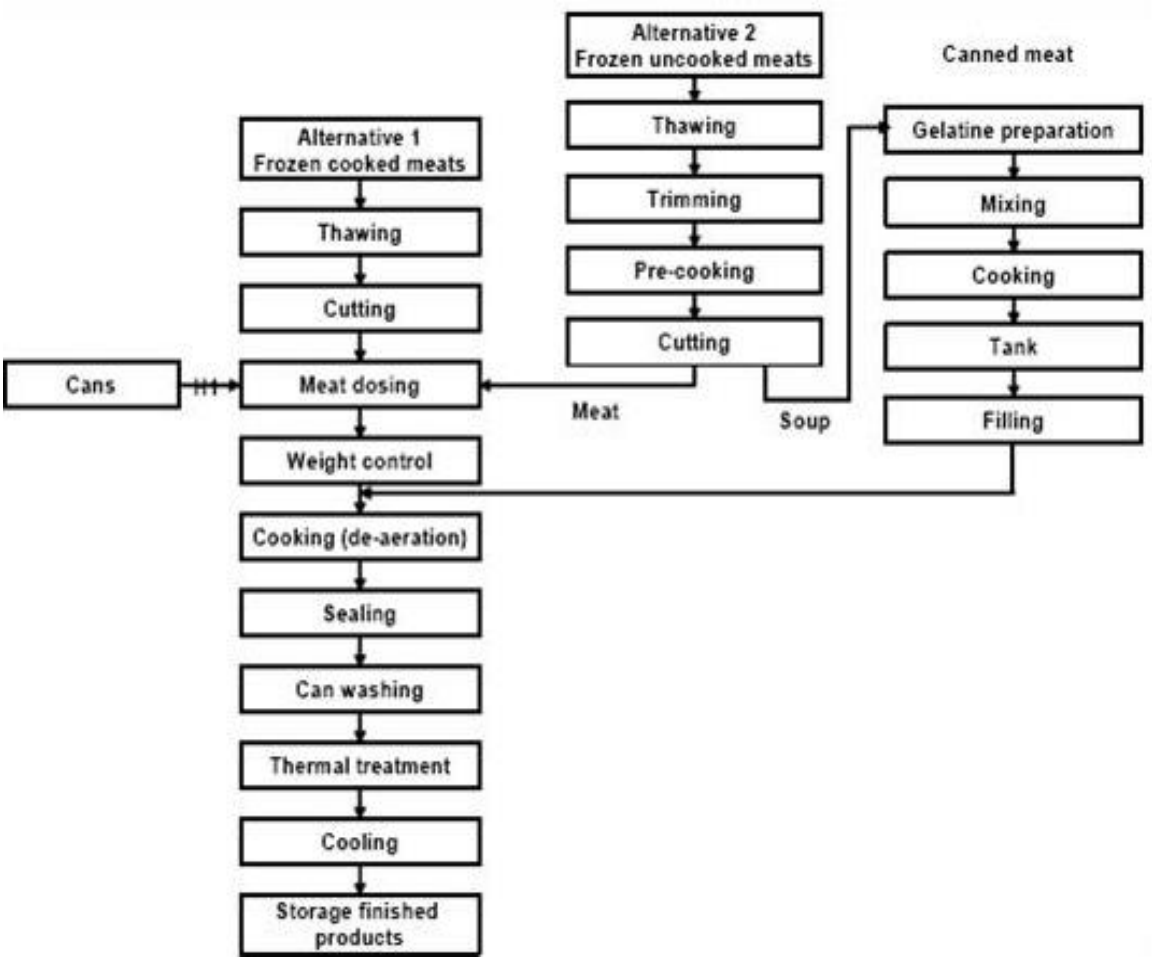

Figure 6.1. Production flowchart for canned meat products

http://wiki.zero-emissions.at/index.php?title=File:Flowsheet_of_canned_meat_production,_figure1.jpg

Highest value packaging types and materials for canned meat products

Canned products are distinguished by a combination of processing and packaging technologies that allow products to be stored at room temperature for a long time. Therefore, the choice of packaging is important. Most often, after the product is packed in a package, the product is thermally treated together with the package. This means that, in addition to the previously mentioned properties, such as barrier properties, the package must have heat resistance properties.

Table 6.1.

The most commonly used packages shapes for packing of canned meat products

Illustration	*Package shape*	*Description*
	Pillow pouch	Usually produced in-house in horizontal flow-pack equipment. Or purchased packaging in the form of ready-made packages with fused three seams. This type of packaging is also common for packaging different types of sausages, as well as for packaging frozen meat.
	Doypack	Usually produced in-house in horizontal flow-pack equipment. Or purchased packaging in the form of ready-made packages with fused three seams.
	Metal cans	Generally, raw product is packaged, both in high-volume machines and in low-volume machines. Boxes tend to have different shapes.

	Glass jars	Often used for meat packing pickled products.

For this type of products, it is important to choose the appropriate packaging with high barrier properties, as well as correctly calculate the time and temperature of heat treatment, as this can significantly affect the expiration date.

Seminar

Package as added value of meat products

The aim of the workshop is to analyse the packaging as attached value for the product, because the packaging often plays an important role in choosing a product. The group of students is divided into teams, and each team analyses products packaged using different packaging solutions, paying significant attention to packaging design.

Materials

In the seminar uses either different prototypes of packaged products or photos found on Internet resources with different packaged products.

Methods and Procedures

Each group of students analyses three different packages. And the characteristics are given in Table 6.2.

Results

The results obtained should be reflected in Table 6.2. After completing the table, different groups of students compare the results. If possible, each group presents and justifies its performance.

During operation, students acquire skills in characterizing packages and analysing situations, as well as experience working in groups.

Table 6.2.

Characteristic parameters	**Samples**		
	Product No. 1	Product No. 2	Product No. 3
Packaging material			
Packaging shape			
What information is printed on the package?			
Does the packaging contain information about the recyclability of the packaging?			
What should be done to make the packaging more attractive?			
Are there any flaws or gaps in the information printed on the package? If so, which ones?			

Conclusion

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Name, Surname, signature

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Practical work

Meat product safety risk assessment

Materials

Theoretical materials

Methods and Procedures

The following tasks must be completed in the practical part of the work:

1. For a selected meat processing product, develop a product description, develop and draw a diagram of the process steps.
2. Identify potential hazards:
   - biological - pathogenic microorganisms,
   - chemical - agricultural chemicals,
   - physical - foreign objects atypical for the product.
3. Evaluate the danger of the identified hazards using a risk matrix.
   1. Record the information in the hazard assessment table.
   2. Complete the CCP identification table and the HACCP plan.
   3. Write conclusions on determining CCP using a risk matrix and a decision scheme.

Results

Table 6.3.

Risk assessment table

Process stage	The identified hazard	Hazard assessment					Means of control
		Possibility	The severity of the consequences	Risk level	Assessment	CCP	

Table 6.4.

CCP identification table

Process stage No.	Process stage	Cause of risk	Description of the cause of the risk	Control actions	Answers to Decision Scheme questions				CCP yes/no
					1	2	3	4	

Table 6.5.

HACCP plan

In process stage	CCP/ CP	Risk the cause	Measurable critical limits of parameters	Monitoring procedures				Order-	Corrections events
				What?	How to?	How often?	What?		

Conclusion

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Name, Surname, signature

Date _____

Practical work
Thermal equipment for meat processing

Materials

Technological schemes of different meat product production, and internet network.

Methods and Procedures

According to interest and wishes, students choose one technological scheme of meat product production, for example, cooking boiled sausages, semi-dried sausages.

In the future, using the Internet resources and educational literature, according to the technological scheme of product production, technological equipment is selected. The selected circuits are arranged according to the technological process and a scheme is created. For each of the selected equipment, its necessity, justification and principle of operation must be explained.

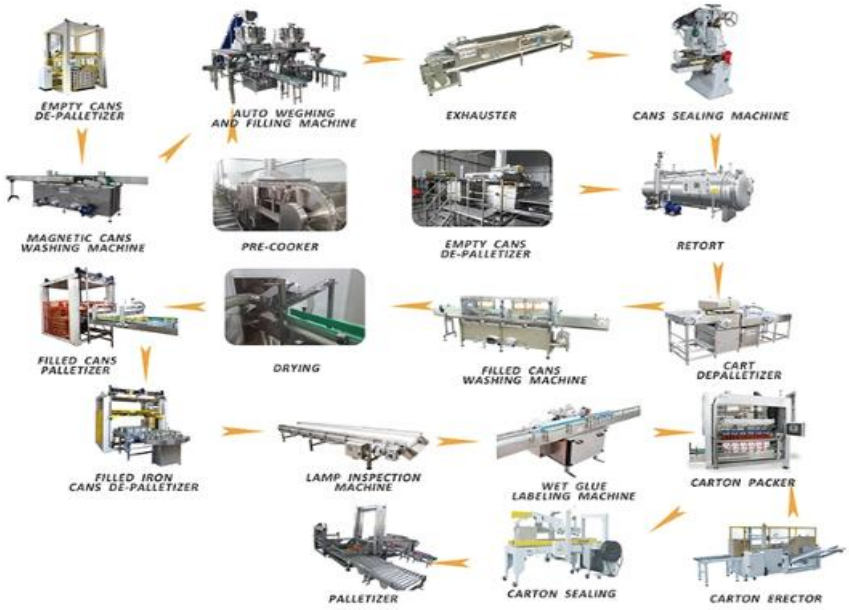

Figure 6.2. Canned meat production line

https://shleadworld.en.made-in-china.com/product/edRGuZYcCVWt/China-Leadworld-Canned-Corned-Beef-Machine-Canned-Meat-Production-Line.html

Results

Students collect the information obtained. Students choose one of the pieces of equipment that can ensure constant quality of the finished product, or provides CCP (critical control point).

Conclusion

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Approved by _____

Name, Surname, signature

Date _____

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Open Food Innovation University (OFINU)

Study module

"Fruit and Vegetable Processing Technologies"

WORKBOOK

for students

2024

Summary

The workbook is elaborated within the project “Open Food Innovation University" (OFINU), being in implementation with support of the European Union Erasmus+ Programme.

Overall objective of the project - to modernise food innovation and technology related higher education in Uzbekistan and Tajikistan, thereby increasing the quality and ensuring relevance of the higher education to the needs of the socio-economic growth of the countries concerned and especially of their regions.

Full partners:
- Lead partner: Latvia University of Life Sciences and Technologies
- Uzbekistan: Samarkand Agro-innovations and Research University, Andijan Institute of Agriculture and Agro-technologies
- Tajikistan: Technological University of Tajikistan, Kulob Institute of Technology and Innovation Management, Isfara Branch of the Technological University of Tajikistan
- Slovakia: Slovak University of Agriculture in Nitra

Associated partners in Uzbekistan:
- A group of companies "AGROMIR"
- "Navigul" MCHJ QK
- “Samarqand don mahsulotlari” JC (Samarkand grain products)

Associated partners in Tajikistan:
- CJSC “Combinati Shiri Dushanbe”
- LTD "Orion Rustam"
- Association of Entrepreneurs of Khatlon

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Partner universities and their academic staff, involved in the development of the study course:

P1 LBTU. Latvia University of Life Sciences and Technologies

Assistant professor, Ph.D. Liene Ozola - fruit and vegetable processing technology; microbiological evaluation, liene.ozola@lbtu.lv

Professor, Dr.sc.ing. Tatjana Ķince: fruit and vegetable processing equipment, tatjana.kince@lbtu.lv

Associate professor, Dr.sc.ing. Evita Straumīte - sensory evaluation of fruit, vegetables and their processing products, evita.straumite@lbtu.lv

Professor, Dr.sc.ing. Sandra Muižniece-Brasava - product packaging materials and technology, sandra.muizniece@lbtu.lv

Quality manager, Mg TQM Egita Sproģe - food safety QM systems, egita.sproge.egita@gmail.com

P2 SAMARU. Samarkand Agroinnovations and Research University

Assistant teacher, MSc Elnara Devletshaeva - technology of storage and processing of agricultural products, elnaradevletshayeva@gmail.com

Ph.D. Haitmurod Tilavov - technology of storage and processing of agricultural products, tilavovhaitmurod@gmail.com

P3 AIAA. Andijan Institute of Agriculture and Agro-technologies

Associate Professor, Ph.D Oybek Egamberdiev - technology of storage and processing of agricultural products, egamberdiyevoybek60@gmail.com

Assistant teacher MSc, Dekhkonova Shakhnozaxon - technology of storage and processing of agricultural products, sahnozadehkonova49@gmail.com

P4 TUT. Technological University of Tajikistan

Assistant Professor, Ph.D. in Tech. Sc. Gulmahmad Mirzozoda- technological equipment for canning production; technology and equipment of vegetable oil production, sosonholov@gmail.com

Assistant Professor, Ph.D. in Tech. Sc. Maksudakhon Abdullaeva - fruit and vegetable processing technologies; new food product development, abdullaevamaksuda183@gmail.com

P5 KITIM. Kulob Institute of Technology and Innovation Management

Assistant Professor, Ph.D. in Tech. Sc. Ziyodullo Obidov - physico: chemical and biochemical foundations of food production; physico-chemical analysis of food products, obidovzr@gmail.com

Senior lecturer, Saidislom Jangov - fruit and vegetable processing technologies; new food product development, saidislomjangov@gmail.com

P6 BTUTI. Branch of the Technological University of Tajikistan in the city of Isfara

Senior lecturer, Sirojiddin Boboev - fruit and vegetable processing technology; microbiological evaluation; food safety QM systems, sirozhiddinboboev76@gmail.com

Senior lecturer, Sunatullo Qodirov - fruit and vegetable processing equipment, qsunnatullo367@gmail.com

Senior lecturer, Turanboy Turanboev - sensory evaluation of fruit, vegetables and their processing products; product packaging materials and technology, turanboevturanboj@gmail.com

P7 SUA. Slovak University of Agriculture in Nitra

doc. Ing.Ph.D Ivana Mezeyová - vegetable technology, ivana.mezeyova@uniag.sk

doc. Ing.Ph.D Miroslav Šlosár - vegetable technology, miroslav.slosar@uniag.sk

doc. Ing.Ph.D Oleg Paulen - fruit technology, oleg.paulen@uniag.sk

doc. Ing.Ph.D Ján Mezey - fruit technology, jan.mezey@uniag.sk

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Theme of the study course

The study module **“Fruit and Vegetable Processing Technologies”** includes the following topics: technological processes and equipment, packaging materials and equipment, raw materials and product quality evaluation, including sensory evaluation. Quality management assurances in fruit and vegetable processing. A lecturer with knowledge in the specific field is involved in the implementation of each section in order to achieve the goal of the study module.

Learning methods

Creating an effective study module for students involves incorporating a variety of learning methods to cater to different learning styles and enhance comprehension and retention.

The **main pedagogical methods taught are as follows: learner centred approach, competence-based approach, experiential learning, cooperative learning, and interactive learning.**

The training includes practice methods, as well as an introduction to modern learning analytics, which are used to support the engagement and responsibility of a student, and to support assessment.

Highly appreciated are the knowledge and skills to produce and deliver classes and lectures in the form of distance learning, because the application of this method broadens the availability of experts and worldwide knowledge (inviting, entrepreneurs, foreign academic staff etc. as lecturers), can be applied in the case of double diploma studies, provide an opportunity to study for persons with limited opportunities to take part in full-time studies (young mothers, students with disabilities). Distance learning is very effective for specific courses where participation of lecturers from foreign partner universities is crucial and discussions with students with diverse experiences and visions are needed to explain and demonstrate possibilities and different solutions and options.

In order to improve and promote the learning in the study module, it is possible to use different teaching methods in the study course, for example:

1. **Lecture-based learning** - Traditional method where an instructor delivers content through spoken presentations, often supplemented by visual aids such as slides.
2. **Interactive learning** – Actively engages students through discussions, Q&A sessions, and interactive activities. This enhances understanding and retention by involving students in the learning process. Techniques include think-pair-share, debates, and group discussions.
3. **Collaborative learning** - Students work together in small groups to solve problems, complete tasks, or create projects. The method helps to develop teamwork skills, fosters peer learning, and encourages diverse perspectives. Examples include group projects, peer reviews, and study groups.
4. **Problem-based learning** - Students learn through the experience of solving open-ended problems. Promotes critical thinking, application of knowledge, and self-directed learning. Typically involves real-world scenarios that require research and collaborative problem-solving.
5. **Case-based learning** - Uses detailed scenarios (cases) to stimulate analysis and application of concepts. Helps students apply theoretical knowledge to practical situations, improving analytical and decision-making skills. Commonly used in business, law, and medical education.

6. **Flipped classroom** - Students review lecture material at home (e.g., video lectures) and engage in interactive activities in class. It maximises classroom time for active learning through discussions, problem-solving, and hands-on activities.
7. **Self-directed learning** - Students take responsibility for their learning, setting goals, finding resources, and assessing their progress. The method encourages lifelong learning skills, autonomy, and self-motivation. Methods include reading assignments, online courses, and independent projects.
8. **Experiential learning** - Learning through reflection on doing, which includes hands-on experience and practical application of skills. Provides real-world context and practical skills. Examples include lab work, internships, simulations, and field trips.
9. **Technology-enhanced learning** - Incorporates digital tools and online resources to support learning. It offers flexibility and access to a wide range of resources. Includes e-learning platforms, educational apps, virtual labs, and online discussion forums.
10. **Socratic method** - Teaching through questioning to stimulate critical thinking and illuminate ideas. This encourages deep thinking, dialogue, and exploration of complex concepts. Often used in philosophy, law, and humanities.
11. **Assessment and feedback** - Regular assessments (formative and summative) and feedback to guide learning and improvement. This ensures understanding, tracks progress, and provides actionable feedback. Includes quizzes, peer assessments, and instructor feedback.

Implementation tips:

1. **Diverse methods** - incorporate a mix of methods to address different learning styles (visual, auditory, practical).
2. **Clear objectives** - define clear learning objectives for each method and activity.
3. **Engagement** - design activities that actively engage students and encourage participation.
4. **Flexibility** - be adaptable to student and study theme needs and feedback, adjusting methods as necessary.
5. **Resources** - provide adequate resources and support for each learning method, including technology and materials.

Masterclasses, open lectures, and discussions, involving internal and external stakeholders, is a new form of teaching and communication of higher education to the society, which has been adopted at the involved UZ universities during the implementation of the project.

Course Schedule

Thematic Study Plan for module "Fruit and Vegetable Processing Technologies"

Date, Time	Study form	Theme	Lecturer
Theme 1. Chemical composition and physical properties of fruit, vegetables, and mushrooms. Fruit and vegetable classification			
Day 1	Lecture (2h)	*Introduction lecture about the study course.* Chemical composition and physical properties of fruit and vegetables.	**L. Ozola**
	Laboratory work (3h)	Chemical composition of fruit, berries and vegetables.	
	Lecture (1h)	Fruit and vegetable classification.	
	Lecture (1h)	Mushrooms - structure and chemical composition.	
Day 2	Lecture (4h)	Chemical composition and quality aspects of herbs, wild and domesticated fruit and berries. Nuts, their chemical composition and quality characteristics. Citrus fruits, their chemical composition.	**L. Ozola**
	Laboratory work (3h)	Natural pigments and their detection, quality changes in fruit, berries and vegetables.	
Day 3	Lecture (1h)	Structure and chemical composition of potato tubers.	**L. Ozola**
	Laboratory work (2h)	Chemical composition and quality parameters of potato tubers.	
Theme 2. Classification of fruit and vegetable processing products			
Day 3	Lecture (1h)	Introduction to the fruit, berry and vegetable processing industry in "Your Country".	**L. Ozola**
	Lecture (2h)	Fruit and vegetable storage conditions. Methods of preserving fruits, berries and vegetables.	**L. Ozola**
Theme 3. Fresh, minimally processed fruit and vegetables			

Day 4	Lecture (1h)	Production of fresh, minimally processed fruits and vegetables.	**L. Ozola**
Theme 4. Packaging equipment and special packaging materials and methods used in fruit and vegetable product production			
Day 4	Lecture (4h)	Packaging equipment and special packaging materials and methods used in fruit and vegetable product production.	**S. Muižniece-Brasava**
	Laboratory work (3h)	*Connected and a continuation of Theme 3* Preparation of fresh, cut and packaged vegetables (1st part).	**L. Ozola / S. Muižniece-Brasava**
Theme 5. Technological equipment for fruit and vegetable processing			
Day 5	Lecture (4h)	Overview of technological equipment for fruit and vegetable processing.	**T. Ķince**
Theme 6. Fermented fruit and vegetable production			
Day 5	Lecture (1h)	Fermented vegetables - technological aspects of preparation and product quality with focus on sauerkraut production).	**L. Ozola**
	Laboratory work (2h)	Preparation of sauerkraut (1st part).	
Theme 7. Assessment of the Safety and Risks of fruit and vegetable products (HACCP)			
Day 8	Lecture (2h)	Assessment of Safety and Risks of fruit and vegetable products (HACCP).	**E. Sproģe**
	Practical work / Seminar (4h)	Assessment of Safety and Risks of fruit and vegetable products (HACCP).	**E. Sproģe**
Day 9	Excursion	Excursion to a local fruit and vegetable processing company.	**L. Ozola**
Theme 8. Microbiological aspects of fruit and vegetable processing			
Day 10	Lecture (2h)	Microbiological aspect in fruit and vegetable processing.	**L. Ozola**
Continuation of laboratory work from Day 4 and in the context of Themes 3, 4 and 8			
Day 10	Laboratory work (2h)	Microbiological evaluation of fresh, cut and packaged vegetables (2nd part).	**L. Ozola**

	Laboratory work (4h)	Quality evaluation of fresh, cut and packaged vegetables (3rd part).	
Theme 9. Production technology of frozen fruits and vegetables			
Day 11	Lecture (2h)	Production of frozen fruit and vegetables	**L. Ozola**
	Laboratory work (1h)	Freezing of fruit and vegetables (1st part)	
Theme 10. Sensory aspects of fruit and vegetable processing products			
Day 11	Lecture (2h)	Fruit, berry and vegetable and their product sensory evaluation.	**E. Straumīte**
Continuation of Themes 6			
Day 12	Laboratory works (2h)	Microbiological evaluation of prepared sauerkraut (2nd part).	**L. Ozola**
	Laboratory work (2h)	Packaging and storage of sauerkraut. Product treatment in sous-vide. (3rd part)	**S. Muižniece-Brasava**
Continuation of Day 10 and conclusion of Theme 3			
Day 15	Laboratory work (1h)	Data collection of microbiological assessment of fresh, cut and packaged vegetables.	**L. Ozola**
	Seminar (1h)	*Conclusion of Theme 3.* Seminar on obtained data and evaluation of laboratory works.	
Continuation of Day 12 and conclusion of Theme 6			
Day 15	Laboratory work (1h)	Data collection of microbiological assessment of prepared sauerkraut.	**L. Ozola**
	Laboratory work (2h)	Sensory evaluation of sauerkraut.	**E. Straumīte**
	Laboratory work (2h)	Quality evaluation of prepared sauerkraut.	**L. Ozola**
	Seminar (1h)	*Conclusion of Theme 6.* Seminar on obtained data and evaluation of laboratory works.	
Theme 11. Thermally processed vegetable preserves			

Day 16	Lecture (2h)	Natural preserves. Testing of canned food sterility.	**L. Ozola**
	Lecture (4h)	Processing of tomatoes. Production of acidified vegetable preserves.	
Day 17	Laboratory work (6h)	Preparation of tomato concentrates and sauces using different technologies.	**L. Ozola/ T. Ķince**
Day 18	Laboratory work (2h)	Quality assessment of prepared tomato products.	**L. Ozola**
	Laboratory work (2h)	Sensory evaluation of prepared tomato products.	**E. Straumīte**
	Lecture (2h)	Potato processing products and technologies, needed equipment, and their characteristics.	**L. Ozola**
Day 19	Laboratory work (4h)	Preparation and analysis of potato processing using different technologies - French fries.	**L. Ozola/ T. Ķince**
	Laboratory work (2h)	Preparation and analysis of potato processing using different technologies – chips -Preparation stage.	**L. Ozola**
Day 22	Laboratory work (2h)	Preparation and analysis of potato processing using different technologies - chips- Analysis stage.	**L. Ozola**
	Laboratory work (1h)	Sensory evaluation of potato chips.	**E. Straumite**
	Seminar (1h)	*Conclusion of Theme 11.* Seminar on obtained data and evaluation of laboratory works.	**L. Ozola**
Continuation of Day 12 and conclusion of Theme 9			
Day 22	Laboratory work (3h)	Quality analysis of frozen fruit, berries and vegetables (2nd part). *Conclusion of Theme 9.* Seminar on obtained data and evaluation of laboratory works.	**L. Ozola**
Theme 12. Thermally processed fruit and berry preserves			
Day 23	Lecture (2h)	Classification of fruit and berry processing products. The technology and equipment of preparation of compotes and jams, purees.	**L. Ozola**

	Laboratory work (2h)	Apple compote preparation (1st part).	**L. Ozola/ S. Muižniece-Brasava**
	Lecture (2h)	The technology of fruit and berry marmalade production.	**L. Ozola**
	Laboratory work (1h)	Preparation of fruit and berry marmalades using different gelling agents.	**L. Ozola**
Day 24	Laboratory work (2h)	Quality evaluation of apple compotes.	**L. Ozola**
	Laboratory work (1h)	Sensory analysis of fruit and berry marmalades.	**E. Straumīte**
	Laboratory work (2h)	Quality analysis of fruit and berry marmalades	**L. Ozola**
	Lecture (2h)	Fruit, berry and vegetable juices, their division and juice production technologies, and equipment.	
Day 25	Laboratory work (5h)	Fruit, berry and vegetable juice production (preparation of samples) and quality evaluation.	**L. Ozola**
	Seminar (1h)	*Conclusion of Theme 12.* Seminar on obtained data and evaluation of laboratory work.	
Theme 13. Vegetable oils			
Day 26	Lecture (3h)	Oils, their division and extraction methods.	**L. Ozola / T. Ķince**
	Laboratory work (2h)	Quality analysis of vegetable oils. *Conclusion of Theme 13.* Seminar on obtained data and evaluation of laboratory work.	**L. Ozola**
Theme 14. Dried fruit and vegetable products			
Day 29	Lecture (1h)	Drying of fruits, berries and vegetables.	**L. Ozola**
	Laboratory work (5h)	Apple drying using different technologies.	**L. Ozola / T. Ķince**
Day 30	Laboratory work	Quality evaluation of dried apples.	**L. Ozola**

	(2h)	*Conclusion of Theme 13.* Seminar on obtained data and evaluation of laboratory works.	
	Excursion	Excursion to a local fruit and vegetable processing company.	

Theme 1

Chemical composition and physical properties of fruit, vegetables, and mushrooms. Fruit and vegetable classification.

Theoretical materials

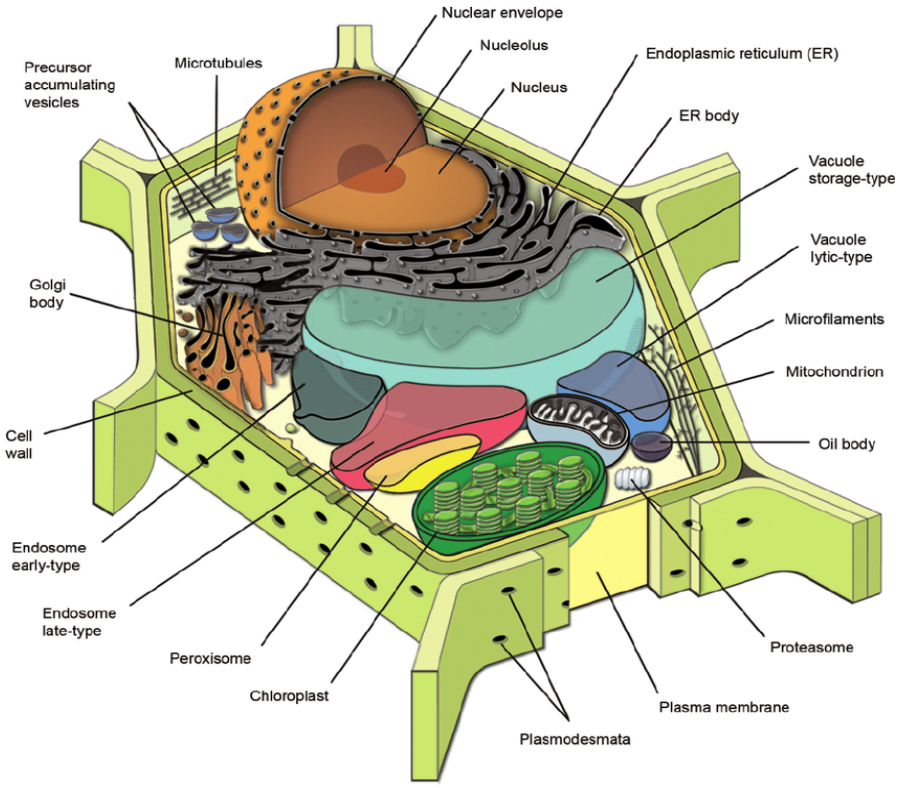

Fig.1.1 Plant cell structure (https://www.researchgate.net/publication/237155186_Illuminating_subcellular_structures_and_dynamics_in_plants_A_fluorescent_protein_toolbox/figures?lo=1)

Fruit, berries and vegetables are composed of both simple and complex cells.

Simple tissue includes:

- Dermal tissue
- Parenchyma tissue

Complex tissue:

- Vascular tissue
- Collenchyma tissue
- Sclerenchyma supporting tissue

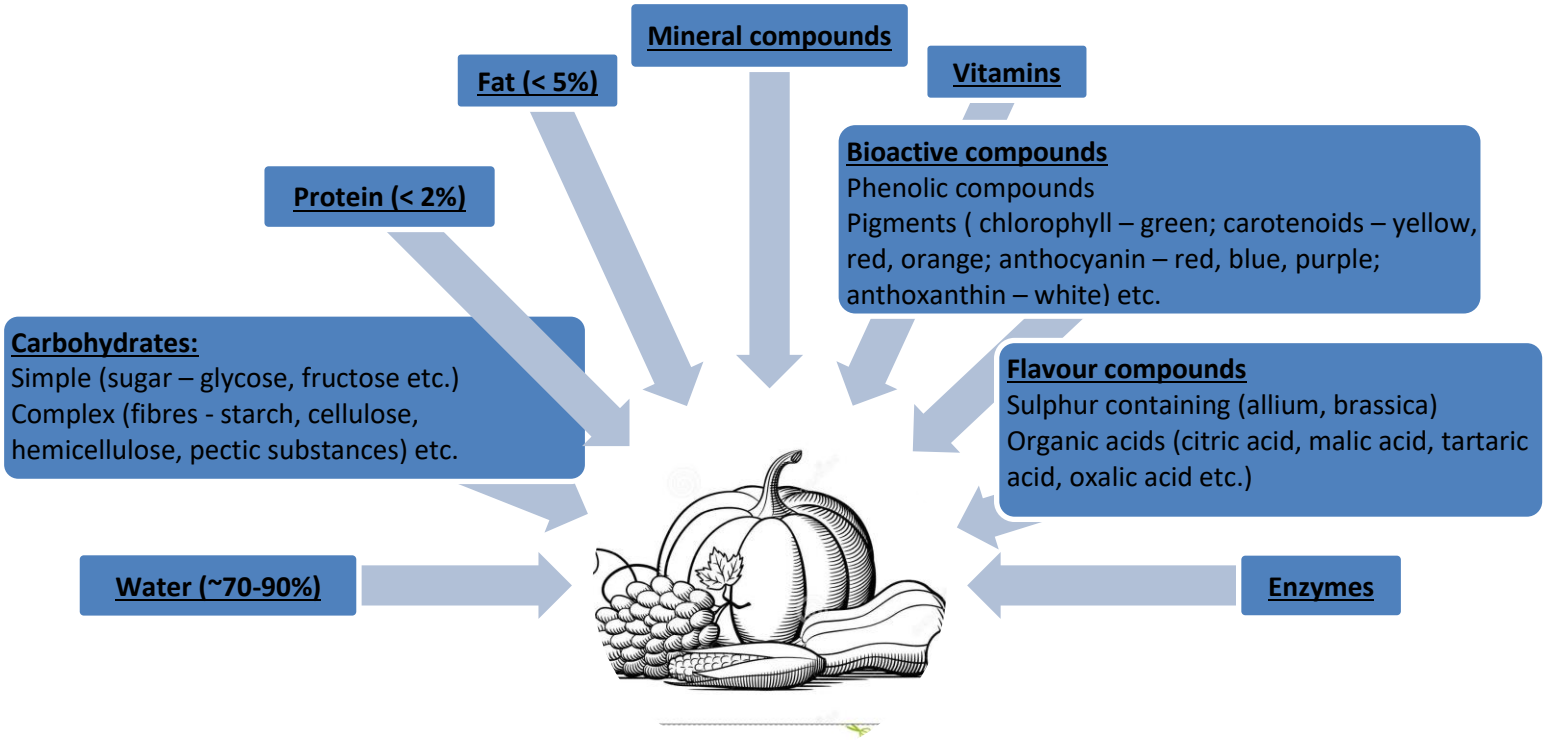

Fig. 1.2. Overall chemical composition of fruit and vegetables

Soluble solids

The content of soluble solids characterises the chemical composition of fruit and berries, as it is made up of organic acids, sugars, pectin substances, tannins, etc. The soluble solids in fruit and berries are highest during their maturity. As the fruit overripe, the content of soluble solids gradually decreases and continues to decrease during fruit storage.

Cherries (16.3%) and blackcurrants (14.4%) have the highest content of soluble solids. The soluble solids content of apples varieties grown in Latvia ranges from 9.7-16.0%.

Titratable acid

The most common acids in fruit are malic acid and citric acid. Apples and pears mostly contain malic acid, while citrus fruits contain citric acid.

The most common acids in berries are citric and malic. For example, raspberries contain 97% citric acid and 3% malic acid, while strawberries contain 90% citric acid and 10% malic acid.

In addition to these common acids, fruits and berries also contain other acids in smaller amounts, such as succinic acid (in blackcurrants, sweet cherries), benzoic acid (in cranberries, lingonberries), salicylic acid (in raspberries), etc.

Some of the acids occur in free form and some - in the form associated with minerals (in the form of salts).

The total amount of acids is characterised by titratable acid or total acid. Average titratable acid content:

- in apples 0.85%
- in pears 0.18%
- currants 2.7%
- raspberries 1.0%
- strawberries 0.8%
- in apple juice 0.8%
- in lemon juice 4.8%
- in mandarin juice 0.5%
- in grape juice 0.4%
- in orange juice 1.2%

Titratable acids in ripe fruits and berries are lower than in unripe ones, and as the fruit overripe, the amount of acid gradually decreases, as it is used in the respiration process.

Tannins

Tannins are polyphenolic compounds widely distributed in the plant kingdom. Tannins give fruit and berries (aronia, rowan, etc.) an astringent, harsh, bitter taste, as well as protect them against various microorganisms. When tannins oxidise, dark-coloured compounds - phlobaphenes - are formed. This explains the dark colouring of the flesh of a cut or mechanically compressed fruit.

Ascorbic acid (vitamin C)

Vitamin C is the most important vitamin that we get almost exclusively from fruit and vegetables. However, it oxidises rapidly both in the presence of oxygen and also at high temperatures, so it is important to evaluate the best way of processing method with the least reduction of vitamin C. Potatoes are not very rich in vitamin C, but due to their high consumption, they can be an important source of daily vitamin C.

Total phenols

The term 'phenols' includes approximately 8,000 compounds of natural origin, all of which are characterised by a common structural element – the phenol ring (i.e. the aromatic ring containing at least one hydroxyl group substituent). The current classification, based on the number of phenolic subunits, divides phenols into polyphenols and simple phenols. Polyphenols that have at least two phenolic rings in their structure belong to the flavonoid subgroup, while compounds with three or more phenolic rings are called tannins. Phenolic compounds have strong **antioxidant activity** and are able to bind reactive oxygen, nitrogen. They can also bind to metal ions, up to thereby reducing pro-oxidant activity.

Anthocyanins

Anthocyanins (plant glycosides) are water-soluble pigments that colour many fruit, berries and vegetables from red to dark blue. For example, the pigment of this group is found in grapes, quercitin, in cherries - keracyanin, in strawberries - fragarin, in beets - betanin, etc. The colour of anthocyanins depends on various conditions, it is affected by increased temperature, environmental reaction, light, ions of several metals.

Anthocyanins are thermolabile compounds, so when fruit, berries and vegetables are heated, they decompose and change colour (for example, sterilised strawberries, cherries, etc.). Betanin found in beetroot is also sensitive to heat. The persistence of the colour depends on its concentration, for example, beetroot cooked with the skin is dark red, but chopped, cooked beetroot is yellow-pink, because the colour has diffused into the solution and broken down due to the low concentration.

The colour of anthocyanins changes depending on the reaction of the environment: they are red in an acidic environment, and blue or even green in an alkaline environment.

The colour of anthocyanins also changes under the influence of light during storage (when canned berries are stored, they seem to fade). The colour change during storage depends on temperature. At lower temperatures, it changes more slowly.

The colour of anthocyanins changes when they combine with ions of various metals (Zn, Al, Fe, Sn, etc.). For example, when cranberry anthocyanins come into contact with Al or Fe, a blue-violet colour is formed. Anthocyanins of cherries, strawberries, blueberries do not react with aluminium, but brown compounds are formed with iron.

Chlorophyll

Chlorophyll – the green pigment that colours the green leaves of plants, various fruits, berries and vegetables. Chlorophyll is found in the chloroplasts of plant cells in compounds with proteins, and it is not soluble in water.

In a living cell, chlorophyll is stable as long as it is bound to proteins. But when heated, living cells die, proteins denature and chlorophyll is easily oxidised when it comes into contact with cell juice acids. As a result, pheophytin (olive-green or brown-green in colour) is formed. This chlorophyll decomposition reaction occurs only in the presence of acid. In order to preserve the beautiful green colour of green peas, cucumbers, spinach, cabbage, etc. during thermal processes, it has been tried to add various substances that inhibit the decomposition of chlorophyll. Adding sodium hydrogen carbonate (soda) to vegetables creates a slightly alkaline environment, which reduces the breakdown of chlorophyll and ensures the preservation of the green colour. But the addition of sodium bicarbonate adversely affects the nutritional value of vegetables (reduces the amount of vitamins C and B1), so this technique is not used in practice.

Unscrupulous manufacturers have tried to add copper salts to canned vegetables. In this case, copper ions exchange places with magnesium ions in the chlorophyll molecules and form a stable green compound. However, the use of copper salts is prohibited, as copper ions not only contribute to the oxidation of ascorbic acid, but can also cause severe poisoning.

Total carotenoids

Carotenoids give fruits and vegetables their yellow and orange colour. They are effective antioxidants with important health-promoting functions, such as provitamin A activity, improving the immune system and reducing cardiovascular disease, as well as helping to prevent atherosclerosis and cancer. The carotenoid group includes: carotenes, which are hydrocarbons, and xanthophylls, which contain oxygen in the form of hydroxyl, methyl, carboxyl, keto, or epoxy groups.

The amount of carotenoids in fruit does not exceed 0.1% of dry matter and the most common are α-carotene, β-carotene, lycopene and xanthophyll, which is in an esterified form.

Laboratory work

Chemical composition of fruit, berries and vegetables

Materials

Various fruit and vegetable juices. Laboratory work is suitable for commercial sample and fresh sample comparison.

Methods

1. Determination of soluble solids

Determination of soluble solids with a handheld refractometer

Open the closing cap of the prism and add 1-2 drops of the juice to be analysed on its dry and clean surface, then close the prism cap and check whether the surface of the prism is wet. Turn the refractometer towards the light (towards a window or artificial lighting) and look through the eyepiece. The field of vision shows a scale, as well as a dark and light area. The dividing line between the light and dark area indicates the dry matter content (%) of the solution as read on the scale.

After determining the dry content, the lid of the prism is opened, and the juice is dried with a paper towel. Readings are performed in triplicate. After that, a few drops of distilled water are added to the prism so that it moistens the surface of the prism, the cap is closed, opened and the water is dried. At the end of the work, the prism must be clean and dry.

Determination of soluble solids with a digital refractometer

Turn on the digital refractometer with its power button. First, the instrument is calibrated with distilled water: put 3-4 drops of distilled water on the prism and press and hold the "Cal" calibration button. When the result appears, press the "OK" button, wipe the prism with a paper towel, and the device is ready for work. Add 3 drops of the juice to be analysed to the clean dry prism and the "OK" button of the device is pressed. When the result appears, write it down, press the "OK" button of the device again until the inscription "READY" appears, wipe the prism with a paper towel and pour the juice again (3 repetitions in total). After the last repetition, the prism is additionally rinsed with distilled water and then wiped. At the end of the work, the prism must be clean and dry.

2. Determination of titratable acid

For titration, measure 10 mL of juice in a 100 - 150 mL beaker with a pipette. Heat the juice in a flask to 90 ℃, add 3 - 5 drops of 0.1% phenolphthalein and titrate with 0.1n NaOH until a pink colour appears.

The amount of acid to be titrated is calculated:

$$x = \frac{n \times f \times 100}{10}$$

x - amount of acid to be titrated,%
n - titrated 0.1n NaOH solution, mL
f - acid factor
Expressing the acid to be titrated :
with malic acid f = 0.067 g;
as citric acid f = 0.064;
as tartaric acid f = 0.075 g
10 - the amount of juice taken for analysis, mL

3. **Determination of pH**

To determine the pH of the environment, the sample to be analysed is poured into a beaker, in which the electrode of the pH meter is dipped and the pH of the product is determined . The pH of the environment is determined according to the instructions for use of the pH meter.

4. **Determination of tannins**

From the sample given for analysis, measure 50 mL of juice in a 100 mL measuring flask with a pipette and fill up to the mark with distilled water. Using a pipette, pour 10 mL of the prepared analysis into a 500 mL volumetric flask, add 20 mL of 0.6% indigo carmine solution, 10 mL of 24% H_2SO_4, 200 mL of water and titrate with 0.1n $KMnO_4$ from a burette, stirring constantly. The titration is stopped when the colour of the solution changes from blue, dark green, light green or blue-yellow to yellow.

To calculate the oxidisable substances of the juice for tanning agents and dyes, pour 10 mL of the analysis into a porcelain bowl, add 1 g of animal charcoal, mix well and heat in a water bath, stirring the solution constantly. After that, the liquid is filtered in a 500 mL flask, and the carbon and the filter are thoroughly rinsed several times with distilled water. The filtrate should be colourless. After that, add 20 mL of 0.6% indigo carmine, 10 mL of 24% H_2SO_4, 200 mL of water to the flask and, while stirring constantly, titrate with 0.1n $KMnO_4$ until a yellow colour is obtained.

The amount of tannins and pigments (%) is calculated (expressed as tannin):

$$x = \frac{(v_1 - v_2) \times 0{,}04157 \times 100}{a}(\%)$$

V_1 - amount of 0.1n $KMnO_4$ in mL, required for titration of all oxidisable substances in the juice, mL;
V_2 - the amount of 0.1n $KMnO_4$ in mL, which is required for the titration of the other oxidisable substances of the juice (which are not tannins and pigments);
a - 10 mL of 0.1n $KMnO_4$ used for oxidation of 0.1n oxalic acid quantity, mL;
0.04157 - the amount of tannin g that oxidises 1 mL of 0.1n $KMnO_4$

The titer of potassium permanganate is determined with **a 0.1n oxalic acid** solution. Fill 10 mL of 0.1n oxalic acid solution with a pipette into a 100 ml beaker, add 2 mL of **sulfuric acid solution (1:4),** heat to 70 ˚C and titrate with **$KMnO_4$** to a faint pink colour.

5. **Determination of ascorbic acid**

Vitamin C is rapidly oxidised both in the presence of oxygen and also at high temperatures, so it is important to evaluate the best way of processing and extracting juices, with the least reduction of vitamin C.

Determine the content of L-ascorbic acid (reduced form) in the given samples by the iodine method.

Methodology:

1. prepare a standard solution of ascorbic acid: 20 mg of ascorbic acid per 100 mL of 6% oxalic acid solution;
2. Add 2 mL of 1% starch solution to 25 mL of ascorbic acid standard solution and titrate with 0.05 M iodine solution while stirring. Observe the colour change. Write down the amount of iodine used;
3. Weigh 25 g of berry juice into a 250 mL beaker;
4. 100 mL of 6% $H_2C_2O_4$ solution is poured over the prepared weight and for 60 s, mix very well;
5. Filter through a cotton filter;
6. Add 2 mL of 1% starch solution to 10 mL of filtrate and titrate with 0.05M iodine solution while stirring. Observe the colour change which does not disappear within 30 seconds and write down the amount.

Calculation of ascorbic acid:

$$C\ vit.\left(\frac{mg}{100g}\right) = 5000 * \frac{V_{J\ sample}}{m * V_{J\ standard}}$$

5000 - coefficient
$V_{J\ sample}$ - the amount of iodine solution used for the titration of 10 mL of the sample
$V_{J\ stndard}$ - the amount of iodine solution used for the titration of 25 mL standard solution
m – sample mass.

6. **Determination of total phenols**

Measure approximately 2 ± 0.001 g of the juice sample to be analysed in a 100 mL beaker, add 20 mL of ethyl alcohol-water mixture (80:20), place the beaker on a magnetic stirrer, put a magnet in it and leave it to stir for 2 hours. When mixing is complete, filter the sample into another conical flask with a funnel through a paper filter until the sample is completely filtered. 0.5 mL of the extract to be analysed is measured with a pipette in three separate dishes, 2.5 mL of *"Folin-Ciocalteus"* phenolic reagent diluted tenfold with distilled water is added to the extract, after 5 min add 2 mL of 7.5% Na_2CO_3, mix and leave for 30 minutes. The result is read on a spectrophotometer at a wavelength of 765 nm.

The gallic acid equivalent used to quantify total polyphenol content. A gallic acid calibration curve is created and, using the absorbances read, the total polyphenol content in the analysed samples is expressed as milligrams of gallic acid equivalent per 100 grams of sample mass (GAE mg 100 g^{-1}).

The total amount of phenols is calculated according to the formula:

$$X = \frac{L}{C} * A$$

Where: X – amount of total phenols (mg 100g^{-1});
C – coefficient of the calibration curve (for example 0.1029);
L – absorption coefficient read from the spectrophotometer;
A – sample dilution.

Results

Make calculations for the detected parameters and summarise the obtained results in table 1

Table 1

Results of the obtained data

Sample (name)		
Parameters	**The result**	**The result**
Soluble solids content		
Titratable acids		
pH		
Content of tannins		

Ascorbic acid content		
Total phenolic content		

Conclusion

1. **Write conclusions on assessment of at least two of the analysed samples.**
2. **Give answers to the following questions:**
   a. What is the soluble solids content?
   b. What is characterised by the content of titratable acids in products and what is characterised by pH of products? Are the obtained readings comparable? Explain your answer.
   c. What is ascorbic acid and what impacts its changes in products?
   d. What are phenols and what is the total phenolic content of products?
   e. What method is used to determine the total phenol content in a product and what is the method based on?

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Laboratory work

Natural pigments and their detection, quality changes in fruit, berries and vegetables

Materials

Various fruit and vegetables that could be considered as representative source of the analysed parameter. Substitutions of juice material can be provided depending on availability of materials. Laboratory work is suitable for commercial sample and fresh sample comparison.

Methods

1. Beetroot anthocyanins and their colour changes

Pour diluted (1:4) beetroot juice in the following amounts into five test tubes: 1, 2, 3, 4 and 5 mL. Then add enough water to each of the five test tubes to make a total volume of 10 mL in each test tube.

All test tubes are placed in a boiling water bath and left there for 15 minutes. The tubes are then removed and cooled. Describe and explain the changes that have occurred. The obtained results are summarised in table 1.2.

2. Fruit and berry anthocyanins

a. Properties of anthocyanins depending on environmental pH.

Pour 5 mL of the given juice into a 300 mL measuring cup and add 100 ml of distilled water. Measure the initial pH and characterise the colour. Carefully add 0.1n NaOH solution drop by drop to the contents of the beaker until the natural colour changes. Periodically measure the pH of the medium. Describe the gradual colour change in the measuring cup depending on the pH of the environment. Compare the results obtained and explain the colour change. The obtained results are summarised in table 1.3.

b. Determination of total anthocyanin content in berries

20 g of berries are weighed on the electronic scale. Add 40 mL of previously prepared ethyl alcohol + 1.5M HCl solution to the weight. Chop with a mixer for 1 min. Filter through a cotton filter, rinsing the precipitate 3x with 3x10 mL of ethyl alcohol and HCl solution (total 30 mL). The obtained extract is further analysed spectrophotometrically at a wavelength of 535 nm. The sample is diluted with an alcohol-hydrochloric acid solution until its absorption coefficient falls within the range of 0.6 ÷ 0.8. The anthocyanin content in the sample is calculated according to the formula:

$$C = \frac{A \cdot v \cdot d \cdot 1000}{980 \cdot m};$$

Which A– absorption coefficient;
v – total volume of the extract;
d – dilution;
m – sample mass g.

3. Changes in chlorophyll under the influence of environment changes

Boil the given vegetable samples:

a) in distilled water;
b) 0.1N NaOH;
c) in 0.1N oxalic acid solution;
d) in 1% copper sulphate solution.

Explain the colour change of the cooked vegetable samples. The obtained results are summarised in Table 1.4.

4. Total carotenoids in fruits and vegetables.

The analysed sample is well crushed (homogenised). Weigh 1-2 g (accurate to 3 decimal places) and place in a 100 mL beaker. 20 mL of 96% ethyl alcohol is added to the weight and a magnet is placed, the sample is then stirred for 15 minutes, then 25 mL of petroleum ether is added and it is stirred on a magnetic stirrer for 1 hour. Allow the sample to stand until complete separation of the two layers has occurred, then carefully pour the top - yellow petroleum ether layer into the glass cuvette. The absorption is measured at a wavelength of 440 nm. If the absorption is very high (high carotenoid content), then reduce the weight to 0.3-0.5 g and repeat the procedure. Using the calibration graph taken with potassium dichromate, the carotene equivalent (KE), i.e. the amount of potassium dichromate corresponding to the measured absorbance, is found. Carotenoid content (mg $100g^{-1}$) is calculated according to the formula:

$$X = \frac{KE \cdot 0.208 \cdot 25}{m \cdot 36}$$

Where: 0.208 and 36 – the coefficients presented in the literature, which describe the relationship between the amount of $K_2Cr_2O_7$;

KE – carotene equivalent found according to the graduation schedule;
KE= (Abs.)/0.0194;
Abs. – absorbance read from the spectrophotometer for the given sample;
M - weight of the researched material, g.

Results

Table 1.2

Changes in beetroot juice of different concentrations after heating

	Beet juice concentrations				
	1 mL	**2 mL**	**3 mL**	**4 mL**	**5 mL**
Colour at the beginning					
Colour after 15 min. of heating					

Table 1.3

Effect of addition of different concentrations of NaOH on juice colour

	Concentrations of added NaOH					
	0 mL	**mL**	**mL**	**mL**	**mL**	**mL**
Sample colour						
The pH of the sample						

Table 1.4

Environmental effects on vegetable colour

Sample	**In distilled water**	**0.1N NaOH**	**in 0.1N oxalic acid solution**	**in 1% copper sulphate solution**

Colour at the beginning				
Colour after 15 min of cooking				

Conclusion

Provide answers to the following questions:

1. Table beet anthocyanins and their colour changes.
2. Fruit and berry anthocyanins.
3. Explain changes in chlorophyll under the influence of environmental changes.
4. Carotenoids in fruit and vegetables.

Approved by _____

Name, surname, signature

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Laboratory work

Chemical composition and quality parameters of potato tubers

Materials

Fresh and raw potatoes of different varieties and quality, depending on the number of student groups and availability.

Methods

1. Determining the amount of dirt

Only whole, uncompressed, dry, healthy, un-sprouted potatoes without straw, husks and other impurities are accepted for processing. The amount of soil adhering to tubers is allowed at 1.5% in alcohol and starch factories, and 1% for table potatoes.

Progress of work

Weigh 1 kg of potatoes, then wash them thoroughly and put them on a sieve to drain excess water for 2-3 minutes. Weigh the washed potatoes. Deduct 1% (adherent water) from the amount of washed potatoes. The amount of dirt (%) is calculated:

$$X = \frac{a - (b - 1\%) \times 100}{a}$$

X - amount of dirt %
a - quantity of dirty potatoes, kg
b - quantity of washed potatoes, kg
1% - amount of stuck water, kg

2. Blackening of potatoes

In certain cases, the natural colour changes of vegetables and fruit are undesirable. When exposed to air, cleaned, cut potatoes turn dark - black. The tyrosine in potatoes oxidises, resulting in a black pigment - melanin. The enzyme polyphenol oxidase takes part in the oxidation reaction. Different varieties of potatoes blacken at different rates. The rate of blackening is related to the activity of polyphenol oxidase, as it is higher, the faster the blackening of peeled and cut potatoes. Blackening can be prevented by completely destroying or inactivating the enzyme.

Progress of work

Clean the potato and cut it into 3 slices of the same size and thickness (3-5 mm thick). One of them is scalded in boiling water (duration of scalding – 3-5 minutes), the other is held for 3 min in 1% HCl solution and rinsed in water, but the 3rd slice is left untreated for control. All three slices are placed on a plate and left exposed to air. **ATTENTION!** First you need to boil the water, prepare the necessary dishes for work and only then clean the potato. Otherwise, the

blackening reaction will start prematurely in the cleaned potato and the final results will not be reliable.

Every 0.5 hour a colour change in the potato slices is observed. The results are summarised in a table 1.5 and explain what and why happened to the colour of the observed potato samples.

3. Determination of sensory quality indicators

Sensory indicators of potato quality are the size of their tubers and the amount of damaged tubers, shape, colour, taste, and smell.

Progress of work

To determine the size of potato tubers, weigh 1 kg of potatoes, measure the largest cross-sectional diameter of all tubers (with an accuracy of ± 1 mm) and divide into the following fractions:

- potato tubers, the dimensions of which correspond to the specified dimensions (see table 1.6),
- potato tubers that meet the permissible dimensions (see table 1.6),
- potato tubers that do not meet the specified and permissible dimensions.

The potato tubers of each fraction are weighed and their percentage in the analysed sample is determined (with an accuracy of 0.1%).

After that, the potato tubers, which in terms of size meet the specified and permissible standard requirements, are inspected and divided as follows:

- tubers without any damage or signs of disease,
- tubers with damage and signs of disease.

The fraction with damaged potatoes is weighed and its percentage in the analysed sample is determined. Compare the results with the data in table 1.7.

Sensory evaluation of cooked potatoes of different varieties.

First, boil 2 peeled potatoes of each variety. For boiled potatoes of different varieties, evaluate the given sensory properties in a 5-point system and write your findings in table 1.8

4. Determination of starch grain form

Different crops have different shapes and sizes of starch grains. By knowing the shape of the starch grains of different plants, it is possible to determine the fake flour, for example, wheat flour mixed with pea flour.

Progress of work

Examine and draw the given starch samples under a microscope, and also, using photographs of starch grains of different plants, determine which plants the given samples correspond to.

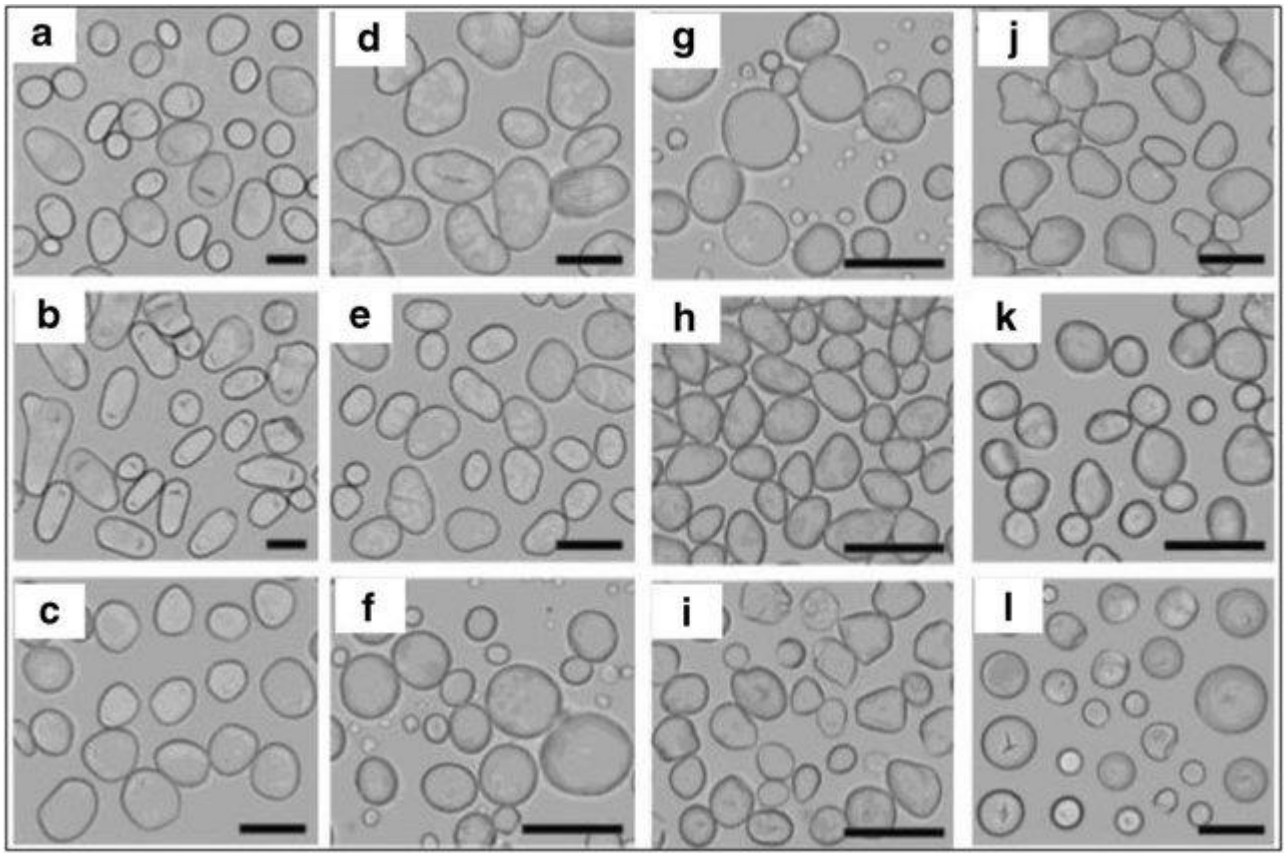

Fig.1.3 Morphology of starch granules under normal light microscope: A) Potato. B) Lotus rhizome. C) Yam. D) Pea. E) Bean. F) Barley. G) Wheat. H) Lotus seeds. I) Water chestnut. J) Water caltrop. K) Ginkgo. L) Sweet potato. DOI: 10.1007/s12551-020-00614-7

To prepare microscope slides, weigh 0.1 - 0.5 g of starch, mix with a small amount of water. A drop of the prepared suspension is placed on a glass slide with a glass rod, covered with a coverslip. The preparation is examined in two magnifications (8x7 and 40x7).

5. Content of vitamin C.

From the given sample of potatoes, choose two medium potatoes, wash and peel one and leave the other with the skin on. Determine the amount of vitamin C in fresh peeled and fresh unpeeled potatoes.

Determine the content of L-ascorbic acid (reduced form) in the given samples by the iodine method.

Progress of work

1. Prepare a standard solution of ascorbic acid: 20 mg of ascorbic acid per 100 mL of 6% oxalic acid solution.
2. Add 2 mL of 1% starch solution to 25 mL of ascorbic acid standard solution and titrate with 0.05 M iodine solution while stirring. Observe the colour change. Write down the amount of iodine used.
3. Weigh 25 g of chopped potato sample into a 500 mL beaker.

4. 100 mL of 6% $H_2C_2O_4$ solution is poured over the prepared weight and for 60 s. Grind with a mixer.
5. Filter through a cotton filter.
6. Add 2 mL of 1% starch solution to 10 mL of filtrate and titrate with 0.05M iodine solution while stirring. Observe the colour change that does not disappear within 30 seconds and write down the amount.

$$C\ vit.\left(\frac{mg}{100g}\right) = 5000 * \frac{V_{J\ sample}}{m * V_{J\ standard}}$$

5000 - coefficient

$V_{Jin\ the\ sample}$ - the amount of iodine solution used for the titration of 10 mL of the sample

$V_{Jst.\ no.}$ - the amount of iodine solution used for the titration of 25 mL standard solution

m – sample mass

Results

Table 1.5

Blackening of potatoes

Samples	**Colour change**			
	after 0.5h	**After 1h**	**after 1.5 hours**	**After 2h**
Raw control				
Treated with 1% HCl				
Treated with boiling water				

Table 1.6

Characteristics of potato tubers

Indicator name	*Characteristics and norm*	*In the given sample*
1. External appearance	Tubers are healthy, dry, clean, not green, not overgrown, without growths, cracks, not twisted, similar in shape and skin colour. For late potatoes – large with a dense skin.	
2. Form	Rounded– oval, elongated.	
3. The colour of a peeled potato	From white to yellow	
Indicator name	***Characteristics and norm***	
4. Smell	Characteristic of potatoes, without side smells.	
5. The smallest potato tuber diameter, mm, not less than: ● for late potatoes ● for early potatoes	 50.0 mm 30.0 mm	
6. The number of potato tubers, the size of which is 5 mm smaller than shown in point 5, mass %, no more than	10.0%	

Table 1.7

Characteristics of potato tubers

Indicator name	*Characteristics and norm*	**In the given sample**
1. The number of potatoes damaged by diseases, % of mass, no more	5.0	
2. The number of mechanically damaged potatoes during harvesting, % of mass, no more	2.0	
3. Amount of soil stuck to potatoes, % of mass, no more than	1.0	

Table 1.8

Sensory characteristics of potato tubers

Sensory characteristics	Potato variety				
Appearance					
Colour					
Aroma					
Taste					
Consistency					
Flouriness					

Conclusion

Write an overview and your own conclusions on the analysed potato tuber samples. Describe your preferences and overall sample compliance with the quality requirements.

Approved by _____

Name, surname, signature

Date _____

Theme 2

Fruit and vegetable preservation

Theoretical materials

Proper storage conditions for fruit and vegetables are essential to maintain their freshness, nutritional value, and overall quality.

General storage principles

Temperature - different produce items have optimal temperature ranges. Some require refrigeration, while others are best kept at room temperature.
Humidity - high humidity levels can prevent dehydration of fruits and vegetables, but too much moisture can promote mould and decay.
Ventilation - good airflow can help prevent the build-up of ethylene gas, which accelerates ripening and spoilage.
Ethylene sensitivity - some fruits produce ethylene gas, which can hasten ripening in other produce items. It's important to store ethylene-producing and ethylene-sensitive items separately.
Cleanliness - ensure storage areas and containers are clean to prevent mould and bacteria growth.
Container choice - use breathable bags or containers for items that need high humidity, and sealed containers for items that should stay dry.
Regular checks - regularly inspect stored produce for signs of spoilage or decay and remove affected items promptly to prevent spread.

Overview of fruit and vegetable storage conditions

Storage Method	Temperature	Humidity	Suitable Produce	Notes	Storage Method
Refrigeration	0 °C to 4 °C	High	Leafy greens (lettuce, spinach, kale), root vegetables (carrots, radishes, beets), cruciferous vegetables (broccoli, cauliflower, Brussels sprouts), berries (strawberries, blueberries, raspberries), apples, pears, bell peppers, cucumbers.	Separate ethylene-producing items (apples, pears) from other produce; use crisper drawers and perforated bags.	Refrigeration
Room temperature	16 °C to 21 °C	Moderate	Tomatoes, bananas, citrus fruits (oranges, lemons, limes, grapefruits), stone fruits (peaches, plums, nectarines), melons (watermelons, cantaloupes, honeydews).	Let stone fruits and tomatoes ripen before refrigeration; bananas should not be refrigerated due to skin darkening.	Room temperature
Cool, dry and dark place	10 °C to 16 °C	Low	Onions, garlic, potatoes, winter squash (butternut, acorn, spaghetti squash).	Avoid storing onions near potatoes; ensure good ventilation to prevent sprouting and moisture build-up.	Cool, dry and dark place
High-Humidity Storage	Cool	High	Root vegetables (for extended storage, such as carrots and parsnips), tubers (sweet potatoes).	Use damp sand or sawdust for long-term storage of root vegetables; cure sweet potatoes before long-term storage.	High-humidity storage
Ethylene producers and sensitive produce	Varies	Varies	Ethylene producers: apples, bananas, pears, tomatoes, avocados, melons. Ethylene sensitive: leafy greens, carrots, broccoli, cucumbers, berries.	Store ethylene producers separately from sensitive items to prevent premature ripening and spoilage.	Ethylene producers and sensitive produce

Preserving fruit and vegetables is essential for extending their shelf life, maintaining nutritional value, and reducing food waste. Various preservation methods can be employed, each with its own set of principles and techniques.

Refrigeration

- Slows down the enzymatic and microbial activities that cause spoilage.
- Suitable for short-term preservation. Most fruits and vegetables can be stored in the refrigerator to keep them fresh for a few days to a couple of weeks.

Freezing

- Stops microbial growth and slows down enzyme activity by lowering the temperature below freezing point.
- Suitable for long-term preservation. Vegetables are often blanched before freezing to preserve colour, flavour, and nutritional value. Fruit can be frozen whole, sliced, or pureed.

Canning

- Involves placing fruits and vegetables in jars or cans and heating them to a temperature that destroys microorganisms and inactivates enzymes.
- Provides long-term shelf stability. There are two main methods: water bath canning for high-acid foods (like fruit and pickles) and pressure canning for low-acid foods (like vegetables).

Drying

- Removes moisture from fruit and vegetables, inhibiting the growth of microorganisms and enzymes.
- Can be done using sun drying, air drying, or using a food dehydrator. Dried fruits and vegetables are lightweight and can be stored for extended periods.

Fermentation

- Uses beneficial bacteria or yeasts to convert sugars in fruit and vegetables into acids or alcohol, which act as preservatives.
- Commonly used for vegetables like cabbage (sauerkraut) and cucumbers (pickles), as well as for fruit in the production of chutneys and relishes. Fermented foods often have a distinct tangy flavour.

Pickling

- Preserves fruits and vegetables in an acidic solution (usually vinegar) with added salt, sugar, and spices.
- Suitable for a wide variety of vegetables (e.g. cucumbers, carrots, onions) and some fruit (e.g. mangoes, peaches). Pickled products are stored in airtight containers.

Jam and jelly making

- Involves cooking fruit with sugar and pectin to create a gel-like consistency.
- Extends the shelf life of fruit by reducing water activity and creating a high-sugar environment that inhibits microbial growth. Jams and jellies are stored in sterilised jars.

Vacuum sealing

- Removes air from the packaging to reduce oxidation and microbial growth.
- Used in combination with refrigeration or freezing to extend the shelf life of fruit and vegetables. Vacuum-sealed produce retains freshness and nutritional value longer.

Pasteurisation

- Involves heating fruits and vegetables to a specific temperature to kill harmful microorganisms without significantly affecting the nutritional value or taste.
- Common in the preservation of fruit juices and some vegetable products. Pasteurised items are then sealed in sterile containers.

Chemical preservation

- Uses chemicals like sodium benzoate, sulphur dioxide, or ascorbic acid to inhibit microbial growth and oxidation.
- Commonly used in commercial preservation. Examples include sulphite -treated dried fruits and chemically preserved juices.

Considerations:

- **Nutritional impact** - Some methods (like freezing and drying) retain more nutrients than others (like canning, which can result in some nutrient loss).
- **Flavour and texture** - The preservation method can affect the flavour and texture of the fruits and vegetables. For instance, freezing can maintain texture better than drying.
- **Safety** - Proper techniques and hygiene are crucial to prevent foodborne illnesses, especially with methods like canning and fermentation.
- **Storage conditions** - Different methods require different storage conditions. For example, canned goods should be kept in a cool, dark place, while frozen items need to remain at sub-zero temperatures.

Knowledge questions

After familiarising yourself with the lecture materials, provide answers to the following questions.

1. What are the main goals of preserving fruit and vegetables?
2. Why is it important to choose the right preservation method for different types of fruit and vegetables?
3. How does refrigeration help in preserving fruit and vegetables?
4. What are some common fruit and vegetables that should be refrigerated to extend their shelf life?
5. What is the ideal temperature range for storing most fruit and vegetables in a refrigerator?
6. What are the key elements for successful fresh fruit and vegetable storage?

Approved by _____

Name, surname, signature

Date _____

Theme 3

Fresh, minimally processed fruit and vegetables

Theoretical materials

Along with the chemical composition of fruit and vegetables, their quality indicators are of great importance. The most important of these are external appearance, size, colour, texture, degree of ripeness, taste, smell, as well as mechanical damage caused by diseases and pests.

External appearance is an important quality criterion by which the consumer evaluates fresh fruits and vegetables. The appearance is determined by various physical factors: size, shape, integrity, defects (spots, bruises, pest damage etc.), gloss and consistency. Size and shape can be affected by variety, level of ripeness, growing conditions and environment.

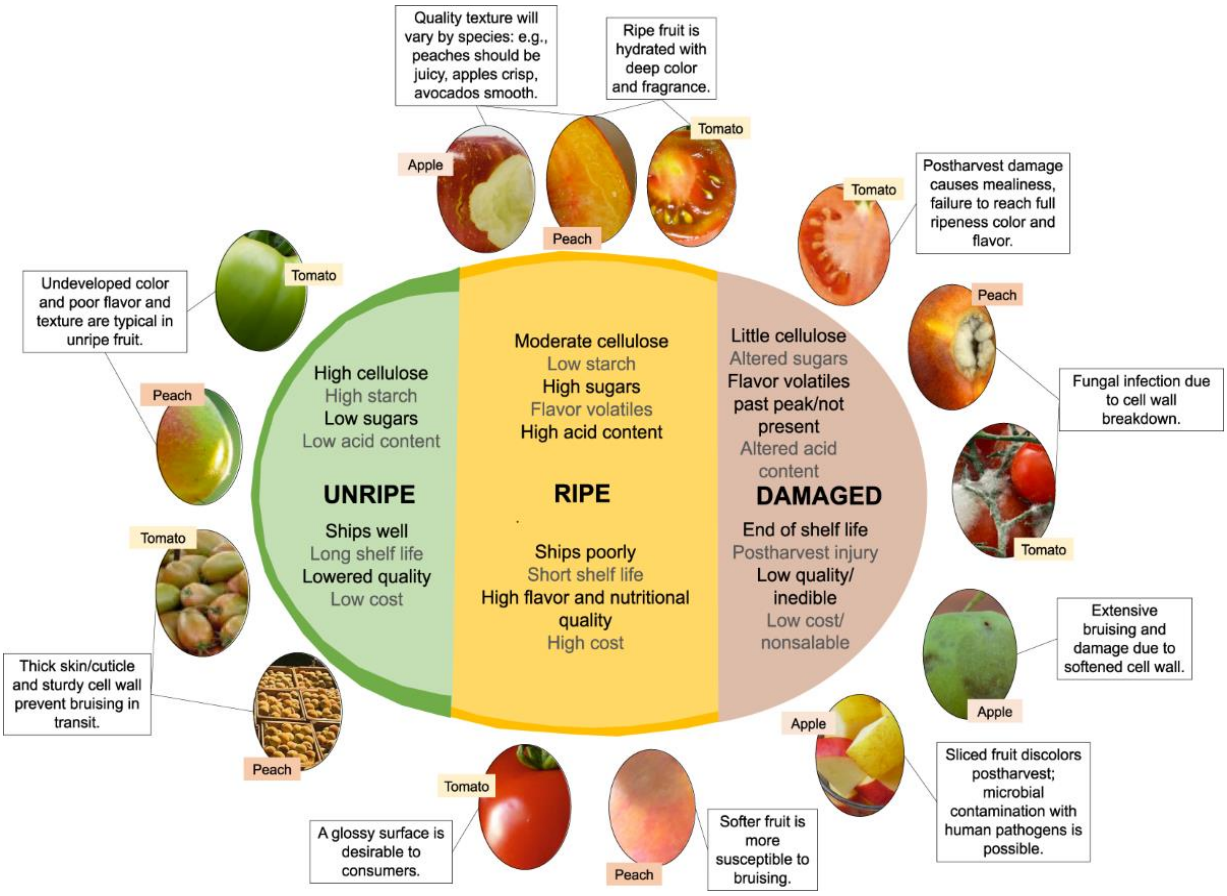

Fig. 3.1. Fruit and vegetable quality and Physico-biological characteristics.
https://www.nature.com/articles/s41438-020-00428-4/figures/3

The colour of fruit and vegetables is determined by the natural pigments that are released during their ripening and other external ones continues to change under the influence of factors such as light, temperature, and air oxygen.

When peeling, cutting and chopping fruit and vegetables, brown, grey and black pigments can be observed forming, as a result the colour of fruit and vegetables changes significantly.

The texture of fruit and vegetables is a property that can be felt by touch or mechanical action. The structure of fruit and vegetables is determined by the degree of ripeness, the specifics of the cell structure and other factors. The composition and content of substances (mostly water) in the skins and pulp of fruit and vegetables affect the formation of structures. The structure of fruit and vegetables can be determined by touch when the product is picked up in the hand or by eating it. Unlike taste, this property is easy to measure using a penetrometer, structures analyser or similar devices.

Fig. 3.2 Penetrometer measuring the density of fruit
https://www.pamalyne.com/articlegroup.asp?gid=1462

Fig. 3.3 Structure analyser https://www.stablemicrosystems.com/TAXTplus.html

Fresh and minimally processed fruits and vegetables are key components of a healthy diet. They retain most of their natural nutrients, flavours, and textures, providing essential vitamins, minerals, fibre, and antioxidants. Here's a breakdown of each category:

Fresh fruit and vegetables

- **Fresh fruit**: These are picked and sold with minimal delay. Examples include apples, bananas, oranges, berries, grapes, and melons. They should be stored properly to maintain freshness.
- **Fresh vegetables**: These are harvested and sold in their natural state. Examples include leafy greens (spinach, kale), root vegetables (carrots, beets), and cruciferous vegetables (broccoli, cauliflower).

Minimally processed fruits and vegetables

Minimally processed foods have undergone slight alterations to make them more convenient without significantly changing their nutritional content. This processing can include cleaning, cutting, peeling, or packaging.

- **Pre-cut and pre-washed**: These fruit and vegetables are cleaned and cut for convenience, such as bagged salad greens, carrot sticks, and fruit salads.
- **Frozen**: Freezing preserves most nutrients and can be a convenient alternative to fresh produce. Examples include frozen berries, peas, and spinach.

Benefits of fresh and minimally processed produce

1. **Nutritional value**: These foods are rich in essential nutrients, including vitamins C and A, folate, potassium, and fibre.
2. **Antioxidants**: They contain antioxidants that help protect the body from oxidative stress and may reduce the risk of chronic diseases.
3. **Low in additives**: Fresh and minimally processed produce typically contain fewer preservatives, sodium, and sugar compared to more heavily processed options.
4. **Flavour and texture**: They offer better flavour and texture, enhancing the overall eating experience.

Tips for selecting and storing

- **Selection**: Choose fruit and vegetables that are firm, vibrant in colour, and free from blemishes or signs of spoilage.
- **Storage**: Store produce properly to extend shelf life. Refrigerate most fruit and vegetables, except those that ripen on the counter (e.g. tomatoes, avocados, bananas).

Importance of packaging

Packaging in a modified environment (vacuum, inert gas environment) is the most suitable technology that can be offered to processors who want to prepare fresh vegetables for commercial needs and meet the modern demands of the public.

It is known that by changing the composition of the environment around the product in the package, it is possible to inhibit or delay the natural deterioration processes and extend the storage time. Therefore, in order to evaluate the importance of storage technologies on product quality, samples must be prepared initially.

If you choose a packaging material with selective properties, it is possible to significantly extend product shelf life.

For fruit, berries and vegetables, the optimal environment is the EMAP environment, where the gas composition inside the package is as follows: O_2 = 2-10% and CO_2 = 5-15%.

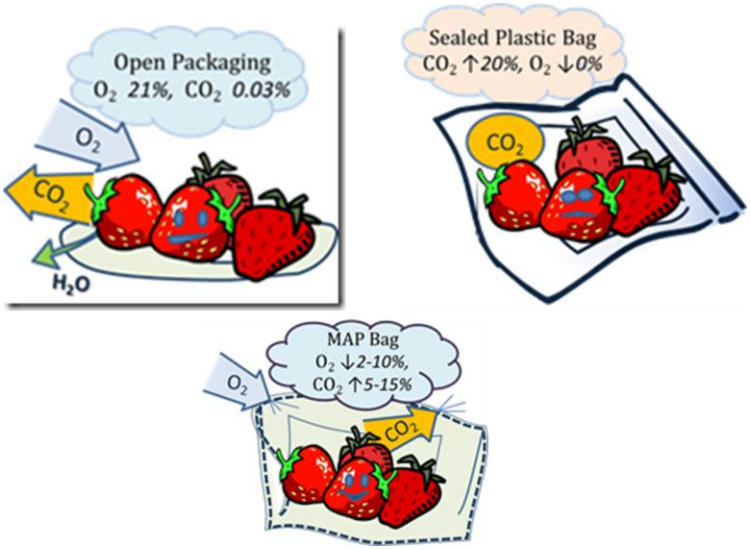

Fig. 3.4 Illustration on the effect of barrier properties of the packaging materials on the product during storage.

Fig. 3.5 Summary of possible packaging equipment https://gpnuy.com/project/tffs-spapor-bassa/

The choice of packaging equipment depends on the volume of product packaging required by the company.

Microbiological aspects of fresh, cut and minimally processed fruit and vegetables

The microbiological aspects of fresh, cut, and minimally processed fruit and vegetables are critical to ensuring food safety and quality. These products are susceptible to microbial contamination at various stages of production, handling, and storage. Below are key points addressing the microbiological concerns:

Fresh produce:

1. **Sources of contamination:**
    - **Soil and water:** Pathogens such as *Escherichia coli*, *Salmonella*, and *Listeria monocytogenes* can be present in soil and irrigation water.
    - **Animals and insects:** Wildlife, livestock, and insects can introduce pathogens to crops.
    - **Human handling:** Contamination can occur through improper handling by farm workers.
2. **Types of microorganisms:**
    - **Pathogenic bacteria:** *E. coli*, *Salmonella*, *Listeria monocytogenes*, *Shigella*, and *Campylobacter*.
    - **Spoilage organisms:** Pseudomonads, lactic acid bacteria, and moulds that cause visible spoilage.

Cut and minimally processed produce:

1. **Increased risk of contamination:**
    - Cutting and peeling can release nutrients and water, creating an ideal environment for microbial growth.
    - Damaged tissues are more susceptible to contamination and spoilage.
2. **Handling and processing:**
    - **Sanitation:** Equipment and surfaces used in cutting and processing must be properly sanitised to prevent cross-contamination.
    - **Temperature control:** Maintaining appropriate refrigeration temperatures (typically below 5°C) is crucial to slowing microbial growth.
3. **Modified atmosphere packaging (MAP):**
    - MAP involves altering the atmosphere inside the packaging to reduce oxygen levels and increase carbon dioxide, inhibiting the growth of aerobic spoilage organisms and pathogens.
    - However, MAP can sometimes promote the growth of anaerobic pathogens if not managed properly.

Control measures and safety practices

1. **Good agricultural practices (GAP):**
    - Ensuring the use of clean water for irrigation and washing.
    - Implementing measures to keep animals away from growing areas.
    - Training farm workers in hygiene and sanitation practices.
2. **Good manufacturing practices (GMP):**
    - Properly cleaning and sanitising equipment and facilities.
    - Implementing Hazard Analysis and Critical Control Points (HACCP) systems to identify and manage potential contamination risks.
3. **Consumer practices:**
    - Washing fresh produce thoroughly under running water.
    - Storing cut fruits and vegetables at appropriate refrigeration temperatures.
    - Avoiding cross-contamination by using separate cutting boards and utensils for raw produce and other foods like raw meat.

Common microbial concerns in specific produce

- **Leafy greens:** High risk due to their large surface area and frequent consumption without cooking.
- **Melons:** The rough rind can harbour pathogens, which can be transferred to the flesh when cut.
- **Berries:** Susceptible to contamination due to their delicate nature and frequent consumption without washing.

Emerging concerns

- **Antimicrobial resistance:** The use of antibiotics in agriculture can lead to the development of resistant strains of bacteria.
- **Novel pathogens:** New pathogens can emerge, posing unexpected risks to food safety.

Maintaining the microbiological safety of fresh, cut, and minimally processed fruit and vegetables requires a comprehensive approach encompassing good agricultural and manufacturing practices, effective sanitation, temperature control, and consumer education. Continuous monitoring and adaptation to emerging threats are also essential to ensure the safety and quality of these perishable products.

Laboratory work

Preparation of fresh, cut and packaged vegetables

Materials

Various vegetables. Different packaging materials:

1. Material with high gas barrier properties;
2. A second material with low gas barrier properties, and
3. A third packaging material with selective barrier properties.

Depending on the application, the finished pillow-shaped packages or products are placed in ready-made trays and sealed in different packaging machines.

Methods

Sample 1 – Potatoes

To observe changes in potato quality during storage, prepare the following variations:
Fresh, unpeeled potato 1-2 pieces.
Fresh, peeled potatoes, cut into 1 cm wide sticks, rinsed, dried and packed in 3 different conditions. One package contains an average of 300 g of potatoes.
Samples need to be prepared for storage under normal conditions and for refrigerated storage.
The prepared samples are documented according to the information required in table 3.1 and evaluated before storage and every 2 days thereafter, making appropriate notes in table 3.1.

Sample 2 – Beetroot

To observe changes in the quality of beets during storage, prepare the following variations:
Fresh, unpeeled beets 1 piece.
Fresh, peeled beets, cut into 1 cm wide sticks, rinsed, dried and packed in 3 different conditions. One package contains an average of 300 g of beets.
Samples need to be prepared for storage under normal conditions and for refrigerated storage.
The prepared samples are documented according to the information required in table 3.1 and evaluated before storage and every 2 days thereafter, making appropriate notes in table 3.1.

Sample 3 – Carrots

To observe changes in the quality of carrots during storage, prepare the following variations:
Fresh, unpeeled carrots 1-2 pieces.
A fresh, peeled carrot, cut into 1 cm wide discs, rinsed, dried and packed in 3 different conditions. One package contains an average of 300 g of carrots.
Samples need to be prepared for storage under normal conditions and for refrigerated storage.
The prepared samples are documented according to the information required in table 3.1 and evaluated before storage and every 2 days thereafter, making appropriate notes in table 3.1.

Results

Table 3.1

Description of samples

Analysed sample:			
Storage conditions	**Storage time**	**Description of the visual appearance of the product**	**Image** *(if possible)*

Conclusion

Provide an overview on the obtained results. Write possible explanations on the detected quality changes.

Approved by _____

Name, surname, signature

Date _____

Laboratory work

Quality evaluation of fresh, cut and packaged vegetables

Materials

In previous laboratory work prepared samples.

Laboratory equipment: gas composition detector; colour analyser; structure analyser.

Methods

1. Visual evaluation of packaged vegetables

Visually evaluate and compare packaged vegetables to see if there are any quality differences or deviations. Briefly describe and summarise the observations in table 3.1.

2. Gas composition analysis

Place an unopened packet of packaged vegetables near the gas analyser, carefully poke the needle through the layer of the packaging material so that the tip of the needle is in the inner environment of the package (without piercing the vegetables), then read the obtained result by pressing the reading button of the device. The results are summarized in table 3.2.

3. Colour (in the L*a*b* system) analysis

To determine the colour of the vegetable in the coordinate system, the unpeeled vegetable is first peeled and cut in the same way as the peeled samples. Following it, 3 pieces of vegetables are taken from each sample, placed on the table on white paper and analysed with a colour analyser in the L*a*b* system. The L*a*b* system uses three perpendicular axes, on which a negative a* value represents the intensity of the green color, a positive a* value represents the intensity of the red color, a negative b* value means an increase in the blue colour intensity, a positive b* value represents the yellow colour intensity, while L* is a representative of white-black or light-dark intensity (Figure 3.6).

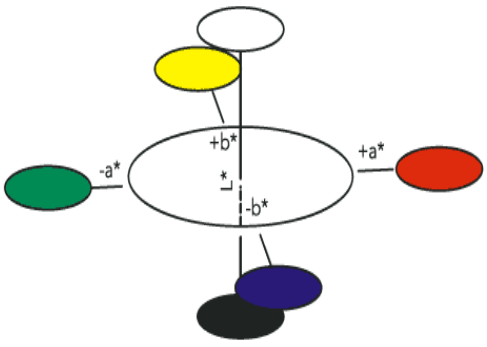

Fig. 3.6 CIE L*a*b* colour system https://www.ulprospector.com/knowledge/16423/pc-the-cielab-system-the-method-to-specify-colors-of-coatings/

4. Hardness, elasticity analysis with structure analyser

The vegetable pieces to be analysed are placed on the texture analyser tray (figure 3.7). Measurements are made by pressing the sample with force and measuring the force (N) with which the vegetable can be cut at a pressing speed of 10 mm s^{-1}.

Fig. 3.7 Structure analyser https://www.stablemicrosystems.com/TAXTplus.html

The result is the maximum force (N) needed to cut the respective vegetable.

The fresher the vegetables are, the easier they are to cut and less force is required, but as vegetables age, losing moisture, they become more flexible and harder to cut. Measurements are made by taking three pieces from each vegetable sample.

5. Determination of pH

To determine product pH changes in vegetable samples, they are first peeled, cut and ground in a blender. From the obtained vegetable mass, juice is squeezed through cheesecloth and poured into a beaker in which the electrode of the pH meter is dipped and the pH of the product is determined.

Results

Table 3.2

Description of samples

Sample	Composition of gases	Colour L*a*b*	Average firmness, N	pH

Conclusion

Provide an overview of the obtained results. Write possible explanations on the detected quality changes.

Approved by _____

Name, surname, signature

Date _____

Laboratory work

Microbiological assessment of fresh, cut and packaged vegetables

Materials

Samples prepared in previous laboratory work or commercial samples.

Laboratory equipment: thermostats (for microorganism incubation at 27 °C, 30 °C and 37 °C); bag mixer (homogeniser); scales, colony counter (optional).

Methods

1. Visually evaluate the samples ready for microbiological evaluation. Based on your findings decide on the levels of dilution you should prepare to detect TPC (total plate count), E.coli, yeasts and moulds, and lactic acid bacteria (if needed).
2. Prepare agars needed to detect TPC (total plate count), E.coli, yeasts and moulds, and lactic acid bacteria (if needed).
3. Sample preparation:
   a. Clean and prepare a sterile working space to prepare the product for microbiological evaluation.
   b. For homogenous samples, blend or homogenise 10 g of sample in a sterile blender with 90 mL of diluent like buffered peptone water.
   c. Prepare serial dilutions (e.g. 1:10, 1:100, etc.) by transferring 1 mL of the homogenate into 9 mL of sterile diluent.
4. Microbial enumeration:
   a. Media preparation - prepare plate count agar (PCA) or another suitable growth medium.
   b. Plating - using a pipette, transfer 1 mL of each dilution onto separate Petri dishes.
   c. Spreading - pour molten agar (cooled to around 40 °C) over the sample and swirl to mix evenly.
   d. Incubation - incubate plates according to table 3.3
   e. Counting - count the colonies on plates and calculate CFU/mL or CFU/g using the dilution factor.
   f. Perform tests in duplicate or triplicate to ensure accuracy and reproducibility.

Table 3.3

Microorganism media and incubation parameters

Microorganism	Agar	Incubation temperature	Incubation time	Characteristics
TPC	Plate Count Agar (PCA)	30 °C	48-72 hours	General growth of bacteria, colony count
E.coli and coliform bacteria	Endo agar (ENDO)	37 °C	24-48 hours	Metallic green sheen colonies
	Chromogenic Agar	37 °C	24-48 hours	Blue/purple colonies
Yeasts and moulds	Potato Dextrose Agar (PDA)	25-30 °C	5-7 days	Yeasts: creamy colonies, moulds: fuzzy colonies
	Sabouraud Dextrose Agar (SDA)	25-30 °C	5-7 days	Yeasts: creamy colonies, moulds: fuzzy colonies
	Malt extract agar (NMA)	25-30 °C	5-7 days	Yeasts: creamy colonies, moulds: fuzzy colonies
Lactic acid bacteria	De Man, Rogosa and Sharpe (MRS) Agar	30 °C	48-72 hours	Small, round, and creamy colonies

5. Data recording and analysis:
    a. Colony counting - count colonies on all relevant plates and calculate CFU based on dilution factors.
    b. Data logging - record all results meticulously, including colony counts, media used, incubation conditions, and any confirmations performed.
    c. Statistical analysis - analyse the data to determine the microbial load, presence of pathogens, and any trends or patterns.

Results

Write down and summarise all of the findings according to work description. Write down and summarise sample description, the methods, results, and interpretations for sample testing.

Conclusion

1. Ensure and compare the report complies with relevant regulatory and safety standards.
2. Based on the findings, provide recommendations for handling, processing, or further testing if contamination is detected.

Approved by _____

Name, surname, signature

Date _____

Theme 4

Packaging equipment and special packaging materials and methods used in fruit and vegetable product production

Knowledge questions

After familiarising yourself with the lecture materials, provide answers to the following questions:

1. How do packaging materials affect the delivery time of fruit, vegetables and berries?
2. How do packaging technologies affect the delivery time of fruit, vegetables and berries?
3. Packaging as an element of added value.
4. How does a vacuum packaging machine work, and what are its benefits for preserving fruit and vegetables?
5. What are the characteristics of polyethylene (PE) and how is it used in packaging fruit and vegetables?
6. Explain the benefits and applications of polypropylene (PP) in packaging.
7. How does the use of biodegradable packaging materials benefit the environment?
8. What are the properties of modified atmosphere packaging (MAP) films, and how do they help in preserving produce?
9. Describe the role of ethylene absorbers in fruit packaging.

Approved by _____

Name, surname, signature

Date _____

Theme 5

Technological equipment for fruit and vegetable processing

Knowledge questions

After familiarising yourself with the lecture materials, provide answers to the following questions:

1. How does automation improve the efficiency and consistency of fruit and vegetable processing?
2. Describe the working principle of a fruit and vegetable washing machine.
3. What are the advantages of using automated sorting machines in processing plants?
4. How do optical sorters differentiate between good and bad produce?
5. How does a dicing machine maintain uniformity in processed vegetable products?
6. What are the main types of juicers used in fruit processing, and how do they differ?
7. Explain the sterilisation process in canning and its importance.
8. Explain the pasteurisation process in canning and its importance.

Approved by _____

Name, surname, signature

Date _____

Theme 6

Fermented fruit and vegetable production

Theoretical materials

Fermenting vegetables is a traditional method of preserving food and enhancing its nutritional value and flavour. The process involves the action of beneficial bacteria, primarily lactic acid bacteria, which convert sugars in the vegetables into lactic acid. This acid acts as a preservative, creating an environment that inhibits the growth of harmful bacteria.

Fermentation is the oldest form of preservation. Modern nutritional science recognises that of all the methods of processing vegetables, only acidification using lactic acid bacteria does not reduce, but even improves the nutritional value of the product - it increases the content of vitamins, free amino acids and other physiologically active substances.

The accumulation of lactic acid does not allow the development of rotting and butyric acid bacteria, therefore, in order for the products to be fermented and not to spoil, conditions must be created that promote the development of lactic acid bacteria.

Steps for fermenting vegetables

1. **Selection of vegetables** - Choose fresh, high-quality vegetables. Common choices include cabbage (for sauerkraut and kimchi), cucumbers (for pickles), carrots, radishes, beets, and peppers.
2. **Preparation** - Wash the vegetables thoroughly. Depending on the type of vegetable and the desired end product, they can be shredded, chopped, sliced, or left whole.
3. **Salting** - Salt is essential for fermentation. It draws out water from the vegetables, creates brine, and inhibits the growth of undesirable bacteria. The salt concentration typically ranges from 1-3% of the vegetable weight.
4. **Adding starter culture (optional)** - While natural fermentation relies on the bacteria present on the vegetables and in the environment, adding a starter culture (such as whey or a previous batch of fermented vegetables) can kick-start the fermentation process.
5. **Packing** - Pack the vegetables tightly into a fermentation vessel (such as a jar or crock), ensuring that they are submerged under the brine. Use a weight to keep the vegetables submerged.
6. **Fermentation** - Cover the vessel with a lid or cloth to keep out dust and insects, but to allow gases produced during fermentation to escape. Place the vessel at room temperature, typically between 18-22 °C.
7. **Monitoring** - Check the vegetables daily to ensure they remain submerged under the brine. Skim off any mould or scum that forms on the surface.
8. **Tasting and storage** - Fermentation time can vary from a few days to several weeks, depending on the vegetable, temperature, and desired flavour. Taste the vegetables

periodically and move them to cold storage (refrigerator or cellar) once they reach the desired level of fermentation.

Important factors for successful fermentation

- **Cleanliness** - Ensure all equipment and work surfaces are clean to prevent contamination.
- **Temperature control** - Fermentation proceeds faster at higher temperatures, but may result in softer vegetables. Cooler temperatures slow the process, but produce crisper vegetables.
- **Salt quality** - Use non-iodised salt, such as sea salt or kosher salt, as iodine can inhibit the fermentation process.
- **Brine levels** - Keeping vegetables submerged in brine prevents exposure to air, reducing the risk of spoilage.

Some health benefits of fermented products

Fermented vegetables are rich in probiotics, which are beneficial for gut health. They can improve digestion, boost the immune system, and increase the bioavailability of nutrients. Additionally, the fermentation process can reduce anti-nutrients and increase levels of certain vitamins, such as B vitamins and vitamin K_2.

Quality defects

- **Slimy vegetables** - Caused by too low a salt concentration or too high a temperature. Adjust the salt and temperature.
- **Mould** - White mould is usually harmless and can be skimmed off. Black, red, or pink mould indicates spoilage, and the batch should be discarded.
- **Off-smells** - While fermentation produces strong smells, a rotten or putrid odour suggests spoilage.

<u>For fermentation of sauerkraut:</u>

1. Raw materials must not be contaminated with soil, containers intended for pickling must be perfectly clean.
2. Fermentation must take place at a temperature higher than 1 5°C (optimal 18-22 °C).
3. It is necessary to ensure that the sugars diffuse quickly and as completely as possible from the raw materials into the juice that surrounds them during fermentation.

During the preparation stage for making sauerkraut, you should not add too much salt to pickling cabbage, as this will reduce the effectiveness of the lactic acid bacteria and vitamin C is not well preserved. The desired amount of salt in sauerkraut is 1.3 - 1.8%. Cabbage with 1.3% of added salt has the best taste and keeps well. In Latvia, the favourite seasoning for sauerkraut is caraway seeds. They contain a lot of essential oils, which give the cabbage a pleasant smell and taste. No more than 0.2% of cumin seeds are added. Carrots are often used as an additive at 2-3% of the total mass. Carrots give sauerkraut a pleasant taste and colour.

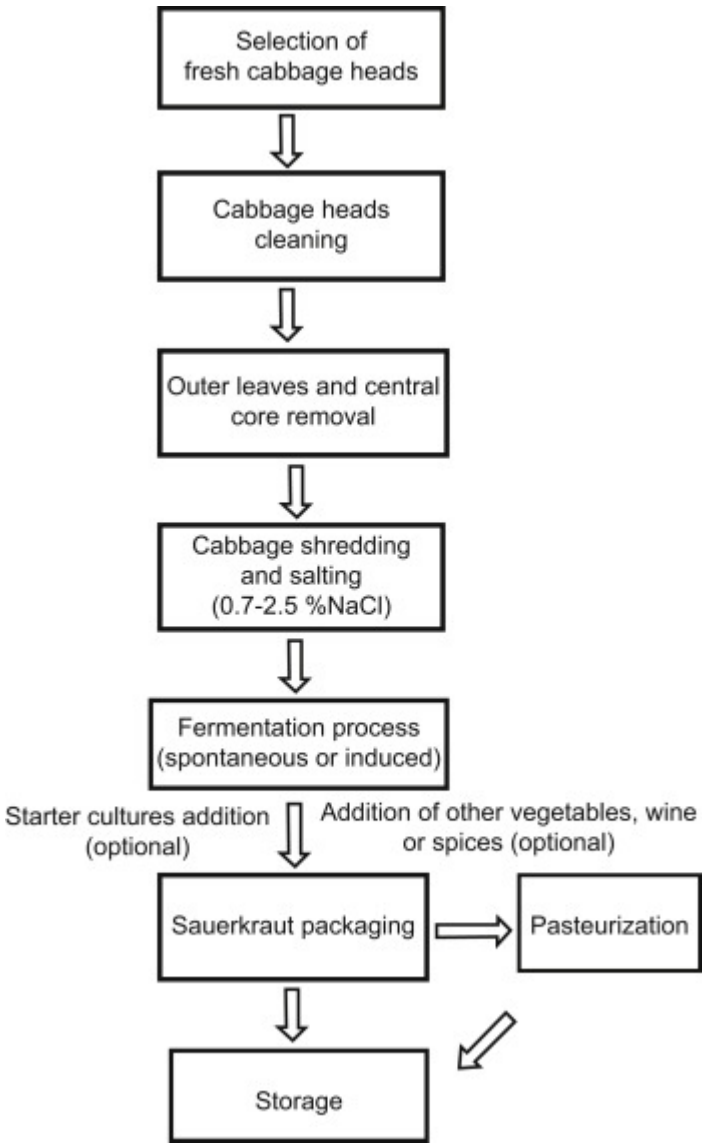

Fig 6.1 Sauerkraut production (https://doi.org/10.1016/B978-0-12-802309-9.00024-8)

Key microbiological aspects of fermented vegetable products

Fermented vegetable products rely on the activity of beneficial microorganisms to preserve the vegetables and enhance their flavour and nutritional value. Understanding the microbiological aspects is crucial for producing safe and high-quality fermented foods. Here's an overview of the key microbiological aspects involved in the fermentation of vegetables:

Key microorganisms in vegetable fermentation

1. **Lactic acid bacteria (LAB)**:
    - **Primary role** - The main drivers of vegetable fermentation, LAB convert sugars into lactic acid, lowering the pH and creating an acidic environment that inhibits the growth of spoilage and pathogenic organisms.

- **Common LAB Species**:
  - *Lactobacillus*: *Lactobacillus plantarum*, *Lactobacillus brevis*, *Lactobacillus acidophilus.*
  - *Leuconostoc*: *Leuconostoc mesenteroides.*
  - *Pediococcus*: *Pediococcus pentosaceus*, *Pediococcus acidilactici.*

2. **Yeasts**:
   - **Role**: Some yeasts can contribute to the flavour profile and secondary fermentation processes. They may also produce alcohol and carbon dioxide.
   - **Common yeast species**: *Saccharomyces cerevisiae*, *Candida spp.*
3. **Other Bacteria**:
   - **Acetic acid bacteria**: Can be involved in surface fermentation, producing acetic acid.
   - **Enterobacteriaceae**: Often present in the initial stages, but usually decline as acidity increases.

Fermentation Process

1. **Initial phase (heterofermentative LAB)**:

Leuconostoc mesenteroides typically dominate, producing lactic acid, carbon dioxide, and some acetic acid and ethanol. This phase lowers the pH and creates anaerobic conditions.

2. **Primary fermentation phase (homofermentative LAB)**:

Lactobacillus plantarum and *Pediococcus spp.* take over, producing primarily lactic acid, which further decreases the pH to around 3.5-4.0, preserving the vegetables.

3. **Final stabilisation phase**:

Further reduction in pH and inhibition of spoilage organisms ensure the longevity and safety of the fermented product.

Factors influencing microbial activity

1. **Salt concentration**:

Optimal salt concentrations (typically 2-3% for many vegetables) help select for LAB while inhibiting undesirable microorganisms. Too little salt can allow spoilage bacteria to thrive, while too much can inhibit LAB activity.

2. **Temperature**:

Optimal fermentation temperatures range from 18-22 °C (64-72 °F). Higher temperatures can speed up fermentation, but may lead to softer textures and increased risk of spoilage, while lower temperatures slow down the process.

3. **Oxygen levels**:

Anaerobic conditions are essential for proper fermentation. Exposure to air can lead to spoilage and growth of aerobic organisms like moulds.

4. **pH Levels**:

A rapid drop in pH to below 4.6 is critical to inhibit the growth of pathogenic bacteria such as *Clostridium botulinum*.

Safety and quality control

1. **Pathogen inhibition**:

The low pH and high lactic acid concentration in fermented vegetables inhibit the growth of most pathogens. Proper salt concentration and anaerobic conditions are key to preventing the growth of harmful bacteria such as *Listeria monocytogenes* and *Clostridium botulinum*.

2. **Hygiene and sanitation**:

Clean equipment and sanitary practices help prevent contamination by spoilage organisms and pathogens.

3. **Starter cultures**:

While traditional fermentation relies on naturally occurring microorganisms, using starter cultures can provide more consistent results and reduce the risk of undesirable microbial activity.

Common issues

1. **Mould growth**:

Typically occurs due to exposure to air. Ensure vegetables are fully submerged in the brine, and use fermentation weights and airlock systems to maintain anaerobic conditions.

2. **Off-flavours**:

Can result from contamination, inadequate salt concentration or improper fermentation temperatures. Adjusting these factors can help maintain desirable flavours.

3. **Soft texture**:

Often due to high temperatures or insufficient salt. Lower fermentation temperatures and correct salt levels can help retain crispness.

Sensory parameters of sauerkraut

Sensory evaluation of sauerkraut means - to assessing and describing its sensory properties (appearance, aroma, flavour, texture, and overall liking). In sensory evaluation, these properties are often assessed by both trained panellists and consumers to ensure that the sauerkraut meets quality standards (company or ISO or GOST or others determined by different countries) and consumer preferences.

The colour of sauerkraut - from pale yellow to light green. The colour should be uniform without dark spots or discolouration, brightness, uniformity, and presence of any discolouration or defects in the sauerkraut.

The aroma of sauerkraut - fresh, without any off-odours; a characteristic tangy, sour smell indicative of the lactic acid fermentation process; may include notes of spices or other ingredients if added during fermentation.

The taste of sauerkraut - balanced sour, resulting from lactic acid produced during fermentation; if spices, herbs, or other vegetables are added, these should complement the primary taste.

The texture of sauerkraut - the cabbage should retain some crunch, indicating it hasn't become overly soft or mushy; pieces of cabbage should have a firm bite, not too hard or too limp.

A Line scale can be used to determine the influence of different sauerkraut preparation technologies and the raw materials used on the intensity of the product's sensory properties (colour, aroma, crispness, sour taste, salty taste). With the Line scale, you can determine the intensity of each sensory property and it is possible to create a profile of the sensory properties of each sample.

Laboratory work

Preparation of sauerkraut

Materials

Fresh white cabbage, salt, cumin and other additives as available and/or preferred.

Methods

Tasks:

1. Calculate the mass loss of cabbage during the pickling process.
2. Ferment cabbage with various additives.

Preparation of sauerkraut using various additives

Sample 1
Cabbage is cleaned, cored and chopped. Place it in a container and add 1.3% table salt (coarse), 0.2% cumin and 0.5% sugar as additives. The mass is mixed, kneaded until the juice is released, covered with cabbage leaves, weight is placed on top, and left at room temperature. After about 3 days, when the cabbage has soured, add another 1.5% of cranberries.

Sample 2
Cabbage is cleaned, cored and chopped. Place it in a container and add 1.3% table salt (coarse), 0.2% cumin as additives. The mass is mixed, kneaded until the juice is released, covered with cabbage leaves, put on a load, and left at room temperature.

Sample 3
Cabbage is cleaned, cored and chopped. Place it in a container and add 1.4% table salt (coarse salt), 0.2% cumin and 1.5% carrots as additives. The mass is mixed, kneaded until the juice is released, covered with cabbage leaves, put on a load, and left at room temperature.

Sample 4
Cabbage is cleaned, cored and chopped. Place it in a container and add 1.5% table salt (coarse salt), 0.3% sugar and 0.3% cranberries as additives. The mass is mixed, kneaded until the juice is released, covered with cabbage leaves, weight is placed on top, and left at room temperature.

Sample 5
Cabbage is cleaned, cored and chopped. Place it in a container and add 1.5% table salt (coarse salt), 0.3% sugar and 0.6% cranberries as additives. The mass is mixed, kneaded until the juice is released, covered with cabbage leaves, weight is placed on top, and left at room temperature.

Sample 6
Cabbage is cleaned, cored and chopped. Place it in a container and add 1.5% table salt (coarse salt) and 2.5% apple as additives. The mass is mixed, kneaded until the juice is released, covered with cabbage leaves, weight is placed on top, and left at room temperature.

Sample 7
Cabbage is cleaned, cored and chopped. Place it in a container and add 1.4% table salt (coarse salt) and 2.5% carrots as additives. The mass is mixed, kneaded until the juice is released, covered with cabbage leaves, weight is placed on top, and left at room temperature.

Sample 8
Cabbage is cleaned, cored and chopped. Place in a container and add 1.6% table salt (coarse salt), 1% sugar and 3% carrots as additives. The mass is mixed, kneaded until the juice is released, covered with cabbage leaves, weight is placed on top, and left at room temperature.

Sample 9
Cabbage is cleaned, cored and chopped. Place it in a container and add 1.4% table salt (coarse salt) and 2.5% carrots as additives. The mass is mixed, kneaded until the juice is released, covered with cabbage leaves, weight is placed on top, and left at room temperature.

Sample 10
Cabbage is cleaned, cored and chopped. Place it in a container and add 1.5% table salt (coarse salt) and 4% apple as additives. The mass is mixed, kneaded until the juice is released, covered with cabbage leaves, weight is placed on top, and left at room temperature. After about 3-5 days, when the cabbage has soured, add another 3% of cranberries.

Approved by _____

Name, surname, signature

Date _____

Laboratory work

Packaging and storage of sauerkraut. Product treatment in sous-vide.

The aim of the laboratory work is to acquire skills in sous-vide packaging technology, using packaging materials with high gas barrier properties and using a chamber-type melting device. An experiment was carried out where the heat treatment time is changed.

The group of students is divided into teams and each team performs experiments.

Materials

Products prepared in previous experiments or commercially available products/materials purchased.

Methods

Take part of the previously prepared sauerkraut or commercially available sauerkraut. The product is placed in packaging bags (pouches) and then hermetically sealed, and then hot water is added in a bath where the temperature and pasteurisation time are controlled. Each group packs at least 6 packs so that different heating/pasteurisation times can be experimented with.

The rest of the prepared sauerkraut is placed in airtight containers and stored refrigerated until further testing - (4±2°C).

During the practical work, students learned the skills of working with packaging equipment and packaging technologies. Students learn to work in groups.

Results

Depict the obtained results in table 6.1.

Table 6.1

Obtained results

Sample	Product No. 1	Product No. 2	Product No. 3
Sample without heat treatment			

Heat treatment - 5 min			
Heat treatment - 10 min			
Heat treatment - 20 min			
Heat treatment - 30 min			

Conclusion

After the products have been packaged, different groups of students compare the results. Write an overview of your findings and give explanations to differences noted between the samples.

Approved by _____

Name, surname, signature

Date _____

Laboratory work

Microbiological evaluation of prepared sauerkraut

Materials

Product samples prepared in previous laboratory work or commercially available product samples.

Laboratory equipment: thermostats (for microorganism incubation at 27 °C, 30 °C and 37 °C); bag mixer (homogeniser); scales, colony counter (optional).

1. Visually evaluate the samples ready for microbiological evaluation. Based on your findings, decide on the levels of dilution you should prepare to detect TPC (total plate count), E.coli, yeasts and moulds, and lactic acid bacteria (if needed).
2. Prepare agars needed to detect TPC (total plate count), E.coli, yeasts and moulds, and lactic acid bacteria (if needed).
3. Sample preparation:
    a. Clean and prepare a sterile working space to prepare the product for microbiological evaluation.
    b. For homogenous samples, blend or homogenise 10 g of sample in a sterile blender with 90 mL of diluent such as buffered peptone water.
    c. Prepare serial dilutions (e.g. 1:10, 1:100, etc.) by transferring 1 mL of the homogenate into 9 mL of sterile diluent.
4. Microbial enumeration:
    a. Media preparation - prepare plate count agar (PCA) or another suitable growth medium.
    b. Plating - using a pipette, transfer 1 mL of each dilution onto separate Petri dishes.
    c. Spreading - pour molten agar (cooled to around 40 °C) over the sample and swirl to mix evenly.
    d. Incubation - incubate plates according to table 6.2
    e. Counting - count the colonies on plates and calculate CFU/mL or CFU/g using the dilution factor.
    f. Perform tests in duplicate or triplicate to ensure accuracy and reproducibility.

Table 6.2

Microorganism media and incubation parameters

Microorganism	Agar	Incubation temperature	Incubation time	Characteristics
TPC	Plate Count Agar (PCA)	30 °C	48-72 hours	General growth of bacteria, colony count
E.coli and coliform bacteria	Endo agar (ENDO)	37 °C	24-48 hours	Metallic green sheen colonies
	Chromogenic Agar	37 °C	24-48 hours	Blue/purple colonies
Yeasts and moulds	Potato Dextrose Agar (PDA)	25-30 °C	5-7 days	Yeasts: creamy colonies, moulds: fuzzy colonies
	Sabouraud Dextrose Agar (SDA)	25-30 °C	5-7 days	Yeasts: creamy colonies, oulds: fuzzy colonies
	Malt extract agar (NMA)	25-30 °C	5-7 days	Yeasts: creamy colonies, moulds: fuzzy colonies
Lactic acid bacteria	De Man, Rogosa and Sharpe (MRS) Agar	30 °C	48-72 hours	Small, round, and creamy colonies

5. Data recording and analysis:
    a. Colony counting - count colonies on all relevant plates and calculate CFU based on dilution factors.
    b. Data logging - record all results meticulously, including colony counts, media used, incubation conditions, and any confirmations performed.
    c. Statistical analysis - analyse the data to determine the microbial load, presence of pathogens, and any trends or patterns.

Results

Write down and summarise all of the findings according to work description. Write down and summarise sample description, the methods, results, and interpretations for sample testing.

Conclusion

1. Ensure and compare the report complies with relevant regulatory and safety standards.
2. Based on findings, provide recommendations for handling, processing, or further testing if contamination is detected.

Approved by _____

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Date _____

Laboratory work

Sensory evaluation of sauerkraut

Materials

A total of six samples are used for the sensory evaluation - five from previously prepared samples and one from the store, already available in the market.

For mouth cleaning between samples - water.

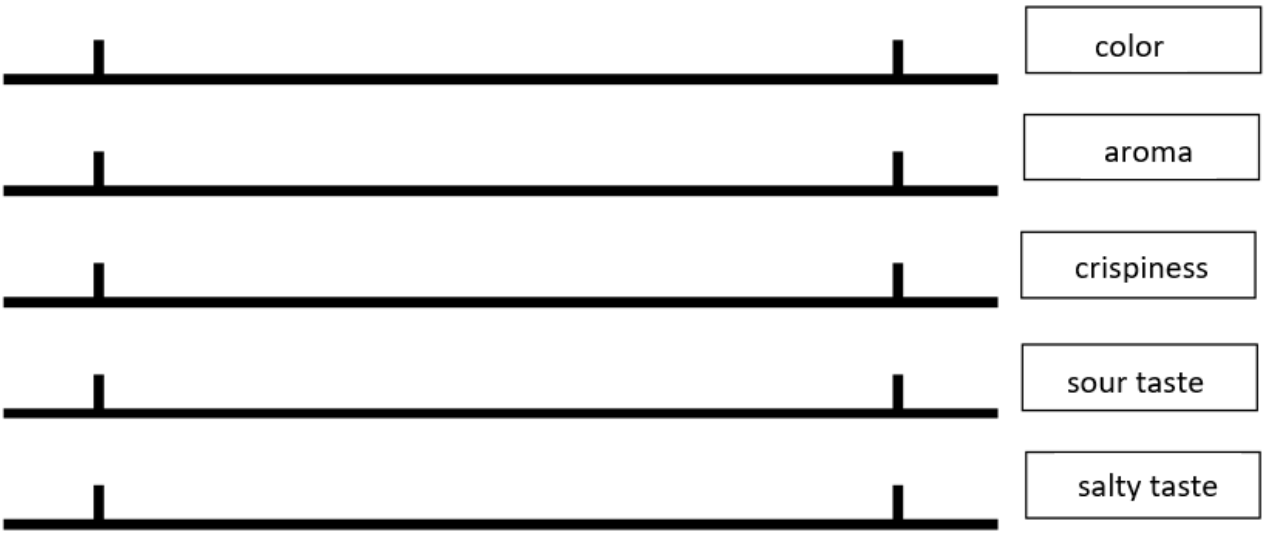
Methods

Task - to evaluate the intensity of sensory properties (colour, aroma, crispness, sour taste and salty taste) for sauerkraut samples.

12 cm Line scale

TRAY NO. _____

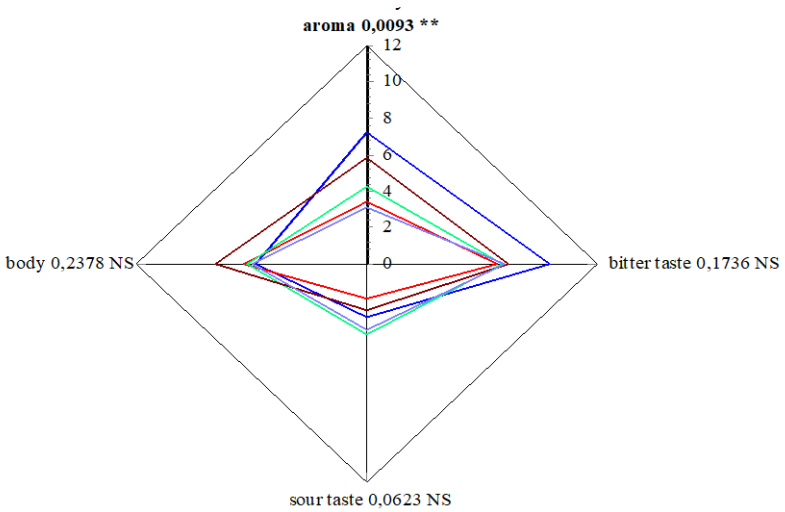
Please mark the intensities of the presented product samples on the Line scale and write the sample number below the marking.



Results

Taste the samples, evaluate them using the Line scale and prepare sensory properties profile of the analysed sauerkraut samples.

EXAMPLE:



Conclusion

Provide an overview on the obtained results. Write possible explanations on the detected sensory differences.

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Date _____

Laboratory work “Quality evaluation of prepared sauerkraut”

Materials

Sauerkraut prepared in previous laboratory work and commercially available product.

Methods

1. **Determining the relationship between cabbage and juice.**

Weigh the dish together with the cabbage, weigh the enamelled bowl (record the mass in the protocol), put a strainer or colander in it and shake the sample to be analysed, leave it for 15 minutes, so that the juice flows freely. Then weigh the container with the sample to be analysed and the container with the drained juice.

After the difference in mass, the ratio of cabbage and juice is calculated in %. The result is recorded in the protocol and compared with the standard requirements.

The calculation can be made according to formulas 1 and 2:

$$X = \frac{m * 100}{M}, \quad \% \qquad \text{Formula 1}$$

$$Y = 100 - X, \quad \% \qquad \text{Formula 2}$$

where: X - content of pickled vegetables, %
M - total mass of the sample, kg
m - mass of sauerkraut after draining the juice, kg
Y - juice content, %.

2. **Determining the percentage of cooking salt**

The amount of cooking salt can be determined either by the chemical method or by the density of sauerkraut juice, the first method is more accurate, but the second one is faster.

a. **Determining the amount of cooking salt by the density of cabbage juice**

The filtered sauerkraut juice is poured into a dry measuring cylinder, the temperature is measured (and recorded) and the aerometer is immersed in the juice, when it stops oscillating, the density is read. The amount of cooking salt can be found from table 6.3.

Table 6.3

The dependence of the amount of salt on the density of the juice

Density	NaCl, %	Density	NaCl,%
1.0053	1	1.0268	4
1.0125	2	1.0340	5
1.0196	3	1.0413	6
		1.0490	7

A recalculation is made, i.e. the correction 0.00045 is multiplied by the number of degrees by which the actual juice temperature differs from 20°C (n=20°C- actual temperature). The obtained value is added to the density (measured) if the temperature of the juice is lower than 20 °C and is subtracted at elevated temperatures.

The introduction of the correction is necessary because density and temperature are inversely related, but the aerometer scale is intended for measuring the densities of solutions at 20 °C.

By calculating the actual density, the amount of table salt can be determined. If the actual density does not match the data in the table, a recalculation is made.

Example: Density of the juice to be determined - 1.0150 g/cm3.

We make the proportion according to the closest data from table 6.3:

1.0196 - 3%
1.0125 - 2%,
0.0071 - 1%
1.0150 - 1.0125=0.0025
0.0071 - 1%
0.0025 - x

$$X = \frac{0{,}0025 * 1}{0{,}0071} = 0{,}4\%$$ Formula 3

2+0.4=2.4% - the content of table salt corresponding to the density of 1.0150 g/cm3.

The results are summarized in table 6.4.

b. Determination of table salt content by chemical method

Cabbage juice is filtered through cheesecloth. Pour 5 mL of the filtrate into a 100 mL beaker, add 3-4 drops of saturated potassium chromate solution (indicator) and titrate from a burette with a 0.1 N silver nitrate solution. The reaction takes place according to the following scheme:

NaCl + AgNO3 = AgCl + NaNO3

AgCl precipitates as a white deposit. As the chloride ion precipitates, the silver nitrate begins to react with the potassium chromate:

2 AgNO3 + K2CrO4 + 2 KNO3.

Ag2CrO4 turns the solution orange-brown, indicating that the titration should be stopped. The amount of table salt is calculated according to the following formula:

$$x = \frac{a * 0.00585 * 100}{b}$$ Formula 4

where x - table salt content, %
a - AgNO3 0.1 n solution consumed for titration (ml).
b - the amount of filtrate taken for titration (ml).
0.00585 - amount of NaCl (g) corresponding to 1 ml of 0.1 n AgNO

3. Determination of titratable acid

Pour 10 mL of cabbage juice into a 100 mL beaker with a pipette, add 10 mL of distilled water, add 3 drops of phenolphthalein, mix thoroughly and titrate with 0.1 n NaOH until a faint pink colour appears. The amount of acid is calculated according to the formula

$$x = \frac{a * 0{,}009 * 100}{b}$$ Formula 5

where x - amount of acid to be titrated, %
a - consumed 0.1 n NaOH solution, mL
b - amount of juice taken for titration, mL
0.009 - the amount of lactic acid in g, which corresponds to 1 ml of 0.1n NaOH.

Table 6.5

Physico-chemical indicators of sauerkraut

Indicator name	**Norms of indicators**
The ratio between cabbage and juice, %	88 - 90
Table salt content, %	1.2 - 1.8
Total acidity, %	0.7 - 1.3
Adjacent impurities	are not allowed

4. Ascorbic acid content in sauerkraut juice

Methodology:

1. Prepare a standard solution of ascorbic acid: 40 mg of ascorbic acid per 100 mL of 6% oxalic acid solution.
2. Add 2 mL of 1% starch solution to 25 mL of ascorbic acid standard solution and titrate with 0.05 M iodine solution while stirring. Observe the colour change. Write down the amount of iodine used.
3. weigh 50 g of cabbage juice into a 250 Ll beaker.

4. 100 mL of 6% $H_2C_2O_4$ solution is poured over the prepared weight and mixed.
5. Filter through a cotton filter.
6. Add 2 mL of 1% starch solution to 10 mL of filtrate and titrate with 0.05M iodine solution while stirring. Observe the colour change that does not disappear within 30 seconds and write down the amount.

$$C\ vit.\left(\frac{mg}{100g}\right) = 5000 * \frac{V_{J\ sample}}{m * V_{J\ standard}}$$

5000 - coefficient

$V_{Jin\ the\ sample}$ - the amount of iodine solution used for the titration of 10 mL of the sample

$V_{Jst.\ no.}$ - the amount of iodine solution used for the titration of 25 mL standard solution

m – sample mass.

Results

Table 6.4

Determination of salt content in acidified products

Measured density	Temperature °C	Amount of %	Temperature difference (n)	Correction n*0.00045	The actual density

Create a table to combine the obtained data on the analysed samples.

Conclusion

1. *Provide an overview on the obtained results. Write possible explanations of the detected differences. Is the obtained data comparable to legislative guidelines?*
2. *Provide answers to the following questions:*

a. What causes cabbage to go sour?
b. What is the best temperature for pickling?
c. Why should cabbage be pounded and strained before pickling?
d. What does adding salt to cabbage do?
e. What additives are usually added when making sauerkraut?
f. What should be observed during the storage of sauerkraut?
g. Why it is not recommended to add apples and cranberries to cabbage during pickling?
h. Why are the results obtained in determining the salt content different? Which method is more suitable for determining the salt content in this type of product?

Approved by _____

Name, surname, signature

Date _____

Theme 7

Assessment of the Safety and Risks of fruit and vegetable products (HACCP)

Theoretical materials

What is food safety?

Food safety is a scientific discipline describing handling, preparation, and storage of food in ways that prevent food borne illnesses. This includes a number of routines that should be followed to avoid potentially severe health hazards. In this way, food safety often overlaps with food defence to prevent harm to consumers.

As it has been known in the EU since 1960, each enterprise that works in the food segment must have a food safety system that is based on 7 HACCP principles.

Seven basic principles are used in the development of HACCP plans that meet the stated goal. These principles include hazard analysis, CCP identification, establishing critical limits, monitoring procedures, corrective actions, verification procedures, and record-keeping and documentation.

The Food Safety Plan - is not a stand-alone programme, but rather part of a larger food safety system. The foundational programmes that are part of the food safety system are frequently termed prerequisite programs. The term was coined to indicate that they should be in place before HACCP based systems are implemented in order to effectively manage risk from foodborne hazards. Good Manufacturing Practice (GMP) regulations address requirements for many prerequisite programmes. The conditions and practices the regulated food industry must follow for processing safe food under sanitary conditions, including personnel, plant and grounds, sanitary operations, sanitary facilities and controls, equipment and utensils, processes and controls, warehousing and distribution, and action levels in case with potentially unsafe product.

The process flow of a food safety plan (HACCP or Preventive Controls) is the centre of a food product's food safety story. It tells how a company makes its products and also what hazards and controls are associated with each step

Monitoring records and logs must include the actual values or observations that document the actual implementation of a Food Safety Plan. For example, if a temperature is being measured, the actual temperature must be recorded rather than a check mark indicating that the temperature complied with the critical limit. To comply with regulations, information must be recorded at the time it is observed.

Suggested record and log types to use:

- Customer complaints,
- Corrective action forms,
- Employee training,
- Food safety quarterly audit,
- Food safety checklist,
- Raw materials/receiving log,
- Worker illness log,
- Refrigerator log,
- Assembly log,
- Shipping temperature log,
- Suggested supply chain documents.

The safety of your product depends on much more than just what you control within your own facility. The use of an ingredient that has a history of association with a specific hazard may require a supply chain programme as a control within your food safety programme. Companies may have extensive supplier programmes that encompass much more than food safety elements to manage their supplier expectations and performance.

Suggested documents to obtain from your supply chain:

- Food safety HACCP or preventive controls plan for each product,
- Food defence/business continuity plan,
- Validation of each product and/or process and ready-to-eat statements (if applicable),
- Certificates of analysis (COA),
- Third party audit certificate, report & corrective actions,
- Product specification,
- Allergen management,
- Country of origin.

Potential Hazards

Biological hazards

Microbiological Contamination – during processing at source of origin – supplier management and HACCP in place and verified to eliminate and reduce potential presence of microbiological contamination.

Microbiological contamination for instance microbiological growth due to breakdown of refrigeration units.

Chemical hazards

Chemical contamination by pesticides at source of origin – chemical/pesticide used at source is verified to be in conjunction with regulations.

Chemical contamination from machine oils or lubricants, as well as cleaning chemicals.

Microbiological / physical / chemical contamination from cross contamination or taint of finished product due to poor hygiene.

Physical hazards

Physical contamination – external contamination from rainwater, bird droppings, vermin/rodents, and flying insects during unloading process.

Glass contamination – glass contamination from internal light sources. Pests/rodents and or flying insects due to poor hygiene/debris build up. Physical risks from straps/thermocouples/staples/foreign bodies found on pallets on intake.

Physical contamination – foreign Bodies found within product and/or packaging from source of origin or during transportation.

Physical contamination – physical contamination from warehouse operative, pests/rodents, and/or flying insects due to poor hygiene/debris build up. Physical contamination from personnel foreign body/dust contamination from production environment.

What are the 5 basic food safety requirements?

1. keep clean;
2. Separate raw and cooked;
3. Cook thoroughly;
4. Keep food at safe temperatures;
5. Use safe water and raw materials.

Recall Plan

According to the Food Safety Modernization Act, the Preventive Controls for Human Food regulation requires the development of a written Recall Plan when a hazard analysis identifies a hazard requiring preventive control. Recalls are actions taken by an establishment to remove an adulterated, misbranded or violative product from the market. In other words, a product for which the FDA or a state could take legal action against the company would be subject to a recall.

Verification

Verification is an important component of supply chain, sanitation, allergen and critical controls. It confirms that the Food Safety Plan is operating as intended. Validation confirms the effectiveness of the Food Safety Plan in controlling food safety hazards. The purpose of verification is to provide a level of confidence that the Food Safety Plan:

1. Based on solid scientific principles that are adequate to control the hazards associated with the product and process.
2. That the plan is being followed correctly every day of operation.

Likelihood	Severity
1 = Improbable event – once every five years	1 = Negligible – no impact or not detectable
2 = Remote possibility – once every year	2 = Marginal – only internal company target levels affected
3 = Occasional event – once per month	3 = Significant – Impact on critical limits
4 = Probable event – once per week	4 = Major – Impact on customers (may not be the public)
5 = Frequent event – once per day	5 = Critical – public health risk / public product recall

Likelihood	Severity				
	1	2	3	4	5
1	1	2	3	4	5
2	2	4	6	8	10
3	3	6	9	12	15
4	4	8	12	16	20
5	5	10	15	20	25

Fig. 7.1 Risk assessment matrix 1

Severity of health effect	Can cause fatality	5	5	10	15	20	25
	Can lead to serious illness	4	4	8	12	14	20
	Can cause illness	3	3	6	9	12	15
	Can cause inconvenience	2	2	4	6	8	10
	Almost of no significance	1	1	2	3	4	5
			1	2	3	4	5
			Unlikely	Rare	Could occur	Likely	Frequent
			(<1/2 years)	(1 / year)	(1/6 month)	(1 / month)	(1 / week)
			Likelihood of occurrence				

Low risk hazards | Medium risk hazards | High risk hazards

Fig. 7.1 Risk assessment matrix 2

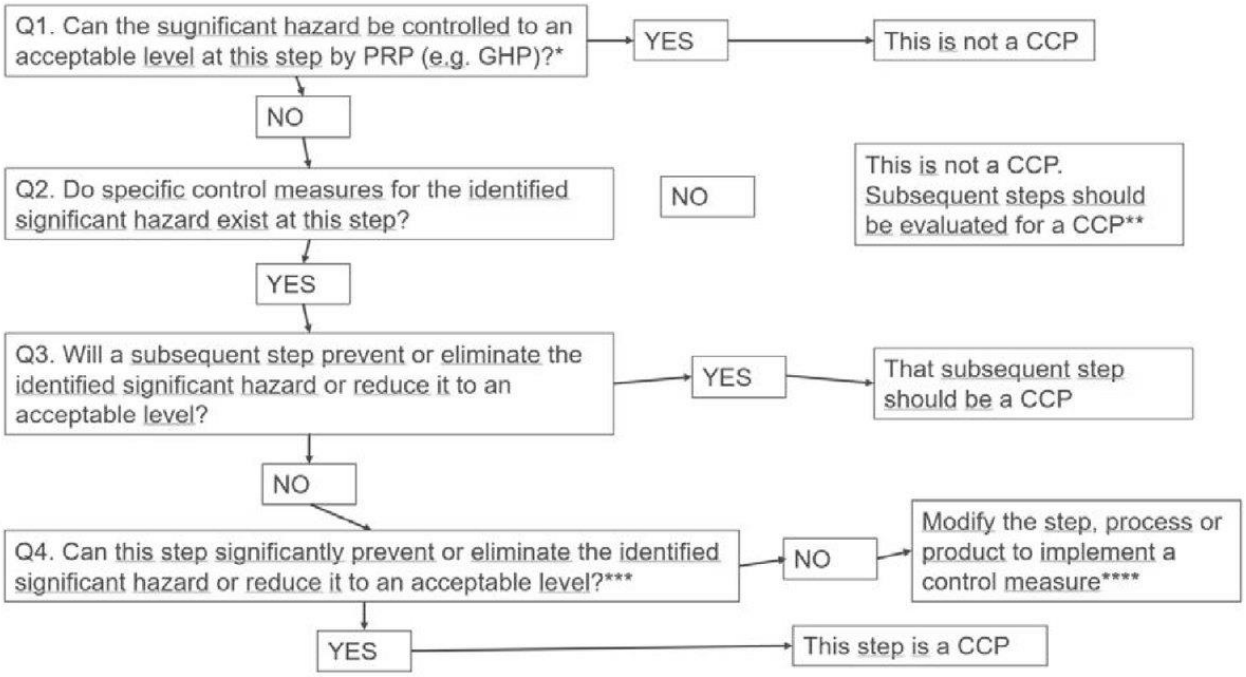


Fig. 7.3 Example of a decision tree to identify critical control points (CCP)
https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52022XC0916%2801%29

Laboratory work

Assessment of potential hazards in fruit and vegetable processing

Methods

Tasks:

1. For a selected fruit and vegetable processing product, develop a product description, and draw a diagram of the process steps.

2. Identify potential hazards:

   - biological: pathogenic microorganisms;
   - chemical: agricultural chemicals;
   - physical: foreign objects atypical for the product.

3. Evaluate the danger of the identified hazards using risk matrix 1 or 2. Record the information in the hazard assessment Table 7.1.

4. Complete the CCP identification Table 7.2 and the HACCP plan table 7.3.

5. Write conclusions on determining CCP using a risk matrix and a decision scheme.

Results

Table 7.1

CCP identification table

Process stage No.	Process stage	Cause of risk	Description of the cause of the risk	Control actions	Answers to Decision Scheme questions				CCP yes/no
					1	2	3	4	

Table 7.2

Risk assessment table

Process stage	The identified hazard	Hazard assessment					Means of control
		Possibility	The severity of the consequences	Risk level	Assessment	CCP	

Table 7.3

HACCP plan

In process stage	CCP/CP	Risk the cause	Measurable critical limits of parameters	Monitoring procedures				Ordered by	Corrections events
				What?	How to?	How often?	What?		

Conclusion

Write conclusions on determining the CCP using a risk matrix and a decision scheme

Approved by _____

Name, surname, signature

Date _____

Theme 8

Microbiological aspects of fruit and vegetable processing

Theoretical materials

Microbiological safety and quality are critical aspects of fruit and vegetable processing. These products can harbour a variety of microorganisms, including bacteria, yeasts, moulds, and viruses. Ensuring their control throughout the supply chain—from harvest to consumption—is essential for public health and product quality.

Sources of microbial contamination

1. **Soil and water**: Fruit and vegetables can be contaminated with soil-borne and water-borne pathogens. Irrigation water, in particular, can be a significant source of contamination.
2. **Handling and processing**: Human handling, equipment surfaces, and processing environments can introduce or spread microorganisms.
3. **Post-harvest practices**: Storage, transportation, and packaging conditions can influence microbial growth.

Table 8.1

Most common microbiological spoilage of fruit, vegetables and their products

Spoilage organism	Type	Conditions favouring growth	Characteristics of spoilage	Visual description
Fruit				
Saccharomyces spp.	Yeast	High sugar content, low pH	Fermentation, off-flavours, gas production	Bubbles, frothy appearance, cloudy liquid
Candida spp.	Yeast	High sugar content, low pH	Slimy texture, off-flavours	Slimy film on surface, white colonies
Aspergillus spp.	Mould	Warm, humid conditions	Visible mould, off-flavours, mycotoxins	Black or green powdery mould
Penicillium spp.	Mould	Cold, moist conditions	Visible mould, soft rot	Blue or green fuzzy mould

Botrytis cinerea	Mould	High humidity	Grey mould, soft rot	Grey, fuzzy mould covering surface
Rhizopus spp.	Mould	Warm, humid conditions	Black mould, soft rot	Black, fuzzy mould with white edges
Lactobacillus spp.	Bacteria	Low pH, anaerobic conditions	Sour taste, off-flavours	Cloudy liquid, off-odour
Vegetables				
Pseudomonas spp.	Bacteria	Moist conditions, refrigeration	Soft rot, sliminess	Water-soaked, mushy areas with a foul odour
Erwinia spp.	Bacteria	Warm, moist conditions	Soft rot, watery decay	Water-soaked, slimy, foul-smelling
Xanthomonas spp.	Bacteria	Warm, humid conditions	Leaf spots, blights	Yellow or brown spots on leaves
Clostridium spp.	Bacteria	Anaerobic conditions	Gas production, off-odours	Swollen packaging, foul odour
Bacillus spp.	Bacteria	High temperatures	Off-flavours, sliminess	Cloudy liquid, off-odour
Penicillium spp.	Mould	Cold, moist conditions	Visible mould, soft rot	Blue or green fuzzy mould
Alternaria spp.	Mould	Warm, humid conditions	Black spots, mould growth	Black spots, fuzzy grey or dark mould
Geotrichum candidum	Mould	High humidity	Sour rot, yeast-like growth	White, yeast-like growth
Fruit Juices and Purees				
Zygosaccharomyces spp.	Yeast	High sugar content, low pH	Fermentation, gas production	Bubbles, frothy appearance, cloudy liquid
Lactobacillus spp.	Bacteria	Low pH, anaerobic conditions	Sour taste, off-flavours	Cloudy liquid, off-odour
Leuconostoc spp.	Bacteria	Low pH, anaerobic conditions	Gas production, sour taste	Swollen packaging, off-odour

Alicyclobacillus acidoterrestris	Bacteria	Acidic conditions, heat resistant	Off-flavours, spoilage after pasteurisation	Off-odour, flat sour taste
Penicillium spp.	Mould	Cold, moist conditions	Visible mould, off-flavours	Blue or green fuzzy mould
Canned Vegetables				
Clostridium botulinum	Bacteria	Anaerobic conditions, inadequate processing	Toxin production, botulism	Swollen cans, off-odour, discoloured contents
Geobacillus stearothermophilus	Bacteria	Thermophilic conditions	Flat sour spoilage, off-flavours	Cloudy liquid, off-odour, no gas production
Bacillus coagulans	Bacteria	Acidic conditions	Flat sour spoilage, off-flavours	Cloudy liquid, off-odour, no gas production

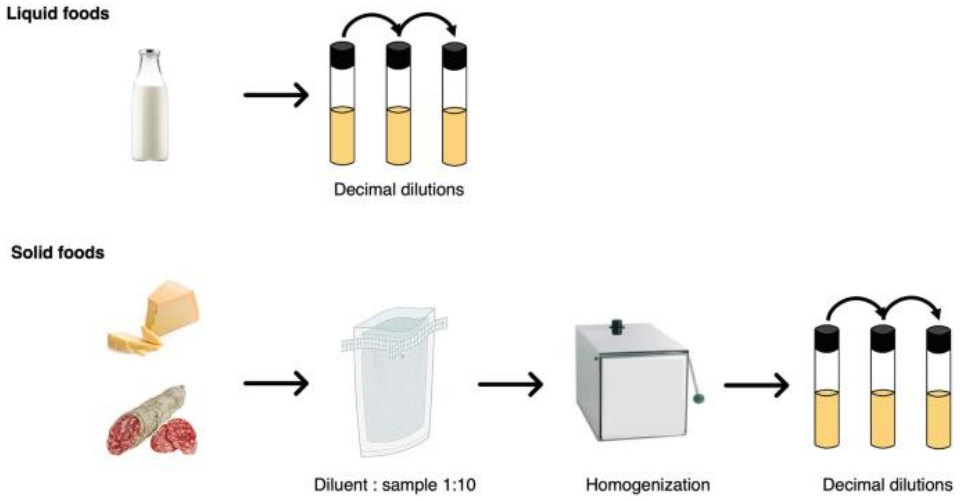


Fig. 8.1 Sample preparation for microbiological analysis
https://link.springer.com/chapter/10.1007/978-1-0716-3413-4_2

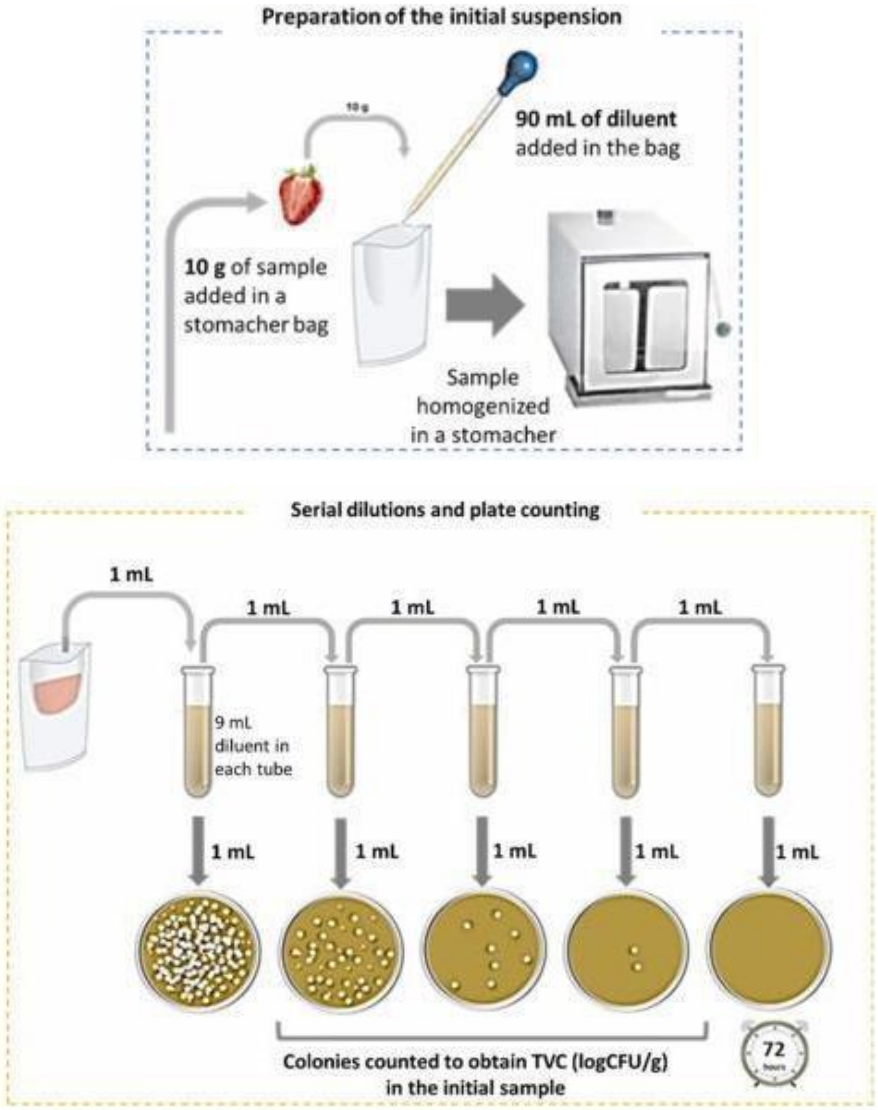


Fig. 8.2 Sample preparation for microbiological analysis
https://www.sciencedirect.com/science/article/pii/S0925400523007311

Knowledge questions

After familiarising yourself with the lecture materials, provide answers to the following questions:

1. What are the common types of microorganisms found on fruits and vegetables?
2. What conditions promote the growth of spoilage microorganisms on fresh produce?
3. What are the primary sources of microbial contamination in fruit and vegetable processing?
4. How can soil and water contribute to the microbial load on fruits and vegetables?
5. What role do handling and transportation play in the contamination of fresh produce?

6. Describe the importance of good agricultural practices (GAP) in reducing microbial contamination.
7. What are some key sanitation practices that should be implemented in processing facilities?
8. What is the role of pH and water activity (aw) in controlling microbial spoilage?
9. What are some common beneficial microorganisms used in the fermentation of vegetables?

Approved by _____

Name, surname, signature

Date _____

Theme 9

Production technology of frozen fruits and vegetables

Theoretical materials

The quality of frozen fruit and vegetables is affected by the quality of the raw material, the type of pre-treatment, the freezing technology (selected equipment, freezing speed, temperature), the storage modes and temperature, as well as its stability.

The variety determines the quality of the raw material, the freezing rate of the product, the specifics of ice crystal formation and other factors. Cultivation and weather conditions affect the water content of fruit and vegetables. For this reason, if one wants to have tight control over the freezing process, one must choose a certain tried and true variety, seed and even fertiliser. One of the most important factors affecting the quality of frozen products is the duration of storage of raw materials before freezing.

Pre-treatment methods used for frozen produce production

- **Blanching** is used to protect products from spoilage caused by enzymes. Blanching affects the permeability of cell membranes. Vegetables must be cooled immediately after blanching, because the amount of vitamins quickly decreases at high temperatures, and the taste and natural colour are lost.
- **Addition of sugar** and other substances. Fruit and berries are frozen with sugar, in sugar syrup or without it. The addition of sugar and its syrup protects the fruit from the effects of ice crystals, inhibits enzymatic reactions, and reduces the amount of oxygen in frozen fruit and berries. Fruit and berries are poured with cooled sugar syrup with a concentration of 20-60% and kept at 0 °C for 8-10 hours.
- **Citric acid** is used to optimise the stability of frozen products and reduce discoloration. Ascorbic acid and sodium ascorbate are widely used as antioxidants and colour stabilisers.
- Adding **pectin** to the sugar syrup used to infuse the berries reduces the release of colourants from the berries during the tempering process and makes the berries firmer.

Industrial fruit and berry freezers are essential for preserving the freshness, texture, and nutritional value of produce on a large scale. These freezers come in various types, each designed to meet specific freezing requirements. Here's an overview of the key types of industrial freezers, notable brands, and important considerations for selecting the right equipment.

Types of industrial freezers

1. **Blast / flash freezers**

a. Utilise extremely cold air (-30 °C to -40 °C) circulated at high speed to rapidly freeze products.
b. Ideal for quick freezing of fruit and berries to preserve texture and quality.
c. Rapid freezing time, prevents large ice crystal formation, and maintains product integrity.

2. Tunnel freezers

a. Products are placed on a conveyor belt and passed through a tunnel where they are exposed to very cold air or nitrogen gas.
b. Suitable for continuous freezing of large quantities of produce.
c. Continuous operation, customisable speed and temperature settings, efficient for high-volume processing.

3. IQF (Individually Quick Freezing) freezers

a. Use cold air or liquid nitrogen to freeze individual pieces of fruit or berries quickly.
b. Ideal for fruit and berries that need to be frozen separately to prevent clumping.
c. Maintains individual pieces, preserves quality and nutritional value, suitable for bulk packaging.

4. Plate freezers

a. Produce is placed between metal plates that are cooled to very low temperatures.
b. Commonly used for block freezing, suitable for packed or boxed produce.
c. Efficient for packed goods, uniform freezing, compact design.

5. Cryogenic freezers

a. Use cryogenic gasses like liquid nitrogen or carbon dioxide to achieve rapid freezing.
b. High-value, delicate fruits and berries that require minimal cellular damage.
c. Ultra-rapid freezing, minimal dehydration, preserve texture and flavour.

Laboratory work

Freezing of fruits and vegetables

Materials

A variety of fresh fruit, berries and vegetables available.

Laboratory equipment: deep freezer; flash freezer; contact type (plate) freezer.

Methods

1. **Pre-treatment before freezing**

a. *Carrots – washed, cleaned, cut into slices and divided into 2 parts:*

1. Place in containers and cool to +4 - +6;
2. Heat water and hold at 90 °C for 7 minutes, cool, dry, put in containers and cool at +4-+6 °C .

b. *Potatoes - washed, cleaned, cut into straws and divided into 2 parts:*

1. Place in containers and cool to +4 - +6 °C;
2. Heat water and hold at 75 °C for 5 minutes, cool, dry, put in containers and cool at +4 - +6 °C .

c. *Potatoes - washed, cleaned, cut into straws and divided into 2 parts:*

1. Heat water and hold at 85 °C for 7 min, cool, dry, put in containers and cool at +4 - +6 °C;
2. Prepare 1 g of citric acid and 200 mg of ascorbic acid per 100 g of water, soak the cut potato straws in it and leave for 20 minutes, then dry, put in containers and cool at +4 - +6 °C.

d. *Beets - washed, cleaned, cut into 7x7 mm cubes and divided into 2 parts:*

1. Place in containers and cool to +4 - +6 °C;
2. Heat water and hold at 95 °C for 7 min, cool, dry, put in containers and cool at +4 - +6 °C.

e. *Apples - wash, peel, remove the seed, cut into slices and divide into 2 parts:*

1. Place in containers and cool to +4 - +6 °C ;
2. Heat water, add sugar (20 g of sugar and 80 g of water) and prepare a sugar syrup in which apples are heated at 85 °C for 5 minutes, cooled, dried, put in containers and cooled to +4 - +6 °C;

f. *Apples - wash, peel, remove the seed, cut into slices and divide into 2 parts:*

1. Prepare 1 g of citric acid and 200 mg of ascorbic acid per 100 g of water, soak the sliced apples in it and leave for 20 minutes, then dry, put in containers and cool at +4 - +6 °C
2. Put the apple slices in the dishes and pour over the prepared, cooled sugar syrup (20 g sugar and 80 g water) and cool it to +4 - +6 °C;

Freezing

1. Freezing is carried out in a standard freezer (deep freezer) at -20±2 °C.
2. In a contact type (plate) freezer: half of the carrots of variant 2, potatoes of variant c) of variant 1, beets of variant 2), apples of variant f) of variant 1).
3. Flash freezer (-40 °C): half of the carrots of variant 2, potatoes of variant c) of variant 1, beets of variant 2), apples of variant f) of variant 1).

NOTE – plan the number of sample sizes according to freezing methods

Results

Package the prepared samples and provide them with the sample name. Leave them in the freezer until further quality analysis.

Approved by _____

Name, surname, signature

Date _____

Laboratory work

Quality analysis of frozen fruits and vegetables

Materials

Previously prepared samples. For quality analysis of frozen produce shop bought samples can be added for quality comparison and evaluation.

Methods

Task 1 *Assess the quality of frozen berries:*

1. **Loss of juice after defrosting**

Weigh the frozen berry sample and leave it to cool at room temperature. Half an hour after the berries are completely released, weigh the berries without the released juice a second time. Determine the mass difference and calculate the juice loss in %.

$$s_z\% = \frac{(m_1 - m_2) * 100\%}{m_1}$$

Where: m_1 – mass at the beginning, g;
m_2 – mass after annealing, g;
$s_z\%$ - juice losses, %.

Then express the juice loss % in points:

s_z 1% - 5 points
1% - 5%: 4 points
5% - 10%: 3 points
10% - 20%: 2 points
s_z 21% - 1: point

2. **Ascorbic acid content in berries**

One of the indicators of the quality of frozen berries is the content of ascorbic acid.

Determine the content of L-ascorbic acid (reduced form) in the given samples by the iodine method.

Methodology:

1. Prepare a standard solution of ascorbic acid: 40 mg of ascorbic acid per 100 mL of 6% oxalic acid solution.
2. Add 2 mL of 1% starch solution to 25 mL of ascorbic acid standard solution and titrate with 0.05 M iodine solution while stirring. Observe the colour change. Write down the amount of iodine used.
3. Weigh 25 g of berries into a 250 mL beaker.

4. 100 mL of 6% $H_2C_2O_4$ solution is poured over the prepared weight and blend for 60 seconds in a mixer.
5. Filter through a cotton filter.
6. Add 2 mL of 1% starch solution to 10 mL of filtrate and titrate with 0.05M iodine solution while stirring. Observe the colour change that does not disappear within 30 seconds and write down the amount.

Calculation of ascorbic acid:

$$C\ vit.\left(\frac{mg}{100g}\right) = 5000 * \frac{V_{J\ sample}}{m * V_{J\ standard}}$$

5000 - coefficient

$V_{Jin\ the\ sample}$ - the amount of iodine solution used for the titration of 10 mL of the sample

$V_{Jst.\ no.}$ - the amount of iodine solution used for the titration of 25 mL standard solution

m – sample mass.

3. Sensory evaluation of chilled berries

When the berries have ripened, each representative of the group should evaluate their appearance, colour, taste and aroma in points according to the descriptions given in table 8.2.

Table 8.2

Sensory characteristics of frozen and thawed berries

Parameter	5 points	4 points	3 points	2 points	1 point
Appearance, structure	Beautiful, firm, completely matching the appearance of fresh berries	Good appearance, firm, little change in shape or structure	Slightly crushed or torn, soft, oozing	The structure is strongly changed, the berries are disintegrated or curled	Berries have completely lost their shape and natural structure and appearance
Colour	Bright, completely matching the colour of fresh berries	The berries are in their natural colour, however, there are slight colour changes in some places	All berries show slight colour changes (browning, etc.)	Most berries show strong colour changes	The berries have completely changed their natural colour
Taste	Perfectly suited to the taste of fresh berries	Basically corresponding to the taste of fresh berries, however, some	Unexpressed, a little bland, an uncharacteristic aftertaste can be felt	Strongly pronounced other uncharacteristic flavours	Completely changed, with a distinct

		other uncharacteristic aftertaste is slightly noticeable		(bitterness, bitterness, etc.)	unpleasant aftertaste
Aroma	Strong aroma of fresh berries	A slightly weaker, yet well-perceived aroma of fresh berries	Very weak, almost imperceptible aroma of fresh berries	There is no aroma or a foreign, uncharacteristic aroma is felt	Strong unpleasant smell

Calculate the average points for the appearance, colour, taste, aroma of berries.

4. **Assessment of berry quality.**

Summing up the obtained results (adding together all the points obtained both after determining juice loss and organoleptic evaluation and extracting the average) and determining the quality of the berries:

4.5 – 5 points – very good quality berries;
4.0 – 4.4 points – good quality berries;
3.5 – 3.9 points – berries of average good quality;
3.0 – 3.4 points – average quality berries;
2.5 – 2.9 points – poor quality berries;
2.4 points – berries of inadequate quality (defective).

Task 2

1. **Comparison of cooking time for fresh and frozen vegetables**

Take fresh and frozen carrots, potatoes and beets and boil them separately. Determine the cooking time of all samples.

2. **Colour (in the L*a*b* system) analysis**

To compare fresh and frozen fruits and vegetables in the colour coordinate system, the sample is placed on a napkin (if the sample is very soft, it is placed in a Petri dish). The sample is then analysed with a colour analyser in the L*a*b* system. The L*a*b* system uses three perpendicular axes, on which a negative a* value represents the intensity of the green colour, a positive a* value represents the intensity of the red colour, a negative b* value means an increase in the blue colour intensity, a positive b* value represents the yellow colour intensity, while L* is a representative of white-black or light-dark intensity.

3. **Structure analysis with Structure Analyser**

Measurements are made on fresh, frozen and cooked samples. Choose 3 pieces of fruit, vegetables, which are placed on the tray of the structure analyser. Measurements are made by pressing the sample with a knife and measuring the force (N) with which the sample can be cut at a pressing speed of 1 mm s^{-1}.

The result is the maximum force (N) required to cut the product in question.

The softer the fruit or vegetable, the less cutting force is required.

The obtained data are compared with the data of other frozen samples and relevant conclusions are made about the effects of processing and freezing.

Results

Compare physical analysis indicators with fresh and frozen fruits and vegetables. Summarise the results in the given tables 8.3 ant table 8.4.

Table 8.3

Compilation of quality indicators of fresh and frozen fruit and vegetables

Option	Colour L*	Colour a*	Colour b*	Boiling time, min.	Hardness, N
Fresh					
v. 1					
v. 2					
v. 3					
v. 4					

Table 8.4

Sensory evaluation of frozen apples and vegetables

Parameters	The fresh ones	Frozen ones			
		v. 1	v. 2	v. 3	v. 4
Colour					
Structure					
Taste					
Aroma					
Boiling time					

If the quality to be evaluated does not differ between the fresh and frozen samples, then both are evaluated with a rating of "1", if they differ, then the one with the weaker quality is evaluated with "0", the best with "1". The notes indicate how pronounced and what the difference is.

Conclusion

Provide an overview on the obtained results. Write possible explanations for the detected differences.

Approved by _____

Name, surname, signature

Date _____

Theme 10

Sensory aspects of processed fruit and vegetable products

Knowledge questions

After familiarising yourself with the lecture materials provide answers to the following questions.

1. What sensory properties should be evaluated for processed fruit and vegetable products?
2. What sensory methods can be used to evaluate processed fruit and vegetable products?
3. How to present and analyse the results obtained in a sensory evaluation?
4. How can sensory evaluation be integrated into the quality control process for processed fruit and vegetables?
5. What are the common sensory defects encountered in processed fruit and vegetables and how are they addressed?

Approved by _____

Name, surname, signature

Date _____

Theme 11

Thermally processed vegetable preserves

Processed potato products

Theoretical materials

Potatoes are used for the production of alcohol, starch extraction, and the production of various food products. The breakdown of processed potato products is summarised in the Figure 11.1.

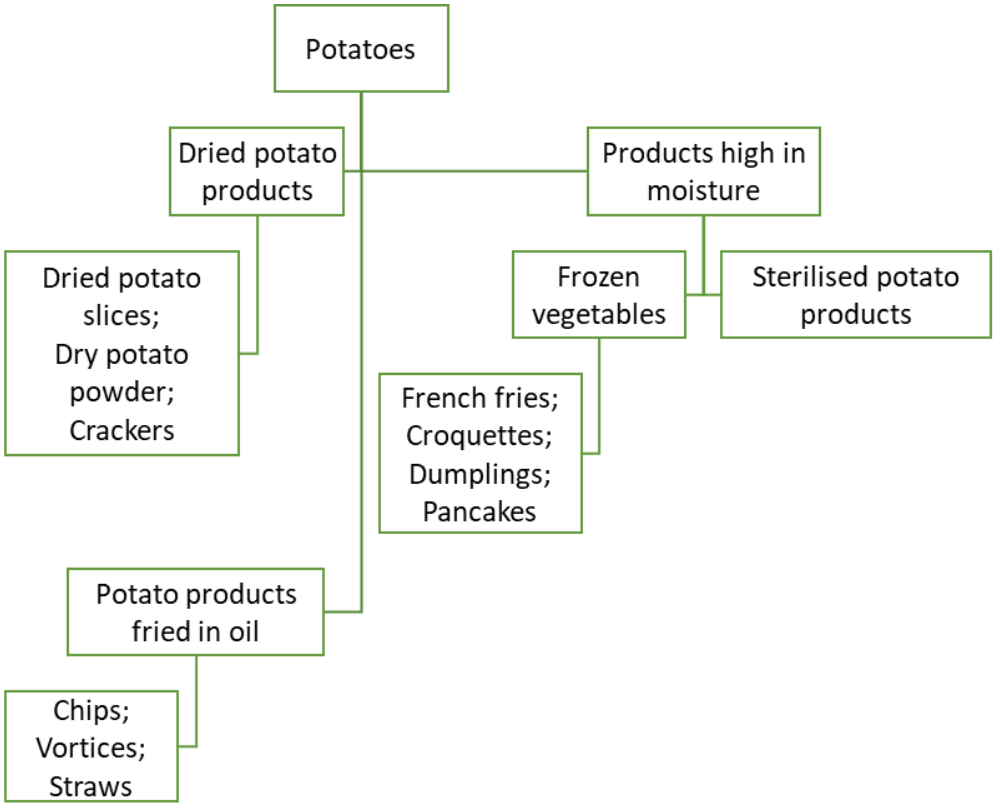


Fig 11.1 Processed potato products

Potato processing involves transforming raw potatoes into various products, each with its own specific processing methods, quality parameters, and production requirements. Here are some common processed potato products, their quality parameters, and an overview of their production processes.

1. Potato chips

Quality parameters:

- Colour - uniform golden-brown,
- Texture - crisp and crunchy,
- Flavour - free from off-flavours, not too oily or burnt,
- Oil content - controlled to avoid greasiness,
- Absence of defects - no brown spots, blisters, or uneven slices.

Production process:

1. **Selection and cleaning**: Choose high-quality potatoes with low sugar content. Wash to remove dirt and debris.
2. **Peeling**: Mechanically or chemically peeled to remove skins.
3. **Slicing**: Potatoes are sliced uniformly using a slicer.
4. **Blanching**: Optional step to remove excess starch and improve texture.
5. **Frying**: Slices are fried in hot oil (typically 175 – 185 °C) until crispy.
6. **Seasoning**: Chips are seasoned with salt and other flavourings.
7. **Packaging**: Cooled chips are packed in moisture-proof packaging.

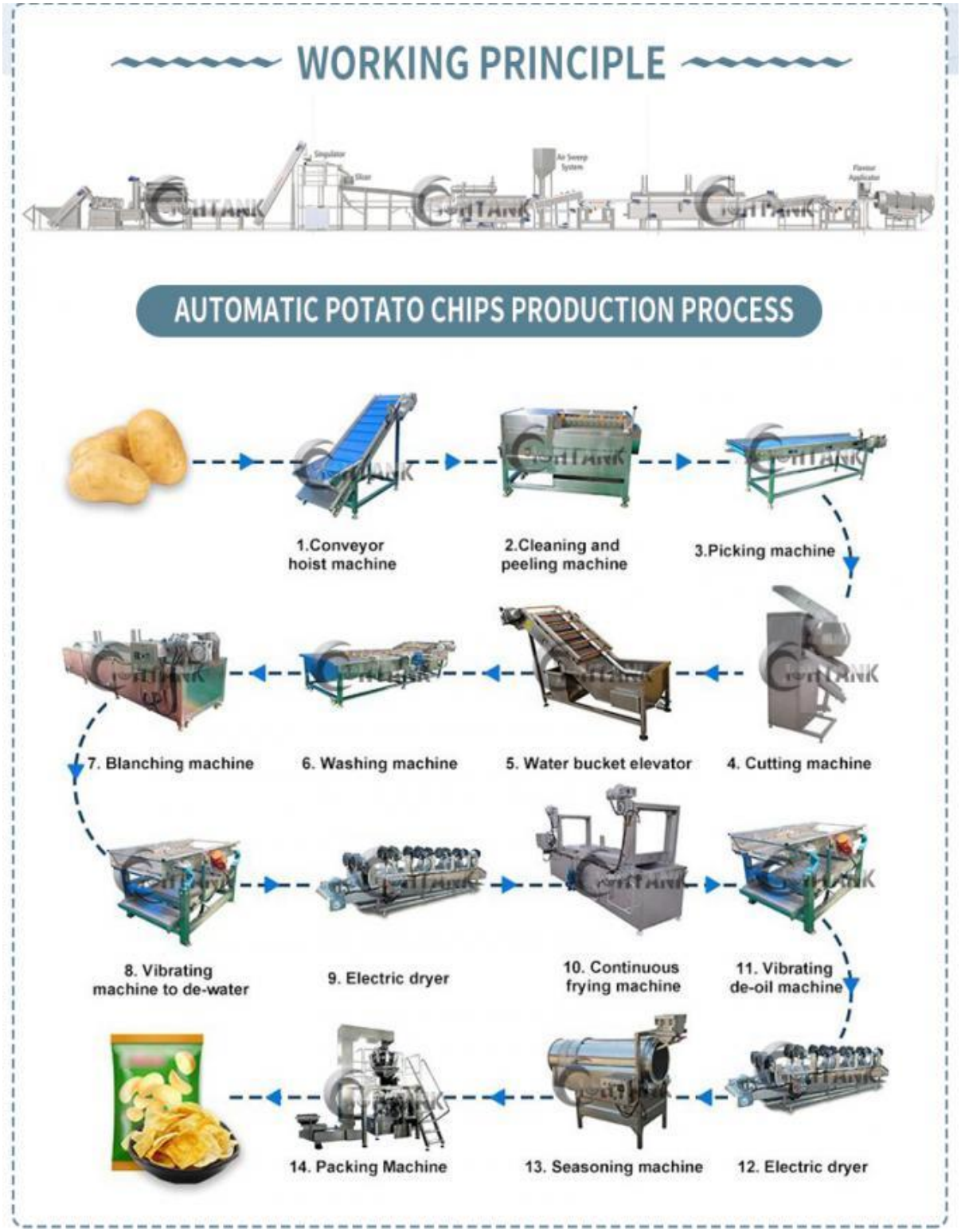


Fig. 11.2 Potato chip production line https://www.potatoproductionline.com/sale-14146204-500kg-h-potato-chips-production-line-potato-chips-making-machine-for-small-business.html

2. French fries

Quality parameters:

- Colour - Light to golden brown,
- Texture - crispy exterior, fluffy interior,
- Length - uniform length preferred,
- Flavour - no off-flavours, consistent seasoning,
- Oil content - not excessively oily.

Production Process:

1. **Selection and cleaning**: Use potatoes with high solids content. Clean thoroughly.
2. **Peeling**: Mechanically or steam-peeled.
3. **Cutting**: Potatoes are cut into strips or wedges.
4. **Blanching**: Blanched in hot water or steam to remove excess starch.
5. **Drying**: Surface moisture is removed to improve frying efficiency.
6. **Par-frying**: Partially fried to set the structure.
7. **Freezing**: Rapidly frozen to preserve quality.
8. **Final frying**: Fully fried at the point of sale or by the consumer.

3. Dehydrated potato products

Quality parameters:

- Colour - light cream to yellow,
- Texture - rehydrates to a smooth, non-gritty texture,
- Flavour - clean potato flavour,
- Moisture content - low to ensure long shelf life.

Production process:

1. **Selection and cleaning**: Choose high-quality potatoes. Clean thoroughly.
2. **Peeling**: Mechanically or steam-peeled.
3. **Cutting and cooking**: Potatoes are cut into desired shapes and cooked.
4. **Mashing**: Cooked potatoes are mashed into a uniform consistency.
5. **Dehydrating**: Water is removed using drum dryers or other dehydration methods.
6. **Packaging**: Dehydrated products are packed in moisture-proof packaging.

4. Potato starch

Quality parameters:

- Purity - high starch content with minimal impurities,
- Colour - white, free from discoloration,
- Granule size - consistent granule size
- Moisture content - controlled for storage stability.

Production process:

1. **Selection and cleaning**: Use high-starch potatoes. Clean thoroughly.
2. **Grinding**: Potatoes are ground to release starch granules.
3. **Separation**: Starch is separated from the potato pulp using water and centrifugal force.
4. **Drying**: Starch is dried to reduce moisture content.
5. **Packaging**: Dried starch is packed in moisture-proof packaging.

Production considerations

1. **Quality control**:
    - Regular inspection of raw materials and finished products.
    - Monitoring of processing conditions (temperature, time, etc.).
    - Sensory evaluation (taste, texture, appearance).
    - Microbiological testing to ensure safety.
2. **Hygiene and sanitation**:
    - Maintaining clean equipment and facilities.
    - Adhering to good manufacturing practices (GMP) and HACCP protocols.
3. **Storage and distribution**:
    - Proper storage conditions to maintain product quality.
    - Effective packaging to protect against moisture, light, and contamination.
    - Efficient distribution channels to ensure timely delivery to markets.

Laboratory work

Preparation and analysis of potato processing products using different technologies - French fries

Materials

Good quality potatoes, vegetable oil, salt and or other seasonings based on preferences or availability.

Laboratory equipment: deep fryer; dehydrator (convective dryer); electric grader (optional); freeze-dryer; plate-type freezer or flash freezer.

Methods

Task 1

Prepare "French fries" using different processing technologies

1) Potatoes are peeled, rinsed, cut into straws, put in water to which salt and spices are added. After 10 minutes, take the potatoes out of the water, dry them and fry them in hot oil at 180 °C until they acquire a golden brown crust.
2) Potatoes are peeled, rinsed, cut into straws, put in water to which salt and spices are added. The potatoes are then blanched in water at 85 °C for 7-8 minutes. After blanching, they are removed from the water, dried and fried in hot oil at 180 °C until they acquire a golden brown crust.
3) Potatoes are peeled, rinsed, cut into straws, put in water to which salt and spices are added. They are then blanched in water at 85 °C for 7-8 minutes. After blanching, they are removed from the water and dried in a convective dryer at 100 °C for 10 minutes. Fry the dried potatoes in hot oil at 180 °C until they acquire a golden brown crust.
4) Potatoes are peeled, rinsed, cut into straws, put in water to which salt and spices are added. The potatoes are then blanched in water at 85 °C for 7-8 minutes. After blanching, the potatoes are removed from the water and dried in a convective dryer at 100 °C for 15 minutes, cooled and frozen in a plate-type freezer. Fry the frozen potatoes in hot oil at 180 °C until they acquire a golden brown crust.
5) Potatoes are peeled, rinsed, cut into straws, put in water to which salt and spices are added. They are then blanched in water at 85 °C for 7-8 minutes. After blanching, they are removed from the water and dried in a convective dryer at 100 °C for 20 minutes. Fry the dried potatoes in hot oil at 180 °C until they acquire a golden brown crust.

Task 2

1. **Analysis of "French fries"**

1) Detection of "French fries" fragility using structure analyser.

The samples to be analysed are placed on the structure analyser tray (figure 11.3). Measurements are performed by pressing the surface of a special tip on the sample and measuring the force (N) with which the sample can be broken at a pressing speed of 1 mm s^{-1}

Fig. 11.3 Structure analyser https://www.stablemicrosystems.com/TAXTplus.html

The result is the maximum force (N) required to break the sample in question. The more fragile the products, the less force will be required to break the product, while hard, unbreakable potato straws will require more force.

2) Detection of moisture content in "French fries"

Drying the sample to constant weight is the most commonly used method for moisture determination in various products.

Chop the potato straws into small pieces with a knife. A heated weighing glass (a metal dish with a lid) is weighed on the balance and approximately 2 g of the sample is weighed (to the nearest 3 decimal places). The weighing cups with the samples are placed in an oven at 105 °C for 3 hours, with the cap placed under the weighing cup. After drying, the measuring cups are removed from the drying oven with tongs, put on a cap and placed in a desiccator to cool. Weigh the cooled, closed measuring cups. Calculate the moisture content of the sample according to the formula:

$$\frac{(M-x)-(m-x)}{(M-x)} \times 100 = \frac{M-m}{M-x} \times 100$$

where M – initial mass of the sample + weighing glass ;
x – mass of weighing glass;
m – final mass of yeast + container

3) Colour analysis (in the L*a*b* system).

Colour is one of the most important criteria for the external appearance of the product. If the product oxidises very quickly, the colour may be unattractive, brownish or greyish, so it is important to evaluate and compare the colour.

To determine the colour of the products in the CIE L*a*b* coordinate system, several potato straws are put together, placed on a table on white paper and analysed with a colour analyser. The L*a*b* system uses three perpendicular axes, on which a negative a* value represents the intensity of the green colour, a positive a* value represents the intensity of the red colour, a negative b* value means an increase in the blue colour intensity, a positive b* value represents the intensity of the yellow colour, but L* is a characteristic of white (L=100) – black (L=0) or light-dark intensity (figure 11.4).

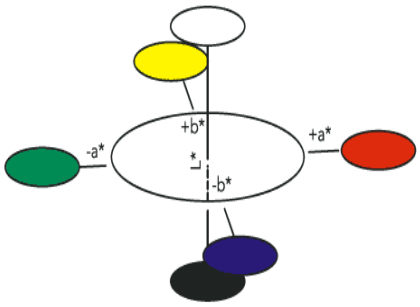


Fig. 11.4 CIE L*a*b* colour system https://www.ulprospector.com/knowledge/16423/pc-the-cielab-system-the-method-to-specify-colors-of-coatings/

4) Please describe sensory properties of prepared French Fries before and after frying

SAMPLE 1_____

Appearance (colour, shape size):
Before frying_____

After frying _____

Aroma:
Before frying_____

After frying _____

Oiliness (oil content):
Before frying_____

After frying _____

Taste:
Before frying_____

After frying _____

SAMPLE 2_____

Appearance (colour, shape size):
Before frying_____

After frying _____

Aroma:
Before frying_____

After frying _____

Oiliness (oil content):
Before frying_____

After frying _____

Taste:
Before
frying_____

After frying _____

SAMPLE 3_____

Appearance (colour, shape size):
Before frying_____

After frying _____

Aroma:
Before frying_____

After frying _____

Oiliness (oil content):
Before frying_____

After frying _____

Taste:
Before frying_____

After frying _____

SAMPLE 4_____

Appearance (colour, shape size):
Before frying_____

After frying _____

Aroma:
Before frying_____

After frying _____

Oiliness (oil content):
Before frying_____

After frying _____

Taste:
Before frying_____

After frying _____

SAMPLE 5_____

Appearance (colour, shape size):
Before frying_____

After frying _____

Aroma:
Before frying_____

After frying _____

Oiliness (oil content):
Before frying_____

After frying _____

Taste:
Before frying_____

After frying _____

Results

Create a table to combine the obtained data on the analysed samples and fill it out.

Conclusion

Provide an overview on the obtained results. Write possible explanations of the detected differences.

Approved by _____

Name, surname, signature

Date _____

Laboratory work

Preparation and analysis of potato processing products using different technologies - chips

Materials

Good quality potatoes, vegetable oil, salt and or other seasonings based on preferences or availability.

Laboratory equipment: deep fryer; dehydrator (convective dryer); electric grader (optional); freeze-dryer.

Methods

Task 1

Preparation of potato chips with different processing technologies.

1) Peel the potatoes, rinse them, chop them into thin slices with an electric grater, put them in water to which salt and spices are added. After 10 minutes, take the potatoes out of the water, dry them and fry them in hot oil at 180 °C until they acquire a golden brown crust and are crispy.
2) Peel the potatoes, rinse them, cut them into thin slices with an electric grater, put them in water to which salt and spices are added. The potatoes are then blanched in water at 85 °C for 7-8 minutes. After blanching, they are removed from the water and dried in a convective dryer 100 °C 10 minutes. Fry the dried potatoes in hot oil at 180 °C until they acquire a golden brown crust.
3) Peel the potatoes, rinse them, cut them into thin slices with an electric grater, put them in water to which salt and spices are added. Then the potatoes are blanched in oil at 180 °C for 45 seconds, and then in water at 85 °C for 5 minutes. The potato slices are removed from the water, drained and dried in a convective dryer at 110 °C until completely dry and crispy.
4) Peel the potatoes, rinse them, cut them into thin slices with an electric grater, put them in water to which salt and spices are added. After that, the potatoes are blanched in oil at 180 °C for 45 seconds, and then in water at 85 °C for 5 minutes. The potato slices are removed from the water, drained, and dried in a freeze-dryer until they are completely dry and crispy.
5) Peel the potatoes, rinse them, cut them into thin slices with an electric grater, put them in water. After that, the potatoes are blanched in water at 85 °C for 5 minutes, dried and fried in oil at 180 °C for 45 seconds. The potato slices are removed from the oil, drained, and dried in a freeze-dryer until they are completely dry and crispy.

Task 2

Analysis of prepared potato chips

1) Determining the brittleness of potato chips with a structure analyser.

The samples to be analysed are placed on the structure analyser tray. Measurements are performed by pressing the surface of a special tip on the sample and measuring the force (N) with which the sample can be broken at a pressing speed of 1 mm s^{-1}.

The result is the maximum force (N) required to break the sample in question. The more brittle the products, the less force will be required to break the product, while hard, unbreakable potato chips will require more force.

2) Determination of moisture content of potato chips

Drying the sample to constant weight is the most commonly used method for moisture determination in various products.

Mash the potatoes into small pieces. A heated weighing glass (a metal dish with a lid) is weighed on the balance and approximately 2 g of the sample is weighed (to the nearest 3 decimal places). The weighing cups with the samples are placed in an oven at 105 °C for 3 hours, with the cap placed under the weighing cup. After drying, the measuring cups are removed from the drying oven with tongs, put on a cap and placed in a desiccator to cool. Weigh the cooled, closed measuring cups. Calculate the moisture content of the sample according to the formula:

$$\frac{(M-x)-(m-x)}{(M-x)} \times 100 = \frac{M-m}{M-x} \times 100$$

where M – initial mass of the sample + weighing glass;
x – mass of weighing glass;
m – final mass of yeast + container.

3) Colour (in the L*a*b* system) analysis.

Colour is one of the most important criteria for the external appearance of the product. If the product oxidises very quickly, the colour may be unattractive, brownish or greyish, so it is important to evaluate and compare the colour.

To determine the colour of the products in the CIE L*a*b* coordinate system, 5 identical chips are selected by colour, the potato chips are placed on the table on white paper and analysed with a colour analyser. The L*a*b* system uses three perpendicular axes, on which a negative a* value represents the intensity of the green colour, a positive a* value represents the intensity of the red colour, a negative b* value means an increase in the blue colour intensity, a positive b* value represents the intensity of the yellow colour, but L* is a characteristic of white (L=100) – black (L=0) or light-dark intensity.

Results

Create a table to combine the obtained data on the analysed samples and fill it out.

Conclusion

Provide an overview on the obtained results. Write possible explanations of the detected differences.

Approved by _____

Name, surname, signature

Date _____

Laboratory work

“Sensory evaluation of potato chips”

The aim of this laboratory work is to evaluate how different preparation methods can affect sensory properties (colour, aroma, crunchiness, salty taste and aftertaste) of potato chips.

Materials

Each panellist receives 4-5 prepared potato samples. The potato chips are served in containers coded with three randomised numbers. At least 3 chips are served to each panellist. Warm black tea is used to neutralise the taste between samples.

Methods

Just about Right (JAR) test - helps in product optimisation by identifying attributes that need adjustment to meet consumer expectation.

JAR (Just about Right) test

TRAY NO. _____

Select and write on the right-hand side of the scale the sensory properties that are specific to potato chips.

Please, evaluate the sensory properties (colour, aroma, crunchiness, salty taste and aftertaste) of potato chips samples using the JAR (Just About Right) test.

Please, indicate your opinion about potato chips sensory properties, marking the squared box that matches your preference and liking.

_____
sample code

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

_____
sample code

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

_____
sample code

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

_____
sample code

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

_____
sample code

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

Conclusion

Provide an overview on the obtained results. Write possible explanations of the detected differences.

Approved by _____

Name, surname, signature

Date _____

Tomato processing products

Theoretical materials

Producing tomato products involves a variety of processes to transform fresh tomatoes into items like tomato paste, tomato sauce, canned tomatoes, and tomato juice. Each product requires specific steps to ensure quality, safety, and flavour.

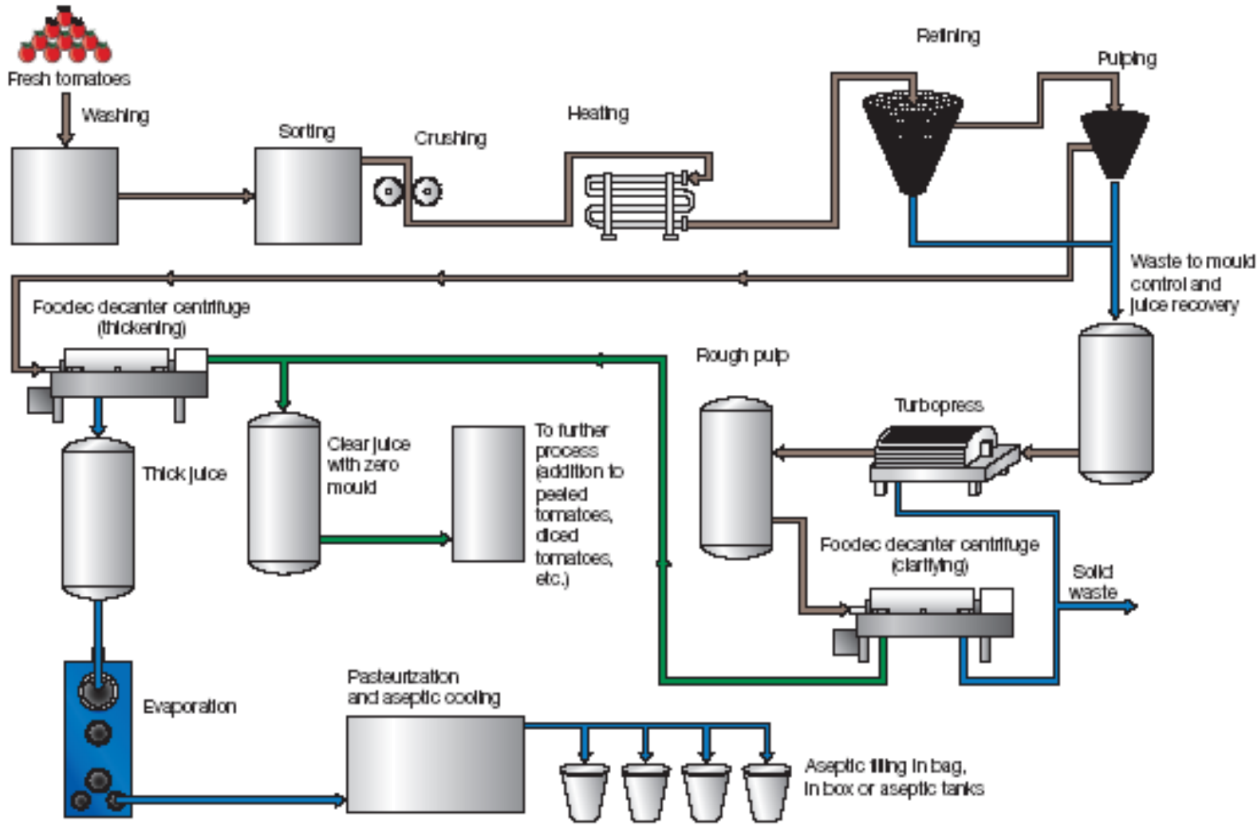


Fig. 11.5 Production of tomato paste https://mazmach.tripod.com/id4.html

Tomato paste, tomato juice, ketchup, hot sauce, and tomato sauce are all tomato-based products, but they differ significantly in their ingredients, consistency, preparation methods, and culinary uses.

Tomato sauce is a product made from concentrated tomato products (paste, puree) or fresh tomatoes with various spices and herbs, packed in hermetically sealed containers. Tomato sauces may be pasteurised or preserved with a preservative.

Table 11. 1

Overview of tomato product characteristics

Product	Ingredients	Consistency	Preparation	Uses
Tomato paste	Tomatoes	Very thick	Long cooking and reduction, strained	Base or thickener for soups, stews, sauces
Tomato juice	Tomatoes, sometimes salt/seasoning	Smooth, liquid	Crushed and heated tomatoes, strained	Beverage, cocktail base, soup base
Ketchup	Tomatoes, vinegar, sugar, salt, spices	Smooth, thick	Cooked tomatoes with vinegar, sugar, spices, pureed	Condiment for fries, burgers, hot dogs, sauces, marinades
Hot sauce	Tomatoes, vinegar, chilli peppers, salt, spices	Thin to moderately thick	Blended tomatoes with chilli peppers and other ingredients, cooked	A condiment to add heat to dishes
Tomato sauce	Tomatoes, onions, garlic, herbs, sometimes meat/vegetables	Thick, smooth to chunky	Cooked tomatoes with other ingredients, blended if desired	Base for pasta, pizza, casseroles, savoury recipes

Tomato sauce and ketchup in Latvia

In Latvia, most companies traditionally produce tomato sauces according to company standards, assuming that no food additives should be added to tomato sauces, except for the preservative - sorbic acid.

At the moment, in Latvia, there is no definition of the difference between tomato sauce and ketchup. In the dictionary, ketchup is translated as "hot tomato sauce" whereas, according to cookbooks, "ketchup" can be any hot sauce, and ketchup was originally a fish sauce.

Since there is no regulation in Latvia of what "ketchup" is, manufacturers freely interpret it, taking into account that ketchup is based on tomatoes, adding many permitted food additives (flavouring agents, thickeners).

The quality of tomato sauce is indicated by organoleptic and physicochemical quality indicators.

Table 11.2

Physico-chemical indicators of tomato sauce

No.	Indicators	The norm	Standard
1.	Dry matter content,%	18-25	VST 8756.2
2.	Salt content, %	2.2-2.5	VST 26186
3.	Titratable acidity, converted to acetic acid, %	1.0-1.3	VST2555.3
4.	Environmental pH	3.8-4.4	VST 26188
5.	Mineral impurities	are not allowed	VST 25555.5
6.	Mass fraction of fat, %	2	-

Laboratory work

Preparation of tomato concentrates and sauces using different technologies

Materials

Tomatoes and other ingredients for tomato product preparation.

Laboratory equipment: digital refractometer, pH meter; colour analyser; rotary juicer; rotary-type vacuum evaporator; vacuum cooker.

Methods

Task 1

Weigh the tomatoes intended for juicing. Obtain tomato juice with a mechanical slow rotation press. If the tomato pulp is very wet when pressed the first time, it can be pressed again. Weigh the resulting juice and calculate the juice yield.

Task 2

Determine the following quality indicators for the finished juice sample.

1. **Soluble solids (using refractometer)**

To compare the degree of sweetness of the juice, the content of soluble solids is determined by using digital refractometer, by placing 3 drops of the liquid part of the product on the prism of the refractometer and taking a reading. Measurements are performed in three replicates and the arithmetic mean is calculated.

2. **Product pH**

To determine the product pH in a juice sample, it is poured into a beaker in which the electrode of the pH meter is dipped and the pH of the product is determined. Measurements are performed in triplicate and averaged.

3. **Colour (in the L*a*b* system) analysis**

Colour is one of the most important criteria for the external appearance of juices. If the juice oxidises very quickly, the colour may be unattractive, brownish or greyish, so it is important to evaluate and compare the colour.

To determine the colour of juices in the CIE L*a*b* coordinate system, the product is poured into a prepared Petri dish so that the cap fits tightly to the product without an air gap, placed on a table on white paper and analysed with a colour analyser. The L*a*b* system uses three perpendicular axes on which a negative a* value reflects the intensity of the green colour, a positive a* value reflects the intensity of the red colour, a negative b* value - an increase in the blue colour intensity, a positive b* value - the intensity of the yellow colour, while L* represents the intensity of the light-dark colour. L=0 corresponds to black, L=100 to white.

Task 3

Concentrate the resulting juice with the following methods.

1. Atmospheric pressure, boiling on the stove in an open pot at 100 °C to a soluble solids content of 24 Brix %. Note the cooking time.
2. In a rotary-type vacuum evaporator at a temperature of 60 °C to a soluble solids content of 24 Brix %. Fix the cooking time.
3. Stephen in a vacuum cooker at 70 °C to a soluble solids content of 20 Brix %. Fix the cooking time.

pH and colour after concentration. All the obtained results are summarised in table 11.3.

Task 4

Using the raw materials available, create your own tomato sauce or ketchup recipe for 500 g of the total product. Prepare the respective product and fill it into 2 jars.

Examples of recipes.

1. Example: **tomato sauce**

INGREDIENTS: 300 g of onion, 1 tablespoon (tbsp) of oil, 1 kg of tomatoes, salt (to taste), 1 tbsp of vinegar, 4 cups of water, 3 tbsp of sugar, 1 chili, 1 cinnamon stick, ground white pepper (to taste), 3 cloves of garlic.

PREPARATION: Peel the onions, cut them into small pieces. Heat the oil in the pot in which to fry the onions. At the end, add garlic and fry for another half a minute.

Spices, sugar, salt, vinegar and chili are added to the tomato puree. Boil.

Fill in jars and cover.

2. Example: **thick ketchup with starch**

The sauce comes out moderately spicy, with aromatic spices that can be added according to your taste and liking.

INGREDIENTS: 1.2 kg of tomatoes, 2 sweet peppers, 5-6 cloves of garlic, 1 tablespoon of starch, 2 teaspoons of salt, 50 g of sugar, 20 mL of 9% vinegar, spices according to taste and preferences – paprika, cumin, black pepper, cloves, bay leaves.

PREPARATION :

Put the tomato puree, paste or other concentrate in the pot. Cleaned and finely chopped sweet pepper is also added there.

Stew for 0.5 hour, stirring occasionally. Allow the mass to cool and blend or strain through a sieve. Pour back into the pot. Clean the garlic, take a piece of clean cheesecloth, put garlic and spices (except salt and sugar) in it. Put this bag in the pot. Stew for 20 minutes. Five minutes before the end, add salt and sugar, add vinegar and stir.

Remove the spice bag with a slotted spoon. Dissolve the starch in the cooled juice, which is poured before, and pour it into the hot ketchup. Leave to simmer over a low heat for another 5 minutes.

The hot sauce is poured into jars and closed.

Results

Table 11.3

Quality indicators of tomato juice concentrates obtained in different ways

Type of sample	Cooking time, min.	Soluble solids	pH	Colour			Consistency (N)
				L*	a*	b*	
Fresh juice							
At atmospheric pressure 100 ℃							
Vacuum- infusion							
Vacuum cooking							

Conclusion

Provide an overview on the obtained results. Write possible explanations of the detected differences.

Approved by _____

Name, surname, signature

Date _____

Laboratory work

Quality assessment of prepared tomato products

Materials

In previous laboratory work prepared tomato products.

Methods

Make a comparison of the physical and chemical parameters of your prepared sample of tomato sauce and two more coded samples. Based on the obtained indicators, evaluate their differences and whether the coded samples correspond to tomato sauce or ketchup.

1. Determination of soluble solids with a refractometer

From the average sample, weigh 10 g of tomato sauce into a measuring cup, put it in a double-folded cheesecloth and press 2 drops of the sauce onto the lower prism of the refractometer. The drops are squeezed between the prisms and viewed in the eyepiece. The % of soluble solids is read on the scale on the right-hand side of the field of vision and compared to the standard requirements. Measurements are made in three replicates, and the dry matter content is determined as the arithmetic mean of the 3 replicates.

2. Determination of table salt content by chemical method

Place 5 ml of tomato sauce or ketchup in a 100 ml beaker, add 3-4 drops of saturated potassium chromate solution (indicator) and titrate from a burette with 0.1 n silver nitrate solution. The reaction takes place according to the following scheme:

$NaCl + AgNO_3 = AgCl + NaNO_3$

AgCl precipitates as a white precipitate. As the chloride ion precipitates, the silver nitrate begins to react with the potassium chromate:

$2\ AgNO_3 + K_2CrO_4 + 2\ KNO_3$.

Ag_2CrO_4 turns the solution orange-brown, indicating that the titration should be stopped. The amount of table salt is calculated according to the following formula:

$$x = \frac{a * 0.00585 * 100}{b}$$

Where: x - table salt content, %

a - AgNO3 0.1 n solution consumed for titration (ml).
b - the amount of filtrate taken for titration (ml).
0.00585 - amount of NaCl (g) corresponding to 1 ml of 0.1 n $AgNO_3$.

3. Determination of titratable acid

Weigh 4 g of tomato sauce or ketchup into a 250 mL conical flask, add 100 mL of distilled water, add 3 drops of phenolphthalein, mix thoroughly and titrate with 0.1 n NaOH until a faint pink colour appears.

The amount of acid is calculated according to the formula:

$$S = \frac{v \times n \times k}{10 \times m}$$

Where: *S* - acid content (mg/g)
v - titrated volume of 0.1 n NaOH (ml)
n - NaOH normality (0.1).
k - acid coefficient, which is 64.047 when converted to citric acid.
m - mass of weight taken for titration (g)

4. Determination of product pH

To determine the pH of the environment in the samples of tomato sauce, it is poured into a beaker in which the pH meter electrode is dipped and the pH of the product is determined.

5. Structure analysis with structure analyser

The samples to be analysed, trying not to destroy their structure, are placed in a structure analyser dish in a 1.5 cm thick layer (Figure 2). Measurements are made by placing the dish with the sample on the base of the structure analyser (figure 2), pressing the sample with a wheel and measuring the compressive force (N) at a deformation rate of 1 mm s^{-1}.

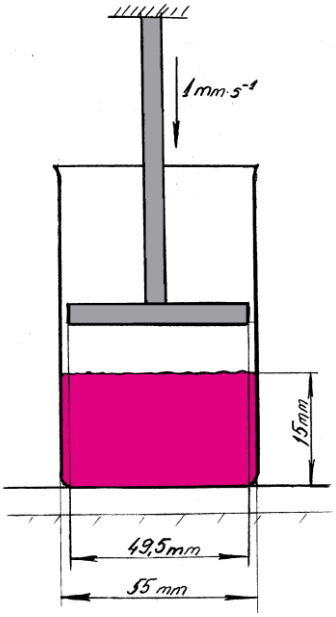


Fig.11.6 Structure analysis of sample

The result is the maximum force (N) required to push the puck through the sample layer.

6. Colour (in the L*a*b* system) analysis

To determine the colour of tomato sauce and ketchup in the coordinate system, the sample is first placed in a clean Petri dish and a second glass cover is placed so that no air bubbles remain between the sample and the glass. The sample is then analysed with a colour analyser in the L*a*b* system. The L*a*b* system uses three perpendicular axes, on which a negative a* value represents the intensity of the green colour, a positive a* value represents the intensity of the red colour, a negative b* value means an increase in the blue colour intensity, a positive b* value represents the yellow colour intensity, while L* is a representative of white-black or light-dark intensity.

Results

Create a table to combine the obtained data on the analysed samples and fill it out.

Conclusion

Provide an overview on the obtained results. Write possible explanations for the detected differences. Provide the data comparison with the parameters regulated in your country for tomato products.

Approved by _____

Name, surname, signature

Date _____

Laboratory work

Sensory evaluation of prepared tomato products

Materials

Each panellist receives 5 samples, which are evaluated according to the recommendation given in table 11.4. Each sample is given to the panellist in a 30 mL glass jar with a screw-on lid. Warm black tea or Maca bread is used to neutralise the taste between the samples.

Methods

Table 11.4

Recommendation of sensory analysis of tomato products

Sensory quality parameters	Evaluation in points
1. Appearance	
Characteristic colour, characteristic of the type of product, homogeneous colour and consistency, shiny	5
Characteristic with small deviations in the product colour, glossy	4
A little matte, a little uncharacteristic colour (light red or brown colour), grainy	3
Uneven, serum separation (solid phase and serum phase), dull	2
Uncharacteristic of the type, lumpy, uneven pieces, beginning to deteriorate	1
2. Consistency	
Characteristic, homogeneous, slow flowing, creamy	5
Characteristic with minor deviations	4
A little too liquid, uneven, floury	3
Watery, a bit lumpy, too thick	2
Lumps / mismatched pieces, flaky, very flowy or very thick	1
3. Aroma	
Adequate, balanced, pleasant, balanced additive aroma	5
Balanced with minor deviations	4
Neutral, weakly expressed, slight unbalanced	3
Vinegar, unbalanced, pungent, empty smell	2
Very sour, very sharp, sour, uncharacteristic / foreign, mouldy	1
4. Taste, aftertaste	
Adequate, balanced, pleasant, pronounced taste and aftertaste of tomatoes and additives	5
Appropriate with minor deviations	4
Characteristic of the product, but weak or too pronounced, unstable, slight unbalance	3
Vinegar, empty, watery, bare, dominated by one of the flavours, uncharacteristic, foreign	2
Bitter, uncharacteristic, sour, unpleasant, very salty, very sour, very bitter, very sweet, pungent vinegar, musty	1

The total score of sensory properties and their transcript:

18-20 ***very good quality***
15-17 ***good quality***
12-14 ***average quality***
11 and under ***inadequate quality***

Results

Evaluate the given tomato product samples according to evaluation recommendations given in table 11.5. For the appropriate evaluation, mark each characteristic with a mark and if any deviations are found, justify them.

Table 11.5

Sensory property	Points and characteristics				
	S1	S2	S3	S4	S5
Appearance					
Consistency					
Aroma					
Taste and aftertaste					
TOTAL					

Conclusion

Provide an overview on the obtained results. Write possible explanations of the detected differences.

Approved by _____

Name, surname, signature

Date _____

Theme 12

Thermally processed fruit and berry preserves

Fruit and berry compotes, jams and purees

Theoretical materials

Heat-treated fruit and berry preserves include compotes, juices and similar products (such as syrups, drinks, nectars, etc.), as well as preserves with a high sugar content (jams, jellies, marmalades, etc.).

Compotes are fruit and berries from which the inedible parts have been removed, the raw materials are whole or cut into pieces, covered with sugar syrup and pasteurised or sterilised.

Fig 12.1 Plum https://www.santa.lv/raksts/ievasreceptes_/receptes/edienu-veidi/konservejumi/plumju-kompots-10512/ and pumpkin compote https://receptes.tvnet.lv/recepte/4339-kirbja-kompots

Canned foods with high sugar content

Jam is a mixture prepared to a jelly-like consistency, consisting of one or more types of fruit pulp or puree, or a mixture of both raw materials, as well as sugar and water.

Fruit jam is a fruit mixture heated and prepared to a flowing consistency, consisting of one or more types of whole or chopped fruit, their pulp or puree, as well as sugar and water, with a soluble solids content of 47-59% according to refractometer readings.

Jelly is a jelly-like consistency product consisting of one or more types of fruit juice or aqueous extracts, or a mixture of both raw materials and sugar.

Marmalade is a mixture prepared to a jelly-like consistency, consisting of water, sugar and one or more fruit raw materials - pulp, puree and juice, aqueous extracts and peel.

Laboratory work

Apple compote preparation

Materials

Apples, sugar, water, different types of additives (cinnamon bark; cranberry berries; rowan fruit; blueberries; sea buckthorn) and other spices based on preference.

Methods

Tasks

1) weigh the apples, wash them, peel them and calculate the losses;
2) prepare sugar syrup with a sugar concentration of your own choosing;
3) prepare apple compote according to all three given processing methods, choosing the same type of additives and the same concentration of sugar for all types.

Winter and autumn apple varieties are the most suitable for making apple compote. Apples should be picked with patience. Apples of the same variety must be selected in one container for making compotes. To make good-looking compotes, choose apples with dense flesh, without bruises, because each bruise causes brown spots during heating.

After washing, peel the apples. Peeling is recommended with a stainless steel knife. Then core the apples and cut them into slices. Cut fruit should not be kept in the air, because they turn dark, and oxidise. Therefore, the cut slices are immediately placed in cold water, to which 2 teaspoons of vinegar or ½ teaspoon of citric acid have been added per litre of water. After preparing the apples, remove them from the water, drain the excess water on a sieve and pour over boiling sugar syrup. The amount of sugar depends on the variety of apples, degree of ripeness and the consumer taste preference.

Preparation of syrup

Dissolve 200-400 g of sugar in one litre of water and boil for 5-6 minutes, ½ litre of syrup is enough to pour over a litre jar.

Technique 1

Remove the prepared apples from cold water, drain, put in a bowl and pour over the prepared boiling sugar syrup, let it cool. During this time, the sugar syrup partially squeezes the air out of the apples (apples sometimes contain up to 25% air), the apple slices become elastic and light. The apples no longer turn dark because the enzymes in them have died.

Remove the apples from the syrup with a slotted spoon and pour them into heated jars. The remaining syrup is strained through a double cheesecloth to separate the remains of the apples, boiled and poured over the fruit.

To make it look prettier, you can add some other colourful berries or fruit.

Place a boiled metal lid on the prepared jar, cover and pasteurise at 85 °C: 0.5 l jar for 15 minutes, 1 l jar for 20 minutes. After that, the jars are covered andkept upside down for ½ hour and then cooled in the surrounding air.

Technique 2

Remove the prepared apples from cold water, drain, put in a bowl and pour over the prepared boiling sugar syrup, let it cool. During this time, the sugar syrup partially expels the air from the apples (apples sometimes contain up to 25% air), the apple slices become elastic and light. The apples no longer turn dark because the enzymes in them have died.

Remove the apples from the syrup with a slotted spoon and pour them into heated jars. The remaining syrup is strained through a double cheesecloth to separate the remains of the apples, boiled and poured over the fruit.

To make it look prettier, you can add some other colourful berries or fruit.

Place a boiled metal lid on the prepared jar, seal and sterilize °at 105 °C: 0.5 l jar for 3 minutes, 1 l jar for 5 minutes. The jars are then cooled.

Technique 3 - hot infusion

Prepared, sliced apples are placed in a pot, poured with previously prepared sugar syrup so that the apples are completely covered, slowly heated to a temperature of 90 °C. Then let it cool for half an hour. After that, the sugar syrup is drained from the apples and the apples are placed in jars, and the syrup is boiled and the boiling water is poured over it. After 10-15 minutes pour out the syrup and boil it for the third time. If the syrup is not clear, before the third boil, strain it through cheesecloth and pour it hot over the apples. Boiled metal lids are put on the jars and closed. The jars are kept upside down for half an hour and then cooled in the surrounding air.

This technique is better for large containers - 2-3 litre jars.

If the apples are not sour, 1-3 g of citric acid can be added to the sugar syrup per litre of syrup.

Approved by _____

Name, surname, signature

Date _____

Laboratory work

Quality evaluation of apple compotes

Materials

Previously prepared apple compote samples.

Methods

Analyse the quality parameters of previously prepared apple compotes.

1) **Colour (in the L*a*b* system) analysis**

Colour is one of the most important criteria for the external appearance of compotes. If the apples have not been properly prepared, they can also be brown or grey in the compote, so it is important to evaluate and compare the colour.

To determine the colour of apple slices in the coordinate system, 5 apple slices of characteristic colour are selected, placed on the table on white paper and analysed with a colour analyser in the L*a*b* system. The L*a*b* system uses three perpendicular axes, on which a negative a* value represents the intensity of the green colour, a positive a* value represents the intensity of the red colour, a negative b* value means an increase in the blue colour intensity, a positive b* value represents the yellow colour intensity, while L* is a representative of white-black or light-dark intensity.

2) **Hardness, flexibility analysis with structure analyser**

Another important indicator of quality in the finished compote is the firmness and consistency of apples and other additives. The fruit must not be disintegrated or too hard, tough.

Choose 3 apple slices of the same size, and place them on the tray of the structure analyser. Measurements are made by pressing the sample with a knife and measuring the force (N) with which the fruit can be cut at a pressing speed of 10 mm s^{-1}.

The result is the maximum force (N) required to cut the product in question.

The softer the apple slices, the less cutting force is required.

Task *Measure the maximum compressive force of the apple slices of your prepared compote and then compare it with the maximum compressive forces of other samples as well as the sensory consistency indicators.*

3) **Soluble solids (refractometrically)**

In order to compare the degree of sweetness of the prepared compotes, the content of soluble solids is determined refractometrically by dropping 3 drops of compote syrup on the prism of the refractometer and taking a reading. The measurements are performed in triplicate. The dry matter content is determined as the arithmetic mean of 3 replicates.

Task *Measure the soluble solids content of your sample and compare the obtained data with the results of other samples, as well as with the obtained sensory evaluations of the degree of sweetness. Draw conclusions.*

4) Sensory evaluation using Quantitative descriptive method

The sensory evaluation of compotes is carried out according to the given table 12.1, which reflects the sensory indicators of a good compote.

Table 12.1

Quantitative descriptive method for compotes

Sensory parameters	Characterisation
Appearance	Apple slices cut the same, evenly arranged throughout the volume of the jar. The poured syrup is clear, evenly covering the fruit in the entire volume of the jar. For plums, the peel must not be cracked and peeling.
Structure	Apple slices are juicy, firm, easy to digest (they should not be hard or mushy).
Aroma	The aroma is pleasant, characteristic of apples, the aroma of added additives can also be smelled. No other side smells are allowed.
Taste	Balanced sweet and sour, pleasant, without bitterness or any other uncharacteristic aftertastes.
Colour	Light yellow or white (if no colouring additives are added), apple slices must not have brownish or other spots. The syrup should be golden clear with no signs of cloudiness. If colouring additives are added, the colouring should be uniform throughout the container.

A total of four compotes samples are used for the sensory evaluation - three from previously prepared samples and one from the store, already available in the market.

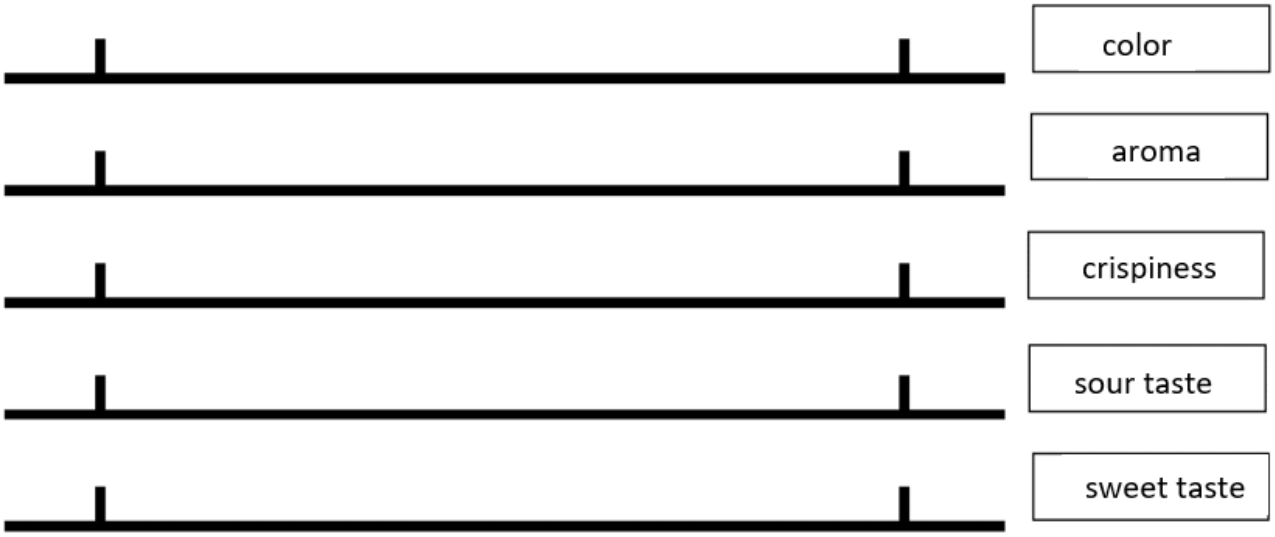
Use water to clean your mouth between samples.

Task *- to evaluate the intensity of sensory properties (colour, aroma, crispness of apples, sour taste and sweet taste) for apple compotes samples.*

12 cm Line scale

TRAY NO. _____

Please mark the intensities of the presented product samples on the Line scale and write the sample number below the marking.



Results

1. Create a table to combine the obtained data on the analysed samples and fill it out.
2. Prepare sensory properties profile of analysed compotes samples in a spider graph!

Conclusion

Provide an overview on the obtained results. Write possible explanations for the detected differences.

Approved by _____

Name, surname, signature

Date _____

Fruit and berry marmalades

Theoretical materials

Thickeners and thickeners used in the production of jams, jellies and marmalades

Thickeners and thickeners are substances that increase the viscosity of the product without significantly changing its other properties.

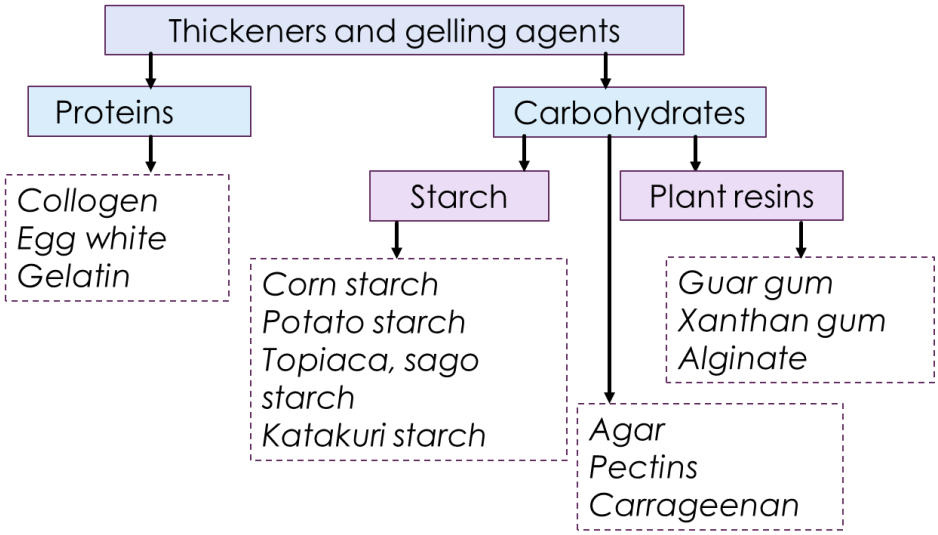


Fig. 12.2 Overview of thickeners and gelling agents used in production of fruit and vegetable products

Table 12.2

Comparison of some of the thickeners and gelling agents

Gelling Agent	Source	Properties	Advantages	Limitations	Applications
Pectin	Fruits (apples, citrus)	Requires sugar and acid, clear gel	Natural, common, firm gel	Needs precise conditions, sensitive to overcooking	Jams, jellies, marmalades
Gelatine	Animal collagen	Sets when cooled, melts upon reheating	Simple to use, versatile	Not vegetarian/vegan, heat sensitive	Fruit desserts, gelatine salads
Agar-Agar	Red algae	Sets at room temp, melts at 85 °C	Vegetarian/vegan, heat stable	Firm, less elastic texture, requires boiling	Fruit jellies, aspics

Carrageenan	Red seaweed	Various textures	Vegetarian/vegan, versatile	Requires careful measurement, potential allergen	Dairy and non-dairy desserts
Agarose	Red algae	Clear, strong gels	High clarity, firm gels	Expensive, specialised use	High-clarity fruit gels, lab uses
Starch	Corn, potato, tapioca	Thickens with heat, smooth texture	Widely available, inexpensive	Not a true gel, can become cloudy	Pie fillings, sauces, preserves

Pectin is a versatile and natural gelling agent derived from fruit, predominantly used in the food industry to create gels, stabilise products, and improve texture. It comes in two main types—high-methoxyl (HM) and low-methoxyl (LM)—each suitable for different applications based on their gelling requirements. Its wide range of uses includes jams, jellies, dairy products, confectionery, and beverages, making it an essential ingredient in fruit and berry production. Proper handling and precise usage are key to leveraging its full potential.

- **Source**: Pectin is a naturally occurring polysaccharide found in the cell walls of fruits and vegetables. It is particularly abundant in citrus fruits (like oranges and lemons) and apples.
- **Structure**: Pectin is a complex carbohydrate composed primarily of galacturonic acid units. These units are linked together to form a chain, with varying degrees of methylation and amidation influencing its gelling properties.

Types of Pectin:

1. **High-methoxyl (HM) pectin**:
    - **Degree of methylation**: More than 50% of the galacturonic acid units are esterified with methanol.
    - **Gelling conditions**: Requires a high sugar concentration (typically 55-65%) and an acidic environment (pH 2.8-3.6) to gel.
    - **Uses**: Commonly used in making traditional jams, jellies, and marmalades.
2. **Low-methoxyl (LM) pectin**:
    - **Degree of methylation**: Less than 50% of the galacturonic acid units are esterified.
    - **Gelling conditions**: Can gel with low or no sugar presence but requires the addition of calcium ions. Works well in a broader pH range (3.2-4.0).
    - **Uses**: Suitable for low-sugar or sugar-free jams, jellies, and dairy products like yogurt.

<u>Functional properties:</u>

- **Gelling agent**: Pectin forms a gel matrix by bonding with sugar and acid (HM pectin) or calcium ions (LM pectin), providing structure and texture to jams, jellies, and preserves.

- **Stabiliser**: Helps stabilize acidic protein systems, preventing curdling in products like yogurt and certain beverages.
- **Thickener**: Increases viscosity in fruit fillings, sauces, and syrups, contributing to the desired mouthfeel and consistency.
- **Emulsifier**: Assists in emulsifying and stabilizing emulsions, particularly in fruit-based products and beverages.

Preparation and usage:

- **Dissolution**: Pectin must be properly dissolved in water. For HM pectin, it is typically dissolved in boiling water with sugar and acid. For LM pectin, calcium ions are introduced to facilitate gelling.
- **Concentration**: The typical usage concentration ranges from 0.5% to 2.0%, depending on the desired gel strength and the type of pectin.
- **Cooking**: Overcooking can break down pectin, reducing its gelling ability. It's important to follow precise cooking times and temperatures.

Quality control:

- **Purity**: High-quality pectin should have a high degree of purity, free from impurities that can affect gelling properties.
- **Consistency**: Consistent performance across batches is crucial for maintaining product quality.
- **Storage**: Pectin should be stored in a cool, dry place to prevent degradation and loss of gelling ability.

Gelatine is a highly versatile gelling agent derived from animal collagen. It forms a thermo-reversible gel and is used widely in the food industry for gummy candies, marshmallows, and jellied desserts, as well as in pharmaceuticals for capsules, and in cosmetics for its protein content. Its key properties include its ability to gel, thicken, foam, and emulsify. While it offers many benefits, such as versatility and safety, its animal origin and sensitivity to heat limit its use in certain applications. Proper handling, including hydration and temperature control, is essential for optimal performance.

- **Source**: Gelatine is derived from the collagen found in animal connective tissues, such as skin, bones, and cartilage. Common sources include bovine (cows) and porcine (pigs).
- **Composition**: Gelatine is a protein made up of amino acids, predominantly glycine, proline, and hydroxyproline. It forms when collagen is partially hydrolysed.

Physical and chemical properties:

- **Appearance**: Gelatine is typically available as a colourless or slightly yellow powder, granules, or sheets.
- **Solubility**: It dissolves in warm water, forming a viscous solution that gels upon cooling.
- **Gel formation**: Gelatine forms a thermo-reversible gel, meaning it sets when cooled and melts when heated. The gelling and melting points depend on the concentration and the type of gelatine.

Types of gelatine:

1. **Type A gelatine**:
    - **Source**: Derived from acid-treated collagen (often from pork skins).
    - **pH range**: Typically has a pH between 4.8 and 5.5.
    - **Uses**: Commonly used in food products like gummy candies, marshmallows, and certain desserts.
2. **Type B gelatine**:
    - **Source**: Derived from alkaline-treated collagen (often from bovine hides and bones).
    - **pH range**: Typically has a pH between 5.0 and 7.0.
    - **Uses**: Often used in pharmaceutical applications, capsules, and some food products.

Functional properties:

- **Gelling agent**: Gelatine can form gels of various strengths and textures, from soft and elastic to firm.
- **Thickening agent**: Increases the viscosity of liquids, providing a rich, smooth texture.
- **Foaming agent**: Stabilises foams in products like marshmallows and whipped desserts.
- **Emulsifying agent**: Helps in stabilising emulsions, improving texture and consistency.

Preparation and usage:

- **Hydration**: Gelatine must first be hydrated in cold water (blooming) before being dissolved in warm water.
- **Concentration**: Typical usage ranges from 0.6% to 3.0%, depending on the desired gel strength.
- **Temperature control**: Proper temperature control is crucial. Gelatine solutions should not be boiled as it can degrade the protein and reduce gelling ability.

Quality control:

- **Bloom strength**: Measures the firmness of the gelatine gel and is an indicator of gel strength. Higher bloom values indicate firmer gels.
- **Clarity and colour**: High-quality gelatine should be clear and free from colour, as this affects the appearance of the final product.
- **Purity**: Should be free from impurities that can affect performance and safety.

Advantages:

- **Versatility**: Can be used in a wide range of applications, both in food and non-food industries.
- **Edible and safe**: Generally recognized as safe (GRAS) by regulatory authorities.
- **Thermo-reversibility**: Can be repeatedly melted and re-gelled, useful for various culinary applications.

Limitations:

- **Not vegetarian/vegan**: Derived from animal sources, unsuitable for vegetarians and vegans.
- **Heat sensitivity**: Gelatine can break down if exposed to high temperatures for extended periods.
- **Texture variability**: The texture can be affected by the presence of other ingredients like acids or salts.

Laboratory work

Preparation of fruit and berry marmalades using different gelling agents

Methods

Make marmalade candies from the given raw materials: juices, purees and chopped berries. Convert marmalade recipes **to 300g of product**.

The gelling agents offered for making marmalades:

a) Pectins
   - HM pectin
   - LM 130 AS
   - LM 102 AS

b) Gelatine

c) Agar

Recipes:

1) Marmalade candies with HM pectin (per 150 g total mass)

Recipe 1: Sugar 65 g; water 20 g; apple juice 40 g; cranberry puree 12 g; glucose syrup 10 g; HM pectin 2 g; citric acid 0.7 g; trisodium citrate 0.3 g.

Preparation : Weigh the liquid and dry ingredients separately. Pectin, citric acid, trisodium citrate are mixed together with sugar and added to the still cool product mass. Then, stirring the product over low heat, it starts to boil. Glucose syrup is added while continuing to stir while boiling. The mass continues to boil for at least 7-10 minutes (until the mass becomes already thick, viscous). The finished mass is quickly poured into previously prepared dishes.

2) Marmalade candies with LM pectin (per 200 g total mass)

Recipe 2.1: Water 28.2 g; cranberry puree 20 g; apple juice 80 g; sugar 60 g; LM pectin 102 10 g; citric acid 1.6 g; ca citrate 0.2 g.

Recipe 2.2: Water 28.2 g; cranberry puree 20 g; apple juice 80 g; sugar 60 g; LM pectin 130 10 g; citric acid 1.6 g; ca citrate 0.2 g.

Preparation: Weigh the liquid and dry ingredients separately. Pectin, citric acid Ca citrate is mixed together with sugar and added to the still cool product mass. When everything is well mixed together, let the pectin swell for 5 minutes. After that, while stirring, the mass starts to heat up to the boiling point on a slow fire and continues to boil for about another 5 minutes. The finished mass is quickly poured into previously prepared dishes.

3) Marmalade candies with gelatine (per 200 g total mass)

Recipe 3: Apple juice 80 g; cranberry juice 21 g; water 26 g; sugar 60 g; gelatine 12 g; citric acid 1 g.

Preparation: Water is mixed with juices and puree, sugar, gelatie, and citric acid. Allow the gelatine mass to swell for 5-10 minutes. When the gelatine swells, the mass is heated to 100 °C while stirring. The finished liquid mass is filled into dishes.

4) Marmalade candies with agar (per 200 g total mass)

Recipe 4: Cranberry juice 30 g; apple juice 86 g; water 20 g; Sugar 60 g; Agar 4 g.

Preparation: Weigh all the ingredients, weigh the dry ingredients separately and mix together. Then they are mixed into the total mass. Boil the mass at 100 °C for about 5 minutes and then pour it into moulds.

Approved by _____

Name, surname, signature

Date _____

Laboratory work

Quality analysis of fruit and berry marmalades

Materials

Previously prepared fruit marmalades.

Methods

The quality of marmalades is determined by various chemical and physical indicators. In addition, the main indicators by which the quality of marmalades can be judged are directly physical: firmness, colour fastness.

Task 1 *To determine the chemical quality indicators of marmalades:*

1) Soluble solids (refractometrically)

Weigh 5 g of marmalade from the sample into a measuring cup, add 5 g of hot distilled water, mix thoroughly, and put 2 drops of the obtained sample on the prism of the refractometer with a chopstick. The measurements are performed in triplicate. The dry matter content is determined as the arithmetic mean of 3 replicates and the dilution factor is included in the calculations.

$$S = a \times k$$

where *S* – content of soluble solids in the product;
a – amount of dry matter measured with a refractometer, %;
k – dilution factor, k=2

2) Titratable acids

Weigh 4 g of marmalade into a 250 mL conical flask, add 100 mL of hot distilled water, mix thoroughly. Then, add 3 drops of phenolphthalein, mix thoroughly and titrate with 0.1 N NaOH until a faint pink colour appears. The amount of acid is calculated according to the formula:

$$S = \frac{v \times n \times k}{10 \times m}$$

where: *S* - acid content (mg/g)
v - titrated volume of 0.1 n NaOH (mL)
n - NaOH normality (0.1).
k - acid coefficient, which is 64.047 when converted to citric acid.
m - mass of weight taken for titration (g)

Task 2 *Get to know the physical quality indicators of marmalades.*

1) Colour (in the L*a*b* system) analysis

To determine the colour of marmalade in the coordinate system, the sample is placed on a napkin (if the sample is very soft, it is placed in a Petri dish). The sample is then analysed with a colour analyser in the L*a*b* system. The L*a*b* system uses three perpendicular axes, on

which a negative a* value represents the intensity of the green colour, a positive a* value represents the intensity of the red u, a negative b* value means an increase in the blue colour intensity, a positive b* value represents the yellow colour intensity, while L* is a representative of white-black or light-dark intensity.

2) Structure analysis with structure analyser

Measure your prepared sample. Choose 3 pieces of marmalade and place them on the structure analyser tray. The measurements are made by pressing the sample with a knife and measuring the force (N) with which the sample can be cut at a pressing speed of 1 mm s^{-1}.

The result is the maximum force (N) required to cut the product in question.

The softer the marmalade, the lower the cutting force required.

The obtained data are compared with the data of other marmalade samples and relevant conclusions are made about the influence of the selected softeners on the hardness of the samples.

Results

Compare the chemical and physical parameters of the marmalade candies with other marmalade candies prepared by other groups or commercially available. Summarise the results in the given table.

Table 12.2

Compilation of marmalade quality indicators

Sample name	Colour L*	Colour a*	Colour b*	Hardness, N	Soluble solids, %	Titratable acids, %

Conclusion

Provide an overview on the obtained results. Write possible explanations for the detected differences.

Approved by _____

Name, surname, signature

Date _____

Laboratory work

Sensory analysis of fruit and berry marmalades

The hedonic scale is a common tool used in sensory evaluation of food products to measure the degree of liking or disliking by consumers. It typically consists of a series of points (often 9 or 7) ranging from extreme dislike to extreme like. A typical 9-point hedonic scale includes the following points:

1. Dislike Extremely
2. Dislike Very Much
3. Dislike Moderately
4. Dislike Slightly
5. Neither Like Nor Dislike
6. Like Slightly
7. Like Moderately
8. Like Very Much
9. Like Extremely

Using the hedonic scale in a sensory evaluation provides valuable insights into consumer preferences, guiding food product development and ensuring products meet consumer expectations.

Materials

Each panellist receives 4 prepared marmalade samples. The marmalades are served in containers coded with three randomised numbers. 1 piece (approximately 20 g) of marmalade is served to each panellist. Water is used to neutralise the taste between samples.

Methods

Evaluate the liking of marmalade sensory properties - aroma, structure and taste, using 5-point hedonic scale.

5-point hedonic scale

TRAY NO. _____

Please evaluate the overall liking of marmalade samples sensory properties. Indicate how much you like or dislike each sample by checking (V or X) the appropriate phrase.

_____
sample code

aroma

Like very much	Like slightly	Neither like nor dislike	Dislike slightly	Dislike very much

structure

Like very much	Like slightly	Neither like nor dislike	Dislike slightly	Dislike very much

taste

Like very much	Like slightly	Neither like nor dislike	Dislike slightly	Dislike very much

_____
sample code

aroma

Like very much	Like slightly	Neither like nor dislike	Dislike slightly	Dislike very much

structure

Like very much	Like slightly	Neither like nor dislike	Dislike slightly	Dislike very much

taste

Like very much	Like slightly	Neither like nor dislike	Dislike slightly	Dislike very much

_____
sample code

aroma

Like very much	Like slightly	Neither like nor dislike	Dislike slightly	Dislike very much

structure

Like very much	Like slightly	Neither like nor dislike	Dislike slightly	Dislike very much

taste

Like very much	Like slightly	Neither like nor dislike	Dislike slightly	Dislike very much

_____
sample code

aroma

Like very much	Like slightly	Neither like nor dislike	Dislike slightly	Dislike very much

structure

Like very much	Like slightly	Neither like nor dislike	Dislike slightly	Dislike very much

taste

Like very much	Like slightly	Neither like nor dislike	Dislike slightly	Dislike very much

Conclusion

Provide an overview on the obtained results. Write possible explanations for the detected differences.

Approved by _____

Name, surname, signature

Date _____

Fruit, berry and vegetable juices

Theoretical materials

When it comes to industrial juicers for extracting fruit and vegetable juice, there are several key factors to consider, including the type of produce being processed, the desired juice quality, the production capacity, and the specific features required for your operation. Here are some of the main types of industrial juicers and notable brands on the market:

Types of industrial juicers

1. Centrifugal juicers:
    - Advantages: High speed, efficient for hard and fibrous produce, relatively low cost.
    - Disadvantages: Not as effective for leafy greens, can produce heat that affects juice quality.
    - Applications: Best for large quantities of apples, carrots, beets, and similar produce.
2. Masticating (cold press) juicers:
    - Advantages: Retains more nutrients due to low heat, effective for a wide range of produce including leafy greens.
    - Disadvantages: Slower process, generally more expensive.
    - Applications: Ideal for high-quality juice production where nutrient retention is important.
3. Twin gear (triturating) juicers:
    - Advantages: Highest juice yield, excellent nutrient retention, handles a variety of produce well.
    - Disadvantages: Expensive, complex to clean and maintain, slower operation.
    - Applications: Premium juice products, diverse product processing.
4. Hydraulic press juicers:
    - Advantages: Exceptional juice quality, high yield, excellent for commercial use.
    - Disadvantages: Very high cost, requires more space, slower compared to centrifugal juicers.
    - Applications: High-end juice production, large-scale operations.

The technology for obtaining fruit and vegetable juice involves several processes and types of equipment designed to extract juice efficiently while maintaining the nutritional quality and flavour of the produce. Here's an overview of the key technologies and processes used in the juice extraction industry:

Key technologies in juice extraction

1. **Washing and sorting**
    - Before juicing, fruits and vegetables are washed to remove dirt, pesticides, and other contaminants. Sorting is also done to remove any damaged or unripe produce.
    - Washing machines, sorting conveyors, and grading machines.
2. **Crushing and grinding**
    - Produce is crushed or ground into smaller pieces to facilitate juice extraction.
    - Crushers, grinders, and shredders.
3. **Juice extraction**
    - Centrifugal extraction:
        - Uses a high-speed spinning mechanism to separate juice from pulp through centrifugal force.
        - Suitable for hard and fibrous produce like carrots, apples, and beets.
        - Centrifugal juicers.
    - Cold press (masticating) extraction:
        - Slowly crushes and presses produce juice, minimising heat generation and preserving nutrients.
        - Ideal for leafy greens, soft fruits, and producing high-nutrient juice.
        - Masticating juicers, twin gear juicers.
    - Hydraulic press extraction:
        - Uses hydraulic pressure to extract juice from produce wrapped in a cloth or mesh bag.
        - High-end juice production with excellent nutrient retention and juice yield.
        - Hydraulic press juicers.
    - Steam extraction:
        - Uses steam to heat the produce, causing cells to burst and release juice.
        - Commonly used for making juice from berries and grapes.
        - Steam juicers.
4. **Filtration and clarification**
    - Removes pulp, seeds, and other solids from the juice to improve clarity and texture.
    - Filters, decanters, centrifuges, and clarifiers.
5. **Pasteurisation**
    - Heat treatment used to kill harmful microorganisms and extend the shelf life of the juice.

- Pasteurisers.

6. **Homogenisation**
    - Breaks down large particles and disperses them evenly throughout the juice to improve texture and stability.
    - Homogenisers.
7. **Packaging**
    - Filling machines, bottling lines, aseptic packaging systems.

Advanced technologies

1. Ultrafiltration
    - Uses semi-permeable membranes to remove suspended solids and microorganisms.
    - Produces clear, high-quality juice without the need for pasteurisation.
    - Ultrafiltration systems/membranes.
2. High Pressure Processing (HPP)
    - Uses high pressure instead of heat to pasteurise juice, preserving more nutrients and flavour.
    - Extends shelf life while maintaining fresh juice characteristics.
    - HPP units.
3. Enzyme Treatment
    - Enzymes like pectinase are added to break down cell walls, increasing juice yield and clarity.
    - Particularly useful for producing clear apple and grape juices.
    - Enzyme dosing systems.

Laboratory work

Principles of production of fruit and vegetable juices, evaluation of prepared juices

Materials

Any available fruit, berries and/or vegetables that can be used for juice production and have the basic processing ingredient quality parameters.

a) Mechanical screw press;
b) Mechanical slow rotation press;
c) Evaporation of juice in a diffusion pot.

Methods

Task 1: Obtain fruit or vegetable juice by one of the proposed methods:

a) Mechanical screw press;
b) Mechanical slow rotation press;
c) Evaporation of juice in a diffusion pot.

Fruit and vegetables intended for the juice, their juice extraction options and comparison:

1) Apples:
    a. grind and press screws in a press;
    b. heat up to 75 ℃, stand for 3-5 minutes, chop and press in a screw press;
    c. Pour the juice into the steaming pot of sliced apples, evaporate.
2) Beets:
    a. grind and press screws in a press;
    b. heat up to 95 ℃, stand for 5 minutes, chop and press in a screw press
3) Carrots:
    a. obtain the juice mechanically in a slow rotation press.
    b. grind and press the screws in a press
4) Gooseberries:
    a. place whole gooseberries into a steaming pot for juice, evaporate;
    b. obtain the juice mechanically in a slow rotation press.
5) Sea buckthorn:
    a. pour whole berries into a steaming pot for juice, evaporate;
    b. Obtain the juice mechanically in a slow rotation press.

Task 2: Determine the following quality indicators for the finished juice samples

1. **Calculation of juice yield %**

To calculate the juice yield, the fruit, vegetables and berries are first weighed before juicing, then the resulting juice is weighed and its percentage of the total product is calculated.

2. **Soluble solids (refractometrically)**

In order to compare the degree of sweetness of the prepared juices, the content of soluble solids is determined refractometrically by placing 3 drops of the liquid part of the product on the prism of the refractometer and taking a reading. The measurements are performed in triplicate. The dry matter content is determined as the arithmetic mean of 3 replicates.

3. **Colour (in the L*a*b* system) analysis**

Colour is one of the most important criteria for the external appearance of juices. If the ingredients are not compatible or if they oxidise very quickly, the colour can be unattractive, brownish or greyish, so it is important to evaluate and compare the colour.

To determine the colour of the juice in the coordinate system, the product is poured into a prepared Petri dish so that the cap fits tightly to the product without an air gap, placed on a table on white paper and analysed with a colour analyser in the L*a*b* system. The L*a*b* system uses three perpendicular axes, on which a negative a* value represents the intensity of the green colour, a positive a* value represents the intensity of the red colour, a negative b* value means an increase in the blue colour intensity, a positive b* value represents the yellow colour intensity, while L* is a representative of white-black or light-dark intensity.

4. **Determination of product pH**

To determine the pH of the environment in the juice samples, they are poured into a beaker in which the electrode of the pH meter is dipped and the pH of the product is determined. Measurements are performed in triplicate and averaged.

5. **Titratable acids**

Weigh 4 g of juice in a 250 mL conical flask, add 100 mL of hot distilled water, mix thoroughly, and leave for 5 minutes. Then, add 3 drops of phenolphthalein, mix thoroughly and titrate with 0.1 N NaOH until a faint pink colour appears. The amount of acid is calculated according to the formula

$$S = \frac{v \times n \times k}{10 \times m}$$

where: *S* - acid content (mg/g)
v - titrated volume of 0.1 n NaOH (mL)
n - NaOH normality (0.1)
k - acid coefficient, which is 64.047 when converted to citric acid, 67.00 when converted to malic acid
m - mass of weight taken for titration (g)

6. Ascorbic acid content in juice

Vitamin C is rapidly oxidised both in the presence of oxygen and also at high temperatures, so it is important to evaluate the best way of processing and extracting juices, with the least reduction of vitamin C.

Determine the content of L-ascorbic acid (reduced form) in the given samples by the iodine method.

Methodology:

1. Prepare a standard solution of ascorbic acid: 20 mg of ascorbic acid per 100 mL of 6% oxalic acid solution.
2. Add 2 mL of 1% starch solution to 25 mL of ascorbic acid standard solution and titrate with 0.05 M iodine solution while stirring. Observe the colour change. Write down the amount of iodine used.
3. Weigh 25 g of juice sample into a 250 mL beaker.
4. 100 mL of 6% $H_2C_2O_4$ solution is poured over the prepared weight and mixed it well for 60 seconds.
5. Filter through a cotton filter.
6. Add 2 mL of 1% starch solution to 10 mL of filtrate and titrate with 0.05M iodine solution while stirring. Observe the colour change that does not disappear within 30 seconds and write down the amount.

$$C\ vit.\left(\frac{mg}{100g}\right) = 5000 * \frac{V_{J\ sample}}{m * V_{J\ standard}}$$

5000 - coefficient
$V_{Jin\ the\ sample}$ - the amount of iodine solution used for the titration of 10 mL of the sample
$V_{Jst.\ no.}$ - the amount of iodine solution used for the titration of 25 mL standard solution
m – sample mass

7. Sensory evaluation of samples

Compare the obtained finished juice samples and record the sensory evaluations in table 2.

Results

Create an additional table to combine the obtained data on the analysed samples and fill it out.

Table 12.3

Sensory evaluation of fruit and vegetable juices

Sensory properties	Sample 1	Sample 2	Sample 3	Notes
Appearance (cloudiness and clearness, colour)				
Consistency				
Aroma				
Taste balance				
Sweet taste				
Sour taste				
Aftertaste				

Conclusion

Provide an overview on the obtained results. Write possible explanations for the detected differences.

Approved by _____

Name, surname, signature

Date _____

Theme 13

Vegetable oils

Theoretical materials

Sunflower seed processing

The first stage – processing of sunflower seeds – is extremely important in production. From the quality of the seeds supplied for processing, ultimately depends on the quality of the final product – vegetable oil. In addition to this indicator, the cleaning of raw materials, the conditions of storage are also taken into account, such as temperature and light conditions. When determining the quality of sunflower seeds, the main thing to take into account is their qualitative indicators - mass and humidity. Different varieties of sunflower have different levels of oil content. At the same time, the yield of vegetable oil depends directly on the level of oil content of seeds. Other indicators - humidity and timing maturation are no less important when choosing raw materials for the production of a quality product. During the processing, the seeds are thoroughly cleaned from husks and defects, pass through the stages of additional cleaning, drying, and separating the seed shells from the kernels. The peeled seeds undergo a grinding process, eventually turning into a pulp. Grinding the seeds is the initial stage of direct oil production. The production technology itself is divided into cold and hot pressing, extraction, and refining.

Cold and hot press

Cold press technology allows the preservation of vegetable oil with a maximum amount of nutrients, as well as its originally organoleptic qualities. During the pressing, the oil production process consists of many stages. First, the prepared crushed raw materials (pulp) are heated to a certain temperature, usually up to 110 ºC. At the same time, the components of the raw materials are carefully mixed on specialised equipment, which results in the maximum volume of progress of the finished quality product (oil). At the next stage, the mixture isolated from the raw material passes through the squeezing process in screw presses. During *hot pressing*, the crushed raw materials are heated at higher temperatures. The result is a product with a richer, more intense aroma, taste and colour, but with this technology the amount of nutrients in the product is reduced. Hot press is one of the most common technologies that does not require knowledge or significant costs for oil production. Waste raw materials obtained during the production of vegetable oil are further processed and used in feed additives for feeding research of farm animals.

Extraction is a method of producing plant oil, which consists of mixing prepared new raw materials with organic solvents. In turn, the fat emulsion also passes through additional processing - filtration and clearing of impurities. As a result, such a multi-level technological process produces a purified concentrated product – unrefined vegetable oil.

Refining

According to the latter, the nutritional value of refined oil is reduced because the level of useful nutrients in this product is significantly reduced as a result of technological processing. This oil contains only trace amounts of essential fatty acids, including linolenic and linoleic, as well as some other vitamins. Therefore, among all types of refined oils it is considered the least beneficial for health. During the refining process, sunflower oil goes through many processing stages. At the initial stage, the prepared raw materials are carefully cleaned from impurities present in it, then it gradually undergoes the processes of settling, filtration and centrifugation. Next comes the stage of hydration, or processing of the resulting fat emulsion with hot water at about 70 °C. This processing method allows eliminating waste that contributes to product spoilage. The next stage of oil refining is neutralisation which removes free fatty acids from a mixture, pesticides and heavy metals that oxidise the product and lead to rapid spoilage. One of the disadvantages of refined oil is its low phospholipids. Bleaching is the purification of a mixture with organic adsorbents from colouring pigments, in particular carotenoids and brightening the product.

At the next stage, the oil undergoes a process of **deodorisation** – removal of all aromatics from the composition substances under the influence of hot steam at a high temperature mode – 220 °C. The removal of impurities, white carbonic and aromatic substances, allows to significantly increase the shelf life of the finished product.

The final technological stage is **oil freezing** - it consists of removing waxy acids from its composition. Freezing completely cleanses fat - a mixture of waxes and makes it colourless.

Thus, the use of different production technologies in the production of vegetable sunflower oil allows for the production of products with different organoleptic characteristics. However, despite some differences, each type of vegetable oil, produced in accordance with technological requirements, represents a high-quality food product.

Advanced technologies

Enzymatic extraction

- **Description:** Uses enzymes to break down cell walls and release oil.
- **Advantages:** Environmentally friendly, can improve oil yield and quality.
- **Applications:** Emerging technology, still under development for commercial use.

Supercritical fluid extraction

- **Description:** Uses supercritical CO2 as a solvent to extract oil.
- **Advantages:** Solvent-free, retains more nutrients, produces high-purity oil.
- **Applications:** High-value oils, pharmaceuticals, and cosmetics.

Membrane technology

- **Description:** Uses membrane filtration to refine oil.
- **Advantages:** Energy-efficient, reduces chemical usage.
- **Applications:** Suitable for degumming, de-acidification, and removal of impurities.

Vegetable oil production technology involves a combination of traditional methods and advanced technologies to extract and refine oil efficiently. The choice of technology depends on factors such as the type of oilseed, the desired oil quality, the scale of production, and environmental considerations. By leveraging appropriate technologies, producers can optimise their processes, improve oil yield and quality, and meet market demands effectively.

Producing vegetable oil involves several stages, each requiring specific types of equipment. Here is a comprehensive list of the equipment needed for the various stages of vegetable oil production:

Seed cleaning and preparation

- **Seed Cleaner:** Removes impurities such as dust, leaves, and stones.
- **Dehuller:** Removes the hull or shell from seeds.
- **Crusher:** Crushes seeds to facilitate oil extraction.

Oil Extraction

Mechanical extraction (Pressing)

- **Oil Expeller/Press:** Uses mechanical pressure to extract oil from seeds.
- **Screw Press:** A type of expeller that uses a screw to press oil from the seeds.
- **Hydraulic Press:** Uses hydraulic pressure to extract oil, suitable for smaller operations.

Solvent extraction

- **Solvent Extractor:** Uses a solvent (usually hexane) to dissolve the oil from the seeds.
- **Desolventizer-Toaster:** Removes the solvent from the extracted oil.
- **Solvent Recovery System:** Recovers and reuses the solvent for further extraction.

Oil refining

Degumming

- **Degumming tank:** Removes gums and other impurities from the crude oil.
- **Centrifuge:** Separates the gums from the oil.

Neutralisation

- **Neutralisation tank:** Adds alkaline to the oil to neutralise free fatty acids.
- **Centrifuge:** Separates the soap stock from the neutralised oil.

Bleaching

- **Bleacher:** Mixes the oil with bleaching clay to remove colour pigments.
- **Filter press:** Filters out the spent bleaching clay.

Deodorization

- **Deodorizer:** Uses steam distillation to remove odour-causing compounds.

Winterisation (Optional)

- **Winterising tank:** Cools the oil to precipitate out waxes.
- **Filter press:** Filters out the precipitated waxes.

Packaging

- **Filling machine:** Fills the refined oil into bottles or containers.
- **Capping machine:** Seals the containers.
- **Labelling machine:** Labels the containers with product information.

Key considerations

- **Capacity:** Choose equipment based on the production scale (small, medium, or large).
- **Seed type:** Equipment specifications might vary depending on the type of seeds (soybean, sunflower, canola, etc.).
- **Quality requirements:** Higher-quality oil might require more refined processing stages.
- **Energy efficiency:** Consider energy-efficient equipment to reduce operational costs.
- **Regulatory compliance:** Ensure equipment meets local safety and food production standards.

By selecting the right combination of equipment tailored to your production needs, you can efficiently produce high-quality vegetable oil.

Peroxide number

Peroxide number is the amount of active oxygen equivalents in 1kg of sample, given in mmol/kg units.

In oxidation processes, hydrogen peroxides are mainly produced as the initial oxidation products, and in parallel with them, small amounts of other peroxides. The peroxide value indicates the degree of oxidation of the sample and therefore, with some limitations, the extent to which the fat has been damaged. It should be noted that as the oxidation processes progress, the division of peroxides increases, and thus the peroxide value decreases. Quality fats and oils have a peroxide value of less than 6 mmol/kg (usually between 0 and 3 mmol/kg).

The maximum permissible peroxide value in edible oils is defined in the *Codex Alimentarius* section named vegetable oils:

- Refined oils up to 10 mEq of active oxygen/kg of oil
- Cold-pressed and virgin oils up to 15 mEq of active oxygen/kg of oil

Fat stability tests

Active oxygen method (AOM) - the fat is heated and filtered air is supplied until the peroxide rises to a certain value, which indicates the onset of rancidity. The peroxide number at which rancidity begins to form is different for each type of fat and is determined organoleptically. For example, for pig fat - 20 mEq/ kg, for vegetable oils - 100 mEq/kg.

Acid number

The acid number is the mass mg of potassium hydroxide required to neutralise the free fatty acids in 1 gram of fat (or fatty acids). It describes the amount of free acids in fats and fatty acids.

Vegetable oils always contain free fatty acids. Their quantity depends on the quality of the seeds, the type of oil extraction and the conditions of seed storage. Oils obtained from unripe, poorly dried seeds have a high acid number.

The Codex Alimentarius specifies the following acid numbers for edible oils:

Refined oil	0.6mg KOH/g oil
Cold pressed and virgin oils	4.0 mg KOH/g oil

The acid number of raw, unrefined fats can reach 10, while it is usually <0.2 for refined fats**.**

Laboratory work

Vegetable oil analysis

Materials

Vegetable oils of different quality, type and/or age.

Methods

1. Determination of the peroxide number

Weigh 3 g of oil into a 200 mL flask, dissolve in 30 mL of solvent (chloroform:acetic acid = 3:2), add 0.5 mL of saturated potassium iodide solution, close the flask and shake for 1 minute. Then add 30 mL of distilled water, 0.5 mL of starch solution, titrate with 0.01 M sodium thiosulfate solution ($Na_2S_2O_3$).

$$P_S=(V\times C\times/m_p)\times 1000$$

V – volume of sodium thiosulfate, mL
C - sodium thiosulfate concentration, mol/l
m_p - sample weight, g

2. Determination of the acid number

Weigh 5 g of oil into a 200 mL flask, dissolve in 50 mL of solvent (diethyl ether:ethanol = 1:1), add a few drops of 1% phenolphthalein and titrate with KOH until a stable red colouration.

$$S_S=VKOH\times CKOH\times 56.1/mp$$

V_{KOH} - volume of KOH, mL
C_{KOH} - KOH concentration, mol/l
56.1 – KOH molar mass
mp – sample weight, g

Results

Create a table to combine the obtained data on the analysed samples and fill it out.

Conclusion

Provide an overview on the obtained results. Write possible explanations for the detected differences.

Approved by _____

Name, surname, signature

Date _____

Theme 14

Fruit berry and vegetable drying

Theoretical materials

Drying is one of the oldest ways of preserving products - it is the amount of water reduction in the product to the extent that the activity of microorganisms ceases. Dried fruit and vegetables are used both as food additives and as ingredients in preparation of various dessert products. The main advantages of dried products are:

- reduced product mass, less consumption of packaging materials, containers and warehouses area, transportation costs;
- very simple storage conditions are required.

Production technology of dried fruit and vegetables

The production of dried fruit and vegetables begins with washing the raw materials.

Inspection, grading and calibration. Inspection of production, selection of unusable raw materials, also cutting out damaged parts. During the inspection, sorting and calibration by quality is also carried out, degrees of ripeness, colour, shape, size, as well as varieties.

The skin of fruit and rhizomes is separated using mechanical, thermal or chemical treatments techniques.

To prevent fruit and vegetables from turning brown after cleaning, sulphitation is performed by immersing them in sulphur dioxide. A 0.1-0.4% sodium bisulfite solution is used in the sulfation of vegetables and potatoes. Most sulphur dioxide evaporates during drying.

Repeat cleaning. After sulphitation, repeated cleaning of the raw materials is carried out, during which the imperfections (dark spots and other unpleasant looking damages) are cut out, or those pieces are removed.

Cutting. To increase the surface area for evaporation, and speed up blanching and drying, vegetables and fruit are cut into cubes, straws, circles or rings 3-7 mm thick.

Blanching. Blanching inactivates enzymes, stabilises the colour of the product, and makes the product tissues softer. Raw materials are blanched with hot water or steam.

Drying off. Drying off is done in order to get rid of the excess amount of water resulting from blanching.

Drying. Drying modes depend on both the type of fruit or vegetable to be dried and the drying method selected.

Fruit and vegetable drying technologies

Today, drying in the sun, solar drying, osmotic-air drying, convection drying (in ovens of tunnel type, shelf type, etc.), microwave drying, vacuum drying, infrared technology, drying in a high-frequency current field and freeze-drying are used.

Table 14.1

Summary of drying methods used for fruit and vegetable drying

Drying Method	Advantages	Limitations	Applications	Required Conditions
Drying in the sun	Low cost, simple	Weather-dependent, risk of contamination	Fruit, vegetables, grains	Hot, dry, sunny weather; clean drying surfaces
Solar drying	More controlled, efficient	Higher initial setup cost, sunlight dependent	Fruit, vegetables, fish	Sunny weather; solar dryer with transparent covers and good ventilation
Osmotic-air drying	Preserves quality, reduces drying time	Additional processing step, solution disposal	Fruit, vegetables	Osmotic solution (sugar/salt); controlled temperature and humidity for air drying
Convection drying (tunnel/shelf)	Uniform drying, controlled environment	High energy consumption, equipment cost	Fruit, vegetables, meats, fish	Controlled temperature (50-90 °C); air circulation
Microwave drying	Rapid drying, preserves nutrients	High cost, risk of uneven drying	Fruit, vegetables, herbs	Microwave oven; precise control of time and power settings
Vacuum drying	Low temperature, fast drying	Expensive, complex operation	Pharmaceuticals, high-value fruit, vegetables	Vacuum chamber; controlled low temperature (20-50 °C) and pressure
Infrared drying	Efficient, short drying times	Surface heating issues	Fruit, vegetables, meat	Infrared heaters; controlled distance and exposure time
High-frequency current field drying	Rapid, uniform, quality preservation	High cost, complex technology	High-value, sensitive products	High-frequency electromagnetic field equipment; controlled field intensity and exposure time
Freeze-drying	Best preserves quality, long shelf life	Very high cost, energy-intensive	Coffee, high-value fruits, vegetables, pharmaceuticals	Freeze at -40 °C or below; vacuum chamber for sublimation; controlled slow heating

Laboratory work

Apple drying using different technologies

Materials

Apples.

Laboratory equipment: convective dryer; microwave-vacuum dryer; freeze dryer.

Methods

Task 1 Different ways of processing apples before drying

1) Wash, peel, cut into slices, soak in 1% citric acid solution. Then drain, and dry.
2) Wash, peel, cut into slices, soak in 1% citric acid solution, and blanch in water at 80-85 °C for 3-5 minutes. Then drain, and dry.
3) Wash, peel, cut into slices, soak in 1% citric acid solution, and blanch in 40% sugar syrup at 80-85 °C for 3-5 minutes. Then drain, and dry.
4) Wash, peel, cut into slices, dip in quince or plum syrup (with soluble solids content of at least 65% Brix), heat to 69 °C, leave for 15 minutes and let the fruit cool in the syrup.

Task 2 Drying apples in different dryers

1) Drain the apple slices carefully in a sieve and place them on trays lined with paper towels.
2) Everything is divided into 5 parts.
3) Dry:

- in a convective dryer at 40 °C ;
- in a convective dryer at 60 °C ;
- in a convective dryer at 80 °C ;
- microwave-vacuum dryer;
- freeze dryer.

Approved by _____

Name, surname, signature

Date _____

Laboratory work

Quality evaluation of dried apples

Materials

Previously dried apples.

Methods

1) Fragility analysis of dried fruits with a structure analyser

The samples to be analysed are placed on the structure analyser tray (figure 1). The measurements are performed by pressing the surface of a special tip on the sample and measuring the force (N) with which the sample can be broken at a pressing speed of 1 mm s^{-1}.

The result is the maximum force (N) required to break the sample in question.

The more fragile the dried products, the lower the measurement results will be, while hard, unbreakable vegetables will have the highest results.

2) Determination of moisture content of dried products

Drying the sample to constant weight is the most commonly used method for moisture determination in dried products. The determination of moisture in dried fruits is carried out at a temperature of 105 °C for 3 hours.

Chop the dried fruit into small pieces with a knife. Weigh the weighing cup on the balance and weigh approximately 2 g (to the nearest 3 decimal places) of the sample into it. The weighing cups with the samples are placed in an oven at 105 °C for 3 hours. After drying, the measuring cups are removed from the drying oven with tongs, put on a cap and placed in a desiccator to cool. Weigh the cooled, closed measuring cups. Calculate the moisture content of the sample according to the formula:

$$\frac{(M-x)-(m-x)}{(M-x)} \times 100 = \frac{M-m}{M-x} \times 100$$

where M – mass of the initial sample + container;
x- mass of the vial;

3) Colour analysis (in the L*a*b* system) of dried fruits

Colour is one of the most important criteria for the external appearance of the product. If the product oxidises very quickly, the colour may be unattractive, brownish or greyish, so it is important to evaluate and compare the colour.

To determine the colour of the product in the coordinate system, solid products are placed on a table on white paper and analysed with a colour analyser in the L*a*b* system. The L*a*b* system uses three perpendicular axes, on which a negative a* value represents the intensity

of the green colour, a positive a* value represents the intensity of the red colour, a negative b* value means an increase in the blue colour intensity, a positive b* value represents the intensity of the yellow colour, but L* is a characteristic of white (L=100) – black (L=0) or light-dark intensity.

4) Product rehydration ability

All dried apples (20 g) are soaked in a glass of water (100 mL), left for 30 minutes, the excess water is drained on a sieve, weighed and calculated how much water each product absorbed.

Results

Please arrange the obtained data in table 14.2

Table 14.2

Product	Colour L*	Colour a*	Colour b*	Fragility, N	Moisture, %	Rehydration ability
K 40						
K 60						
K 80						
MV						
FD						

Conclusion

Provide an overview on the obtained results. Write possible explanations for the detected differences.

Approved by _____

Name, surname, signature

Date _____

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OFINU

Open Food Innovation University (OFINU)

Study module

“Cereal technology”

WORKBOOK

for students

2024

Summary

The workbook is elaborated within the project “Open Food Innovation University" (OFINU), being in implementation with support of the European Union Erasmus+ Programme.

Overall objective of the project - to modernise food innovation and technology related higher education in Uzbekistan and Tajikistan, thereby increasing the quality and ensuring relevance of the higher education to the needs of the socio-economic growth of the countries concerned and especially of their regions.

Full partners:

- Lead partner: Latvia University of Life Sciences and Technologies
- Uzbekistan: Samarkand Agro-innovations and Research University, Andijan Institute of Agriculture and Agro-technologies
- Tajikistan: Technological University of Tajikistan, Kulob Institute of Technology and Innovation Management, Isfara Branch of the Technological University of Tajikistan
- Slovakia: Slovak University of Agriculture in Nitra

Associated partners in Uzbekistan:

- A group of companies "AGROMIR"
- "Navigul" MCHJ QK
- “Samarqand don mahsulotlari” JC (Samarkand grain products)

Associated partners in Tajikistan:

- CJSC “Combinati Shiri Dushanbe”
- LTD "Orion Rustam"
- Association of Entrepreneurs of Khatlon

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Partner universities and their academic staff, involved in the development of the study course:

P1 LBTU. Latvia University of Life Sciences and Technologies

Dace Klava, Dr. sc. ing. - dace.klava@lbtu.lv

Tatjana Ķince, Dr. sc. ing. - tatjana.kincwee@lbtu.lv

Evita Straumite, Dr. sc. ing. Assoc. Professor - evita.straumite@lbtu.lv

Sandra Muizniece-Brasava, Dr. sc. ing. - sandra.muizniece@lbtu.lv

Egita Sproge, Mg. oec. - egita.sproge.egita@gmail.com

P2 SAMARU. Samarkand Agroinnovations and Research University

RahmatilloTashmanov, Dr. PhD tashmanovraxmatillo@gmail.com

Temurbek Mikhliev, Msc - mixliyevt@gmail.com

Yigitali Tashpulatov, Dr. PhD - t.yigitali1981@gmail.com

Babur Eshonkulov, Dr. PhD - b.eshonqulov0201@gmail.com

Kamoliddin Bozorov, Dr. PhD - k.bozorov84@gmail.com

P3 AIAA. Andijan Institute of Agriculture and Agro-technologies

Murodjon Atajanov, Dr. PhD - atajanov.aqxai@gmail.com

Muhammad Zahiriddin Zaynobiddinov, Dr. PhD - mr.zaynobiddinov@gmail.com

Oybek Egamberdiev, Dr. PhD - egamberdiyevoybek60@gmail.com

P4 TUT. Technological University of Tajikistan

Mavzuna SHARIPOVA, Dr. PhD, Bread technologist - sharipovamavzuna123@gmail.com

P5 KITIM. Kulob Institute of Technology and Innovation Management

Iskandar HAKIMOV, PhD in Tech. Sc. - iskandarhakimov40@gmail.com

P6 BTUTI. Branch of the Technological University of Tajikistan in the city of Isfara

Zokirkhoja Soliev, Dr. PhD in agriculture - zokir13051975@gmail.com

P7 SUA. Slovak University of Agriculture in Nitra

Eva Ivanišová, Dr. Ing. PhD - eva.ivanisova@uniag.sk

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Theme of the study course

The study module “Cereal technology” includes the following topics: technological process and equipment, packaging material and equipment, raw materials and product quality evaluation, including sensory evaluation. Quality management assurance in grain processing. A lecturer with knowledge in the specific field is involved in the implementation of each section in order to achieve the goal of the study module.

Learning methods

In the implementation of the module, the teachers use the learner-centred approach. It empowers students to take charge of their own learning, leading to increased engagement and motivation. The use of digital tools for interactive learning has made classes more dynamic and accessible - students can access learning materials from anywhere, leading to increased flexibility and convenience. Interactive methods, such as seminars, methods for providing laboratory and practical work (individually, group work, discussions, re –training).

Course Schedule

Thematic Study Plan for module "Cereal Technology"

Date, Time	Study form	Theme	Lecturer
Theme 1 - Cereals, their characteristics, and quality			
1st day	Lecture (1h)	Introduction lecture about the study course.	LBTU Dr. sc. ing. D. Kļava
	Lecture (3h)	Grains and their characteristics.	LBTU Dr. sc. ing. D. Kļava
		Types of grains, chemical composition - carbohydrates, proteins, lipids, their properties, vitamins, minerals, pigments, water. Physical properties of grains. Developmental processes in grains.	LBTU Dr. sc. ing. D. Kļava
	Laboratory work (4h)	Analysis of grain mechanical and physical properties (thousand grain weight, bulk density, first class proportion, moisture content, hardness, trial milling).	Ing. Eva Ivanišová, PhD. (SUA Nitra, Slovakia)
2nd day	Lecture (2h)	Equipment for receiving and pre-treatment grain.	LBTU Dr. sc. ing. T. Ķince
	Laboratory work (4h)	Determination of grain quality parameters (0rganoleptic, TTA, pH, ash content, moisture).	LBTU Dr. sc. ing. D. Kļava
	Practical work (2h)	Equipment for receiving and pre-treatment grain.	LBTU Dr. sc. ing. T. Ķince
3rd day	Lecture (3h)	Quality management in the grain processing industry.	E. Sproģe
	Practical works (2h)	Quality management in the grain processing industry.	E. Sproģe
4th day	Excursion	Visit grain processing factory or grain production farm.	LBTU

			Dr. sc. ing. D. Kļava
Theme 2 - Grain processing: flour, groats, flakes			
5th day	Seminar (1h)	Grains and quality	LBTU Dr. sc. ing. D. Kļava
	Lecture (2h)	Flour production. Production of semolina, couscous, semolina and flakes.	LBTU Dr. sc. ing. D. Kļava
	Lecture (1h)	Equipment and lines for the production of flour, semolina, and flakes.	LBTU Dr. sc. ing. T. Ķince
6th day	Laboratory works (3h)	Flour and breakfast flake quality assessment.	LBTU Dr. sc. ing. T. Ķince
	Practical works (2h)	Packaging of flour and flakes and evaluation of the quality of flakes and muesli.	LBTU Dr. sc. ing. S. Muizniece - Brasava
7th day	Laboratory works (3h)	Flour quality analysis (determination of ash, protein, Zeleny index, acidity, falling number, quantity and quality of gluten, rheological properties).	Ing. Eva Ivanišová, PhD. (SUA Nitra, Slovakia)
	Lecture (2h)	Sensory evaluation of flour and flakes.	LBTU Dr. sc. ing. E. Straumite
	Laboratory works (2h)	Sensory evaluation of breakfast cereals, granola and muesli.	LBTU Dr. sc. ing. E. Straumite
Theme 3 Pasta production and quality evaluation			
8th day	Seminar (1h)	Seminar - flour production and quality	LBTU Dr. sc. ing. D. Kļava

	Lecture (2h)	Characteristics of pasta. Technological process of pasta production.	LBTU Dr. sc. ing. D. Kļava Ing. Eva Ivanišová, PhD. (SUA Nitra, Slovakia)
	Lecture (1h)	Pasta production equipment.	LBTU Dr. sc. ing. T. Ķince
9th day	Laboratory works (4h)	Pasta production in laboratory condition. Evaluation of pasta quality (cooking ability, water absorption, volume).	Ing. Eva Ivanišová, PhD. (SUA Nitra, Slovakia)
	Practical work (2h)	Packaging of pasta.	LBTU Dr. sc. ing. S. Muizniece - Brasava
10th day	Laboratory work (4h)	Sensory evaluation of pasta.	LBTU Dr. sc. ing. E. Straumite
11th day	Excursion	Visit to a pasta processing factory or mill.	
Theme 4 - The basics of bread making			
12th day	Seminar (1h)	Pasta in the word.	LBTU Dr.sc.ing. D.Kļava Ing. Eva Ivanišová, PhD. (SUA Nitra, Slovakia)
	Lecture (3h)	Characteristics of the bread industry and tendencies. Characteristics and quality requirements of raw materials used in bread baking. Sourdough role in bread preparation.	LBTU Dr. sc. ing. D. Kļava

	Lecture (2h)	Equipment for wheat bread making.	LBTU Dr. sc. ing. T. Ķince
	Lecture (2h)	Sensory evaluation of bread.	LBTU Dr. sc. ing. E. Straumite
13th day	Laboratory work (2h)	Quality evaluation of raw materials.	LBTU Dr. sc. ing. D. Kļava
	Laboratory work (1h)	Microbiology analyses of raw materials.	LBTU Dr. sc. ing. D. Kļava
	Laboratory l work (2h)	Sourdough preparation (I stage) of sourdough and quality evaluation.	LBTU Dr. sc. ing. D. Kļava
	Laboratory work (1h)	Microbiology analyses of sourdough (I stage).	LBTU Dr. sc. ing. D. Kļava
14th day	Laboratory work (2h)	Sourdough preparation (II stage) of sourdough and quality evaluation Microbiology analyses of sourdough (II stage).	LBTU Dr. sc. ing. D. Kļava
	Laboratory l work (2h)	Sourdough preparation (III stage) of sourdough and quality evaluation Microbiology analyses of sourdough (III stage).	LBTU Dr. sc. ing. D. Kļava
Theme 5 - Wheat bread technology			
15th day	Lecture (2h)	Wheat dough processing (dividing, rounding, pre-fermentation, shaping, baking).	LBTU Dr. sc. ing. D. Kļava
	Lecture (2h)	Equipment for wheat bread making.	LBTU Dr. sc. ing. T. Ķince

	Laboratory work (2h)	Microbiology analyses of raw materials – results. Microbiology analyses of sourdough I stage, microbiota identification of sourdough.	LBTU Dr. sc. ing. D. Kļava
	Laboratory work (2h)	Baking test of wheat bread with sourdough (kneading dough and fermentation time not less than 8 h).	LBTU Dr. sc. ing. D. Kļava
16th day	Laboratory work (2h)	Baking test of wheat bread with sourdough.	LBTU Dr. sc. ing. D. Kļava
	Lecture (2h)	Freeze technologies in wheat bread making.	LBTU Dr. sc. ing. D. Kļava
	Laboratory work (2h)	Microbiology analyses of sourdough II and III stage, microbiota identification of sourdough I stage results.	LBTU Dr. sc. ing. D. Kļava
17th day	Laboratory work (5h)	Wheat bread with yeast baking test and freezing processes.	LBTU Dr. sc. ing. D. Kļava
	Laboratory work (1h)	Microbiota identification of sourdough I stage results.	LBTU Dr. sc. ing. D. Kļava
	Practical work (2h)	Wheat bread packaging.	LBTU Dr. sc. ing. S. Muizniece - Brasava
18th day	Lecture (2h)	Sensory evaluation of different types of bread.	LBTU Dr. sc. ing. E. Straumite

	Laboratory work (2h)	Sensory evaluation of different types of bread.	LBTU Dr. sc. ing. E. Straumite
	Laboratory work (2h)	Evaluation of wheat bread quality.	LBTU Dr. sc. ing. D. Kļava
	Laboratory work (2h)	Evaluation of wheat bread microbiology quality.	LBTU Dr. sc. ing. D. Kļava
19th day	Excursion	Visit a bread bakery.	LBTU Dr. sc. ing. D. Kļava
Theme 6 - Wholegrain and traditional bread technology			
20th day	Seminar (1h)	Seminar - nutrition aspects of wheat bread.	LBTU Dr. sc. ing. D. Kļava
	Lecture (3h)	Ways of preparing rye (wholegrain) dough. Dividing, shaping, and fermentation of rye (wholegrain) dough. Baking rye (wholegrain) bread.	LBTU Dr. sc. ing. D. Kļava
	Lecture (3h)	Quality management in a bread bakery.	E. Sproģe
21th day	Laboratory work (8h)	Baking test of wholegrain bread with sourdough	LBTU Dr. sc. ing. D. Kļava
22th day	Practical work (2h)	Packaging and pasteurisation of rye (wholegrain) bread.	LBTU Dr. sc. ing. S. Muizniece - Brasava

	Laboratory work (2h)	Sensory evaluation of bread	LBTU Dr. sc. ing. E. Straumite
	Practical work (2h)	Presentation of analysis of bread faults and their reasons.	LBTU Dr. sc. ing. E. Straumite
	Laboratory work (2h)	Evaluation of rye bread microbiology quality.	LBTU Dr. sc. ing. D. Kļava
	Practical work (2h)	Quality management in a bread bakery.	LBTU E. Sproģe
Theme 7 - Flour confectionery and traditional confectionary			
23th day	Seminar (1h)	Seminar bread around the word	LBTU Dr. sc. ing. D. Kļava
	Lecture (4h)	Characteristics of raw materials used in flour confectionery. Types and differences of dough Fillings and their variety using in confectionery	LBTU Dr. sc. ing. D. Kļava
	Laboratory work (4h)	Creating new ideas for traditional desserts/cakes - new versions. Prepare innovative desserts/cakes.	LBTU Dr. sc. ing. D. Kļava

Theme 1

Cereals, their characteristics and quality

Theoretical materials

Cereals are one of the most commonly used plants in food production. Maize, rice and wheat are the world's top three food grains. Their nutritional value is determined by agrotechnical conditions, grain structure, processing technological processes. Figure 1.1. shows a general description of the structure and chemical composition of wheat grains, while table 1.1. shows the chemical composition of different cereals.

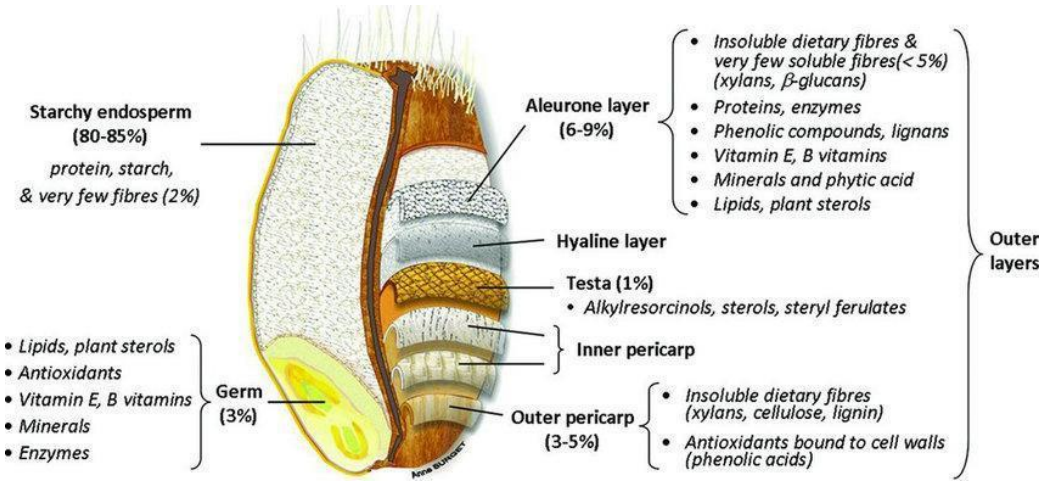


Fig. 1.1. Wheat grain structure. Adapted from Surget & Barron (2005) and Brouns et al. (2012) with permission.

Table 1.1.

Chemical composition of different grains, g/100g

Parameters	Wheat	Barley	Rye	Rice	Corn	Oat
Moisture	12.6	12.1	13.6	13.0	11.3	13.1
Carbohydrate	71	76	65	74	65	66
Protein	12	11	9	7.7	8.8	10.8
Lipids	1.8	1.2	1.7	2.2	3.8	7.2
Dietary fibre	12	15	13	2.2	9.8	12
Ash	1.7	1.2	1.9	1.2	1.3	2.9

Technological quality - the degree of raw material suitability for the utilisation (processing) purpose. Technological qualitative parameters of raw materials that are based on standards: ISO, ICC (each country has the same parameters, but different values). ISO - International Organisation for Standardisation. ICC – International Association for Cereal Science and Technology (publishers of international standard methods).

Technological (processing) quality includes the following quality parameters:

Sensory parameters:

Colour – uniform colour, according to type of grain used to obtain the flour. **Smell** – smell after heated sample in hand, must be typically pleasant, straw, no side smell (e.g. mould, chemical, etc.). etc.

The moisture content of a product is defined as the loss in weight under the conditions specified in the Standard, expressed as a percentage of the weight of the original sample. Standard value is **max. 14%.**

Hygienic condition of grain – good condition without pests, impurities (organic, inorganic) – max 2%.

Milling parameters characterise the structural and mechanical structure of the grain and its chemical composition. Evaluated parameters:

One thousand grain weight – weight of 1000 grains. The bigger and heavier grains give more endosperm= more flour.

First class proportion – is the weight of grains proportion retained by a sieve with a slot size of 2.5 mm. The amount of full, round grains.

Bulk density – is the weight of 1 litre (l) of grains in grams (g).

Vitreosity – depends on the arrangement of starch in the cells. More proteins in the cells give harder grains.

Hardness – hard endosperm, use more for semolina flour.

Trial milling – it is characterises flour extraction, colour of flour, ash matters in flour, power consumption and more.

Technological equipment for grain preparation - grain drying, grain cleaning, hydrothermal treatment and grain precipitation, grain cleaning, secondary hydrothermal treatment, weighing and magnetic control, grinding / storage.

The process of reducing the grain's moisture content can take place using various methods, such as hot air drying or ventilation. Grain can only be stored safely if the moisture content is 14% or less. The moisture content of harvested grain in Latvia is approximately 18-20%, so drying and cleaning should be done as soon as possible. If wet or insoluble grains are stored, a self-heating process can occur, resulting in a decrease in grain quality and nutritional value, as well as an increase in the activity of microscopic fungi.

The grain dryer is intended for drying pre-cleaned materials: seeds or grains, cereals, legumes and oilseeds with an initial moisture content of up to 35%. The grain dryers can be installed

separately or as part of a grain cleaning and drying complex in grain farms, flour mills, grain receiving companies, alcohol plants, poultry plants and feed mills.

Main types of dryers - shaft type (grain drying is carried out in vertical shafts on boxes, with the heat carrier flowing through), tower type (the grain is pushed between two metallic plates through which hot air is blown), cylinder type (rotary) (the grains are mixed and transported with the help of special paddles), carousel type (the grain is treated with warm air), conveyor type (grain is heated and moved on conveyor belts), modular type (the grains are distributed in a vertical column between metal plates through which the heat carrier is directed), mobile grain dryers.

Grain treatment - separation of impurities, grain surface washing, grain conditioning, preparation of batches of grain for grinding.

Grain separators - intended for cleaning grain from various impurities.

Stone separation plant - in the flour industry, vibro-pneumatic stone separation equipment is more often used. The main operating mechanism of the equipment is a vibrating air-permeable threshing box, where, thanks to the inclination of the equipment and the air flow, the flow of the grain is ensured, as well as the fractionation of the grain by mass.

Magnetic separator - a magnetic separator is used for additional grain purification. Metal impurities are separated from the grain with a static magnet or, less often, with the help of an electromagnet.

Dehusking plant - dehusking equipment is designed to separate the husks from the grain. According to the design, they can have a steel surface (the effect on the grain is very gentle), with an abrasive surface (intensive grain cleaning) and equipment with a metal mesh (medium effect on the grain).

Grain storage equipment - grain warehouses, grain elevators (procurement, mill, ports, reserves), assembly of silos. A ventilation system in silos is necessary during long-term grain storage to ensure grain drying, cooling and heating.

Laboratory work
Analysis of grain mechanical and physical properties

The aim of the laboratory work is to strengthen the theoretical knowledge of the methods of determining grain quality parameters and the importance of quality indicators in the storage and processing process. During the laboratory work, the basic parameters of grain quality will be analysed - moisture, thousand grain weight, bulk density, first class proportion, moisture content, hardness).

Materials and procedures

Wheat, rye, barley, oat varieties, laboratory scales, hygroscope, hectolitre scale, round sieves, calculator of seeds, beakers, watch glass.

1. Moisture content determination

The moisture content of the grains is determined by drying. Determination of grain moisture can be done using the express method or the standard method. The moisture content is calculated from the difference in weight before and after drying. Grains are classified according to their moisture content (Table 1.2.).

Table 1.2.

Moisture content, %

Dry grains	Moderately dry grains	Wet grains	Very wet grains
< 14	14.0 - 15.5	15.5 – 17	> 17

Express method. Pour wheat grains into the hygroscope until you reach the line. A hygroscope will measure the% of actual grain moisture (GM). Using the value and formula to calculate dry matter content (DM).

DM i(%) = 100 – GM (%)

Standard method (AACC 44-19). Weigh 20 g of grain, grind in a grinder. Wheat, rye, rice, buckwheat grind for 30 s, but barley and oats - 60 s.
Dry 2 aluminium dishes of about 55mm, not more than 40mm deep, in an oven at 105 °C for 1 hour, then cool in a desiccator for 10 to 15 minutes and extract to the nearest 0,01 g. Weigh 2 ± 0,05 g of the ground grain into the heated and weighed aluminium dishes. With lids removed. Place the dishes and lids in the oven as quickly as possible and dry the samples for 2 hours at 135 °C. Place lids on dishes and transfer to the desiccator to cool.

Weigh and calculate the loss in weight as moisture.
Grain moisture is calculated:

$$X\ \ moisture\ content, \% = \frac{Loss\ of\ moisture, g\ \times\ 100}{Weight\ of\ sample, g}$$

Summarise the obtained results in Table 1.4.

2. Bulk density determination

Bulk density is the mass of 1 litre of grain, g/l (Table 1.3.). It is determined using special scales - slings. The method of determination is based on the assumption that dry, well-ripened grains with a high endosperm content and a thin skin have a high bulk density and thus a higher flour yield. The results of bulk density measurements are influenced by moisture, grain chemical composition, shape, impurities. Light impurities (leaves, weed seeds, etc.) reduce the bulk density of grains, while impurities of mineral nature (sand, stones, etc.) increase the bulk density. For cereals, the bulk density is determined to calculate the storage capacity, or the number of vehicles required.

Table 1.3.

Bulk density of grain, g/l

Culture	Bulk density			Culture	Bulk density		
	min	common	max		min	common	max
Wheat	700	730-785	810	Barley	530	570-650	680
Rye	650	680-715	735	Oats	440	460-550	590

Procedure. Place wheat grains into hectoliter scales and measure the bulk density and summarise in Table 1.4. Please see video https://youtu.be/PWLS5IO5WJs?si=iGmIXKA-BRTGV12f.

3. Proportion of I. class of grains

The quality of grain is characterised by its purity. When determining purity, various impurities are distinguished from the grain. A distinction is made between granular and gritty, granular or other grains or damage grains and pests impurities.

The group of cereal impurities includes the green, immature grains of the main crop and damaged grains, provided that at least 50% of the endosperm is preserved.

This group of impurities also includes grains of other crops specified in the standards, for example, oats, wheat, and rye grains may be mixed with barley.

Grainy impurities can be live (pests, weed seeds, microorganisms, as well as seeds of other crops that are not included in the standards as grain impurities). Dead debris can be mineral (sand, stones, soil particles, etc.) or organic (stalks, weeds, leaf parts, etc.). Debris-like impurities can also be poisonous (poisonous weed seeds, mould-damaged grains, etc.). Gritty impurities make it difficult to store grain, as they are usually wetter, spoil faster and also cause grain damage.

Procedure

Sift 50 grams of grain through a sieve with movements of 110 to 120 sieves per minute for 3 minutes. A sieve with 1.0x1.0 mm mesh is used for rye and wheat, and 1.5x1.5 mm mesh for oats and barley. After sifting, the grain is spread on a glass plate and divided into 3 fractions with

tweezers - greasy impurities, main crops and other cereals. The fractions are weighed and expressed as a percentage (separately for each fraction).

The amount of impurities is calculated:

$$X = m_0 - m_1$$

X – amount of impurities, %

m_1 – mass of impurities, g

m_0 – mass of the test sample, g

4. Thousand grain weight determination (TGW)

The absolute mass of the grain is the mass of 1000 grains in dry matter. The absolute mass of the grain is an indicator of quality and a physical property. Grains with a higher absolute weight contain more endosperm. More flour and groats are obtained from grains with a higher absolute weight. For the production of malt, it is recommended to use beer barley with a weight of more than 44 grams per 1000 grains. The absolute weight of the grain depends on the grain size, chemical composition, moisture and other conditions.

Procedure

Enter proportion of grains of I. class into the calculator. Start the procedure and the calculator will automatically count 1000 grains. Weigh the grains and calculate.

If you do not have the equipment you can count by hand.

50 g of clean grains (without impurities) are spread in a square layer of equal thickness, which is divided into four parts in diagonals - triangles. From each two opposite triangles deduct (without sampling) 500 grains (250 grains each). Both deductions (2x500) are weighed separately. Weigh to the nearest 0.01 g on an analytical scale. The difference between the two weights must not exceed 5% of the average weight. If the difference is greater, the weighing must be repeated. Convert 1000 g mass to absolute mass using the formula:

$$g = \frac{(100 - N)}{100} \cdot G$$

where,

g - absolute mass of grains, g

G - mass of 1000 grains with actual moisture, g

N - grain moisture, %

Obtained results summarize in Table 1.4.

5. Trial milling

Procedure

100 g of wheat grains milling by using a laboratory mill M3 (Figure 1.2.). This mill gives four milling fractions:

I. fraction (flour I – endosperm, size of fragment <155 μm);

II. fraction (flour II. – endosperm, size of fragment <195 μm),

III. fraction (fine bran, size of fragment 195 – 265 μm),

IV. fraction (coarse bran, size of fragment > 530 µm).

Yield of milling products, calculated using formulas:

Y, % = I. fraction (g) + II. fraction (g) + III. fraction (g) + IV. fraction (g)

Yield of eating milling products, % = I. fraction (g) + II. fraction (g) + III. fraction (g)

Evaluate of eating milling products:

> 73% very good,

73 – 69% good,

69 – 66% above average,

66 – 63% average,

63 – 60% below average,

< 60% low.

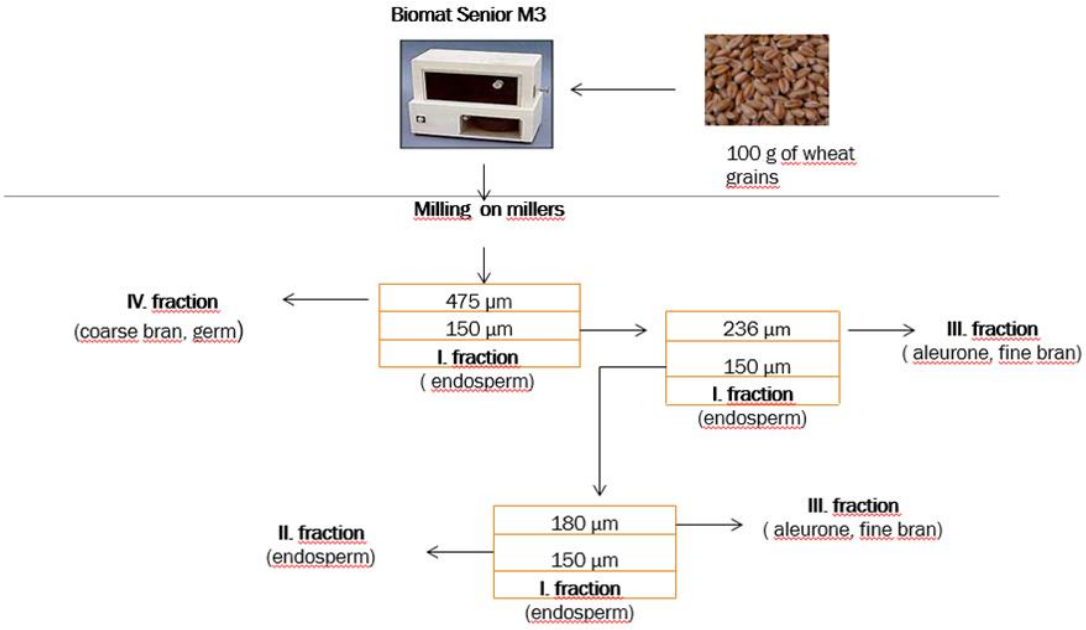


Fig. 1.2. Laboratory Mill M3 and flour fractions.

6. Determination of grain glassiness

The endosperm of the grain may be vitreous and floury. In vitreous grains, proteins stick together the grains of starch and form a mass that is partially textured. If microscopic air spaces remain

between the starch grains, light diffusion occurs (light does not pass through) and the grain is floury.

Procedure

The vitreous aspect of the grains is determined with a grainscope (Figure 1.3.). Place the wheat grains in the metal grid of the grainscope/diaphanoscope to fill all the cavities. First examine the first row of grains through the eyepiece of the grainscope /diaphanoscope, counting the vitreous, semi-vitreous and floury grains. Count the grains in the other rows in the same way. The results are summarised in Table 1.5.

Fig. 1.3. Laboratory grainscope OLISLAB 5100 .
https://olis.com.ua/en/osnashenie/visual-optic-en/diaphanoscope-dsz-3/

Please find video https://youtu.be/qBHHTLRslDk on how to perform the analysis.

7. Sprouting and germination of cereals

Sprouting and germination are the course of grain life. Sprouting is the number of grains sprouted in 3 days (%). Germination is the number of germinated grains in 5 days (%).

A high sprouting rate (close to 100%) indicates that the grains have been prepared correctly for processing. Such grains germinate quickly and evenly.

Sprouting is an indicator of quality in malt production. The sprouting capacity of beer barley must not be less than 95%. It may be reduced if barley drying and storage regimes are not followed. Non-sprouting grains reduce the quality of green malt as well as finished malt.

Procedure

Subtract 2 x 100 grains from the sample and place (each grain must be separately) in specially prepared filter paper containers. Place a filter paper on the Petri dish on which the grains will be arranged. Apply water to the filter paper, preferably so that the entire filter paper is moist but not soaking wet. The filter paper absorbs water, but the grains placed on it slowly swell and begin to sprout. Sprouting takes place at 16-17 °C. After 3 days, the sprouted grains are counted and sprouting is calculated, and the germination is calculated after 5 days. Obtained data summarised in Table 1.3.

Results

Table 1.3.

Results of grain quality parameters

Variety	MC [%]	BD [g/L]	TGW [%]
Standard	Max. 14%	Min. 780 g/L	Min. 30%

Table 1.4.

Results of glassiness

Method of determination	Glassiness group	Number of grains, pcs.	Number of grains, %	Total glassiness, %
With grainscope /diaphanoscope	glassy			
	semi - glassy			
	flour			

The total glass content (%) is calculated by:

S - number of vitreous grains, pcs

Ps - number of semi-vitreous grains, pcs

Table 1.5.

Results of Germination

Variety	Germination test	Repetitions 1 and 2		Avg., %
	Amount of grains sprouted in 3 days			
	Sprouting			
	Amount of germinated grains after 5 days			
	Germination			

Calculate the addition or deduction of grain mass and summaries previous results in Grain quality Protocol (Table 1.6.).

The reference mass is calculated, taking into account the grain moisture and the compliance of the amount of impurities with the norms set by the condition.

If these indicators differ from the norms, the paid physical, accounting mass of the grain is increased or decreased.

For each percentage of moisture and impurities, that is lower than the specified condition, 1% is added to the mass of the invoice. For each percentage, that is higher than the specified condition, it is deducted from the mass.

If the quality of the grain, assessed by volume, amount of gluten, grain impurities, the presence of pests, is higher or lower, the grain payment is increased or decreased accordingly:

- for every 10 g of volumetric weight above the norms set for base conditions, 0.1% surcharge;
- for every 10 g of volumetric weight under base conditions, 0.1% is deducted;
- for every 1% of granular impurity above the indicators set in the norms, 0.1% is deducted;
- if there are mites in the grain, 0.5% is deducted.

Table 1.6.

Grain quality protocol

Indicators	Wheat		Barley	
	Base conditions	Actual quality	Base conditions	Actual quality
Physical mass of accepted grains, kg	160 000		110 000	
Moisture, %	14		14	
Granular impurities, %	1		2	
Deviations from the base norms, %				
Natural addition (+) or deduction (-)				
Reference weight, kg				
Bulk Density, g/l bases actual	 750 782		 590 640	
Granular impurities, % Bases actual	2 3.6		2 2.2	
Pest infestation	ticks		ticks	
Purchase price, EUR/t	80.00		65.00	
The amount for the registration weight, EUR				
Actual payment, EUR				

Conclusions

Approved by _____

Name, surname, signature

Date _____

Laboratory work
Determination of grain quality parameters

Grain quality indicators such as acidity, pH, and ash content are important factors in the processing process. They can change under the influence of agrotechnical conditions, during storage, as well as under the influence of storage conditions. The aim of the laboratory work is to strengthen the theoretical knowledge of the methods of determining grain quality parameters and the importance of quality indicators in the storage and processing process.

Materials and Procedures

1. Evaluation of sensory properties of grain sample

Prepare an average sample of grains and evaluate their smell, colour, grain size and uniformity. Summarise the results in Table 1.7.

2. Titratable acidity (standard method AACC 02-31)

Dissolve and disperse 10 g of samples in 100 mL of water and mix thoroughly. Let stand for approximately 1hour. Stir gently and then pipette 17.6 mL into a porcelain casserole dish. Rinse out the same pipette with 17.6 mL of water and add this to the sample in the casserole dish.

Add 0.5 mL phenolphthalein indicator and titrate with standardized 0,1N NaOH until faint pink colour persists for 30 seconds.

$$X = 2 \times a$$

where, X - Titratable Acidity of grain, ml NaOH

a – amount of NaOH, ml

The results are summarised in Table 1.7.

3. pH acidity of grain

Dissolve and disperse 10 g of samples in 100 mL water and mix thoroughly. Use a pH indicator or pH meter and fix results in Table 1.7.

Results

Table 1.7.

Sensory properties and acidity of grain

Type of grains	Aroma	Colour	Size, shape of grains	Titratable acidity	pH

Conclusions

Approved by _____

Name, surname, signature

Date _____

Practical Work
Equipment for receiving and pre-treatment of grain

The aim of the practical work is to get opportunities for the development of cereal processing.

Materials and procedures

1. Using the lecture materials and available internet resources, please provide information on the following questions:

1. What are the main grain quality parameters that should be taken into account for the preparation of flour, bread, pasta, flakes and confectionery?
2. What equipment should be used to prepare grades for grinding?
3. Which equipment for grain processing is mandatory and which can be dispensed with?
4. Which grain chisel would you choose? Justify your answer.
5. What latest technological solutions for grain processing are you aware of?
6. What would you recommend for promoting the development of the segment of grain processing products?

2. Make a batch (calculate) of grain for grinding so that the glassiness of the grain is 60%. Batch preparation will use grains with a glassiness of 86% (a) (Group I) and 43% (b) (Group II). The weight of the grain lot must be 1000t (A). Summarise the results in Table 1.8.

Table 1.8.

Parameter	**Mixture components**		**The required mixture**
	Grain group I	**Grain group II**	
Vitreous, %			
Vitreous displacement from assigned creators, %			
Calculated ratio of components in the batch	**(B)**	**(C)**	**(D)**
Calculation of the mass of the first component	$m_1 = \frac{A \cdot B}{D}(t)¤$		
Calculation of the mass of the second component	$m_2 = \frac{A \cdot C}{D}(t)¤$		
Checking the correctness of the calculation	$x = \frac{m_1 \cdot a + m_2 \cdot b}{A}(\%)¤$		

Conclusions

Approved by _____

Name, surname, signature

Date _____

Practical work
Quality management in the grain processing industry

What is food safety?

Food safety is a scientific discipline describing handling, preparation, and storage of food in ways that prevent food borne illnesses. This includes a number of routines that should be followed to avoid potentially severe health hazards. In this way, food safety often overlaps with food defence to prevent harm to consumers.

As it is known since the 1960s in the EU, each enterprise that works in the food segment must have a food safety system that is based on 7 HACCP principles. Seven basic principles are used in the development of HACCP plans that meet the stated goal. These principles include hazard analysis, CCP identification, establishing critical limits, monitoring procedures, corrective actions, verification procedures, and record-keeping and documentation.

The Food Safety Plan - is not a stand-alone programme, but rather part of a larger food safety system. The foundational programmes that are part of the food safety system are frequently termed prerequisite programmes. The term was coined to indicate that they should be in place before HACCP based systems are implemented in order to effectively manage risk from foodborne hazards. Good Manufacturing Practice (GMP) regulations address requirements for many prerequisite programs. The conditions and practices the regulated food industry must follow for processing safe food under sanitary conditions, including personnel, plant and grounds, sanitary operations, sanitary facilities and controls, equipment and utensils, processes and controls, warehousing and distribution, and action levels in case of potentially unsafe products.

The process flow of a food safety plan (HACCP or Preventive Controls) is the centre of a food product's food safety story. It tells how a company makes its products and also what hazards and controls are associated with each step.

Monitoring records and logs must include the actual values or observations that document the actual implementation of a Food Safety Plan. For example, if a temperature is being measured, the actual temperature must be recorded rather than a check mark indicating that the temperature complied with the critical limit. To comply with regulations, information must be recorded at the time it is observed. Here are suggested record and log types to use:

Customer complaints, corrective action forms, employee training, food safety quarterly audit, food safety checklist, raw materials/receiving log, worker illness log, refrigerator log, assembly log, shipping temperature log.

Suggested Supply Chain Documents

The safety of your product depends on much more than just what you control within your own facility. The use of an ingredient that has a history of association with a specific hazard may require a supply chain programme as a control within your food safety programme. Companies

may have extensive supplier programmes that encompass much more than food safety elements to manage their supplier expectations and performance.

Here is a list of suggested documents to obtain from your supply chain:

Food safety HACCP or preventive controls plan for each product, food Defence/business continuity plan, validation of each product and/or process and ready-to-eat statements (if applicable), certificates of analysis (COA), third party audit certificate, report & corrective actions, product specification, allergen management, country of origin, potential hazards.

Biological hazards:

Microbiological contamination – during processing at source of origin – supplier management and HACCP in place and verified to eliminate and reduce potential presence of microbiological contamination.

Microbiological contamination for instance microbiological growth due to breakdown of refrigeration units.

Chemical hazards:

Chemical contamination by pesticides at source of origin – chemical/pesticide used at source is verified to be in conjunction with regulations.

Chemical contamination from machine oils or lubricants, as well as cleaning chemicals.

Microbiological / physical / chemical contamination from – cross contamination or taint of finished product due to poor hygiene.

Physical hazards

Physical contamination – external contamination from rainwater, bird droppings, vermin/rodents, and flying insects during unloading process.

Glass contamination – glass contamination from internal light sources. Pests/rodents and or flying insects due to poor hygiene/debris build up. Physical risks from straps/thermocouples/staples/foreign bodies found on pallets on intake.

Physical contamination – physical contamination from foreign bodies found within product and/or packaging from source of origin or during transportation.

Physical contamination – physical contamination from warehouse staff, pests/rodents, and/or flying insects due to poor hygiene/debris build up. Physical Contamination from personnel foreign body/dust contamination from production environment.

What are the 5 basic food safety requirements?

The core messages of the Five Keys to Safer Food are: (1) keep clean; (2) separate raw and cooked; (3) cook thoroughly; (4) keep food at safe temperatures; and (5) use safe water and raw materials.

Recall Plan

According to the Food Safety Modernisation Act, Preventive Controls for Human Food regulation requires the development of a written Recall Plan when a hazard analysis identifies a hazard requiring preventive control. Recalls are actions taken by an establishment to remove an adulterated, misbranded or violative product from the market. In other words, a product for which FDA or a state could take legal action against the company would be subject to recall.

Verification

Verification is an important component of supply chain, sanitation, allergen and critical controls. It confirms that the Food Safety Plan is operating as intended. Validation confirms the effectiveness of the Food Safety Plan in controlling food safety hazards. The purpose of verification is to provide a level of confidence that the Food Safety Plan is: 1) based on solid scientific principles that are adequate to control the hazards associated with the product and process, and 2) that the plan is being followed correctly every day of operation.

Table 1.9.

Risk assessment matrix

Likelihood	Severity
1 = Improbable event – once every five years	1 = Negligible – no impact or not detectable
2 = Remote possibility – once every year	2 = Marginal – only internal company target levels affected
3 = Occasional event – once per month	3 = Significant – Impact on critical limits
4 = Probable event – once per week	4 = Major – Impact on customers (may not be the public)
5 = Frequent event – once per day	5 = Critical – public health risk / public product recall

Likelihood	Severity				
	1	2	3	4	5
1	1	2	3	4	5
2	2	4	6	8	10
3	3	6	9	12	15
4	4	8	12	16	20
5	5	10	15	20	25

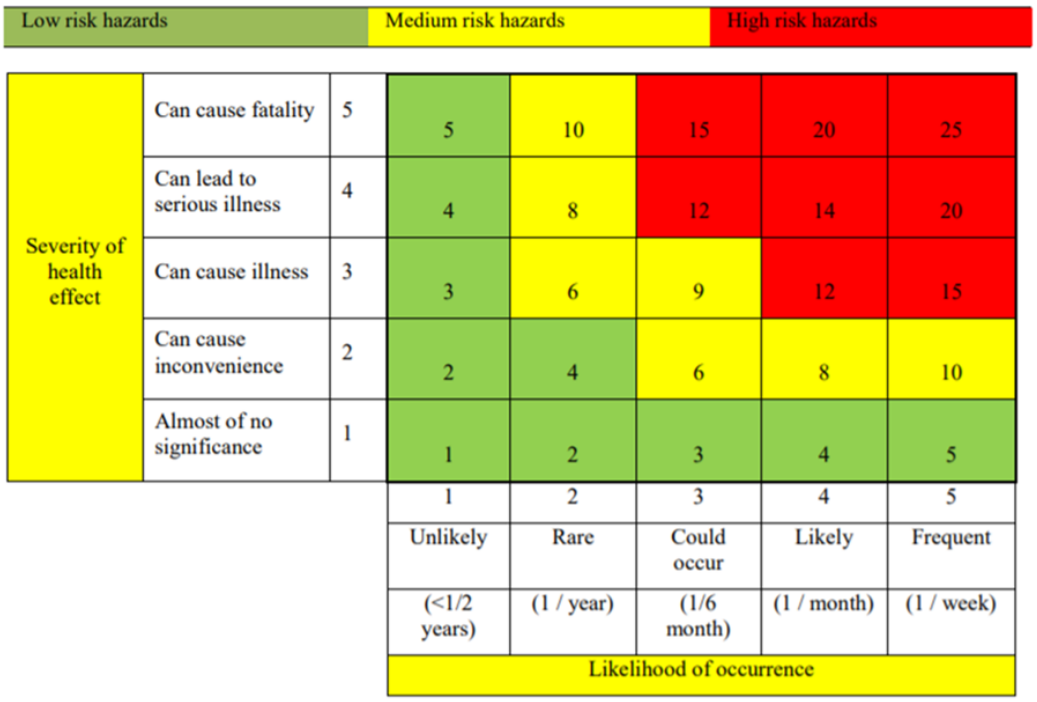


Fig. 1.4. Risk assessment matrix.

Example of a decision tree to identify critical control points (CCP)

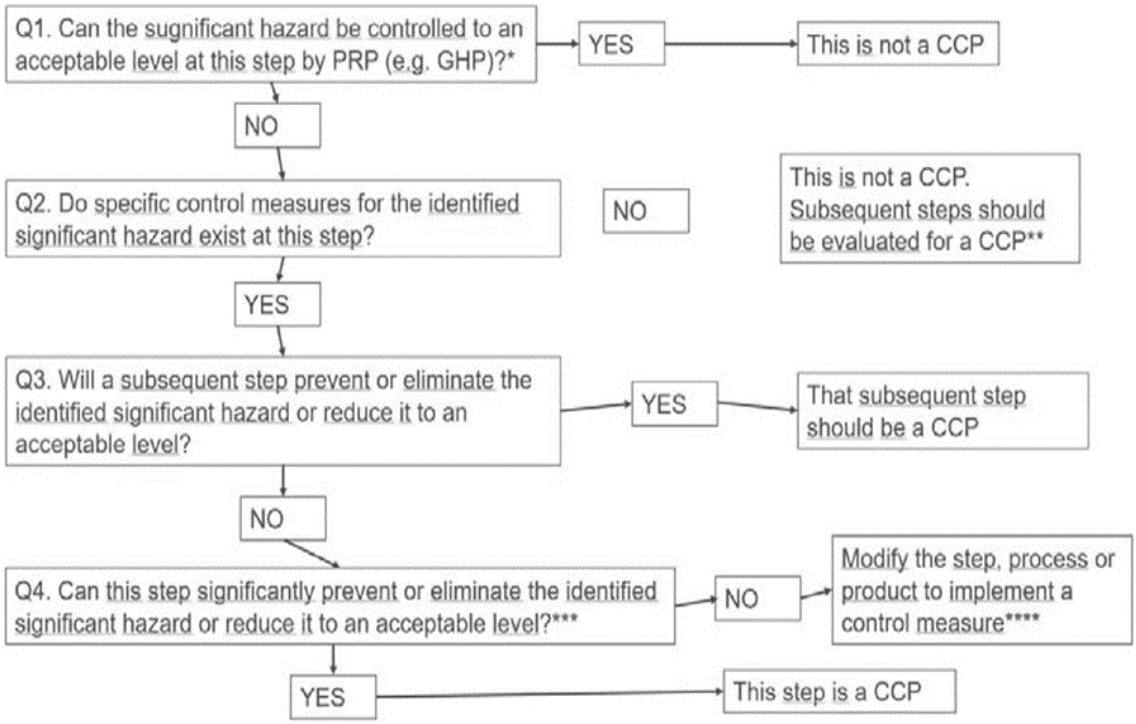


Fig. 1.5. Decision tree to identify CCP.

Materials and Procedures

Method - assessment of potential hazards in grain processing

1. For a selected processed grain product, develop a product description, develop and draw a diagram of the process steps.
2. Identify potential hazards:

- Biological:
    - pathogenic microorganisms;
- Chemical :
    - agricultural chemicals;
- Physical :
    - foreign objects atypical for the product.

3. Evaluate the danger of the identified hazards using a risk matrix 1 or 2 (Table 1.9 or Figure 1.4). Record the information in the hazard assessment Table 1.10.
4. Complete the CCP identification Table 1.11 and the HACCP plan (Table 1.12).
5. Write conclusions on determining CCP using a risk matrix (Table 1.9 or Figure 1.4) and a decision scheme.

Remember: Monitoring activities at a CCP. Some types of monitoring activities at a CCP may include:

- physical measurements:
    - time
    - weight
    - temperature
    - belt speed
- chemical measurements:
    - pH
    - water activity
    - % salt
- microbiological testing:
    - microbiological analysis of critical raw materials before their use in processing (for example, analytical results in dried milk used in chocolate products, or in starch used in canned foods)
    - microbiological analysis of critical finished products before their release to highly sensitive consumers (for example, infant formulas)

Note: You need to consider the time required to obtain results when deciding what monitoring activity should be used at a CCP. Rapid tests are preferable for monitoring procedures taking place on dynamic processing lines.

Results

Table 1.10.

Hazard assessment

Process stage	The identified hazard	Hazard assessment					Means of control
		Possibility	The severity of the consequences	Risk level	Assessment	CCP	

Table 1.11

CCP identification table

Process stage	Process stage	Cause of risk	Description of the cause of the risk	Control actions	Answers to Decision Scheme questions				CCP yes/no
No.					1	2	3	4	

Table 1.12

HACCP plan

In process	CCP/ CP	Risk	Measurable	Monitoring procedures				Records /document	Corrections
stage		the cause	critical limits of parameters	What?	How to?	How often?	What?		events

Conclusions

Approved by _____

Name, surname, signature

Date _____

Seminar Grains and Quality

Student teams research information and develop presentations for discussion on the following issues:

1**.** Which cereals and why will you use for gluten-free product development?

2. Which cereals are grown, processed and exported the most in the EU, Central Asia, USA or other regions or countries?

3. Are quinoa and amaranth grown in your country? What is valuable in these pseudo-cereals?

4. Describe what cereals and pseudo-cereals are grown in your country and what is their application in food processing.

5. What are the quality requirements of wheat grain?

6. How is the volumetric weight of grains and the absolute (1000) grain weight determined and what does it characterise?

7. What are the quality requirements of rye grain?

8. How is the amount of gluten and the quality of gluten determined and what does it characterise?

9. How is the fall number determined and what is it characterised by?

10. Protein extraction from legumes.

11. Resistant starch, its types and production.

12. Types of extrusion and characteristics of the obtained products.

13. Types of flour used in the production of extruded products.

Theme 2

Grain processing - flour, groats and flakes

Theoretical materials

Processing parameters - characterise colloid complex of grain: starch and proteins and activity of enzymes

Crude protein content – is the amount of all nitrogen substances multiplied by a factor of 5.7 (for wheat) and 6.62 (for barley).

Ash content –refers to the minerals and inorganic substances left after heating to 600 °C temperatures to remove moisture, volatiles, and all organic materials.

Gluten content – gluten is a plastic-elastic protein substance made of gliadin and glutenin (proteins) insoluble in water.

Gluten tensibility – ability to keep consistency by pulling.

Gluten swelling – ability to expand its volume in low acid medium.

Zeleny index – ability of all proteins of wheat flour to swell in a lactic acid solution during standard time.

Falling number – is defined as the time in seconds required to measure starch liquefaction (gel) due to alpha-amylase activity (enzymes) in flour.

Rheological (physical) properties of dough – physical properties measured by specialised equipment.

Flour acidity (titratable acidity) – number of acidic substances, which are determined by titration with sodium hydroxide solution.

Rheological properties of dough

Rheology

- a branch of physics that studies the deformation and flow of matter in response to applied stress or strain,
- the term rheology was coined by professor Eugene C. Bingham in 1920 - inspired by the aphorism of Greek philosophers, *panta rhei*, ”everything flows”.
- in cereal, an important rheology part – the dough,
- dough – the most unique system from the point of material science,
- it is viscoelastic system which exhibits shear-thinning and thixotropic behaviour (viscosity decrease with time),
- this behaviour is the consequence of dough complex structure in which starch granules (75 – 80 %) are surrounded by three-dimensional protein (20 – 25%) network,

Wheat proteins – consisted of gluten proteins (80 – 85% of total wheat proteins) which comprise of prolamins (in wheat - gliadins) and glutelins (in wheat - glutenins) and non-gluten proteins (15-20% of the total wheat proteins) such as albumins and globulins,

Gluten complex – viscoelastic protein responsible for dough structure formation,

Gliadin – protein fraction soluble in alcohol solution, single bonds, provides extensibility of dough - responsible for allergenicity.

Glutenin – protein fraction soluble in alkali solution (KOH, NaOH), more chains, molecules are linked by disulphide bonds, provides flexibility to dough.

Farinograph

- the most popular and accepted device for measuring dough physical properties is Brabender Farinograph,
- measures and records the mechanical resistance of the dough during mixing and kneading,
- physical properties of the dough are measured by placing a defined mass of flour in a tempered (30°C) mixing bowl equipped with two Z-type kneaders,
- depending on the available quantity of flour, tests can be performed in 300 g, 50 g and 10 g mixing bowls,
- In order to obtain the dough, the rheological properties of which are actually measured, water is added to the flour in amount to ensure the dough consistency of 500 FU (farinograph units).

Extensograph

- Brabender Extensograph is an internationally accepted standard method that is in compliance with ISO 5530-2, ICC 114/1, AACC 54-10,
- it is applicable for the measurement of physical properties of dough subjected to mechanical handling and resting,
- provides information about the resistance of dough to stretching and extensibility by measuring the force to pull a hook through a cylindrically shaped piece of dough,
- during the measurement, the resistance of dough to stretching and the distance the dough stretches before breaking is recorded in the form of a diagram extensograph.

Amylograph

The baking properties of flour depended on the gelatinisation of the starch and on the enzyme activity (α-amylase) in the flour. The Amylograph measures wheat, rye, maize, and rice flour and enables:

- assessment of the flour quality,
- suitability of the flour for various applications,
- measurement of the baking characteristics of flour,
- control of enzyme addition.

The Amylograph test measures the flour starch properties and enzyme activity, which results from sprout damage (alpha amylase enzyme activity).

Sprouting in wheat, as indicated by high enzyme activity, produces sticky dough that can cause problems during processing and results in products with poor colour and weak texture.

For Asian noodle products, flour of medium to high peak viscosity is preferred because it gives noodles better texture characteristics.

Preparation of grain for grinding - modern wheat, rye and c. mills can be both industrial, 5-6 floors high, and modular complexes. The modular mill comes complete with a frame and platforms. Takes up little space and is not that expensive.

Construction of a grain mill includes - preparation of grain for grinding, grain grinding, fractionation of the ground product into fractions (by particle size), breakdown of the ground

product by quality, separation of metallic impurities, air purification and transportation of the ground product, filling of the ground product into tanks, etc.

Mill types - roller (used for grinding rye, wheat, barley, beans, rapeseed, corn - the resulting product is homogeneous), hammer type, disc type mill, pneumatic hammer mill.

Technological equipment for the production of groats - technological lines.

The main technological equipment for the production of flakes - technological lines, aspiration column, grit separation plant, steamer, roller.

Laboratory work
Flour and breakfast flakes quality assessment

The aim of the work is to acquire skills in developing of flour and determining its quality, however to determine the quality parameters of commercially available breakfast cereals. The group of students is divided into teams and each team prepares different products.

Materials and Procedures

Wheat, Rye, Barley and Oat grains for processing. Commercial breakfast cereals.

1. Obtaining flour and quality assessment

1) Using the scales in the laboratory, _____ weigh the _____ grains.
2) Grind _____ grains using the _____ mill in the laboratory.
3) Determine flour yield as well as milling losses.
4) Determine the moisture content of the obtained flour using a moisture scale.
5) Using the water activity determination equipment in the laboratory, _____ should determine the water activity of the obtained flour.
6) Using the colour analyser in the laboratory _____ should determine the colour intensity of the obtained flour.
7) Using the flour sifter in the laboratory _____ the flour should be sifted and the percentage distribution of the existing fractions should be determined.
8) Calculate the amount of residual products that occur during flour sifting.
The results obtained in the experiments should be reflected in Table 2.1.

Table 2.1.

Quality of flour

The parameter to be analysed	Type of flour		
Grain mass, g			
Flour yield, %			
Flour milling losses, %			
Flour moisture, %			
Water activity of flour, units			
Flour colour, units L* a* b*			

Distribution of flour by fractions, g 160 µ 250 µ 315 µ 450 µ			
Residual products obtained during flour sifting, %			

2. Flakes quality assessment

1. Determination of water activity using the _____ water activity determination device.
2. Determination of moisture content using _____ moisture scales.
3. Determination of hardness and crispness using _____ structure analyser.
4. Determining the volumetric mass using the volumetric mass determination device _____.

The results obtained in the experiments should be reflected in Table 2.2.

Table 2.2.

Quality of flakes

No.	Parameter	Sample		
		1	2	3
1	Water activity, units			
2	Moisture, %			
3	Hardness, N			
4	Crispness, units			
5	Volumetric mass, g L			

Conclusions

Approved by _____

Name, surname, signature

Date _____

Practical work
Packaging of flour and flakes and evaluation of the quality

The aim of the work is to acquire skills in packaging of flour and flakes with different packaging equipment using various packaging materials. The group of students is divided into teams and each team packs products using different solutions.

Materials and Procedures

Products prepared in previous experiments or raw materials purchased at the discretion of the teacher.

The vertical flow-pack packaging equipment and the pulsed simple hermetically sealed equipment. Single-layer film packaging material on a roll with high moisture barrier properties and multi-layer packaging. Ready-made stand-up packages made of material with high moisture barrier properties and multi-layer packaging.
The results obtained in the experiments should be reflected in Table 2.3.

Table 2.3.

Summaries of experiments

Characteristic parameters	Samples		
	Product No. 1	Product No. 2	Product No. 3
Packaging material			
Packaging shape			
How well the sealing went			
What is the sealing temperature of the package?			
What is the sealing time (sec.) of the package?			

Conclusions

After packaging the products, different groups of students compare the results. If possible, each group packs 5 packages of each type, and then observes and determines the quality of the products during storage over the course of the study.

During the practical sessions, the students learnt the skills of working with packaging equipment.

Approved by _____

Name, surname, signature

Date _____

Laboratory work
Flour quality Analysis

Aim of laboratory work – analyse organoleptic properties of flour, crude protein content, ash content, Zeleny index, acidity, falling number, quantity and quality of gluten, rheological properties.

Materials and Procedures

1. Organoleptic evaluation of flour

Organoleptic properties is quality indicators that are determined for each type of flour.

The smell of fresh flour should be characteristic of flour. Since flour is hygroscopic, it easily attracts moisture and foreign smells. If the flour is stored in inappropriate conditions, for example at elevated temperature and room humidity, near odorous substances, the smell and also the taste can change. It can be rancid, bitter, sour, wormwood or with some other smell.

The taste of fresh flour is characteristic of flour and is designated as "normal". If a bitter, sweet, sour, mouldy, rancid or other aftertaste is felt, it indicates that the quality of the flour does not meet the requirements. Flour that is characterised by a foreign taste cannot be used in the preparation of dough, as it may remain during baking. When checking the taste of the flour, it is also determined whether there are any mineral impurities in the flour, which can be felt as a crunch between the teeth. In certain cases, control cakes can be baked and mineral impurities can be determined organoleptically in bread samples.

Procedure. Warm a small amount of flour (approx. 20 g) in your hands with warm breath and smell it. Pour 10-15 grams of flour into a clean beaker, pour hot - about 60 °C water over it, cover the beaker with a lid and leave for 2-3 minutes. After that, the water is drained and the smell of the flour is determined again. In the protocol, it is noted whether in this case the smell of flour is more pronounced, easier to feel and describe in Table 2.6.

The taste of flour and the presence of mineral impurities are determined by tasting it once or twice in 1 g. Obtained results should be described in Table 2.6.

2. Crude protein content

Flour samples from last Laboratory works, pipettes, 0.1 M solution of NaOH, lactic acid, bromophenol blue reagent, Zeleny cylinder, Zeleny mixer, thermostat, 2% solution of NaCl, beakers, Kjeldahl apparatus, muffle oven, watch glass, viscometer, farinograph, extensograph, amylograph, laboratory scales.

Mineralization

1. 1 g of sample with pure acid H_2SO_4 and catalyst, organic nitrogen converted to NH_3 and with acid H_2SO_4 forms $(NH_4)_2SO_4$.
2. Distillation – displacement of NH_3 from $(NH_4)_2SO_4$ by means of NaOH, and the displaced NH_3 is bound in a sample with a known amount of boric acid.
3. Titration – it is determined how much NH_3 reacted in the sample with boric acid, sample is titrated with 0.05 M H_2SO_4 with Tashir indicator from green to purple colour.

4. Calculation

Step 1

$$Crude\ protein, \% = \frac{1.4007\ \times\ 0.05 \times (a - b) \times 2}{w}$$

where,
a – amount of H_2SO_4 in mL for sample titration
b – amount of H_2SO_4 in mL for blank titration
w – weight of sample, g

Step 2

$$Crude\ protein, \% =\ result\ from\ step\ 1\ \times 5.7$$

5.7 (factor for wheat)

Step 3

$$Crude\ protein. \% = \frac{Result\ from\ step\ 2\ \times\ 100}{DM}$$

Where, DM – dry matter

5. Results are recorded in Table 2.6.

3. Ash content

Weigh 3 g of the sample into a special porcelain cup.

The door of the muffle oven is opened until the material starts to burn, then it is closed until it is completely decomposed, cooled to a room temperature and immediately weighed to the nearest 0.001 g.

Calculation.

$$Ash, \% = \frac{W1\ x\ 100}{W0} \times \frac{100}{100 - MC}$$

where, W0 – weight of the sample in g,
W1 – weight of the residue in g,
MC – moisture content, % of the flour sample.

Results should be recorded in Table 2.6.

4. Zeleny index

Ability of all proteins in wheat flour to swell in lactic acid solution during standard time. Higher gluten content of wheat and better gluten quality give rise to higher sedimentation test values. Zeleny sedimentation test assessing the quality of wheat as a means of predicting the baking strength of the flour, which can be made from it.

Procedure

weigh 3.2 g of flour onto cellophane paper and pour into the Zeleny cylinder. Add 50 mL of solution bromophenol blue and leave for 5 minutes. Then shake and add 25 mL of lactic acid solution and leave for 5 minutes and then shake. At the end, it is left for 5 minutes. The sediment and the height of the formed sediment are read. Obtained results should be summarised in Table 2.6.

5. Flour titratable acidity

Titratable acidity amount of solution NaOH (mmol) necessary to neutralise the acidic substances in 1 kg of flour. Titratable acidity depends on the type of cereal and milling process, in wheat flours 4 to 8 ml NaOH, in rye flours at 5 to 9 mL NaOH.

Procedure

10 g of flour is mixed with 100 cm^3 of distilled water and left at a laboratory temperature for 30 minutes. After this time, add 2-3 drops of phenolphthalein and titrate with 0.1 M sodium hydroxide until a clear pink colour appears.

$$X = 2 \times a$$

X - Titratable Acidity of grain, ml NaOH

a – amount of NaOH, ml

The results should be summarised in Table 2.6.

6. Falling number

Falling number is defined as the time, in seconds, required to measure starch gelatinisation (gel) due to α - amylase activity (enzymes). Starch gelatinisation - during baking enzymes α - amylase degrade starch (complex sugar) to simple sugars (glucose, fructose). Simple sugars become nutrition for yeast during bread baking.

Low FN (< 200s): α-amylase activity is high and the time of starch liquefaction is short and it causes high porosity of wheat bread in terms of technological quality.

High FN (>300s): α-amylase activity is low and the time of starch liquefaction is long and it causes that shape and volume of bread are not optimal in terms of technological quality. Wheat bread does not have porosity and it has small volume.

Standard 220 - 300 s for wheat flour and 180 – 220 s for rye flour.

Procedure

Weigh 6 g of flour, add 25 mL of distilled water and put on a slide and place in a visco bath (Figure 2.1). Use the video for information on how to evaluate falling number of flour https://youtu.be/-XmsT080DNM?si=lDHRMXJcb4PLCBdE. All results should be summarised in Table 2.6.

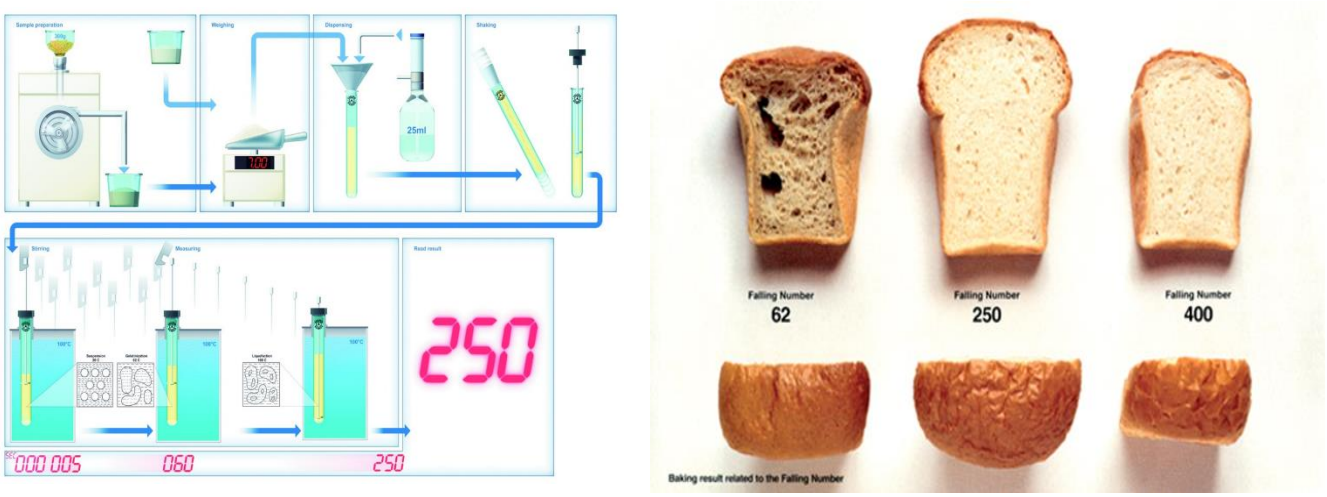


Fig. 2.1. Procedure of falling number evaluation and quality of bread.

6. Gluten content

Gluten is a plastic-elastic substance made of gliadin and glutenin (proteins) insoluble in water. Gluten content in wheat flour is min. 26 %. Gluten tensibility is 5 – 14 cm. Gluten swelling:
low-quality gluten, ≤8
medium quality gluten, 9 – 10
good gluten, 11 – 12
very good gluten, 12≤

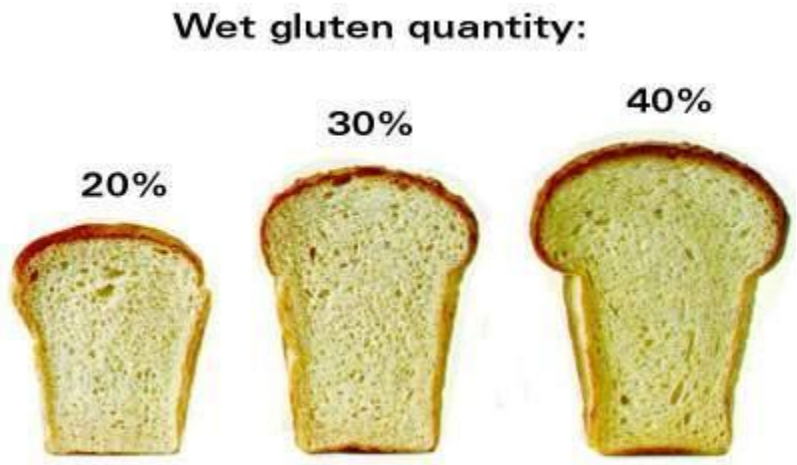


Fig. 2.2. Gluten and influence of wheat bread quality.
(https://www.perkinelmer.com/product/perten-glutomatic-pergm)

<u>Procedure</u>

Weigh 10 g of wheat flour and add 5 mL of 2 % NaCl solution and make a ball of dough. Wash it immediately under running cold water over a sieve until clear water flows (this stops the leaching of starch and water-soluble proteins). Washed gluten has a gummy texture. After washing the

gluten, weigh and recalculate to dry matter. For washing use Perten Glutomatic® 2000 System (Figure 2.3.)

Fig. 2.3. Glutomatic 2000 system.
(https://www.calibrecontrol.com/main-product-list/perten-glutomatic).

Calculation.

$$Gluten, \% = \frac{a \times 100}{DM} \times w$$

a – weight of gummy gluten, g
DM – dry matter content
w – weight of sample (flour), g

Gluten tensibility
Form a cylinder (diameter 6 – 7 mm) from the wet gluten, which is then stretched over a ruler until it breaks. Repeat 3 times and calculate the average results and write it in Table 2.6.

Gluten swelling
Procedure. Pour 80 mL of lactic acid into the Berliner flask, cut 1 g of gluten into 30 approximately equal pieces, put in the flask and let it swell in the thermostat for 90 minutes at 32 °C and read the volume of the swollen gluten in mL.
All results summarize in table 2.6.

6. Rheological properties - Farinograph

Water absorption – the amount of water required to centre the farinograph curve on the 500 farinographg unit (FU) line. This relates to the amount of water needed for flour to be optimally processed into finished products. Absorption is expressed as a percentage.
Development time – time when the top of the curve leaves the 500-FU line. This indicates the time when the dough is beginning to break down and is an indication of dough consistency during processing. Development time is expressed in minutes.

Stability – is the difference in time between the time when the curve first touches the 500 FU line and the time when the curve leaves the 500 FU line. It is generally accepted that the longer the stability of flour, the greater the tolerance to mixing.
Degree of softening (12 minutes after start) – the difference in FU value at the top of the curve at the peak time and the value at the top of the curve 12 minutes after the peak. This indicates the degree of softening during mixing. It is expressed in farinographic units (FU).
Farinograph quality number (FQN) – the distance from the start of the measurement to the point where the consistency (middle curve) fell by 30 FU from 500 FU.

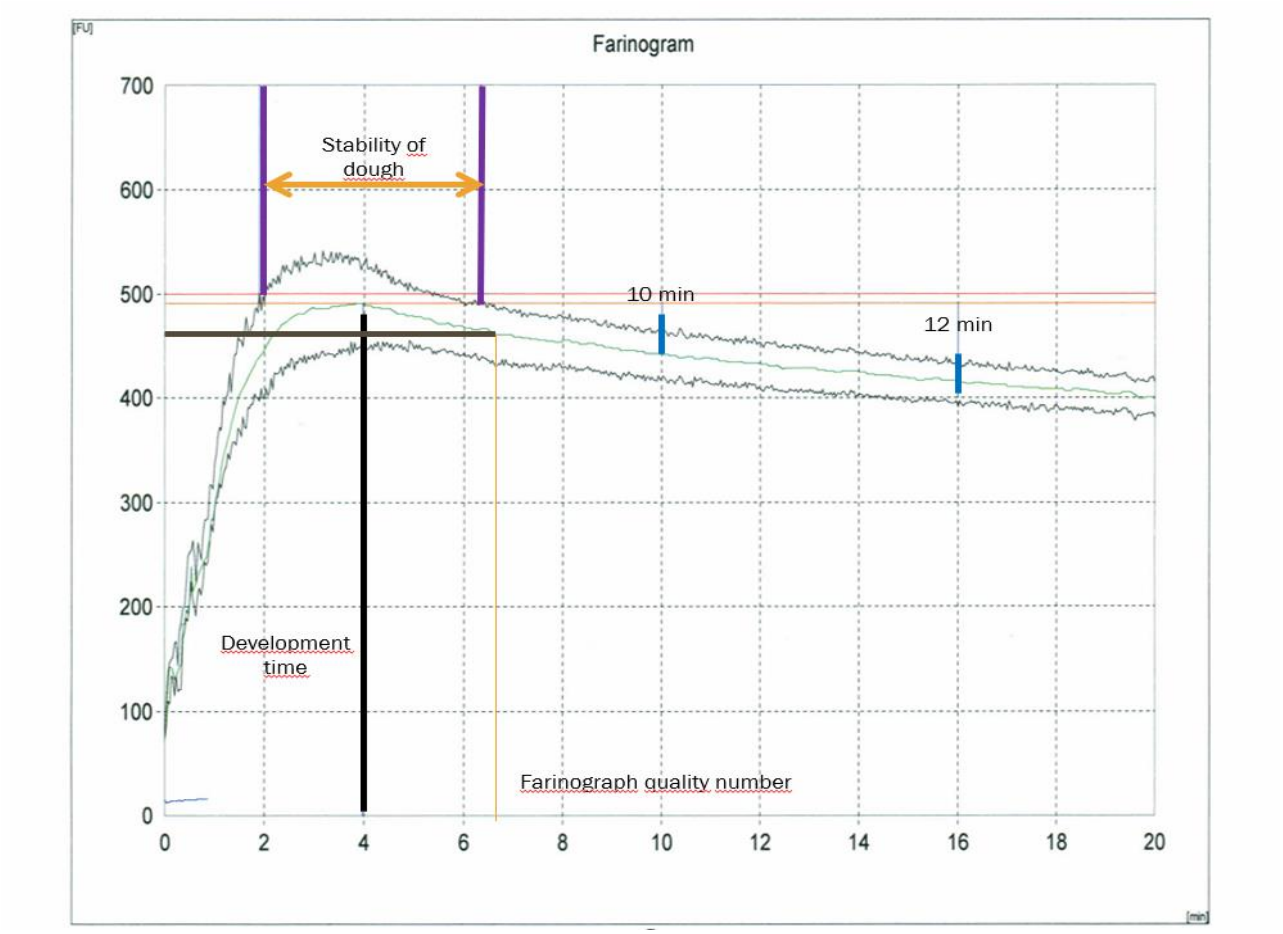


Fig.2.4. Curve of Farinogram.

For evaluation of wheat flour quality use data from Table 2.4.

Table 2.4.

Quality parameters from Farinograph.

Flour	Weak	Middle strong	Strong
Water absorption, %	<50	52 - 56	57 - 60
Development time, min	<1	1 - 2	>2

Stability, min	<1	1 - 3	>4
Degree of softening, FU	>90	40 - 90	<40
FQN	<40	40 – 99	>100

Procedure

Please use the video to learn about the analysis method https://youtu.be/6ZhfQYz_Cko?si=E9AH2zj_P0DT2GB8.

Connect the Farinograph device (Figure 2.5.) to the power supply and turn on water circulation. Turn on the computer and open the Farinograph computer program

Preparing the equipment for work:

- water circulation is performed to heat the water and avoid air bubbles by pressing the green icon with a droplet "Flush...",
- it is necessary to calibrate the equipment before working,
- press the yellow icon "Calibrate..." and follow the instructions,
- press the "start" button on the device, the paddles start working,
- water circulation begins,
- weigh glass for water measurements,
- insert the tube into the glass and perform the first water weight calibration,
- record the actual weight in the computer program,
- weigh the glass with water and leave the tube in the glass to calibrate the next amount of water and record the actual weight in the computer program.

Taking measurements:

- open a new page in the computer program,
- enter the necessary information (sample humidity, predicted water binding capacity),
- start measurements by pressing the "start" key,
- follow the instructions - pour in 300 g of flour, implement water circulation and only then insert the blue tube into the mixer.

If the maximum resistance (in Brabender units) is 500, the measurement was performed correctly, otherwise the analysis should be repeated, taking into account the recommended corrections in the program.

According to the schedule, the water absorption capacity of the flour, the time of mixing the dough and the stability of the dough is read.

Analyse the obtained data and summarise it in Table 2.6.

Fig. 2.5. Brabender Farinograph
(https://scientificservices.eu/id/item/5369/farinograph-R--at-version-12.html)

7. Dough resistance Extensiograph

For dough resistance properties use Extensiograph (Figure 2.6.).

Fig. 2.6. Brabender Extensiograph.
(https://www.anton-paar.com/corp-en/products/details/extensograph/)

The curve of the obtained results (Figure 2.7.) shows us the following parameters:

The maximum resistance (Rmax), or the resistance at constant deformation usually corresponds to the height of the curve at 50 mm from the beginning of stretching (R50). The latter is preferably expressed within the cereal testing laboratories since it represents the resistance at a fixed extension for all tested doughs. This parameter is expressed in Extensograph units.

The dough extensibility (E) expressed in mm, which represents the distance of stretching before rupture.

The ratio of resistance to extensibility – high ratio indicates the short gluten properties resulting in low volume of baked products.

The area under the curve, which is proportional to the **energy** required to stretch the test piece to its rupture point. This parameter, expressed in cm^2, is a convenient single figure for characterising flour strength. The stronger the flour, the more energy is required to stretch the dough.

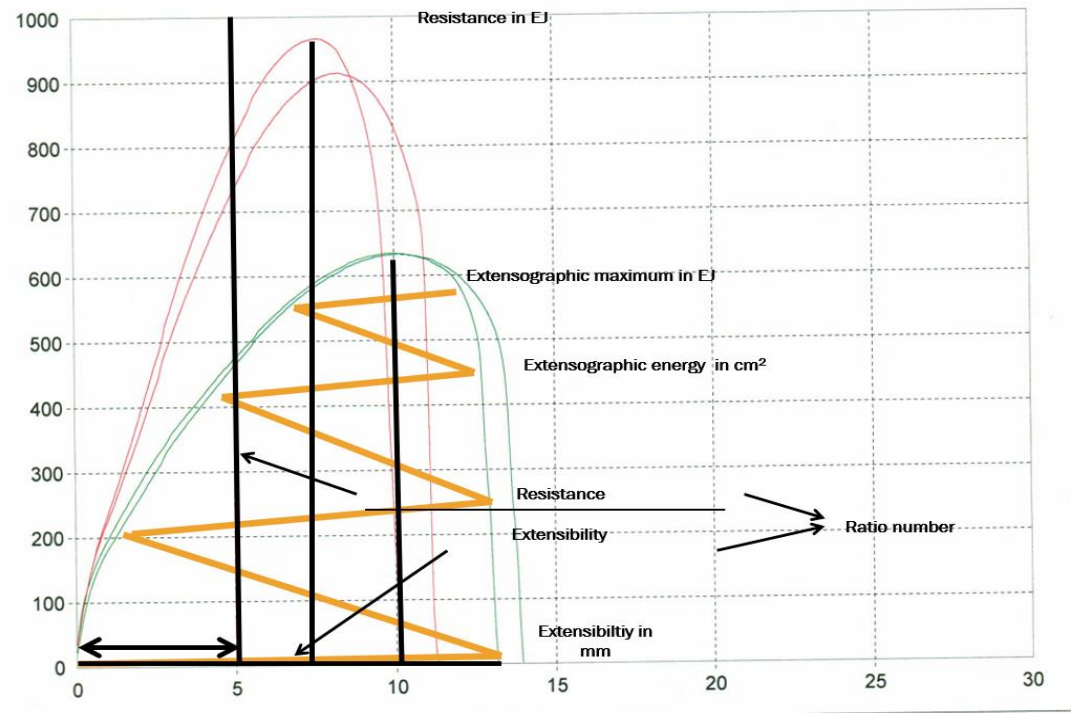


Fig.2.7. Extensiograph Curve.

For evaluation of wheat flour quality, use data from Table 2.5.

Table 2.5.

Quality parameters from Extensiograph.

Technology quality	Extensiographic parameters			Ratio number
	Resistance (EU)	Extensibility (mm)	Energy (cm^2)	
Weak	150	180	37	0.8
Middle strong	350	160	90	2.2
Strong	550	155	150	3.5

Procedure

- Preparation of dough (with 2% salt based on flour weight) in the Brabender Farinograph mixer, usually at 2% less than its optimum absorption to compensate the salt addition,
- Moulding of dough pieces on the Extensograph into a cylindrically shaped dough piece.
- Resting of the dough pieces for a fixed period of time (15, 30, 45, 90, 135 min),

- Stretching the dough pieces until they rupture and recording the extensibility of the dough and its resistance to stretching.

Obtained data should be summarised in Table 2.6.

8. Wheat flour viscosity Amylograph

The Brabender Viscograph E (Figure 2.8.) provides you with a complete picture of the gelatinisation behaviour of starches and all modified starches. To ensure compliance with Viscograph-E, use a standard starch viscometer that measures the gelatinisation properties of starch according to ICC 169 and AACCI Method No. 61-01.01.

Fig. 2.8. Brabender Viscograph E.
(https://www.calibrecontrol.com/main-product-list/brabender-viscograph-e)

The curve of the Viscograph (Figure 2.9.) shows starch gelatinisation max temperature and the viscosity of starch. Peak viscosity is the maximum resistance of a heated flour and water slurry to mixing with pins. It is expressed in Bradbender units (BU) or Amilograph units (AU). Flours with different starch viscosities can be used to produce different qualities of bread (Figure 2.10.).

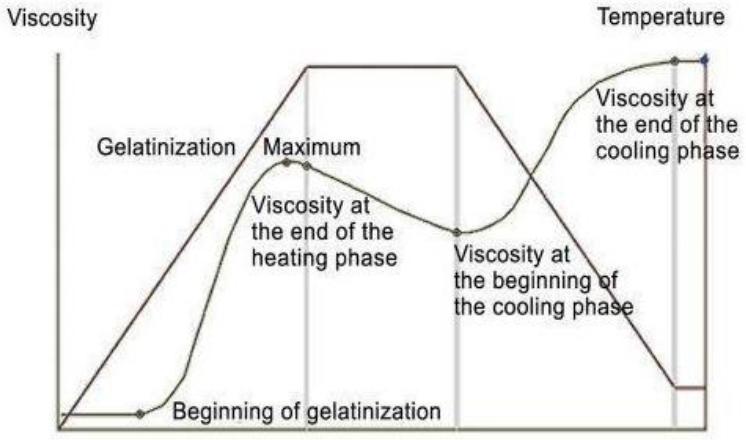


Fig. 2.9. Viscograph E curve.
(https://www.nexus-analytics.com.sg/product/viscograph-e/)

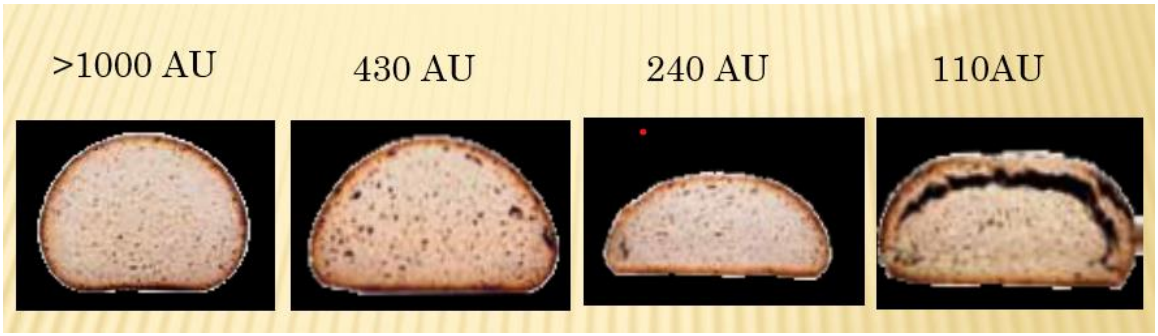


Fig. 2.10. Bread quality samples.

Procedure

A sample of 80 grams of flour is combined with 450 mL of distilled water and mixed to make slurry.

The slurry is stirred while being heated in the amylograph, beginning at 30 degrees Celsius and increasing at a constant rate of 1.5 degrees Celsius per minute until the slurry reaches 95 degrees Celsius.

The Viscograph E records the resistance to stirring as a viscosity curve on graph paper.

The viscograph analyses the viscosity by measuring the resistance of a flour-and-water slurry to the stirring action of pins or paddles.

When the slurry is heated, the starch granules swell and the slurry becomes paste.

A thicker slurry has more resistance to the pins during stirring and has a higher peak viscosity. Generally, a thicker slurry indicates less enzyme activity and makes better products.

Obtained results are summarised in Table 2.6.

Results

Table 2.6

Flour quality

Quality indicators	Score and rating
Organoleptic evaluation of flour	Colour: Smell: Taste:
Flour moisture	
Flour titratable acidity	
Amount of ash	
Amount of gluten Gluten quality	
Farinograph Dough kneading time Dough persistence Water absorption capacity	
Extensiograph Resistance, EU Extensibility, mm Energy, cm^2	
Viscograph: Starch gelatinization, °C; Max gelatinization temperature, °C; Max Viscosity, BU	

Conclusion

Approved by _____

Name, surname, signature

Date _____

Laboratory work

Sensory evaluation of breakfast cereals, granola and muesli

Sensory evaluation of breakfast cereals involves assessing and measuring various sensory attributes such as appearance, aroma, flavour, texture, and overall acceptability. This evaluation can be conducted using both trained sensory panels and consumer panels. In the sensory evaluation of breakfast cereals, granola and muesli, a method will be used, which assumes that the product is evaluated in a group and a common opinion is adopted for the entire group of experts.

Materials and Procedures

In each evaluation group - 4-5 experts; for each group - 5-7 samples of breakfast cereals or granola or muesli. About 30 g of the product is prepared for each group and placed in transparent zip bags. Each sample is coded with three randomised numbers.

To clean the mouth between samples, use water or warm black tea.

Use the recommendations given in Table 2.7 for sensory evaluation of products.

Table 2.7.

Recommendation for breakfast cereals sensory evaluation

	Appearance*	**Consistency**	**Aroma**	**Taste, aftertaste**
5	Even, not stuck together, not broken flakes	The flakes are evenly swollen, soft	Pronounced, characteristic smell of grain	Pleasant, balanced and typical for product
4	Minor deviations	Some flakes unevenly swollen	Pleasant cereal	Typical for cereals, but not pronounced
3	Some of the flakes are broken, crumbled, visible stuck together flakes or ingredients	Flakes unevenly swollen	A faint, straw smell	Unbalanced, too sweet
2	Unsightly, uneven colours, crumbled	Hard unswollen flakes, difficult to chew or dissolved flakes	Uncharacteristic, off-odour	Bitter taste and aftertaste
1	Unattractive appearance	Flakes too soft or hard, flakes completely dissolved	Inappropriate	Inappropriate, unpleasant taste and aftertaste

*Appearance is evaluated for dry samples. For evaluation of external appearance the flake sample is weighed into 15 g beakers and visually assessed.

For evaluation of consistency, smell and taste - pour over a sample of flakes (15 g) over 50 mL milk, mix and evaluate after 5 minutes.

The total score of sensory properties and their transcript:

20-19 very good quality
16-18 good quality
15–12 average quality
12 and less inadequate quality

Results

1. Evaluate breakfast cereal samples and fill each expert group, results write in table 2.8.

Table 2.8.

Breakfast cereals sensory evaluation sheet

Sample code	Appearance*	Consistency	Aroma	Taste, aftertaste	TOTAL

Conclusions

Approved by _____

Name, surname, signature

Date _____

Seminar flour production and quality

Using the available internet and bibliographic resources, teams of students prepare an infographic on one of the issues and develop a discussion during the seminar between the teams using the Bingo method (preparing questions to which other students must find answers).

1. What cereals are used in the production of flour?
2. Classification of flour according to the amount of grain sheaths.
3. What are the by-products of flour production?
4. What kind of products is barley used in?
5. What products are oats used in production?
6. What is the market demand for breakfast cereals in the EU and Central Asia?
7. Protein extraction from legumes.
8. Resistant starch, its types and production.
9. Types of extrusion and characteristics of the obtained products.
10. Types of flour used in the production of extruded products.

Theme 3

Pasta production and quality evaluation

Theoretical materials

Pasta is a ready to eat, extruded product having higher nutritional properties. It is really suited for a daily balanced diet because of the higher concentration of unsaturated fatty acid. Mixing, extrusion, drying, cooling and packaging are the major steps used in the production of pasta. Pasta can be produced from different cereals like sorghum, maize, wheat, rice, oats and the addition of these cereals can change the textural, functional, physicochemical properties and microstructure of pasta.

Pasta is an ancient ready to eat product made from durum wheat, water by using a high-capacity cold extruder with different types of dyes to ensure different shapes of product. It contains carbohydrates, proteins, vitamin-B Complex, iron whether it is low in sodium, amino acids and total fat. Semolina pasta contains about 74 % of carbohydrates, 11-12% of protein, 2% of fat and 12% of water. The Uncooked pasta contains about 68.2 g of starch, 11 g of protein, 4.3 g of soluble sugars, 2.8 g of fibre and 1.4 g of fat which provides 353 kcal.

Mixing, extrusion, cooling, packing are the major steps in the production of pasta. Cold extrusion method is commonly used here. After the drying process, the product retains 10% of moisture in it. The major things that should be taken care of for high quality pasta are proper selection of raw materials, other additives and ingredients, processing line and packaging requirements.

Storage of pasta

- Dried pasta should be tightly wrapped and stored in a cool, dry place.
- Fresh pasta should be kept in the refrigerator until the “use by” date.
- Cooked pasta will keep for two to three days in the refrigerator.

Evaluation pasta quality

Sensory evaluation:

- before cooking (shape, colour), by touch considered properties of surfaces – smooth, semi-smooth, rough.
- after cooking with 1 % of NaCl: evaluating taste, smell and adhesiveness.
- cooking ability – indicate the time in minutes for perfect cooking of pasta.
- pasta water absorption – amount of water in %, which pasta absorbed during cooking.
- pasta volume index – volume of pasta before and after cooking, expressed as multiple of original volume.

Technological solutions for the production of extruded products - breakfast cereals, flakes (grit sifting, washing, boiling groats in a sugar-salt solution, cereal drying, grit flattening, heat treatment ("expansion"), airy products (whole grains or prepared pellets, the raw materials are placed in a high-pressure chamber, hermetically sealed and heated, when the moisture in the product heats up, overpressure is formed, hermeticity is broken, pressure drops, product increases in volume (expansion); extruded products (gluten-free cereals with high starch content are used as raw materials, bran, sprouts, malt can be added, various spices are added: sugar,

salt, chopped nuts, etc., the extrusion process includes: cold forming, heat treatment and low pressure forming, or heat treatment and high pressure forming). Production possibilities of extruded products with filling. Dry component mixer. Glazing equipment.

Extrusion characteristics. Equipment for the extrusion process - Extrusion. Types of extrusion. Extrusion cooking. Classification of extruders. Construction of the extruder. Twin screw extruder. Single-screw and double-screw barrel. Variations of extruder screws and matrix.

Laboratory work
Pasta production in laboratory condition

Evaluation of pasta quality

Pasta production in laboratory conditions. Evaluation of pasta quality – evaluation of cooking ability, water absorption and pasta volume.

Materials and procedures

Semolina, eggs, salt, water, extruder for pasta preparing, cooker, pots, plates, fork, sieve, cylinder, laboratory scales.

1. Prepare pasta dough

Ingredients: Semolina 1kg; 2 eggs; Water 300 mL; Salt 5g.
Mix all the ingredients for 15 minutes in a pasta extruder into a dough, after preparation of the dough, form various shapes (spaghetti and node) using matrix and cutter.
After packing the pasta, the following quality indicators are determined:

2. Evaluate quality parameters of pasta and compare with industrial pasta samples

Pasta cooking ability

Procedure: Bring 1 l of water with 10 g NaCl heat to boil and add 100 g of pasta, mix and simmer. Good pasta preparation (cooking) is determined by taste; pasta's starch must be gelling, i.e. the starch changes its structure and swells. The pasta doesn't have must have gelatine on the whole surface, a hard core. The result is the time in minutes.

Pasta water absorption

Procedure: after cooking, leave pasta for 2 minutes in a sieve (remove water) and after that determine the weight.
Calculation: the weight of cooked pasta – the mass of uncooked pasta = water absorption in g/%.

Pasta volume

Procedure: place 100 g of fresh uncooked pasta into a glass cylinder 1000 cm3, which is filled with water to 500 cm^3mark slowly mixing (to run-off air) and passing the volume. Repeat the same procedure with cooked pasta.
Calculation: the volume of cooked pasta (cm^3): the volume of uncooked pasta (cm^3) = multiple (dimensionless number).

Results

Summarise the results obtained in the laboratory work in table 3.1.

Table 3.1.

Results of pasta quality evaluation

Sample	Sensory characteristics	Pasta cooking ability	Pasta water absorption	Pasta volume

Conclusions

Approved by _____

Name, surname, signature

Date _____

Practical works

Packaging of pasta

The aim of the work is to acquire skills in packaging of pasta with different packaging equipment using various packaging materials. The group of students is divided into teams and each team packs products using different solutions.

Materials

Products prepared in previous experiments or raw materials purchased at the discretion of the teacher.

The vertical flow-pack packaging equipment and the pulsed simple hermetically sealed equipment. Single-layer film packaging material in a roll with high moisture barrier properties. Ready-made pillow packages made of material with high moisture barrier properties.

Procedures and results

The results obtained in the experiments should be reflected in Table 3.2.

Table 3.2.

Parameters	Sample packed in flow-pack shape	Sample packed in pillow shape packages
Characteristics of the packaging material.		
Which packaging machine is more suitable for packaging of pasta? Describe why?		
How well the sealing went (excellent, good, bad)?		
What is the sealing temperature of the package?		
What is the sealing time (sec.) of the package?		

Results

Conclusion

After packaging the products, different groups of students compare the results. If possible, each group packs 5 packages of each type, and then observes and determines the quality of the products during storage during the study course.

During the practical work, the students learnt the skills of working with packaging equipment.

Approved by _____

Name, surname, signature

Date _____

Laboratory works
Sensory evaluation of laboratory-prepared pasta

Pasta from the laboratory work and industrial samples are used for the sensory evaluation.

Materials and Procedures

Evaluate the sensory properties of pasta using Table 3.3. and summarise results in table 3.4.

Table 3.3

Sensory evaluation of Pasta

Colour (intensity 1 - 5)	**Aroma** (intensity)	**Aroma** (pleasantness)	**Taste**	**Structure**
1	very weak	pleasant	excellent	soft
2	weak	very pleasant	very good	little soft
3	middle weak	middle pleasant	middle good	thicker
4	strong	weak pleasant	good	little thick
5	very strong	unpleasant	bad	thick

Results

Table 3.4.

Results of sensory properties of pasta

Sample	**Colour**	**Aroma (intensity)**	**Aroma (pleasant)**	**Taste**	**Structure**

Conclusion

Approved by _____

Name, surname, signature

Date _____

Seminar
Pasta in the world

Using the available internet and bibliographic resources, student teams prepare an infographic on one of the issues and develop a discussion during the seminar between the teams using the Bingo method (prepare questions to which other students must find answers).

Themes:

1. What types of flour can be used in the production of gluten-free pasta?
2. What are the quality requirements for gluten-free pasta?
3. Analysis of the demand for gluten-free pasta in the EU and Central Asian countries.
4. Latest trends in pasta production.
5. Volumes of production and consumption of pasta in the EU, Central Asia and other regions and countries.
6. Types of flour used in the production of pasta and their characteristics.
7. The latest trends in the production of pasta in the world.
8. Types of pasta, their classification and characteristics.
9. Compare the quality requirements of pasta production in the EU and Central Asia.

Theme 4

The basics of bread making

Theoretical materials

Bread and its products are food products made from flour, water, yeast and with/without lactic acid bacteria, salt, with/without additional ingredients, by kneading the dough, fermentation, dividing it, shaping it, post-fermentation and heat treatment.

Wheat bread is bread made with at least 90% wheat flour.

Rye bread is bread made with at least 90% rye flour.

No less than 51% of wheat flour is used in the preparation of wheat-rye bread.

No less than 51% of rye flour is used in the preparation of rye-wheat bread.

Whole grain bread - rye or wheat whole grain flour must be at least 95% from all flour.

The baking properties of flour are a complex concept. A set of several properties that ensure the production of high-quality bread.

Important for wheat flour: gas formation capacity, gluten quantity and quality - flour strength - dough properties, flour colour and its changes during baking.

Gluten is a complex of the water-insoluble proteins gliadin and glutenin, which may contain other proteins and minerals.

Important for rye flour: starch and enzyme complex; falling number (a B amylase activity); a complex of proteins and their enzymes that break down proteins; proteins do not form gluten, starch gels more easily and at a lower temperature than wheat starch, starch is more easily exposed to amylolytic enzymes, always active α-amylase breaks down starch into dextrins and maltose, rye flour contains 6-8% pentosans, which swell very strongly, bind water well, proteins peptize and become viscous.

Baker's yeast (*Saccharomyces cerevisiae*) is a thermophilic yeast, as the optimal temperature for its activity is around 30-35 °C.

Salt improves the structural and mechanical properties of the dough, regulates enzyme activity, affects the organoleptic indicators of bread, especially the taste.

A small amount of sugar promotes fermentation processes, an increased amount of sugar (20%) inhibits the fermentation process, and doughs with a large amount of sugar must be prepared with caution.

Fat improves the structure and porosity of the bread crumb, taste characteristics, extends the shelf life of products.

Light (unfermented) malt - contains active enzymes - diastatic power. Added to dough to speed up the rate of starch breakdown.

Sourdough - a dough made from flour, water and yeast, in which, as a result of the action of microorganisms, mostly lactic acid bacteria and yeast, a continuous increase in acidity and the formation of carbonic acid gas have been achieved.

Starter culture – specially selected lactic acid bacteria (with or without yeasts), without pathogenic microorganisms, in order to ensure the start of lactic acid fermentation in the shortest possible time when preparing the yeast.

The total colony units of lactic acid bacteria $10^8 – 10^{10}$ cfu/g.
The number of yeast cells is $10^5 – 10^7$ cfu/g.
Titratable acidity - shows the amount of acids and determines the taste of bread. In sourdough on average: 12 - 17 degrees.
pH of the environment - shows the strength of acids and determines the properties of the pulp (stickiness, elasticity, porosity) - average in sourdough: pH 3.6 - 4.0.

Laboratory work
Quality evaluation of raw materials

Quality control of bread production raw materials is carried out to determine the total count of yeast cells live cells and gas production of yeast. Quality yeast should have no less than 10^6 CFU/g, 70% of which should be live. Gas production time should be up to 5 minutes.

Materials and procedures

1. Determination of the total count of yeast cells

The Gorjaev chamber is used to determine the number of microorganisms in a pure culture suspension. Gorjaev's chamber is a thick object glass, in the middle part of which four grooves are hollowed out transversely, between which there are plates. The middle plate, which is divided in half by the special cavity, is 0.1 mm lower than the outer ones. Therefore, when covering the chamber with a cover glass, a microspace is created, the depth of which is 0.1 mm. On the surfaces of both sides of the middle plate, a grid is engraved in the glass (Figure 4.1). The grid consists of 225 (15×15) squares. Every third square is divided into 16 small squares. There are 25 such squares in the grid. The edge of the small square is 1/20 mm, its volume is 1/4000 mm3.

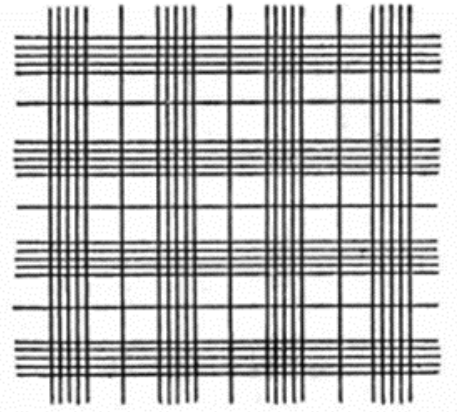


Fig. 4.1. Goryaev's camera.

<u>Procedure</u>

The procedure for determining the number of microorganisms with the Gorjaev's chamber:

1. From the starting material (bread yeast *S. cerevisiae*) a dilution suspension of 1:100 is prepared, that is, 1 g of yeast is placed in 99 mL of sterile physiological solution and stirred for 2 minutes.
2. The suspension prepared with a sterile droplet is applied to both sectors of the Gorjaev's chamber and fixed with the cover glass.
3. Position the microscope so that the camera is clearly visible.
4. Yeast cells are counted in 5 squares, which are divided into small squares (80 small ones) along the diagonal of the camera grid. For this purpose, find the large divided square in the upper left

corner of the visual field and count the cells visible in it. After that, moving the camera diagonally down and finding the next divided square, count again, repeating this 5 times. In order not to count the same cells twice, the following rule should be followed: count the cells that are in the small squares, but if the cells are on the edge of the square, then count only on two edges, for example, the cells on the left and upper edge, if at least half cells are in a square,
5. The number of cells in 1 mL of suspension is calculated according to the formula:

$$X = \frac{a \times 1000}{S \times h \times n},$$

where,

X – the number of cells in 1 mL of suspension;
a – average arithmetic number of cells in 5 large or 16 small squares;
1000 – conversion factor;
S – chamber area, mm^2 (large – 1/25 mm^2, small – 1/400 mm^2);
h – chamber depth, mm (0.1 mm);
n – number of squares.
6. Summarise the obtained results in a table.

2. Determination of living and non-living cells

Vital staining is an express method that can be successfully used to determine the activity of pure cultures of microorganisms by identifying and determining the amount of living and non-living cells in the respective culture medium or in the pure culture suspension of the prepared physiological solution. Living cells of microorganisms did not stain with methylene blue dye, but dead cells, whose cell envelopes have become permeable, stained blue.

Procedure.
1. The slide and coverslip are sterilised;
2. Place a drop of the suspension or culture medium in which the microorganisms are cultured on a sterile slide with a sterile pipette or loop and fix it with a coverslip;
3. Place a small drop of methylene blue dye next to the coverslip. When filter paper is applied to the other side of the coverslip, the deposited material is stained as a result of the flow of the solution;
4. The prepared sample is put under a microscope and the living and non-living cells are counted (preparation with methylene blue).
5. Obtained results summarised in Table 4.1.

3. Yeast Activity, Gas Production

To determine the yeast's ability to produce gas, knead the dough from 50 g of flour with 1 g of yeast and 25 mL of water. Make a ball of dough and place it in a beaker with 200 mL of water (t-30 °C). Take time and observe the fermentation process. Mark after how many minutes the ball of dough rises to the top of the beaker.
Summarise the obtained results in Table 4.1.

Results

All results should be summarised in Table 4.1.

Table 4.1.

Evaluation of yeast quality

Quality indicator	Sample 1	Sample 2	Sample 3
Yeast cell count			
Number of live cells			
The number of dead cells			
Yeast activity count			
Yeast activity (min)			

Conclusions

Approved by _____

Name, surname, signature

Date _____

Laboratory work
Microbiology analyses of raw materials

Total Viable Counting (TVC) is a laboratory technique used to count all the microorganisms in food. It is sometimes referred to as Standard Plate Counting (SPC) and Aerobic Plate Counting (APC). The TVC, as its name suggests, is a quantitative analysis that provides the number of microorganisms that are viable and thrive on microbiological media for food. The food industry has made extensive use of it to assess the efficacy of cleanliness programmes, processing conditions, food quality, and food safety. The conditions under which food is processed have a big impact on the microorganism populations found in it. The microbiota is made up of a variety of microorganisms that are typically found in raw and uncooked foods. The majority of vegetative germs will die when exposed to heat, although certain heat-resistant spores will survive. The microbe may also develop spores or go into a viable but non-culturable (VBNC) condition as a result of additional non-thermal processing.
The TVC has a number of limitations, including the inability to distinguish between different types of microorganisms and the inability to estimate microbial cells that do not develop on plates, such as anaerobic bacteria or bacteria that have formed spores. To ensure food safety, the TVC is therefore more helpful in microbial food quality assessment than in food pathogen assessment.

Materials and procedures

Task 1. Preparation of samples and inoculation preparation for yeasts, moulds, mesophilic aerobic and facultative anaerobic microorganisms (MAFAm) in raw materials

Procedure
Dilutions are prepared for determining the amount of microorganisms for all food products, and the degree of dilution should be chosen so that the number of colonies in the Petri plate is between 50-200 - the maximum permissible limit is 300 KVV. Raw materials are weighed, placed in a bag with a filter and homogenised with physiological solution in a homogeniser. The time and speed of homogenisation is chosen depending on the consistency of the product, a harder and thicker sample requires a longer time and a higher speed.
As a result, a homogeneous suspension should be obtained from which inoculations can be made. If necessary, prepare a dilution of the analysed product (see dilution preparation scheme in Figure 4.2.);

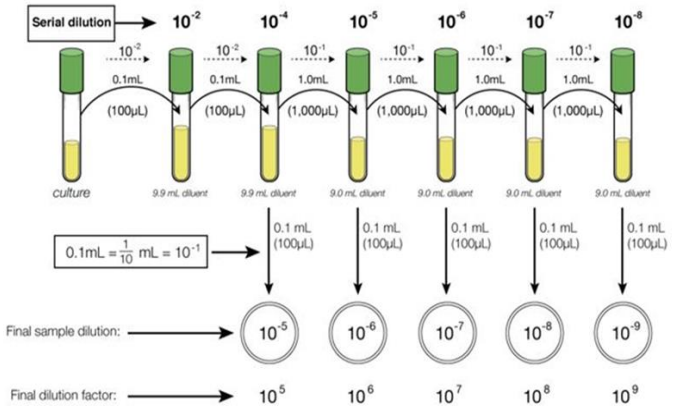


Fig. 4.2. Serial dilution and plating.

Spread Petri plates. Thaw previously prepared sterile agarised media and prepare Petri plates. Apply 1 mL of the product or its dilution to 2 Petri dishes with a sterile pipette in the Laminar box in sterile conditions. Gently push the liquid inoculum applied to the centre of the plate, two or three times clockwise around the dish, then several times anticlockwise, turning the plate on the turntable as needed to obtain complete coverage. Remember that the plates should be labelled. After the spread plating, leave plates agar side down for at least 30 min in order for the inoculum to adhere onto the agar, then invert the plates and incubate at 30 °C, 37 °C or 27 °C according to microorganisms.

2. Counting colonies on plates

Looking at your dilution plates you prepared last time, choose the plates that have from 30-300 colonies on them. As this might take some practice in plate counting, you might need to choose all plates with what looks like a reasonable number of colonies to count.

- Those plates that have no microbial growth can be recorded as 0 or NG, No Growth.
- Those plates on which colonies are not individually distinct (their edges run together) can be recorded as TNTC, Too Numerous To Count.
- Those plates on which you cannot distinguish any individual colonies, the entire surface is covered with microbial growth, can be recorded as *confluent*.

2. Count each colony to give a total colony count for each plate chosen. You will avoid counting a colony twice by marking off the colonies on the bottom of the plate as you count them. This requires, of course, that the plate be upside down. Be sure to count any small colonies.

3. Record your results in Table 4.3.

Results

Table 4.2.

Count of microorganisms, CFU/g

Raw materials	Microorganisms	Count of colony forming units	Method	Notes

Conclusions

Approved by _____

Name, surname, signature

Date _____

Laboratory work Sourdough preparation

The laboratory work is designed to learn the process of making spontaneous sourdough and to understand the processes taking place during fermentation. Here you will find the technological parameters of sourdough preparation.

Materials and procedures

Task 1. Using the parameters indicated in table 4.3. on the protocol, prepare the sourdough.
In the protocol, describe the observations (appearance, colour, smell, acidity to the taste) at each stage of sourdough preparation. Add a picture and explain the ongoing fermentation processes.
Note: Instead of rye flour, you can also choose whole grain flour from other cereals.

Results

Table 4.3.

Sourdough preparation and quality evaluation

No.	Parameters	Sample 1	Sample 2	Sample 3	Notes
Day 1					
1	Flour	100	100	100	
2.	Water	200	200	200	
3.	Sourdough temperature				
4.	Fermentation camera temperature				
5.	Fermentation time				
6.	Sourdough consistency				
7.	The smell of sourdough				
8.	Sourdough taste				

	Image				
No.	Parameters	Sample 1	Sample 2	Sample 3	Notes
Day 2					
1	Flour	100	100	100	
2.	Water	100	100	100	
3.	Sourdough	100	100	100	
4.	Sourdough temperature				
5.	Fermentation camera temperature				
6.	Fermentation time				
7.	Sourdough consistency				
8.	The smell of Sourdough				
9.	Sourdough taste				

10.	Image				
No.	Parameters	Sample 1	Sample 2	Sample 3	Notes
Day 3					
1	Flour	100	100	100	
2.	Water	100	100	100	
3.	Sourdough	100	100	100	
4.	Sourdough temperature				
5.	Fermentation camera temperature				
6.	Fermentation time				
7.	Sourdough consistency				
8.	The smell of sourdough				
9.	Sourdough taste				

10.	Image				
No.	Parameters	Sample 1	Sample 2	Sample 3	Notes
Day 4					
1	Flour	100	100	100	
2.	Water	100	100	100	
3.	Sourdough	100	100	100	
4.	Sourdough temperature				
5.	Fermentation camera temperature				
6.	Fermentation time				
7.	Sourdough consistency				
8.	The smell of sourdough				
9.	Sourdough taste				

10.	Image	

Conclusion

Approved by _____

Name, surname, signature

Date _____

Laboratory work
Microbiology analyses of Sourdough

When preparing spontaneous sourdough, it is important to monitor the development of microorganisms in order to obtain sourdough with appropriate quality parameters. The sourdough used in bread production must have:

The total colony units of lactic acid bacteria $10^8 – 10^{10}$ cfu/g.
The number of yeast cells is $10^5 – 10^7$ cfu/g.
Titratable acidity - 12 - 17 NaOH ml.
Acidity pH 3.6 - 4.0.
When performing the laboratory work of spontaneous sourdough preparation, the microbiological parameters of sourdough and changes in acidity are additionally analysed.

Materials and procedures

Procedure
Dilutions are prepared for determining the amount of microorganisms for all stage sourdough, and the degree of dilution should be chosen so that the number of colonies in the Petri plate is between 50-200 - the maximum permissible limit is 300 KVV. Sourdough first stage and after each fermentation stage are weighed, placed in a bag with a filter and homogenised with physiological solution in a homogeniser. The time and speed of homogenisation is chosen depending on the consistency of the product, a harder and thicker sample requires a longer time and a higher speed.
As a result, a homogeneous suspension should be obtained from which inoculations can be made. If necessary, prepare a dilution of the analysed product (see dilution preparation scheme in figure 4.2.).
Spread Petri plates. Thaw previously prepared sterile agarised media and prepare Petri plates.
Apply 1 mL of the product or its dilution to 2 Petri dishes with a sterile pipette in the Laminar box, with sterile conditions. Gently push the liquid inoculum applied to the centre of the plate, two or three times clockwise around the dish, then several times anticlockwise, turning the plate on the turntable as needed to obtain complete coverage. Remember that the plates should be labelled. After the spread plating, leave plates agar side down for at least 30 minutes in order for the inoculum to adhere onto the agar, then invert the plates and incubate at 30 °C, 37 °C or 27 °C according to microorganisms.

2. Counting colonies on plates
Looking at your dilution plates you prepared last time, choose the plates that have from 30-300 colonies on them. As this might take some practice in plate counting, you might need to choose all plates with what looks like a reasonable number of colonies to count.

- Those plates that have no microbial growth can be recorded as 0 or NG, No Growth.
- Those plates on which colonies are not individually distinct (their edges run together) can be recorded as TNTC, Too Numerous To Count.
- Those plates on which you cannot distinguish any individual colonies, the entire surface is covered with microbial growth, can be recorded as *confluent*.

2. Count each colony to give a total colony count for each plate chosen. You will avoid counting a colony twice by marking off the colonies on the bottom of the plate as you count them. This requires, of course, that the plate be upside down. Be sure to count any small colonies.
3. Record your results in Table 4.4.

3. Identification of lactic acid bacteria and yeasts in spontaneous sourdough

After the final fermentation of the sourdough, the identification of microorganisms is carried out.

Sample inoculations are prepared using the procedure described above. After isolation of pure cultures on agar medium, lactic acid bacteria or yeasts are identified using API tests.

Procedure.

1. On the agarised medium, the material is removed from the grown colony-forming units and, using dilution the relevant microorganism is isolated in the form of a pure culture.
2. Prepare a suspension of microorganism cells in the API enteric inoculation liquid according to the method instructions. The Densimat device measures the concentration of cells introduced into the suspension.
3. The suspension is poured into the wells of the API matrix strip (Figure 4.3.). The inoculation rehydrates the substrate and the metabolism of microorganisms begins.
4. The matrix is closed, placed in a thermostat and incubated under optimal conditions for the growth of the microorganism.
5. After the specified incubation time, observe changes in colour or turbidity that occur as a result of metabolites released by microorganisms.
6. From the results of biochemical reactions– changes in the well of each strip – a numerical code (Figure 4.4.) is formed, which is used as a basis for identification.
7. The digital code is entered into a computer that has an electronic code book of the API ID system.
8. The name of the identified microorganism, its biotype, as well as the reliability coefficient of the obtained results appear on the screen.

Fig. 4.3. API 50 CH and API ID 32 C matrix strip.

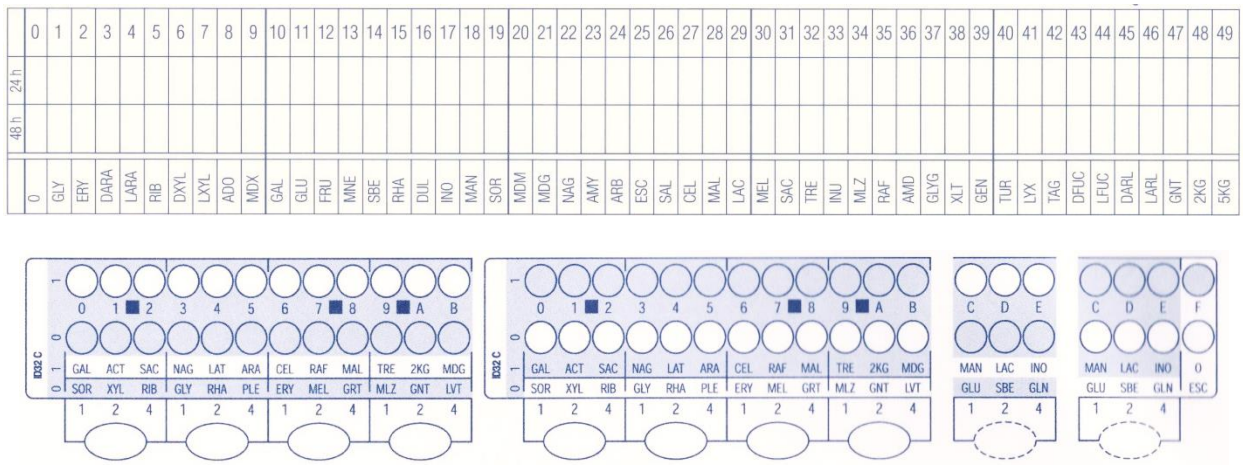


Fig. 4.4. API 50 CH and API ID 32 C microorganism identification results sheet.

More information and instruction on how to use tests can be found onhttps://www.biomerieux-usa.com/clinical/api.

Conclusions

Describe (optimal conditions for development, released metabolites) the identified microorganisms and their influence on the quality of sourdough and bread.

Approved by _____

Name, surname, signature

Date _____

THEME 5 Wheat bread technology

Theoretical materials

Wheat bread is known in many countries of the world, however, the traditions of its preparation tend to be different. In this topic, we will learn more about and understand the basic principles of wheat bread making and explain the processes involved.

The basic principle of the wheat bread recipe
Wheat flour - 100%
Yeast - 0.5 - 5%
Salt - 1 - 2%
Water - 50 - 60%
Sugar - 2 - 5%
Fatty substances margarine/oil- 2 - 5%
Bread improver - 0.5 - 2%
Malt products - 2 - 5%
Other additives - 5 – 20%

There are three ways of making bread:
1. Direct.
2. With leaven. Leaven is a dough with flour, yeast and water. Leaven preparation types are divided into short, medium and long. The fermentation time, temperature and the amount of flour and yeast used differ for each.
3. With sourdough. Sourdough is a dough made with active lactic bacteria, yeast, flour and water.
The mixing time of wheat dough is on average 8-10 minutes. For doughs with a large amount of fibre, it increases to 20 minutes and more.
Stages of the kneading process:

- mixing of raw materials (approx. 1 minute),
- formation of dough structure (2-3 minutes for wheat dough),
- stabilisation of the dough structure (3-5 minutes for wheat dough).

Fermentation for wheat dough takes an average of 60-90 minutes.
Processes taking place in the dough: the swelling of the dough ingredients continues; the activity of yeast and enzymes that break down the components of the flour continues; the amount of gas increases; pore size increases, pore walls remain thinner; the amount of flavouring increases.
During baking (as the temperature in the dough gradually rises to 90 °C), proteins denature under the influence of temperature (60-80 °C), acids or bases, losing the fourth, third, second structure; as a result of denaturation, they stick together, compact, coagulate; they release water, which is attracted to the starch. Starch gelatinisation – changes in the structure of starch grains – swelling by attracting water; the starch properties of different grains are different.
As the temperature increases in the bread crust, the formation of light and dark dextrins and the caramelisation of sugar occur.

At the beginning of the wheat bread baking process, steam must be provided so that condensation forms on the dough preparation - the surface of the dough is elastic, the products increase in volume, do not crack; dextrins are formed - a shiny crust.

Some recommendations for the use of steam during baking:

- A lot of steam - the products are not risen, a hot oven, for small products with strong gluten,
- Little steam - products are well risen, cool oven,
- Keep the steam for a long time - for doughs with strong gluten, slightly risen and in a hot oven,
- Keep steam for a short time - for doughs with weak gluten, well-leavened, cool ovens,

Loss of mass of bread:

- Technological losses 1-2%,
- During baking (losses of moisture and volatile compounds) - 10-12%,
- During cooling of bread 1-2%.

Laboratory work
Baking test of wheat bread with sourdough

The purpose of the work is to acquire knowledge and practical skills in preparing rye and wheat bread using sourdough from previous laboratory work.

Materials and procedures

Tasks:

1. Prepare sourdough, dough and bake products using the recipe in table 5.1.
2. To justify the importance of raw materials in ensuring product quality.
3. Present the obtained product and evaluate the quality.
4. Justify and explain the obtained results.

Table 5.1.

Recipe

Ingredients	Amount, %	Amount, g
Whole wheat flour	50	250
Wheat flour 550 types	50	250
Sourdough	30	150
Salt	1.5	7
Sugar	10	50
Seed mixture (of your choice)	20	100
Water	50 - 55	250 - 300

Procedure

1. Making the dough. The pre-prepared sourdough, or for those who have kept the activated sourdough in the refrigerator, and the other raw materials are slowly kneaded to form dough of medium firm consistency, the amount of water may therefore vary.

Sourdough activation **–** flour and water are added to the stored sourdough in a ratio of 1:1:1 (you can also use a teaspoon of sugar), mix, the consistency should be like thick yoghurt. Put in a fermentation camera (27-30 °C) until the fermentation processes are felt (pores appear and the yeast increases in volume), it can take up to 6-12 hours.

2. Dough making and fermentation. Here are two options, choose which one seems easier for you:

A. We monitor the dough completely (T= ~2 – 3h); the temperature of the fermentation room is 32±5 °C) and then carefully (without pressing or sticking too much) we make a dough, press the patterns and leave the marks to bake.

B. We knead the dough a little (T-45 min), make a ball and put it in a shape, then leave it for ~1.5h at a temperature of 32±5 °C, providing moisture and let it bake. If we bake the bread in a form (cake forms can be used), then we make the dough softer - add more water.

3. Baking bread. We heat the oven to a temperature of 220 °C. Place the dough blanks in the hot oven and bake for ~ 1 hour. It depends on the weight of the bun. Readiness is determined by tapping the bottom of the bun or by measuring the temperature in the middle of the bun, it should be 98 °C.
4. Cooling the bread**.** The bread must cool down and ripen, so you will be able to feast only after 4-6 hours.
5. Evaluate the bread sensory parameters according to Table 5.2.
6. Summarise all parameters and results in table 5.2.

Results

Table 5.2.

Baking report

Name of sample	Amount, g / parameters	Notes
Ingredients		
Whole wheat flour		
Wheat flour 550 types		
Sourdough		
Salt		
Sugar		
Seed mixture (of your choice)		
Water		
Technological parameters		
Dough mixing time, min		
Mass of dough, g		
Dough temperature, °C		
Mass of semi – finished product, g		
Dough properties	Soft / Normal / Hard	
Fermentation time, min	60	
Fermentation temperature, °C	36–40	

Baking time, min	60	
Baking temperature, °C	220–230	
Mass of hot bread, g		
Value of baking loss, %	6 – 10	
Mass of cooled bread, g		
Value of dry off, %	3 - 4	
Sensory parameters		
Bread form / crust		
Colour of bread crust		
Properties of bread soft part		
Regularity of pores	Regular / non-regular, big / small	
Properties of bread soft part	Springy / non - springy Regular colour, aroma and taste	
Aroma		
Taste		

Value of bread baking loss (%) is decreases of dough mass during baking process.

$$X = \frac{Ms - Mkm}{Ms} \times 100$$

where,
X – baking loss, %
M_s – mass of dough, g
M_{km} – mass of ready hot bread, g

Value of bread dry off (%) is decrease of bread mass during cooling.

$$X = \frac{Mkm - Mam}{Mkm} \times 100$$

where,
X – value of bread dry off, %
M_{km} – mass of hot bread, g
M_{am} – mass of cooled bread, g

Conclusions

Approved by _____

Name Surname, signature

Date _____

Laboratory work
Wheat bread with yeast baking test and freezing processes

The aim of the work is to acquire knowledge and practical skills in preparing wheat bread with yeast and about the bread freezing process.

Methods and procedures

1. Prepare wheat dough with yeast and bake bread using the recipe in table 5.3.

Table 5.3.

Recipe of wheat bread with yeast.

Ingredients	Amount, %	Amount, g
Wheat flour 405 type	100	1000
Salt	1.5	15
Yeast	3	30
Rapeseed oil	3	30
Sugar	3	30
Water	50 - 55	500 - 550

Procedure

1. Dough making. Mix wheat flour, salt, sugar, yeast, sourdough and red beet puree for 15 seconds and gradually add water and slowly knead for 2 minutes until the dough forms has medium firm consistency, then mix intensively for 6 minutes until you obtain an elastic, firm dough.
2. Loaf of bread making and proofing. Proof the dough T-15min, t – 21 °C, divide dough by 75g, make a loaf as a ball and proof in a proof camera at a temperature of 32±5 °C, approx. 45 minutes, ensuring moisture.
3. Bread baking.
   For ready to use bread, heat the oven to the temperature of 180 – 200 ℃. Baking takes ~ 17 minutes. Readiness is determined by measuring the temperature in the middle of the loaf, it should be 98 °C. But the crust of bread is light. Continuing the baking process after defrosting will fry it golden brown.
   For frozen bread, heat the oven to the temperature of 160 – 180 ℃. Baking takes ~ 15minutes. The crust must be light yellow. Golden brown colour bread is obtained after the second baking process in the customer's home.
5. Cooling both types of bread. Wheat bread must cool down to 25 °C.
6. Evaluate bread sensory parameters according to Table 5.3.
7. Summarise all parameters and results in Table 5.3.

2. Partially baked bread is cooled after baking and frozen using the shock freezing method t -40 °C freeze to -18 °C inside of loaf. Packed and stored in a freezer (-18 °C) for quality assessment.

Procedure.

1. After baking, the bread samples are placed in a shock freezer (-40 °C) and frozen for 30-40 minutes.

2. The Frozen breads are placed in the refrigerator (-18 °C) for storage.
3. The frozen products defrost in the fermentation chamber - temperature +35 °C, chamber humidity at 75 %, defrosting time 20-30 minutes.
4. The bread samples bake for 10 minutes, in a temperature of 180-220 °C with steam until the loaf acquires a golden-brown colour.
5. Cooling both types of bread. Wheat bread must cool down to 25 °C.
6. Evaluate bread sensory parameters according to Table 5.4.
7. Summarise all parameters and results in Table 5.4.

Results

Summarise all results in baking report.

Table 5.4.

Baking report

Name of sample	**Amount, g / parameters**	**Notes**
Ingredients		
Wheat flour 405 type		
Salt		
Yeast		
Rapeseed oil		
Sugar		
Water		
Technological parameters		
Dough mixing time, min		
Mass of dough, g		
Dough temperature, °C		
Mass of semi – finished product, g		
Dough properties	Soft / Normal / Hard	
Fermentation time, min	60	
Fermentation temperature, °C	36–40	
Baking time, min	60	
Baking temperature, °C	220–230	
Mass of hot bread, g		
Value of baking loss, %	6 – 10	
Mass of cooled bread, g		

Value of dry off, %	3 - 4	
Sensory parameters		
Bread form / crust		
Colour of bread crust		
Properties of bread soft part		
Regularity of pores	Regular / non-regular, big / small	
Properties of bread soft part	Springy / non - springy Regular colour, aroma and taste	
Aroma		
Taste		

Value of bread baking loss (%) is decreases of dough mass during baking process.

$$X = \frac{Ms - Mkm}{Ms} \times 100$$

X – baking loss, %
M_s – mass of dough, g
M_{km} – mass of ready hot bread, g

Value of bread dry off (%) is decrease of bread mass during cooling.

$$X = \frac{Mkm - Mam}{Mkm} \times 100$$

X – value of bread dry off, %
M_{km} – mass of hot bread, g
M_{am} – mass of cooled bread, g

Conclusions

Approved by _____

Name, Surname, signature

Date _____

Practical work
Wheat bread packaging

The aim of the work is to learn skills in wheat bread packaging using different packaging technologies (packing in air, vacuum, modified gas composition (MAP)) with different packaging technologies using various packaging equipment (simple sealer and chamber-type vacuum packaging equipment). Experiments with different vacuum depths were carried out during vacuum packing. The group of students is divided into teams and each team packs products using different solutions.

Materials and procedures

Products prepared in previous experiments or raw materials purchased at the discretion of the teacher.
Pulsed simple hermetically sealing equipment. Ready-made pillow packages made of mono material with high moisture barrier properties and multi-layer packaging material with high weather barrier properties.

Results

The results obtained in the experiments should be reflected in Table 25.

Table 5.6.

Summary of experiments results

Parameters	Packaging in AIR	Packaging in Vacuum	Packaging in MAP
Characteristics of the mono packaging material			
Characteristics of the multi-layer packaging material			
Which packaging solution is more suitable for packaging of wheat bread? Describe why?			
How well the sealing went (excellent, good, bad)			
What is the sealing temperature of the package?			
What is the sealing time (sec.) of the package?			
Is it possible to close the package non-hermetically? Will it affect the expiration date?			
How eco-friendly is the chosen packaging? How sustainable is the chosen packaging?			

Conclusions

After packaging the products, different groups of students compare the results. If possible, each group packs 5 packages of each type, and then observes and determines the quality of the products during storage during the course of the study.
During practical work, the students learned the skills of working with packaging equipment and packaging technologies.

Approved by _____

Name, surname, signature

Date _____

Laboratory work

Sensory evaluation of different types of bread

A 10-point line scale can be used to determine the intensity of the sensory properties (colour, aroma, porosity, sweet taste and sour taste) of bread samples. With the line scale, you can determine the intensity of each sensory property and it is possible to create a profile of the sensory properties of each sample.

The hedonic scale is a common tool used in the sensory evaluation of food products to measure the degree of liking or disliking by consumers. It typically consists of a series of points (often 9 or 7) ranging from extreme dislike to extreme like. A typical 9-point hedonic scale includes the following points:

1. Dislike Extremely
2. Dislike Very Much
3. Dislike Moderately
4. Dislike Slightly
5. Neither Like nor Dislike
6. Like Slightly
7. Like Moderately
8. Like Very Much
9. Like Extremely

Using the hedonic scale in sensory evaluation provides valuable insights into consumer preferences, guiding food product development and ensuring that products meet consumer expectations.

Materials and procedures

For each panellist - 5-7 different types of bread (wheat, rye, wheat-rye, rye-wheat, baguette, ciabatta etc.) samples. The bread samples are served in portions of approximately 20 g or half a slices. The bread samples are served on coded plates.

For taste neutralisation between samples - water or black tee.

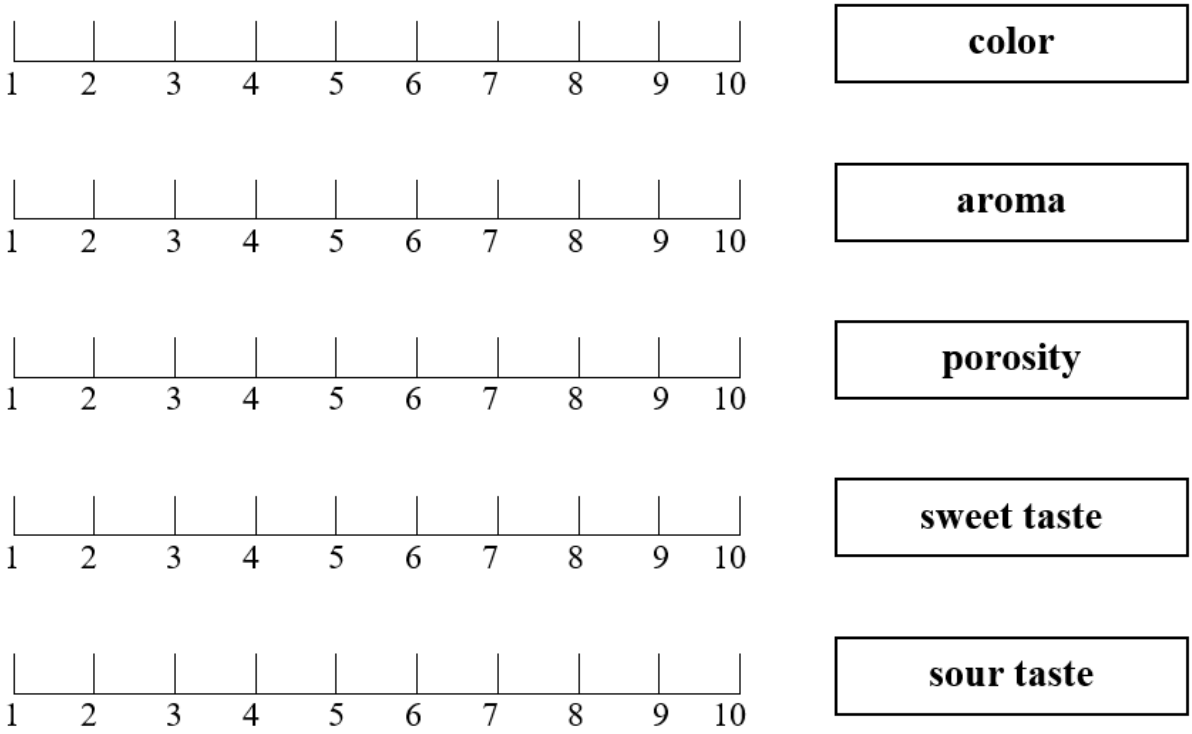
1. To evaluate the intensity of the sensory properties (colour, aroma, porosity, sweet taste and sour taste) for bread samples (worksheet 5.1.)

Worksheet 5.1.

10-point Line scale

TRAY NO. _____

Please mark the intensity of the sensory property for the presented bread samples on the Line scale and write the sample number below the marking.



2. To evaluate the overall liking of bread samples, using 7-point Hedonic scale (work sheet 5.2.).

7-point Hedonic scale

TRAY NO. _____

Please evaluate the overall liking of the bread samples. Indicate how much you like or dislike each sample by checking (V or X) the appropriate phrase.

_____
sample code

like very much	like moderately	like slightly	neither like nor dislike	dislike slightly	dislike moderately	dislike very much

_____
sample code

like very much	like moderately	like slightly	neither like nor dislike	dislike slightly	dislike moderately	dislike very much

_____
sample code

like very much	like moderately	like slightly	neither like nor dislike	dislike slightly	dislike moderately	dislike very much

_____
sample code

like very much	like moderately	like slightly	neither like nor dislike	dislike slightly	dislike moderately	dislike very much

_____
sample code

like very much	like moderately	like slightly	neither like nor dislike	dislike slightly	dislike moderately	dislike very much

sample code

like very much	like moderately	like slightly	neither like nor dislike	dislike slightly	dislike moderately	dislike very much

sample code

like very much	like moderately	like slightly	neither like nor dislike	dislike slightly	dislike moderately	dislike very much

Conclusion

Approved by _____

Name, surname, signature

Date _____

Laboratory work
Evaluation of wheat bread quality

The purpose of bread evaluation is to determine the quality of bread products and deviations from it. The properties of each product are evaluated with a certain number of points, and if deviations are detected, the number of points is reduced. In the sensory evaluation of bread, the following product properties are evaluated: moisture, titratable acidity, pH, porosity, specific volume of bread and comparison with an industrial wheat bread sample.

Materials and procedures

Wheat bread (from the last laboratory work) after defrosting and final baking. Industrial wheat bread as control.

1. Evaluate wheat bread moisture

Bread moisture is one of the most important indicators of bread quality. Increased bread moisture lowers the nutritional value of bread, changes the structural properties of bread, and also contributes to bread mould. Optimum amount of bread moisture:

For wheat bread 41-43%
For rye bread 44-45%

Determination of bread moisture by express method

Procedure

The bread moisture content is determined using a moisture scale 9 (express method). Cut out and weigh 5 g of bread pulp from a loaf of bread. Place the prepared sample on a foil plate and press the "T" (tare) key; weigh the product - about 5 g, spreading evenly on the plate, without scraping the product past the plate; selects a program, presses the "start/stop" button; when the humidity of the product no longer changes, the lamp of the device turns off; record the result; carefully open the lid of the device; clean the foil plate, put it back in the machine;

Determination of bread moisture by standard method.

Procedure

Two weighing cups with lids are weighed on the electronic scale with an accuracy of up to 0.01 g, each weighing 5 g of the flour to be analysed. The weighing cups with the sample are placed in a drying cabinet with a temperature of 130 °C and heated for 40 minutes. The lids are placed next to each other. Weighing glasses with crucible rods are taken out of the cabinet, covered and placed in a desiccator for 15-20 minutes, cooled and weighed.

Flour moisture is calculated:

$$X = \frac{(a - b)}{a} \times 100$$

where,

X - flour moisture, %
a - mass of flour before drying, g
b - flour mass after drying, g

Summarise the results in Table 5.7.

2. Determination of bread acidity

The acidity of bread is the amount of NaOH consumed, which is necessary to neutralise the acid in 100g of the product.

Optimum acidity for bread:

For wheat bread	2.5 – 6 mL NaoH
For wheat-rye bread	6 – 8 mL NaoH
For rye - wheat bread	7 - 9 mL NaoH
For rye bread	10-12 mL NaoH

Procedure

Weigh 25 g of chopped bread crumbs and place it in a 500 mL flask. About 50 mL of distilled water is poured on the bread and mixed with a glass chopstick until a homogeneous mass is obtained. Then add all the remaining water up to the mark of the flask. Close the flask with a cork and shake vigorously for 2 minutes. After the solution has settled, pour 50 mL of the solution into a volumetric flask, add phenolphthalein and titrate with 0.1N NaOH solution until the suspension turns a uniform pink colour.

Bread acidity is calculated:

$$X = 2 \times a$$

where,

X – sourness of bread, ml NaoH

a – amount of NaOH consumed, ml

Summarise the results in Table 5.7.

3. Determination of porosity of bread

Porosity is the total volume of pores in the bread pulp, expressed as a percentage of the total volume of the bread.

Optimum porosity of bread:

Wheat bread	58-73%
Rye bread	45-55%

Procedure

With Zhuravlyov's apparatus, 3 pieces of bread crumbs of a certain size are cut out of the bread sample to be analysed. To cut out the pieces with a twisting motion, the entire cylinder is introduced into the bread pulp, when it is pulled out of the loaf of bread, it is filled with bread. The cylinder is placed on a board and with a wooden roller, a small piece of bread is pushed out of it to the mark, and a 3.8 cm long piece is cut with a knife. The cut pieces of bread are weighed to an accuracy of 0.01g and the results are calculated using formula.

$$X = \frac{(V - \frac{G}{V1})}{V} \times 100$$

where,
X - bread porosity %;
V - volume of the cylinder of cut bread pulp - 27 cm^2
V1 - density of non-porous bread pulp, which is assumed to be 1.31;
G - average mass of one cut out cylinder of bread pulp, g

Summarise the results summarize in Table 5.7.

4. Determining the specific volume of a loaf

Loaf volume shows the total volume of bread. It is influenced by raw materials, fermentation conditions, baking process, as well as weight. Different devices can be used to determine the loaf volume (Figure 5.1.).

Fig. 5.1. Devices for measuring loaf volume.
https://store.ttech.vn/bread-volume-meter-13300-bastak-p44173

Procedure
The cylinder is filled with rapeseed and the edges are filled. The cylinder is placed in the box. The loaf of bread is placed in a cylinder with rapeseed so that it is not visible and the surface is smoothed. Pour the spilled seeds into the cylinder and measure the volume. Summarise the results in Table 5.7.

Results

Table 5.7.

Wheat bread quality parameters

Sample	Moisture, %	Titratable acidity, ml NaOH	pH	Bread Porosity, %	Specific Volume of loaf, mL

Conclusions

Approved by _____

Name, Surname, signature

Date _____

Laboratory work
Evaluation of wheat bread microbiology quality

Purpose of the laboratory work: to get acquainted with the bacteriological research methods of wheat bread and, based on the obtained results, to give an assessment of its quality. Moulds and yeasts, the total number of MAFAm colony-forming units and the presence of Bacillus subtilis will be practically evaluated.

Materials and procedures

Task 1. Preparation of samples and inoculation preparation for yeasts, moulds, mesophilic aerobic and facultative anaerobic microorganisms (MAFAm) in wheat bread

Dilutions are prepared to determine the amount of microorganisms for all food products, and the degree of dilution should be chosen so that the number of colonies in the Petri plate is between 50 and 200 - the maximum permissible limit is 300 KVV. Wheat bread is weighed 10 g, placed in a bag with a filter and homogenised with physiological solution in a homogeniser. The time and speed of homogenisation is chosen depending on the consistency of the product, a harder and thicker sample requires a longer time and a higher speed.
As a result, a homogeneous suspension should be obtained from which inoculations can be made. If necessary, prepare a dilution of the analysed product (see dilution preparation scheme in figure 4.2.).
Spread Petri plates. Thaw previously prepared sterile agarised media and prepare Petri plates;
Apply 1 mL of the product or its dilution to 2 Petri dishes with a sterile pipette in the Laminar box, which is in sterile condition. Gently push the liquid inoculum applied to the centre of the plate, two or three times clockwise around the dish, then several times anticlockwise, turning the plate on the turntable as needed to obtain complete coverage. Remember that the plates should be labelled. After the spread plating, leave the plates agar side down for at least 30 minutes in order for the inoculum to adhere onto the agar, then invert the plates and incubate at 30 °C, 37 °C or 27 °C depending on the microorganisms.

Task 2. Counting colonies on plates

1. Looking at your dilution plates you prepared last time, choose the plates that have from 30-300 colonies on them. As this might take some practice in plate counting, you might need to choose all the plates with what looks like a reasonable number of colonies to count.
   - Those plates that have no microbial growth can be recorded as 0 or NG, No Growth.
   - Those plates on which colonies are not individually distinct (their edges run together) can be recorded as TNTC, Too Numerous To Count.
   - Those plates on which you cannot distinguish any individual colonies, the entire surface is covered with microbial growth, can be recorded as *confluent*.
2. Count each colony to give a total colony count for each chosen plate. You will avoid counting a colony twice by marking off the colonies on the bottom of the plate as you count them. This requires, of course, that the plate be upside down. Be sure to count any small colonies.
3. Record your results in Table 5.8.

Results

Table 5.8.

Count of microorganisms, CFU/g

Samples	Microorganisms	Count of colony forming units	Method	Notes

Conclusions

Approved by _____

Name, surname, signature

Date _____

SEMINAR
Nutrition aspects of bread

1. The seminar is organised as work in groups, where students learn about different topics and introduce fellow students. Themes of the seminar:

1. Nutritional characteristics of wheat bread.
2. Describing the technological methods of increasing the nutritional value of wheat bread.
3. Describing the possibilities of increasing the nutritional value of wheat bread by using different plant and animal raw materials.
4. The latest trends in wheat bread production.
5. Raw materials used in the production of gluten-free bread, their differences compared to whole wheat flour.
6. Differences between the gluten-free bread production process and the traditional wheat bread production technology.

2. Each group of students is given one package of bread with information about the ingredients in the bread, nutritional value and other mandatory requirements are indicated. The task of the students is to evaluate the compliance of the label with the requirements established by the legislation and give a solution. Evaluate the amount of nutrients and explain their importance from the nutritional point of view. Find a solution for increasing or decreasing the amount of fibre, protein, carbohydrates or fat and present a proposal based on calculations to your fellow students.

THEME 6

Wholegrain and traditional bread technology

Theoretical materials

Rye bread has a special place in the culture of the Baltic States. It is produced in large factories, artisan bakeries and at home using various recipes based on rye sourdough. The whole process of rye bread preparation includes rye sourdough fermentation, leavening, and baking. Frequently, scalding is also applied. Although the Baltic States, Estonia, Latvia and Lithuania, are neighbour countries, there are some differences in the making of rye bread.

Sourdough rye bread (*Rudzu rupjmaize*) is a naturally fermented bread, baked in Latvia from rye flour, with scalded rye flour and sourdough being used in the fermentation process. This type of sourdough bread is baked in a hearth oven and the loaf weighs about one or more kilograms, with a smooth and glossy crust, to which starch paste or water is applied after baking.

The external appearance and shape of this traditional Latvian sourdough rye bread may be described as an elongated loaf with rounded ends, at least twice as long as it is wide. Moreover, a mark may be made on the top of the crust, and imprints may be made on the sides.

Traditionally, the scalded rye flour or scald is prepared in wooden tubs made from planks of deciduous wood from aspen or lime trees, with a volume of approximately 30 l. The scald is mixed with a wooden spatula. After the dough preparation process the tub is not washed but is carefully scraped out and kept in a dry place. Therefore the microbiota being present in the wood pores of the tub from previously fermented dough stimulates fermentation. Each baker has his own special rye bread recipe, some are sweeter other are more sour. The main ingredients used for "Salinātā rye bread" recipe is summarised in APPLICATION FOR REGISTRATION OF A TSG COUNCIL REGULATION (EC) No 509/2006 on agricultural products and foodstuffs as traditional specialities guaranteed (2) 'SALINĀTĀ RUDZU RUPJMAIZE' EC No: LV-TSG-0007-01043-11.10.12. Available at: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2013:177:0012:0017:EN:PDF.

Rye flour does not contain gluten, so the dough is not elastic, and the starch gels more easily and at a lower temperature than wheat starch, so it breaks down into sticky dextrins.

The enzyme α amylase is much more active than in wheat flour and breaks down starch into dextrins and maltose.

Rye flour contains 6-8% pentosans, which swell very strongly, bind water well, but the dough is sticky.

Scald is the dough phase in which the flour is poured over with hot water (above 90 °C), with or without additives (malt), to intensively breakdown starch into maltose and dextrins. The purpose of scald is to intensively break down starch into maltose, which is an excellent environment for the development of lactic acid bacteria and yeast.

The effects of scalding on bread quality are: the bread has a strongly aromatic, sweet and sour taste; the physical properties of the dough improve; the crumb of the bread is more elastic and with more homogeneous structure and it keeps fresh for longer.

Rye bread baking implement in a falling temperature mode, in two stages:
1. **Roasting** stage - for a short time (1 to 3 minutes) at a high temperature (300 400 °C). In this stage, a thin crust is formed, it does not crack, it produces the largest volume of loaf, it has more pronounced aroma and taste.
2. **Baking** stage **-** the loaf is carefully transferred to an oven at a temperature of about 260-240 °C, where the temperature decreases to 180 - 200 °C during the baking process.

Fig. 6.1. Traditional sourdough rye bread (Photo G. Duka).

Laboratory work
Baking test of wholegrain bread with sourdough and scald

The aim of the work is to acquire knowledge and practical skills in preparing rye wholegrain bread with scald and sourdough.

1. Prepare Wholegrain rye dough with scald and sourdough and bake bread using the recipe from Table 6.1.

Table 6.1.

Recipe of rye bread with sourdough and scald.

Ingredients	Amount, %	Mass, g
Scald		
Rye flour	30	250
Malt	2.5	20
Cumin	1.5	12
Water		~750
Sourdough		250
Dough		
Rye flour	50	400
Wheat flour	25	200
Salt	1.5	12
Sugar	4	30

Procedure

1. Scald preparation.

Flour, malt and cumin are poured over with boiling water (92 - 100 °C). If there is no malt, then only flour and cumin are used. It is then mixed and beaten quickly to form a mass similar to the consistency of cream. The scald is left to cool (~4-6h) to 37 °C, stirring occasionally. During this time, sugaring takes place - the scald becomes sweet because of the enzymes a β amylases break down starch into reducing sugars. Adding malt promotes this process, if there is no malt, then the process will be slower and the malt will not be as sweet. Add all the results in Table 6.2.

2. Adding active sourdough prepared in previous laboratory work.

The sourdough is added to the scalding (scalding temperature 37 °C – so that the hand, fingers in the middle of the screed do not burn) and left for at least 6 hours. If there was no malt in the preparation of the wort, then at this point add the specified amount of sugar. The scald is slowly stirred 1-2 times during fermentation. It is better to ferment in a camera with temperature 32±5

°C, if it is not possible, leave it in the warmest possible place. Ready-made fermented scald should have an intense sweet-sour taste.

3. Making the dough.

The rest of the ingredients are added to the fermented scald, the dough is slowly kneaded and left to ferment in the heat (conditions similar to when fermenting the scald).

4. Dough making and proofing.

Here are two options, choose which one seems easier for you:

a. Monitor the dough completely (T= ~1.5 – 2h; the temperature of the fermentation room is 32±5 °C) and then carefully (without pressing or sticking too much) make a loaf, press the patterns and leave the marks to bake.

b. Knead the dough (T-15min), make a loaf, press a shape and then ferment it at a temperature of 32±5 °C, providing moisture and let it bake.

5. Baking bread. Heat the oven to the maximum temperature - 250 - 300 °C. Place the dough loaf in the hot oven and after 3-4 minutes, when a light crust has formed, reduce the temperature to 180 – 200 °C. The oven will gradually cool down and the dough will turn into bread. Baking takes ~ 1-1.5 hours depending on the weight of the loaf. Readiness is determined by tapping the bottom of the bread or by measuring the temperature in the middle of the bread - it should be 98 °C.

6. Cooling the bread. Rye bread must cool down and ripen, so you will be able to feast only after 4-6 hours.

7. All results should be summarised in the baking protocol for evaluation (Table 6.3.).

Results

Table 6.2.

The protocol for preparation and quality assessment of scald

No.	Raw materials / parameters	Sample 1	Sample 2	Notes
1.	Flour			
2.	Water			
3.	Rye malt			
4.	Cumin			
5.	Flour temperature			
6.	Water temperature			
7.	Organoleptic assessment of scald			
8.	Scald temperature			
9.	Scald pH			
10.	Scald titratable acidity			
11.	The time of over-sugaring of the scalding			

12.	Organoleptic assessment of scald after sugaring			
13.	Scald temperature after 1h			
14.	Scald temperature after 2h			
15.	Scald temperature after 3h			
16.	Images of scald			

Table 6.3**.**

Baking Report

Ingredients	**Amount, g / parameters**	**Notes**
Scald		
Sourdough		
Dough		
Rye flour		
Wheat flour		
Salt		
Sugar		
Technology parameters		
Dough mixing time, min		
Mass of dough, g		
Dough temperature, °C		
Mass of semi – finished product, g		
Dough properties	Soft / Normal / Hard	
Fermentation time, min	60	
Fermentation temperature, °C	36–40	
Baking time, min	60	
Baking temperature, °C	220–230	
Mass of hot bread, g		
Value of baking loss, %	6 – 10	
Mass of cooled bread, g		
Value of dry off, %	3 - 4	
Bread form / crust		
Colour of bread crust		
Properties of bread soft part		
Regularity of pores	Regular / non-regular, big / small	
Properties of bread soft part	Springy / non - springy Regular colour, aroma and taste	

Aroma		
Taste		

Value of bread baking loss (%) is decreases of dough mass during baking process.

$$X = \frac{Ms - Mkm}{Ms} \times 100$$

where,
X – baking loss, %
M_s – mass of dough, g
M_{km} – mass of ready hot bread, g

Value of bread dry off (%) is decrease of bread mass during cooling.

$$X = \frac{Mkm - Mam}{Mkm} \times 100$$

where,
X – value of bread dry off, %
M_{km} – mass of hot bread, g
M_{am} – mass of cooled bread, g

Conclusions

Approved by _____
Name, surname, signature

Date _____

Practical work
Packaging and pasteurisation of rye (wholegrain) bread

The aim of the work is to learn skills in rye (wholegrain) bread packaging using different packaging technologies (packing in air and vacuum) and simple sealer and chamber-type vacuum packaging equipment. Pasteurisation/sterilisation of packaged bread was carried out. The group of students is divided into teams and each team packs products using different solutions.

Materials and procedures

Wheat or Rye bread prepared in previous experiments or purchased at the discretion of the teacher.

Pulsed simple hermetically sealing equipment. Ready-made pillow packages made of mono material with high moisture barrier properties and multi-layer packaging material with high weather barrier properties. Pasteurisation equipment.

Results

The results obtained in the experiments should be reflected in Table 6.4.

Table 6.4.

Results of experiments

Parameters	Packaging in AIR	Packaging in Vacuum	Vacuum packed bread and pasteurised together with the package
Characteristics of the mono packaging material			
Characteristics of the multi-layer packaging material			
Which packaging solution is more suitable for packaging of rye bread? Describe why?			
How well the sealing went (excellent, good, bad)			
What is the sealing temperature of the package?			

What is the sealing time (sec.) of the package?			
Is it possible to close the package non-hermetically? Will it affect the expiration date?			
How eco-friendly is the chosen packaging? How sustainable is the chosen packaging?			

Conclusions

After packaging the products, different groups of students compare the results. If possible, each group packs 5 packages of each type, and then observes and determines the quality of the products during storage during the study course.

During practical operation, students learned the skills of working with packaging equipment and packaging technologies.

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Laboratory work
Sensory evaluation of bread (quality evaluation of bread as experts)

Materials and Procedures

In each evaluation group - 4-5 experts; for each group - 5-7 different types of bread samples (wheat, rye, wheat-rye, rye-wheat, baguette, ciabatta etc.). The bread samples are removed from their original packaging and placed in transparent zip bags. Each sample is coded with three randomised numbers.

To clean the mouth between samples - water or warm black tea.

Table 6.5.

Recommendation for evaluation of bread defects

Sensory quality characteristics	Points
1. Shape of bread, appearance	
Characteristic volume, even, symmetrical	5
Small deviations – uneven shape, flat, round shape, too small volume, narrower middle part of the loaf, different thickness of slices, different size of slices	4
Unsightly loaf, sticky sides, sticky ends, unevenly strewn, too much sprinkled, dirty loaf bottom	3
Pronounced deviations mentioned above and cracked bread connection site, concave surface	2
Serious defects in shape and appearance	1
2. Bread surface, crust	
Even crust colour of bread, not cracked, crispy crust, crust thickness uniform throughout the loaf	5
Uneven brown bread crust, uneven crust thickness, slightly wrinkled crust, too light, too dark crust colour, cracked crust, no shine, too thin, too thick crust	4
Side and surface cracks larger than 1.5 mm, burnt crust	3
Pronounced above deviations for the surface and crust of the bread	2
Serious defects in the crust and surface of the bread	1
3. Porosity, bread crumb	
Uniform, void-free, characteristic porosity	5
Uneven porosity, insufficient porosity, large pores, small cracks in bread crumb, small voids, slightly bounced crust	4
Inadequate porosity, pronounced voids, water ring, water band, bounced crust, inappropriate crumb colour, uneven crumb colour, insufficiently swollen grains, cracks in the bread crumb	3
The aforementioned porosity deviations are pronounced	2

Serious defects in the bread porosity and crumb	1
4. Structure, elasticity of crumb	
Well-baked, elastic, non-crumbling, dry-to-the-touch bread crumb	5
Bread crumb too dry, bread crumb too hard, sticky crumb, uneven colour of crumb, insufficient elasticity	4
Crumbles when cut, spongy crumb, lumps of flour in crumb, crumbly crumb, slice does not hold together, slices stick together	3
Pronounced defects of the aforementioned bread crumb	2
Serious defects in bread structure and crumb elasticity	1
5. The taste and aroma of bread	
Pronounced, pleasant, characteristic taste and smell of the respective type of bread	5
Less aromatic, but pleasant, without aftertaste and smell	4
Not enough aroma, yeasty, doughy taste, sour, bitter, salty and sweet taste, too much spice, one sided sour	3
More pronounced characteristics of the aforementioned bread taste and smell, as well as the taste and smell of thin, over-leavened dough, foreign smell and taste	2
Bad taste and smell, rancid	1

The total number of points for the sensory properties of bread and their transcription:

25 - 20	**very good quality**
15-19	**good quality**
10 -14	**average quality**
5 – 9	**inadequate quality**

The task is to evaluate given bread samples and fill each expert group Table 6.6.

Table 6.6.

Bread sensory evaluation sheet

Sample code	Shape of bread, appearance	Bread surface, crust	Porosity, bread crumb	Structure, elasticity of crumb	Taste, aroma	TOTAL

Conclusion

Approved by _____

Name, surname, signature

Date _____

Practical work
Presentation of analysis of bread faults and their reasons.

1. Collect photos, descriptions and look for explanations for bread defects!

Laboratory work
Evaluation of rye bread microbiology quality

Rye bread is characterised by high acidity and moisture content. Purpose of the laboratory work: to get acquainted with the bacteriological research methods of rye bread and, based on the obtained results, to give an assessment of its quality. Moulds and yeasts and the total number of MAFAm colony-forming units are evaluated practically.

Materials and procedures

1. Preparation of samples and inoculation preparation for yeasts, moulds, mesophilic aerobic and facultative anaerobic microorganisms (MAFAm) in rye bread.

Dilutions are prepared to determine the amount of microorganisms for all food products, and the degree of dilution should be chosen so that the number of colonies in the Petri plate is between 50-200 - the maximum permissible limit is 300 KVV. Wheat bread is weighed,10 g, and placed in a bag with a filter and homogenised with physiological solution in a homogeniser. The time and speed of homogenisation is chosen depending on the consistency of the product, a harder and thicker sample requires a longer time and a higher speed.
As a result, a homogeneous suspension should be obtained from which inoculations can be made. If necessary, prepare a dilution of the analysed product (see dilution preparation scheme in Figure 4.2.).
Spread Petri plates. Thaw previously prepared sterile agarised media and prepare Petri plates;
Apply 1 mL of the product or its dilution to 2 Petri dishes with a sterile pipette in the Laminar box, which is in sterile condition. Gently push the liquid inoculum applied to the centre of the plate, two or three times clockwise around the dish, then several times anticlockwise, turning the plate on the turntable as needed to obtain complete coverage. Remember that the plates should be labelled. After the spread plating, leave plates agar side down for at least 30 minutes in order for the inoculum to adhere onto the agar, then invert the plates and incubate at 30 °C or 27 °C depending on the microorganisms.

2. Counting colonies on plates.
Looking at your dilution plates prepared last time, choose the plates that have from 30-300 colonies on them. As this might take some practice in plate counting, you might need to choose all plates with what looks like a reasonable number of colonies to count.

- Those plates that have no microbial growth can be recorded as 0 or NG, No Growth.
- Those plates on which colonies are not individually distinct (their edges run together) can be recorded as TNTC, Too Numerous To Count.
- Those plates on which you cannot distinguish any individual colonies, the entire surface is covered with microbial growth, can be recorded as *confluent*.

2. Count each colony to give a total colony count for each plate chosen. You will avoid counting a colony twice by marking off the colonies on the bottom of the plate as you count them. This requires, of course, that the plate be upside down. Be sure to count any small colonies.
3. Record your results in Table 6.7.

Results

Table 6.7.

Count of microorganisms, CFU/g

Samples	Microorganisms	Count of colony forming units	Method	Notes

Conclusions

Approved by _____

Name, surname, signature

Date _____

Practical work
Quality management in a bread bakery

Materials and procedures

Method - Assessment of potential hazards in bread baking process.

1. For a selected bread baking process product, develop a product description, develop and draw a flow chart of the technological process.
2. Identify potential hazards:

- Biological:
  - pathogenic microorganisms;
- Chemical:
  - agricultural chemicals;
- Physical:
  - foreign objects atypical for the product.

3. Evaluate the danger of the identified hazards using a risk matrix 1 or 2 (Table 1.9 or Figure 1.4). Record the information in the hazard assessment Table 6.8.
4. Complete the CCP identification Table 6.8. and the HACCP plan (Table 6.9.).
5. Write conclusions on determining CCP using a risk matrix (table 1.9 or figure 1.4) and a decision scheme.

Remember: Monitoring activities at a CCP. Some types of monitoring activities at a CCP may include:

- physical measurements:
  - time
  - weight
  - temperature
  - belt speed
- chemical measurements:
  - pH
  - water activity
  - % salt
- microbiological testing:
  - microbiological analysis of critical raw materials before their use in processing (for example, analytical results in dried milk used in chocolate products, or in starch used in canned foods)
  - microbiological analysis of critical finished products before their release to highly sensitive consumers (for example, infant formulas)

Note: You need to consider the time required to obtain results when deciding what monitoring activity should be used at a CCP. Rapid tests are preferable for monitoring procedures taking place on dynamic processing lines.

Results

Table 6.8.

Hazard assessment

Process stage	The identified hazard	Hazard assessment					Means of control
		Possibility	The severity of the consequences	Risk level	Assessment	CCP	

Table 6.9.

CCP identification table

Process stage	Process stage	Cause of risk	Description of the cause of the risk	Control actions	Answers to Decision Scheme questions				CCP yes/no
No.					1	2	3	4	

Table 6.10

HACCP plan

In process	CCP/ CP	Risk	Measurable	Monitoring procedures				Records /document	Corrections
Stage		The cause	Critical limits of parameters	What?	How to?	How often?	What?		Events

Conclusions

Approved by _____

Name, surname, signature

Date _____

SEMINAR
Bread around the world

The value of every country and culture is bread. Traditions related to the preparation and use of bread are inherited from generation to generation. Therefore, the seminar will introduce the types of bread from different countries and cultures, their differences and diversity.

Student teams will choose one of the bread varieties - see below. Add all the results from the discussion in Table 6.11. Prepare a presentation on bread types from the EU and Central Asia.

Rye Bread - traditional bread in Baltic state.

Knackerbrod -thin, unleavened dried rye bread.

Ciabatta - Italian bread, large pores a bit of sour taste.

Pizza - Italian bread (loaf).

Baguette - French bread. A long, thin loaf of bread with a crispy crust.

Brioche - Light, hearty French bread (flour-butter ratio is 2:1).

Croissant - Small French pastry. A cone of puff pastry.

Tortilla - Round unleavened Mexican cornbread.

Table 6.11.

Common and different for different types of bread

Parameters	Common	Different
Shape		
Recipe		
Technology process		
Taste		
Aroma		

THEME 7

Flour confectionery and traditional confectionary

Theoretical materials

Flour confectionery means any cooked food which is ready for consumption without further preparation (other than reheating), of which a characterising ingredient is cereal, including shortbread, sponges, crumpets, muffins, macaroons, ratafias, pastry and pastry cases, and also includes meringues, petits fours and uncooked pastry and pastry cases.

Confectionery does not include bread, pizzas, biscuits, crispbread, extruded flat bread or any food containing a filling which has as an ingredient such as cheese, meat, offal, fish, shellfish, vegetable protein material or microbial protein material.

The most important ingredients for confectionery are flour; sugar and other sweeteners; eggs; dairy products; fats, oils and emulsions; chocolate and products containing cocoa; nut masses; for leavening - baking powder, yeast; stabilisers; flavourings, colouring; spices.

Wheat flour is more often used in pastry. An important quality indicator is the amount of starch. Flour with a higher amount of starch is used in the preparation of confectionery products. Sometimes rice, corn, potato flour is also used to increase the proportion of starch.

Sugar and sweeteners are used not only for taste, but also to ensure technological processes. Sugar is more often used for making dough. In yeast dough, it ensures fermentation processes. Sugar also provides colour to the finished product. In biscuits, cream masses, fillings, glazes, it affects the foaming properties. Sucrose is used more often, but today it is also possible to use glucose or fructose syrup, stevia and other sweeteners. Their characteristics are different from sucrose, so it is always necessary to check how they affect the technological properties of confectionery products.

Eggs are an indispensable raw material in the preparation of confectionery. In European countries, mostly chicken eggs or egg masses are used. Duck and goose eggs have a higher microbiological safety risk, so they are used less often. Eggs have a high foaming ability, they act as emulsifiers in yeast doughs, and they also affect the colour of the product's crust.

Dairy products improve the taste, affect the properties of the dough, and the products stay fresh longer. Milk, cottage cheese, cheese, butter are used more often in flour confectionary.

Fats, oils and emulsions are used not only in the preparation of dough, but also in the preparation of creams. Butter or special margarines are more often used in the preparation of creams. On the other hand, more oil, animal fat or butter is used in the preparation of dough. A special margarine is used in the preparation of puff pastry, which helps ensure the formation of layers during baking.

Chocolate and products containing cocoa are indispensable confectionary ingredients, they are used in decorating and making glazes. Chocolate is offered as couverture, cocoa powder, and cocoa mass. Its quality is determined by the amount of cocoa butter and cocoa content.

Leavening agents in confectionery are divided into three groups - physical, chemical (baking powder, potash), and biological (yeast, sourdough). They improve the structure of the products, increase the volume, affect the flavour characteristics, soften the consistency of the product. Chemically modified starch, hydrocolloid system, agar - agar, alginates, carrageenates, pectin, gelatine are more often used as stabilisers. They increase the viscosity of the products, bind free water and form gel structures, thereby stabilising the structural properties.

Flavourings, colouring, and spices give products nuanced taste characteristics and appearance. In confectionery, the following doughs are more often used - yeast dough, puff pastry, choux dough, and egg mass products. **Yeast dough** can be used in pastry for both sweet and savoury products. Sweet dough is characterised by a high sugar and fat content (more than 10%). As a leavening agent - yeast is more often used to ensure the fermentation process, and the technique of making yeast is often used. There are different types of **puff pastry**. Yeast puff pastry is made with yeast and has a softer, more elastic structure and requires supervision before baking. Puff pastry without yeast is drier with crispier layers. Puff pastry with butter and butter puff pastry differ in the way the fat and dough are placed, the folding and layering process. Dutch puff pastry is made by mixing all the ingredients into one dough. A characteristic indicator of layered dough is the type of laminating and the number of layers and the number of dough rounds obtained, which can reach 109 layers.

Choux dough uses boiling water, fats, flour and eggs. Its difference is the technological process of puffing and the binding of a large amount of water in the dough, as a result of which a large volume, moist pores near the crust and an empty centre are formed when the water evaporates during baking.

Egg mass products are biscuits, egg white masses, muffins. They are characterised by a large proportion of eggs and good foamability, which is provided by the proteins contained in the eggs.

Creams and glazes. Creams are made from raw materials with a high fat content. It should be well foamed (the volume should not be less than 2-3 times that of the original), melt easily and gently in the mouth with a pleasant, nuanced aroma and taste. Creams are divided into lightly whipped creams, boiled creams, butter creams, and whipped cream.. Glazes are a coating of a homogeneous mass of melted sugar, which is used to make pastries more beautiful. White sugar and chocolate glazes are often used.

Laboratory work

Creating new ideas for traditional desserts/cakes in new versions. Prepare innovative desserts/cakes

Innovation is the process of turning knowledge and ideas into commercial value, and is highly dependent on linkages within the enterprise sector and on linkages with research institutions.

Trends of flour confectionery – health and wellbeing; consumer insights; sustainability; fermentation, and functional food.

Latvia Traditions pastries:

Sklandrausis (Figure 7.1.) is a traditional dish of the Livs, and over time it has been adopted in the Latvian cuisine of Kurzeme. It is a sweet pie, made of unleavened rye dough, sprinkled with caraway and filled with potatoes and carrots. Sklandrausis is usually consumed cold with tea or milk.

Fig. 7.1. Sklandrausis.

Honey cake (Latvian: Meduskūka) is a true Latvian classic dessert that's bound to satisfy your sweet tooth cravings (Figure 7.2.).

Fig. 7.2. Honey cake, Meduskūka.

Creamy rhubarb cake (Latvian: Rabarberu maize) is made from soft cake with rhubarb and sweet cream. Traditional Latvian spring cake (Figure 7.3.).

Fig. 7.3. Creamy rhubarb cake, Rabarberu maize.

Poppy seeds pastries (Latvian: Magoņmaizītes) are made from wheat yeast dough, filled with poppy seeds, sugar and butter (Figure 7.4.).

Fig. 7.4. Poppy seeds pastries, Magoņmaizīte.

Layered rye bread (Latvian: Rupjmaizes kārtojums) is a traditional Latvian dessert made from rye breadcrumbs, blackcurrant or lingonberry jam, and whipped cream (Figure 7.5.).

Fig. 7.5. Layered rye bread, Rupjmaizes kārtojums.

Materials and Procedures

1. Use a context map and develop a product concept and a development plan for new desserts or cakes using traditional pastries or desserts.

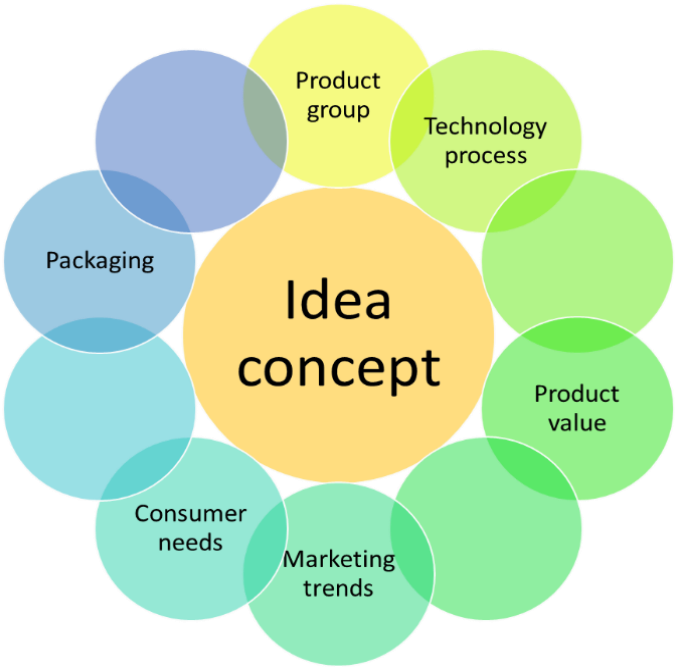

Fig. 7.6. Product context map.

2. Prepare new recipes or use recipes from table 7.1 – 7.3. for innovative desserts or pastries or cakes.

Table 7.1.

Recipe for creamy rhubarb cake with rye soft cake. (Figure 7.7.)

Ingredients	**Mass, g**	**Note**
Soft cake		
Rye crumbles	250	
Soft butter	100g	
Water	100g	
Rhubarb		
Rhubarb	500	
Sugar	150	
Cinnamon	2	
Cream filling		

Sour cream or natural yoghurt	500	
Egg	50	
Sugar	50	
Custard cream powder	50	

Procedure:
Soft cake. Mix all ingredients together. Put in to the mould and bake at 180 ^{0}C for 15 minutes to partly bake.
Clean the rhubarbs, cut in pieces and sprinkle with sugar. Leave for 15 minutes.
On the partly baked soft cake sprinkle the rhubarbs and continue baking until the cake is ready.
At the end, pour the cream mixture on the top and finish the baking. Bake till the cream sets.
Sprinkle with cinnamon.

Fig.7.7. Creamy rhubarb cake with rye soft cake.

Table 7.2.

Recipe for Rye sponge roll. (Figure 7.8.)

Ingredients	**Mass, g**	**Note**
Sponge		
Eggs, pc.	6	
Sugar brown	40	
Rye bread crumble	60	
Whipped cream		
Cream	500	
Sugar	100	

Vanilla	2	

Procedure

Whip eggs with sugar until you get stiff peaks (approx. 10 min), then add spoon by spoon rye bread crumbles. Spread on a tray with baking paper 30 x 40 cm. Bake at 180 ^{0}C till ready.
Whipped cream with sugar and vanilla.
Fill the sponge roll with whipped cream and cranberry jam.

Fig. 7.8. Rye sponge roll.

Table 7.3.

Recipe for innovative carrot desert. (Figure 7.9.)

Ingredients	**Mass, g**	**Note**
Rye cake base		
Rye bread short crust crumbs	200	
Soft butter	75	
Carrot pudding		
Boiled carrots	500	
Eggs	100	
Sour cream	100	
Sugar	100	
Vanilla	1	
Cinnamon	1	
Decoration		
Whipped cream	200	

Procedure

Chop the carrots, add other ingredients and mix together. Pour the mass into a baking tray covered with baking paper. Bake at 180 ^{0}C for 20-25 minutes, till set. Cool down.

Use baked rye bread short crust crumbs, add soft butter and make the cake bases.

Make a 10cm diameter base, place the carrot pudding on top and decorate with whipped cream.

Fig. 7.9. Innovative carrot desert.

Conclusions

Approved by _____

Name, surname, signature

Date _____

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Open Food Innovation University (OFINU)

Study module

"FOOD SAFETY MANAGEMENT"

WORKBOOK

for students

2024

Summary

The workbook is elaborated within the project “Open Food Innovation University" (OFINU), being in implementation with support of the European Union Erasmus+ Programme.

Overall objective of the project - to modernise food innovation and technology related higher education in Uzbekistan and Tajikistan, thereby increasing the quality and ensuring relevance of the higher education to the needs of the socio-economic growth of the countries concerned and especially of their regions.

Full partners:
- Lead partner: Latvia University of Life Sciences and Technologies
- Uzbekistan: Samarkand Agro-innovations and Research University, Andijan Institute of Agriculture and Agro-technologies
- Tajikistan: Technological University of Tajikistan, Kulob Institute of Technology and Innovation Management, Isfara Branch of the Technological University of Tajikistan
- Slovakia: Slovak University of Agriculture in Nitra

Associated partners in Uzbekistan:
- A group of companies "AGROMIR"
- "Navigul" MCHJ QK
- “Samarqand don mahsulotlari” JC (Samarkand grain products)

Associated partners in Tajikistan:
- CJSC “Combinati Shiri Dushanbe”
- LTD "Orion Rustam"
- Association of Entrepreneurs of Khatlon

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Partner universities and their academic staff, involved in the development of the study course:

P1 LBTU. Latvia University of Life Sciences and Technologies

Egija Sproge - HACCAP, egita.sproge.egita@gmail.com

P2 SAMARU. Samarkand Agroinnovations and Research University

Hayitmurod Tilavov, PhD., Food safety - tilavovhaitmurod@gmail.com

Shakhista Ishniyazova, PhD, Food safety, standardization and certification of livestock and crop products - ishniyazova04@gmail.com

P3 AIAA. Andijan Institute of Agriculture and Agro-technologies

P4 TUT. Technological University of Tajikistan

Gafurjon Hakimov, PhD in Tech. Sc., Ass. Prof., Food Safety Management - Hgk907728197hgk@gmail.com

Shuhratjon Nazarov, PhD in Tech. Sc., Ass. Prof., Food Safety Management - nazarovshuhratjon@gmail.com

P5 KITIM. Kulob Institute of Technology and Innovation Management

Bobokhon Qurbonzoda, PhD in Tech. Sc., Ass. Prof., - qurbonzodabobokhon@gmail.com

Isso Rajabov, PhD in agriculture, Ass. Prof. - radzabovisso7@gmail.com

Shomuddin Zuhurov, Senior Lecturer, Food safety management - shomudinz@gmail.com

P6 BTUTI. Branch of the Technological University of Tajikistan in the city of Isfara

Sirojiddin Boboev, Senior Lecturer - sirozhiddinboboev76@gmail.com

P7 SUA. Slovak University of Agriculture in Nitra

Jozef Čapla, Ing. PhD., assistant professor, HACCP system, Food safety management system

Simona Kunová, doc. Ing. PhD., associated professor, Food hygiene and safety - simona.kunova@gmail.com

Peter Zajác, associate professor. Ing. PhD., HACCP system, food safety management system - peter.zajac@uniag.sk

Group of companies "AGROMIR" (UZ)

Irina Krasilnikova, BSc. - irinarafikovaev@gmail.com

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Theme of the study course

The study module includes the following topics on food safety, sanitary hygiene in food production enterprises and the HACCP management system. Ensuring the safety and quality of the food supply chain is a complex task that requires robust measures and effective food safety management systems. The food safety management systems protect consumer health and the integrity of the supply chain and ensure constant quality and integrity of the supply chain, therefore several lecturers with different, and specific knowledge are involved in the implementation of the study module.

Learning methods

Creating an effective study module for students involves incorporating a variety of learning methods to cater to different learning styles and to enhance comprehension and retention.

The **main pedagogical methods taught are as follows: learner centred approach, competence-based approach, experiential learning, cooperative learning, and interactive learning.**

The training includes the practice methods, as well as an introduction to modern learning analytics, to be used to support the engagement and responsibility of a student, and to support assessment.

In order to improve and promote the learning of the study module, it is possible to use different teaching methods in the study course:

1. **Lecture-Based Learning** - Traditional method in which an instructor delivers content through spoken presentations, often supplemented by visual aids such as slides.
2. **Interactive Learning** - Engages students actively through discussions, Q&A sessions, and interactive activities. This enhances understanding and retention by involving students in the learning process. Techniques include think-pair-share, debates, and group discussions.
3. **Collaborative Learning** - Students work together in small groups to solve problems, complete tasks, or create projects. The method helps to develop teamwork skills, fosters peer learning, and encourages diverse perspectives. Examples include group projects, peer reviews, and study groups.
4. **Problem-Based Learning** - Students learn through the experience of solving open-ended problems. It promotes critical thinking, application of knowledge, and self-directed learning. Typically involves real-world scenarios that require research and collaborative problem-solving.
5. **Case-Based Learning** - Uses detailed scenarios (cases) to stimulate analysis and application of concepts. This helps students apply theoretical knowledge to practical situations, enhancing analytical and decision-making skills. Commonly used in business, law, and medical education.
6. **Assessment and Feedback** - Regular assessments (formative and summative) and feedback to guide learning and improvement. This ensures understanding, tracks progress, and provides actionable feedback. It includes quizzes, peer assessments, and instructor feedback.

Course Schedule

Thematic Study Plan for module Food Safety management

Date, Time	Study form	Theme	Lecturer
Theme 1. Introduction to food safety			
Day 1	Lectures (3 h)	Food Safety Introduction and historical perspective	Assoc. prof. Simona Kunová, SUA Nitra, Slovakia
	Practical work (2 h)	Major challenges of food safety	Assoc. prof. Simona Kunová, SUA Nitra, Slovakia
Theme 2. Rapid Alert System for Food and Feed (RASFF)			
Day 2	Lectures (2 h)	Rapid Alert System for Food and Feed (RASFF) - How does RASFF work?	Assoc. prof. Simona Kunová, SUA Nitra, Slovakia
	Lecture (1 h)	The RASFF Window	Assoc. prof. Simona Kunová, SUA Nitra, Slovakia
	Practical work (3h)	The RASFF Consumers' Portal - working with the portal	Assoc. prof. Simona Kunová, SUA Nitra, Slovakia
Theme 3. Biological safety			
Day 3	Lectures (2 h)	Biological safety - definition	Assoc. prof. Simona Kunová, SUA Nitra, Slovakia
	Lectures (2 h)	Biological hazards in food - dividing of biological hazards, causes, examples	Assoc. prof. Simona Kunová, SUA Nitra, Slovakia
	Practical work (4h)	Types of biological hazards in food and feed	Assoc. prof. Simona Kunová, SUA Nitra, Slovakia
Theme 4. Food hygiene and safety			
Day 4	Lectures (2h)	Food hygiene Management of food safety and hygiene	Assoc. prof. Simona Kunová, SUA Nitra, Slovakia
	Practical works (3 h)	Consumer perceptions of risks from food	Assoc. prof. Simona Kunová, SUA Nitra, Slovakia

Theme 5. Food-borne diseases (Zoonoses)			
Day 5	Lectures (2 h)	Food-borne diseases	Assoc. prof. Simona Kunová, SUA Nitra, Slovakia
	Practical work (2 h)	Challenges in emerging food-borne diseases	Assoc. prof. Simona Kunová, SUA Nitra, Slovakia
Theme 6. Food fraud and food authenticity			
Day 6	Lecture (1 h)	Food fraud and food authenticity – definitions, examples of food fraud	Assoc. prof. Simona Kunová, SUA Nitra, Slovakia
	Practical works (1 h)	Food authentication methods – food authenticity databases	Assoc. prof. Simona Kunová, SUA Nitra, Slovakia
Theme 7 Chemical safety			
Day 7	Lectures (2 h)	Chemical safety – chemical hazards in food	Assoc. prof. Simona Kunová, SUA Nitra, Slovakia
	Lectures (2 h)	Contaminants Residues of veterinary medicinal products	Assoc. prof. Simona Kunová, SUA Nitra, Slovakia
	Lecture (1h)	Food contact materials	Assoc. prof. Simona Kunová, SUA Nitra, Slovakia
Theme 8. Food labelling			
Day 8	Lecture (1h)	Food supplements. Addition of vitamins and minerals	Assoc. prof. Simona Kunová, SUA Nitra, Slovakia
	Lecture (1h)	Food information to consumers - legislation	Assoc. prof. Simona Kunová, SUA Nitra, Slovakia
	Practical work (2 h)	Labelling - food labelling information system	Assoc. prof. Simona Kunová, SUA Nitra, Slovakia
Theme 9. Novel food			
Day 9	Lecture (1h)	Novel Food, authorisations and legislation	Assoc. prof. Simona Kunová, SUA Nitra, Slovakia
	Lecture (1 h)	Nanomaterials in food	Assoc. prof. Simona Kunová, SUA Nitra, Slovakia
	Practical work (2h)	Novel Food status Catalogue	Assoc. prof. Simona Kunová, SUA Nitra, Slovakia

Theme 10. Sanitation in food industry			
Day 10	Lectures (2 h)	Sanitation – introduction, definitions	Assoc. prof. Simona Kunová, SUA Nitra, Slovakia
	Lectures (2 h)	Cleaning and disinfection	Assoc. prof. Simona Kunová, SUA Nitra, Slovakia
Theme 11. Disinfection methods			
Day 11	Lectures (2 h)	Chemical methods of disinfection – application advantages, disadvantages	Assoc. prof. Simona Kunová, SUA Nitra, Slovakia
	Lectures (1 h)	Physical methods of disinfection – application advantages, disadvantages	Assoc. prof. Simona Kunová, SUA Nitra, Slovakia
	Practical work (2 h)	Examples of disinfection. Choosing the appropriate disinfectant	Assoc. prof. Simona Kunová, SUA Nitra, Slovakia
Theme 12. Sanitation program			
Day 12	Lectures (2 h)	Sanitation program - content and methodology of the sanitation program	Assoc. prof. Simona Kunová, SUA Nitra, Slovakia
	Practical work (4 h)	Preparing of Sanitation program	Assoc. prof. Simona Kunová, SUA Nitra, Slovakia
Theme 13. Microbial biofilms in food industry			
Day 13	Lectures (2 h)	Biofilm risks in food processing Biofilm formation on food processing surfaces	Assoc. prof. Simona Kunová, SUA Nitra, Slovakia
	Lecture (1 h)	Biofilm removal methods	Assoc. prof. Simona Kunová, SUA Nitra, Slovakia
Theme 14. Genetically modified foods			
Day 14	Lectures (2 h)	Genetically modified foods – safety and risks	Assoc. prof. Simona Kunová, SUA Nitra, Slovakia
Theme 15. Detection of contamination			
Day 15	Lectures (2 h)	Surface sampling and the detection of contamination	Assoc. prof. Simona Kunová, SUA Nitra, Slovakia

	Laboratory work (3 h)	Detection of contamination - swabs	Assoc. prof. Simona Kunová, SUA Nitra, Slovakia
		Detection of contamination - Petrifilm plates	Assoc. prof. Simona Kunová, SUA Nitra, Slovakia
Theme 16. Pest control in food industry			
Day 16	Lectures (2h)	Pest control in food industry - rodent control, insect control. Prevention and methods of pest control	Assoc. prof. Simona Kunová, SUA Nitra, Slovakia
Theme 17. Personal hygiene			
Day 17	Lectures (2h)	Personal hygiene rules	Assoc. prof. Simona Kunová, SUA Nitra, Slovakia
Theme 18. HACCP system			
Day 18	Lectures (6 h)	HACCP system and implementation	Assistant prof. Jozef Čapla, Assoc. prof. Peter Zajác, SUA Nitra, Slovakia
Theme 19. Preparation of the HACCP plan			
Day 19	Practical work (8 h)	Preparation of the HACCP plan	Assistant prof. Jozef Čapla, Assoc. prof. Peter Zajác, SUA Nitra, Slovakia
Day 20	Practical work (8 h)	Preparation of the HACCP plan	Assistant prof. Jozef Čapla, Assoc. prof. Peter Zajác, SUA Nitra, Slovakia
Theme 20. Food safety management system			
Day 21	Lecture (1h)	Food safety management system. Food safety management systems – introduction, basic terms and definitions, process principle	Assistant prof. Jozef Čapla, Assoc. prof. Peter Zajác, SUA Nitra, Slovakia
	Lecture (5h)	Food safety management system – context of the organisation, leadership, planning, support, operation, performance evaluation, improvement	Assistant prof. Jozef Čapla, Assoc. prof. Peter Zajác, SUA Nitra, Slovakia
Theme 21. Management systems – documentation			
Day 22	Practical work (4h)	Food safety management system – documentation	Assistant prof. Jozef Čapla, Assoc. prof. Peter Zajác, SUA Nitra, Slovakia

Day 23	Practical work (8h)	Management systems - documentation Solving practical tasks	Assistant prof. Jozef Čapla, Assoc. prof. Peter Zajác, SUA Nitra, Slovakia
Day 24	Practical work (8h)	Management systems - documentation Solving practical tasks	Assistant prof. Jozef Čapla, Assoc. prof. Peter Zajác, SUA Nitra, Slovakia
Theme 22. Legislative requirements for food of animal and plant origin			
Day 25	Lectures (2 h)	Legislative requirements for food of animal and plant origin	Assoc. prof. Simona Kunová, SUA Nitra, Slovakia
Day 26	Laboratory work (4 h)	Laboratory examination of milk and dairy products	Assoc. prof. Simona Kunová, SUA Nitra, Slovakia
	Laboratory work (3 h)	Laboratory examination of meat	Assoc. prof. Simona Kunová, SUA Nitra, Slovakia

Theme 1

Introduction to food safety

Theoretical materials

Food safety

Food safety deals with the practical measures and scientific discipline taken to make certain that food products are safe for human consumption, free from contamination and do not pose any risk to public health.

Food safety encompasses a set of practices, procedures, and regulations aimed at ensuring that we are consuming food which is safe for consumption, free from contamination, and poses no harm to human health. This is a global concern, as food is a fundamental necessity, and unsafe food can lead to a wide range of health issues, from mild food poisoning to severe diseases, and even fatalities.

Historical perspectives of food safety

Ancient civilisations - in ancient civilizations like Egypt, Greece and Rome, there were rudimentary food safety practices. People would inspect food for visible signs of spoilage and use preservation methods such as drying, salting, and fermentation to increase the shelf life of perishable foods.

Middle Ages - during the Middle Ages, food safety was a significant concern, especially in densely populated urban areas. There were instances of food adulteration and contamination.

Industrial revolution - in the mid-19th century, scientists such as Louis Pasteur and Robert Koch made ground-breaking discoveries about the role of microorganisms in food spoilage and illness, laying the foundation for modern food microbiology and safety practices.

Twentieth century and beyond - the 20th century witnessed the establishment of regulatory authorities such as the World Health Organisation (WHO) and the U.S. Food and Drug Administration (FDA), which played crucial roles in setting food safety standards and regulations on a global scale. Advances in food science, technology, and inspection methods have allowed for more effective monitoring of food safety, including the development of food safety management systems like Hazard Analysis and Critical Control Points (HACCP).

A public health priority and a global responsibility

Nearly two decades into the 21st century, the challenges of ensuring food security, food safety, and nutrition on a global scale continue to grow in complexity. Recent statistics show that the levels of world hunger, malnutrition, and food- and water-borne diseases are among the most critical global public health issues facing the international community. For example:

- According to FAO of the United Nations, 10.9% of the world's population are undernourished, down from 14.5% in 2005. This percentage still represents roughly 770 million people.
- WHO reports that more than 1000 children under five die every day from diarrhoeal diseases caused by inadequate access to water and sanitation.
- In 2015, foodborne diarrhoeal disease agents alone were the cause of death for more than 230,000 people.
- Worldwide, nearly 1 in 10 people fall ill from all foodborne diseases, which equates to 33 million healthy life years lost and results in the deaths of approximately 420,000 people.

- In the developed countries, one in three consumers get a foodborne disease associated with microbes or their toxins every year.

Rapid globalisation has exposed critical gaps in national and international capabilities to assure adequate levels of food safety and quality. WHO and other food-related international public health, development, and standard-setting bodies have targeted these gaps as priority items and are working together to reinforce the need to use an integrated international food safety regulatory system in the era of “one global market”.

Harmonising global regulations will aid the uptake and application of new technologies and encourage the food industry to invest in technologies to ensure the safety, quality, and security of the global food supply.

Regulatory framework and standards

FDA (Food and Drug Administration)

The FDA is a key regulatory agency that is responsible for ensuring the safety of most food products in the United States. They establish and enforce regulations related to food labelling, additives, contaminants, and manufacturing practices.

USDA (United States Department of Agriculture)

The USDA primarily focuses on the safety of meat, poultry, and egg products in the United States. They regulate and inspect these products from farm to processing and distribution.

CDC (Centers for disease control and prevention)

The CDC is a federal agency responsible for tracking and investigating foodborne outbreaks and diseases. They provide epidemiological expertise and surveillance to identify the source of outbreaks.

WHO (World Health Organisation)

The WHO is a global organisation that sets international food safety standards and guidelines. It works in partnership with the Food and Agriculture Organisation (FAO) through the Codex Alimentarius Commission to develop and harmonise global food safety standards.

These agencies collaborate to develop, implement, and enforce food safety regulations that protect consumers from foodborne hazards. Their roles extend beyond national borders, as international cooperation is essential in ensuring the safety of the global food supply chain.

Food safety regulations

HACCP (Hazard analysis and critical control points)

HACCP is a systematic approach that helps in identifying, controlling and evaluating food safety hazards at critical points during food production, processing, and handling. HACCP principles include conducting hazard analysis, identifying critical control points, establishing critical limits, monitoring, corrective actions, verification, and record-keeping.

Codex Alimentarius

The Codex Alimentarius, often referred to as the Codex, is a collection of worldwide recognised standards, guidelines, and codes of practice for food safety, established by the Food and Agriculture Organisation (FAO) and the World Health Organisation (WHO). It serves as a reference point for international trade and aims to harmonize food safety standards and regulations globally.

International food safety standards

International food safety standards are a set of guidelines and regulations established at the global level to ensure the safety and quality of food products traded across borders. These standards, often developed through organisations like the Codex Alimentarius Commission (a joint initiative of the Food and Agriculture Organisation and the World Health Organisation), provide a common framework for countries to follow. They cover various aspects of food safety, including permissible levels of contaminants, food additives, labelling requirements, and hygiene practices.

Practical work

Major challenges of food safety

Students will work in groups.

1. Students will create questions related to food safety and they will search for solutions related to deficiencies in food safety problematic:

What are the solutions to food safety?
What is the best way to describe food safety?
What is the best way to prevent poor food safety practices?

2. Students will prepare the questionnaire with problematic food safety. Major challenges of food safety.

Theme 2
Rapid Alert System for Food and Feed (RASFF)

Theoretical materials

History of RASFF

RASFF was created in 1979 in response to an incident concerning oranges. The 'founding members' were Belgium, Denmark, France, Germany, Ireland, Italy, Luxembourg, the Netherlands and the United Kingdom. Other member countries accessed RASFF as soon as they joined the European Union.

Why RASFF

As part of the food safety tools, the Rapid Alert System for Food and Feed (RASFF) was established to ensure the exchange of information between member countries to support swift reaction by food safety authorities in case of risks to public health resulting from the food chain.
Its legal basis is Article 50 of **Regulation (EC) N° 178/2002** also known as the General Food Law.

RASFF was set up to allow food safety authorities to rapidly exchange information on health risks derived from food or feed so that they can take immediate action to avert the risk.
- RASFF provides a round-the-clock service to ensure that urgent notifications are sent, received and responded to collectively and efficiently.
- Vital information exchanged through RASFF can lead to products being recalled from the market.
- Thanks to RASFF, many food safety risks are averted before they can cause harm, from farm to fork.

While access to RASFF is exclusively granted to member countries' authorities and the European Commission, an interactive, searchable online database, called the RASFF Window, offers public access to summary information about the most recently transmitted RASFF notifications and allows searching for information on any notification issued in the past (currently limited to 2020 and later).

The European Commission created this RASFF database to make information available to consumers, business operators and authorities worldwide. Notifications in the RASFF Window do however, not reveal commercial details such as brands and business operators.

RASFF Window is the main interface for non-member countries to get informed about notifications concerning products that either were produced there or dispatched from there or that had been exported there by a member country.
RASFF Window includes a RASFF consumers' portal, which provides information on recent food recalls and public health warnings in member countries linked to RASFF notifications.

What products does the RASFF warn about?
The RASFF warns against foods, food contact materials and animal feeds that pose a health hazard. For example, in the case of food, the detection of mould toxins, foreign matter, or undeclared allergens can trigger a RASFF notification. Food contact materials include, for example, tableware, cooking utensils such as pots, pans and baking dishes, food packaging or disposable cups. These articles can pose a risk if substances hazardous to health migrate from the container into the food.

Who performs which tasks in the RASFF?
Efficiency through short notification channels and clear hierarchies: RASFF contact points at the surveillance authorities and hubs both in each member state and at the European Commission, including the involved European authorities, allow for a fast flow of information around the clock, even on weekends.

How does the RASFF work?
If a consumer product is found to be objectionable, for example in the course of an official control, during a company's own inspection or on the basis of a consumer complaint, and poses a potential health risk, the competent surveillance authorities will take action. The authorities prepare a notification draft via the iRASFF online platform which contains all essential information on the identification of the product, on possible hazards, product tracing and distribution, but also on already taken measures.

This draft is then sent to the national contact point. At this level, each notification is checked, partly translated and then forwarded for validation to the European Commission. The notification is also reviewed by the European Commission and distributed to all contact points of the network members, so that they can take the necessary measures and carry out further investigations on their part, if necessary.

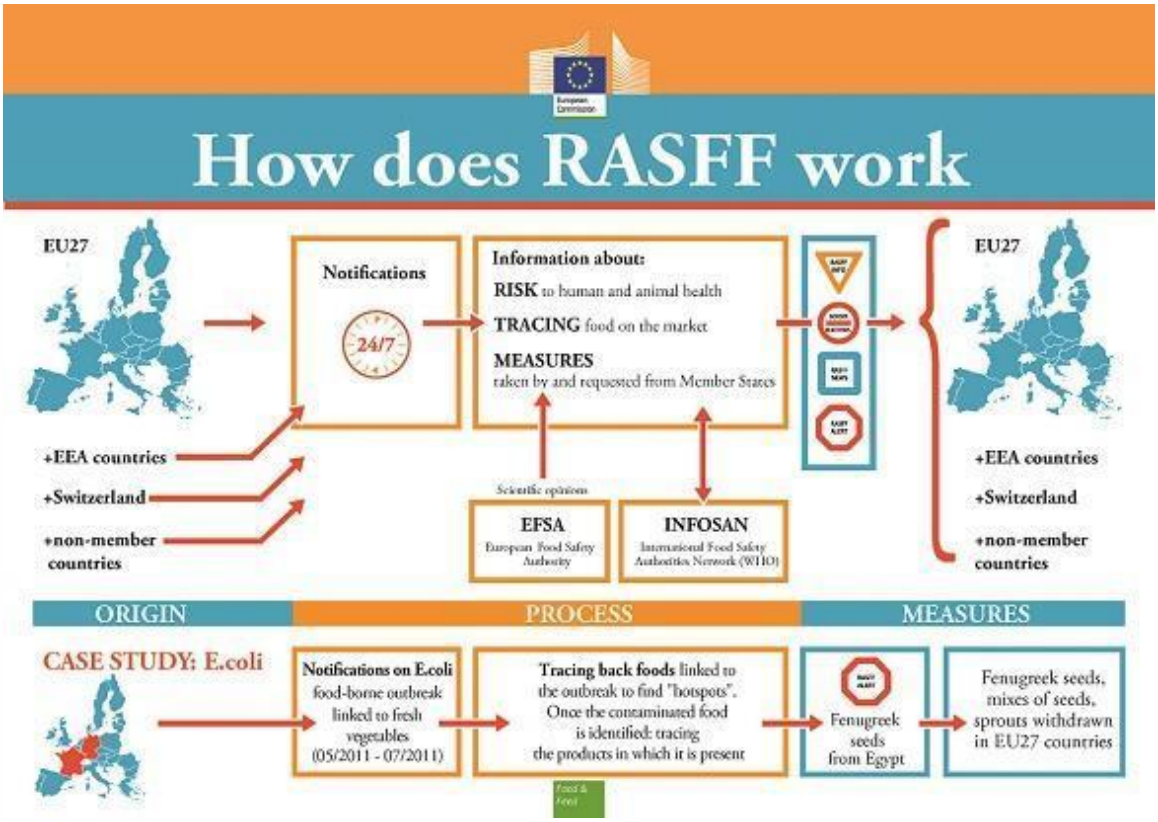

Fig. 2.1. Work of RASFF (https://www.eftasurv.int/internal-market/notifications-and-applications/rapid-alert-system)

Different types of notifications

Depending on the severity of the identified risk and the distribution status, the notifications are categorised and prioritised differently:

The highest priority - **alert notifications**: When a food or feed poses a serious risk to humans, animals, or the environment and therefore requires immediate action in another member state, an alert notification is issued.

Information notifications do not require immediate action in other member countries because the product is not on the market there (information notification for attention) or because the risk associated with the concerned product does not require immediate action (information notification for follow up).

A border rejection notification is transmitted when suspect food or feed has been rejected by a border post or a designated point of entry into the EU. The consignment concerned is returned to the country of origin or destroyed on site.

A news notification is a communication based on information that has not yet been verified or in which the cause of a risk has not yet been identified.

Notifications from the RASFF

RASFF notifications are published on the internet. To provide consumers, businesses or stakeholders with access to notifications from the European Rapid Alert System for Food and Feed, the European Commission hosts the "RASFF Window".

Practical work

The RASFF Consumers' Portal – working with the portal

Work with RASFF Window.

Comparison of RASFF reports between individual countries.

Table 2.1.

Features of the RASFF

Feature	Description
Notification country	Country registering the issue.
Product	The specific name of the product.
Hazard	The hazards or anomalies that have caused the issue.
Origin country	Country of origin of the product. Any country in the world.
Destination country	Country or countries of the product's destination. Any country in the world.
Distribution country	Countries within the transportation chain of the product between the origin and destination. Any country in the world or certain international regulatory organisations.

Results

Table 2.2.

Origin countries

Country	Notifications	Percentage (%)

Table 2.3.

Products

Product	Instances	Percentage (%)

Table 2.4.

Identified hazards

Hazard	Instances	Percentage (%)

Conclusions

Approved by

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Name, surname, signature

Date

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Biological safety

Theoretical materials

Biological hazards include **bacteria**, **viruses**, **parasites, prions, biotoxins**. Some of these hazards have posed serious risks to public health, such as *Salmonella*, *Listeria monocytogenes*, biotoxins in live molluscs or BSE. Exposure of consumers to those through food **should thus be prevented**.

A comprehensive legal framework has been established by the European Commission to increase the level of food safety in Europe, building European consumers' confidence while preventing **food crises**. It is based on scientific advice delivered by the **European Food Safety Authority (EFSA**).

Biological hazards in food are pathogenic organisms or their products that can cause health problems when ingested, such as foodborne illnesses or food poisoning. It is one of the major types of hazards. Biological hazards are a significant concern in the food industry. In fact, major biological hazards caused most of the foodborne illness outbreaks recorded in history.

Because of poor food safety practices, biological hazards become dangerous to public health when they enter the food chain system.

The organisms considered biological hazards can either cause infection or intoxication in humans.

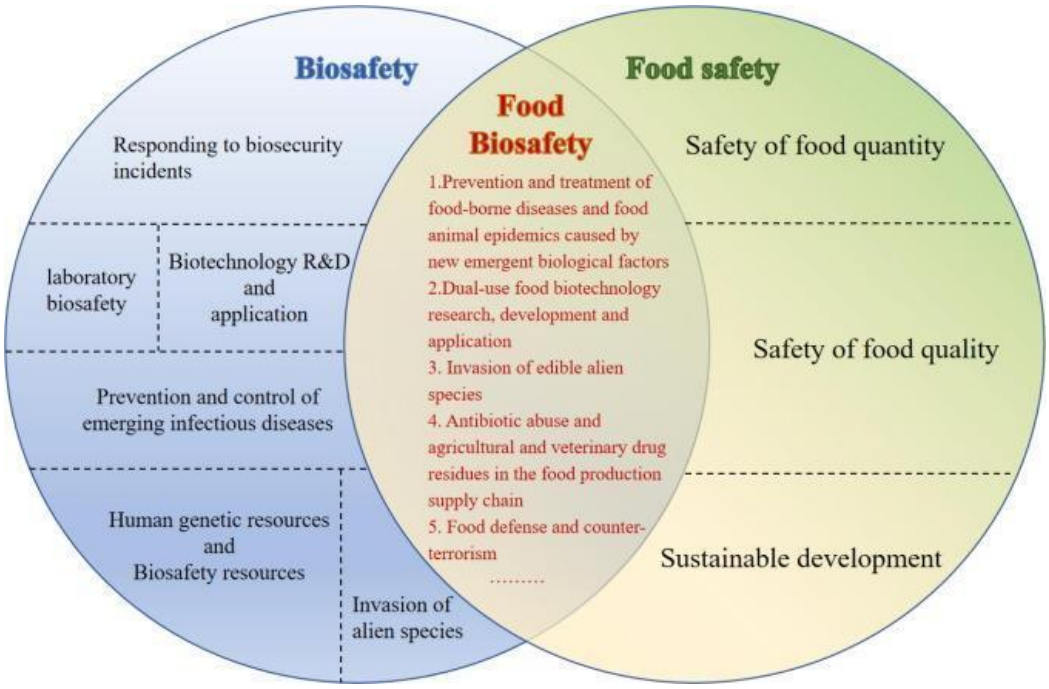

Fig. 3.1. Biosafety/Food Biosafety/Food Safety (Xu et al., 2022)

Biological hazard vs. biological contamination

Biological hazard refers to the organism that causes foodborne illnesses and other risk factors to human health. On the other hand, biological contamination occurs when pathogenic hazards enter the food chain.

Biological contamination is caused by foodborne hazards such as bacteria, viruses, fungi, and parasites, which are all collectively known as biological hazards that make food unsafe for consumption.

Major types of biological hazards

Virus. Foodborne viruses contribute to the most number of cases of foodborne illnesses and communicable diseases in the U.S., with norovirus as the most recognised among them. Other known viruses in the food industry include the following:

- enterovirus,
- rotavirus,
- astrovirus,
- hepatitis A virus (HAV).

Viruses are very resistant to intense conditions such as high acidity and heat and can be easily transferred from the food handler to the food being prepared.

Viruses are most commonly associated with contaminated water, seafood, vegetables, and food handlers. Some of the most common infectious diseases caused by viruses include gastroenteritis and hepatitis.

Bacteria. Bacteria are single-celled microorganisms that can live on moist food items and cause unwanted changes and hazardous effects. Foodborne bacteria are very common in food businesses as they can be found in the water, air, soil, and the gastrointestinal tract of animals. Some types can cause both intoxication and infection.

The types of foodborne bacteria vary greatly. Some can survive extreme conditions, whereas some bacteria can be eliminated easily and pose minimal threat to human health. Some bacteria can stay inactive in the form of spores and multiply when the conditions are favourable again. This mechanism of bacteria makes them a major concern in food preparation.

Some of the most commonly known foodborne bacteria include the following:

- *Escherichia coli (E. coli;* commonly found in water, leafy greens, raw milk, and meat).
- *Bacillus cereus* (commonly found in rice and other starchy foods).
- *Salmonella* (commonly found in raw meat and poultry products).
- *Staphylococcus* (commonly found on the skin of food handlers and poultry products).
- *Listeria* (commonly found in unpasteurised milk, ice cream, and vegetables).
- *Campylobacter* (commonly found in undercooked poultry).
- *Clostridium* (commonly found in undercooked meat products).

Fungi. This type of biological agent includes both yeasts and moulds. Microscopic fungi are known for their ability to survive in very acidic and dry conditions. This makes them a critical concern for intermediate moisture foods and preserved products. Foodborne fungi are also known to have significant economic use. Some types of fungi are used to produce new food products, such as cheeses and wines. Despite this, there are examples of fungi that can cause serious illnesses.

Several fungi are known to produce toxins that are very hard to remove when they have contaminated foods. In such cases, prevention is a better approach to protecting human health. Some of the most common foodborne fungi include the following:

- *Aspergillus sp. (commonly found in grains and nuts).*
- *Candida* sp. (commonly found in grains, dairy products, and processed meats).

Parasites. Parasites are microorganisms that gain their source of nutrition at the expense of their host. They can live in moist foods and transfer to humans, where they can cause foodborne illness. The Centres for Disease Control and Prevention consider protozoa as the most common foodborne parasites.

Other examples of foodborne parasites include:

- *Trichinella sp.* (commonly found in raw meats).
- *Cryptosporidium* sp. (commonly found in raw milk and contaminated water).

Among the mentioned types of biological hazards, a few species are recognised to cause the most foodborne illness cases worldwide. The big 6 major pathogens include:

1. Norovirus
2. Nontyphoidal *Salmonella*
3. *Salmonella* Typhi
4. *E. coli*
5. *Shigella*
6. Hepatitis A

Practical work

Types of Biological Hazards in food and feed

Work in groups.

Students will develop solutions to problems related to biohazards:

Where are biological hazards commonly found?

What can biological hazards in food cause?

Which food safety practice will help prevent biological hazards?

Conclusions

Approved by

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Name, surname, signature

Date

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Theme 4

Food Hygiene and safety

Theoretical materials

General principles

Food safety and suitability should be controlled using a science-based preventive approach, for example a food hygiene system. Good Hygienic practices (GHPs) should ensure that food is produced and handled in an environment that minimises the presence of contaminants.

Food hygiene systems should be reviewed to determine if modifications are needed. This should be done periodically and whenever there is a significant change that could impact the potential hazards and/or the control measures (e.g. new process, new ingredient, new product, new equipment, new scientific knowledge) associated with the food business.

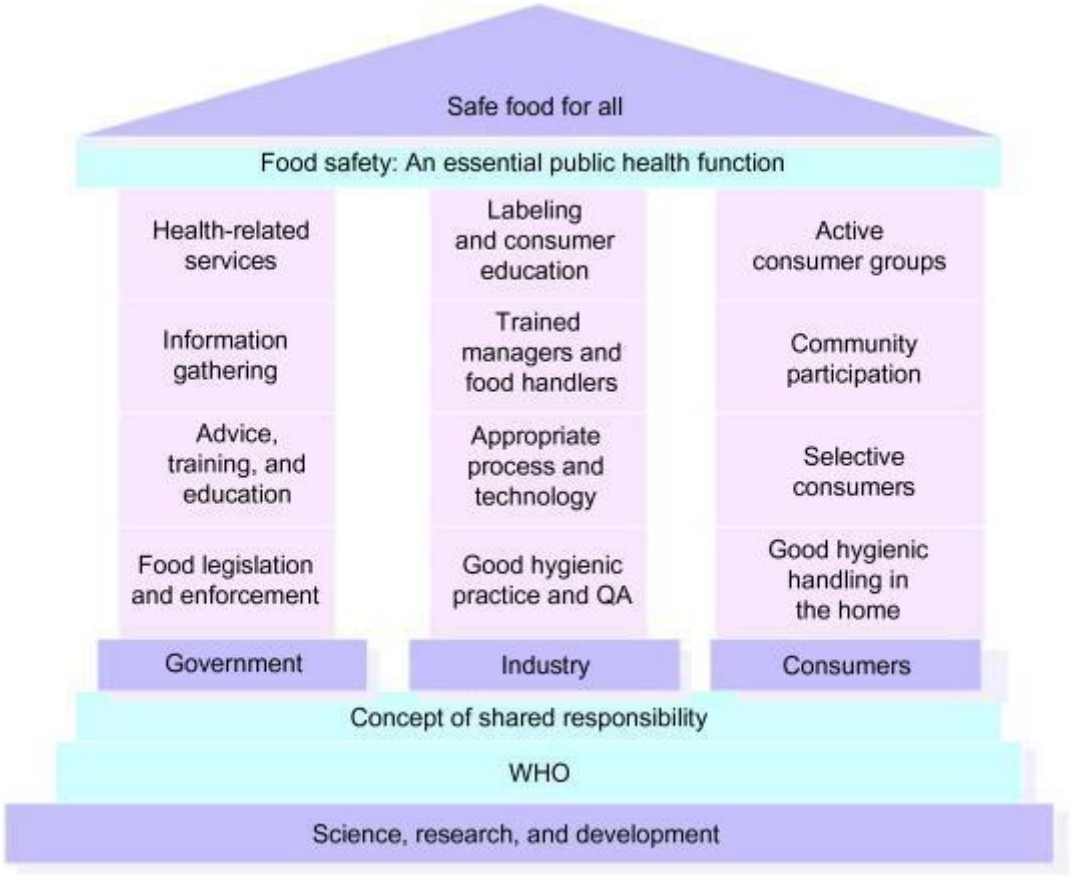

Fig. 4.1. Concept of shared responsibility according to the World Health Organisation (Motarjemi, 2014)

Good hygiene practices

Control of food hazards

The development, implementation, and maintenance of GHPs provide the conditions and activities that are necessary to support the production of safe and suitable food at all stages of the food chain from primary production through to the handling of the final product. Applied generally, they assist in controlling hazards in food products.

Knowledge of the food and its production process is essential for the effective implementation of GHPs.

GHPs manage many sources of food hazards that could contaminate food products, e.g. persons who handle food during harvest, manufacturing, and preparation; raw materials and other ingredients purchased from suppliers; cleaning and maintaining the work environment; storage and display.

As previously noted, all FBOs should be aware of and understand the hazards associated with their businesses, and the control measures required to manage these hazards, as appropriate. FBOs should consider (using external resources as needed) whether the application of GHPs alone is sufficient to manage some or all of the hazards associated with the operation through control of their sources, such as:

- control of water quality – minimises the presence of many potential hazards (e.g. biological, chemical, and physical);
- control of faecal contamination – minimises the potential for contamination with many foodborne pathogens such as *Salmonella, Campylobacter, Yersinia*, pathogenic strains of *E. coli*;
- control of food handler practices and hygiene – prevents many potential communicable diseases that could be foodborne; and
- control of food contact surfaces by cleaning – removes bacterial contaminants, including foodborne pathogens, and allergens.

After consideration of the conditions and activities in the business, it may be determined that GHPs alone may be sufficient to manage the hazards. However, it may also be determined that it is necessary to place greater emphasis on some GHPs that are particularly important for food safety (e.g. increased stringency of cleaning of a mincer for producing minced meat for raw or lightly cooked consumption compared to equipment used for producing meat to be cooked prior to consumption; increased monitoring and/or verification of disinfection of food contact surfaces).

Hazards that occur or are present at levels such that GHP procedures are not sufficient to provide safe food, should be managed by an appropriate combination of control measures that are capable of preventing the occurrence of the hazards or eliminating or

reducing them to an acceptable level. The control measures can be identified in one or more steps throughout the production process.

Primary production should be managed in a way that ensures that food is safe and suitable for its intended use. Where necessary, this will include:

- an assessment of the suitability of water used where it may pose a hazard, for example, crop irrigation, rinsing activities, etc.;
- avoiding the use of areas where the environment poses a threat to the safety of food (e.g. contaminated sites);
- controlling contaminants, pests and diseases of animals and plants, to the extent practicable, to minimise the threat to food safety (e.g. appropriate use of pesticides and veterinary drugs); and
- adopting practices and measures to ensure food is produced under appropriately hygienic conditions (e.g. cleaning and maintaining harvest equipment, rinsing, hygienic milking practices).

The types of activities involved in primary production may make eliminating or reducing some hazards difficult. However, by applying prerequisite programmes such as good agricultural practices (GAPs) and/or GHPs, steps can be taken to minimise the occurrence and level of hazards in the food chain, e.g. at milking for dairy production, steps taken in the hygienic production of eggs, or the controls on irrigation water used for growing salad crops. Not all provisions apply to all primary production situations and consideration will need to be given by the FBO on the appropriateness of the measures to be taken.

Hygienic production

The potential effects of primary production activities on the safety and suitability of food should be considered at all times. In particular, this includes identifying any specific points in such activities where a high probability of contamination may exist and taking specific measures to minimise and, if possible, eliminating that probability.

Producers should as far as practicable, implement measures to:

- control contamination from soil, water, feedstuffs, fertilisers (including natural fertilisers), pesticides, veterinary drugs or any other agent used in primary production;
- protect food sources from faecal and other contamination (e.g. zoonotic foodborne agents);
- control plant and animal health so that it does not pose a threat to human health through food consumption, or adversely affect the suitability of the product (e.g. observe the withdrawal period of veterinary drugs and pesticides, keeping records where applicable); and
- manage waste and store harmful substances appropriately.

Handling, storage and transport

Procedures should be in place to:

- sort food to remove material, which should not be used for human consumption;
- dispose of any rejected material in a hygienic manner; and
- protect food from contamination by pests, or by chemical, physical or microbiological contaminants or other objectionable substances during handling (e.g. sorting, grading, washing), storage and transport.

Care should be taken to prevent deterioration and spoilage through the appropriate measures which may include controlling temperature, humidity, and/or other controls.

Microbiological physical, chemical and allergen specifications

Where microbiological, physical, chemical and allergen specifications are used for food safety or suitability, such specifications should be based on sound scientific principles and state, where appropriate, sampling parameters, analytical methods, acceptable limits, and monitoring procedures. Specifications can help ensure that raw materials and other ingredients are fit for purpose and contaminants have been minimised.

Practical work

Consumer perceptions of risks from food

1. Students will propose how to maintain food safety and hygiene.
2. Students will propose the correct food handling practices for food.

Conclusion

Approved by

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Name, surname, signature

Date

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Theme 5

Food-borne diseases (Zoonoses)

Theoretical materials

Food-borne diseases are among the most widespread public health problems. These growing problems may be biological or chemical in nature.

The following factors play a role in the epidemiology of emerging food-borne problems:

- ***Changes in the pathogens****.* Microbial adaptation through natural selection is a key process in the emergence of pathogens.
- ***Development****.* Economic and technical developments have introduced new foods. New production systems or environmental changes increase access to certain foods.
- ***Poverty and pollution.***
- ***Dietary habits.***
- ***Health sector****.* Many governments are under increasing pressure to reduce staff and decentralise and privatise their health systems.
- ***Demographic changes*****.**
- ***Travel and migration***.
- ***Trade in food, animal feed and animals***.
- ***New food vehicles of transmission***. An array of new food vehicles of transmission have been identified, including street food. While undercooked foods of animal or marine origin were traditionally implicated in outbreaks of food-borne illnesses, increasing attention is now being focused on items such as fruit, vegetables and apple cider.

Biological or chemical agents

Bacteria

***Escherichia coli* O157.** Referred to as enterohaemorrhagic *E. coli* (EHEC), this pathogen produces toxins known as verotoxins. Transmission to humans is principally through the consumption of contaminated foods, such as raw or undercooked meat products and raw milk. Freshly pressed apple juice or cider, yoghurt, cheese, salad vegetables and cooked maize have also been implicated. Faecal contamination of water and foods, as well as cross-contamination during food preparation, can lead to infection, as can person-to-person contact. It is a major cause of bloody and non-bloody diarrhoea and often leads to long-term complications such as haemolytic uraemic syndrome.

Enteroaggregative *Escherichia coli.* Enteroaggregative *E. coli* (EAEC) has increasingly been recognised as an agent of a watery mucoid diarrhoea - especially in children - in

developing and, recently, industrialised countries. It is particularly associated with persistent diarrhoea (lasting for more than 14 days), a major cause of illness and death.

Listeria monocytogenes. This ubiquitous microorganism has been isolated from various environments, including decaying vegetation, soil, animal feed, sewage and water. It is resistant to diverse environmental conditions and can grow at temperatures as low as 3 °C. It is found in a wide variety of raw and processed foods - such as milk and cheeses, meat (including poultry) and meat products, and seafood and fish products - where it can survive and multiply rapidly during storage. *L. monocytogenes* is responsible for opportunistic infections, preferentially affecting individuals whose immune systems are weakened, including pregnant women, newborn babies and the elderly. It primarily causes meningitis, encephalitis or septicaemia and, when pregnant women are infected, it can lead to abortion, stillbirth or premature birth.

Multidrug-resistant *Salmonella typhi-murium* DT 104. This microorganism has been isolated from cattle, poultry, sheep, pigs and horses. Antimicrobial therapy is used extensively to combat *S. typhimurium* infection in animals, and the evolution of a strain resistant to the commonly used antibiotics has made infections with *S. typhimurium* in food animals difficult to control. The primary route by which humans acquire the infection is through the consumption of a large range of contaminated foods of animal origin.

Salmonella enteritidis. This bacterium is the dominant cause of human salmonellosis in many parts of the world. Poultry, eggs and egg products, in particular, are contaminated, but the microorganism has also been found in other foodstuffs such as ice cream. Cross-contamination, undercooking and inadequate cooling procedures promote the spread and growth of salmonella during processing and handling. One important characteristic of *S. enteritidis* is its ability to contaminate the contents of intact egg shells. Manifestation of illness includes invasive disease and reactive arthritis.

Campylobacter jejuni. Most sporadic infections with this pathogen are associated with improper preparation or consumption of mishandled poultry products. Most *C. jejuni* outbreaks, which are far less common than sporadic illnesses, are associated with the consumption of raw milk or unchlorinated water. Campylobacteriosis may lead to Guillain-Barr syndrome, a cause of flaccid paralysis. The reservoirs of this organism include poultry, cattle, swine, sheep, rodents and birds.

Vibrio vulnificus. The consumption of raw molluscan shellfish that are contaminated with this microorganism, which is a normal inhabitant of some marine environments, often leads to primary septicaemia and death. Individuals most susceptible to infection with this agent include those with chronic liver disease or chronic alcoholism, or those who are immunosuppressed in some way.

Streptococcus parasanguinis. Pure isolates of this bacterium were recovered from two sheep in Spain during a recent bacteriological survey to determine the prevalence of subclinical mastitis. As this bacterium has been associated with the development of

experimental endocarditis, its presence at relatively high concentrations in apparently healthy sheep's milk may pose a health risk in persons with predisposing heart lesions.

Viruses

Hepatitis E. The hepatitis E virus (HEV) usually enters the body through water or food, especially raw shellfish that has been contaminated by sewage. Anti-HEV activity has been determined in the serum of a number of domestic animals in areas with a high endemicity of human infection, indicating that this may be an emerging zoonosis.

Norwalk virus and Norwalk-like viruses. These agents cause mild to moderate disease with gastrointestinal symptoms. Outbreaks have been associated with the consumption of contaminated drinking-water and food, especially raw or undercooked shellfish.

Protozoa

Cyclospora cayetanensis. This coccidian parasite occurs in tropical waters worldwide and causes watery, and sometimes explosive, diarrhoea in humans. It was initially associated with water-borne transmission but has also been linked to the consumption of raspberries, lettuce and fresh basil. The incubation period is one week after the ingestion of the contaminated food and the agent is shed in the faeces for more than three weeks.

Toxoplasma gondii. The primary hosts of this protozoan are cats, and human infection takes place when contact is made with their faeces. It can also occur through the ingestion of raw or undercooked meat from intermediate hosts, such as rodents, swine, cattle, goats, chicken and birds. Toxoplasmosis in humans often produces mononucleosis-type symptoms, but transplacental infection can result in foetal death if it occurs early in pregnancy. In immunocompromised individuals infection can cause pneumonitis, myocarditis, meningoencephalitis, hepatitis, chorioretinitis or combinations of these. Cerebral toxoplasmosis is often seen in AIDS patients.

Cryptosporidium parvum. The mode of transmission of this coccidian protozoan is faecal to oral, including water-borne and food-borne means. The reservoirs include humans and domestic animals, including cattle. Oocysts can survive in the environment for long periods; they remain infective and are capable of resisting chemicals used to purify drinking-water. They can, however, be removed from water supplies by filtration. Symptoms of cryptosporosis in humans include fever, diarrhoea, abdominal pain and anorexia. The disease usually subsides within 30 days, but may be prolonged and even fatal in immunodeficient individuals.

Helminths

The genus Anisakis. Anisakiasis is an infection of the human intestinal tract caused by the ingestion of raw or undercooked fish containing larval stages of the nematodes *Anisakis simplex* or *Pseudoterranova decipiens*. Infections caused by the latter roundworm are not a serious threat to human health, but those caused by *A. simplex* are more problematic because this agent penetrates the gastrointestinal tissue and causes disease that is

difficult to diagnose. The primary hosts are warm-blooded marine mammals such as seals, walruses and porpoises. Their larvae pass via krill to fish such as cod, pollock, halibut, rockfish, salmon and herring.

Unconventional agents

Prions

Transmissible spongiform encephalopathies in animals and humans are caused by an unconventional virus or prion. These conditions include scrapie in sheep, bovine spongiform encephalopathy (BSE or mad cow disease) in cattle and Creutzfeldt Jacob disease (CJD) in humans. It is commonly accepted that BSE was first caused in the United Kingdom when cattle were fed carcass meal from scrapie-infected sheep. It is also accepted that humans contracted the non-classic form of CJD after consuming cattle meat, in particular nerve tissue.

Mycotoxins[1]

Mycotoxins are the toxic products of certain microscopic fungi which, in some circumstances, develop on or in foodstuffs of plant or animal origin. They are ubiquitous and widespread at all levels of the food chain. Hundreds of mycotoxins have been identified and are produced by some 200 varieties of fungi. The most important ones from the food safety point of view are discussed individually in the following sections. In terms of their implications for human health and the economy, mycotoxins are by far the most important contaminants of the food chain.

Of particular importance in current toxicological studies are the combined and possible synergistic effects that some of the mycotoxins may have on human and animal life.

Fumonisins. Fumonisins are a group of fusarium mycotoxins occurring worldwide in maize and maize-based products. Their causal role in several animal diseases has been established. Available epidemiological evidence suggests that there is a link between dietary fumonisin exposure and human oesophageal cancer in some locations with high disease rates. Fumonisins are mostly stable during food processing.

Zearalenone. This fungal metabolite is mainly produced by *Fusarium graminearum* and *F. culmorum*, which are known to colonise maize, barley, wheat, oats and sorghum. These compounds can cause hyperoestrogenism and severe reproductive and infertility problems in animals, especially in pigs, but their impact on human health is difficult to evaluate.

Trichothecenes. These mycotoxins are produced by many species of the genus Fusarium. They occur worldwide and infect many different plants, most notable of which are the cereal grains, especially wheat, barley and maize. There are over 40 different trichothecenes, but the best known are deoxynivalenol and nivalenol. In animals they

cause vomiting and feed refusal, and also affect the immune system. In humans they cause vomiting, headache, fever and nausea.

Ochratoxins. These compounds are produced by *Penicillium verrucosum* and by several species of *Aspergillus*. The major dietary sources are cereals, but significant levels of contamination can be found in grape juice and red wine, coffee, cocoa, nuts, spices and dried fruits. Contamination may also carry over into pork and pig blood products and into beer. Ochratoxin is potentially nephrotoxic and carcinogenic, the potency varying markedly among species and sexes. It is also teratogenic and immunotoxic.

Pesticide residues

Restrictions are now being placed on some of the older organochlorine pesticides because of their environmental persistence and their potential accumulation in fatty tissues. Although exposure to these pesticides is usually below acceptable daily intake (ADI) levels, breastmilk in both developed and developing countries has occasionally been found to contain relatively high levels of organochlorine pesticides. It has also been found that, although there may be a high variability in residue levels of pesticides in individual units of commodities, this is unlikely to cause any direct adverse health effects.

Veterinary drugs

The intake of veterinary drug residues in food at levels below the ADI is also considered to be safe. In recent years, however, growing concern has been expressed about the development of antimicrobial drug resistance. Some important contributing factors to the development of this resistance are the widespread use of veterinary drugs, the misuse of such drugs and the feeding of low doses to animals in order to promote weight gain and improve feed efficiency. Resistant microorganisms may be passed on to humans via food originating from the animals that harboured them. In addition, the development of resistance may also lead to the application of larger and larger therapeutic doses to food producing animals.

Environmental contaminants

Chemicals such as dioxins, chlorinated biphenyls, furans and heavy metals may contaminate the environment as a result of industrial activities. From the environment, these chemicals may enter the food chain via plants or animals and cause a variety of health problems. These are considered as emerging problems in countries that are in the early stages of industrialisation.

Biotechnology

The production of genetically modified foodstuffs offers tremendous opportunities and benefits for future food production. However, the emergence of this new technology has also given rise to a number of problems, although such problems are often regarded as potential or perceived, rather than real. The concerns that have been expressed relate mainly to changes in the nutritional quality of food, an increase in toxicity or hazards with

respect to food intolerances or food allergies, and the development of antimicrobial resistance.

Other agents

Other food-related problems or agents, such as cholera, "aeromonas" and rotavirus may be added to the list, but differences of opinion as to what is regarded as emerging will not have any impact on the basic issues at stake.

Practical work

Challenges in emerging food – borne diseases.

Students will work in groups. Students will work with the Internet.

1. Students will search for diseases, assign to them the causative agent and the type of food where the pathogenic microorganism is most often found. They mark the data in the table Ways to prevent against food-borne diseases (table 5.1).

2. Students will look for ways to prevent foodborne illnesses (food handling methods, use of natural/synthetic antimicrobials to protect food) (table 5.2).

Proposal of antimicrobials against food borne pathogens.

Table 5.1. Most often foodborne diseases and causative agents

Microorganism	Food	Disease

Table 5.2. Methods of protection against foodborne diseases

Foodborne disease	Prevention	Antimicrobials (Synthetic/natural)

Conclusion

Approved by

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Name, surname, signature

Date

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Theme 6

Food fraud and authenticity

Theoretical materials

The determination of food authenticity and the detection of adulteration have become an important question in quality control and food safety. Indeed, consumer awareness has increased about food quality and safety, geographical origin, and agricultural practices, mainly after the spread of foodborne diseases around the world.

The replacement of original substance partially or completely with more easily available and cheap substance is the most common procedure performed by fraudsters such as the addition of:

- flavours/aromas to improve the value of cheap products;
- and/or cheap substances to the food products.

Types of food fraud

Several types of fraud exist, as it can be seen in the figure below. They can appear alone or in a combination in the food fraud.

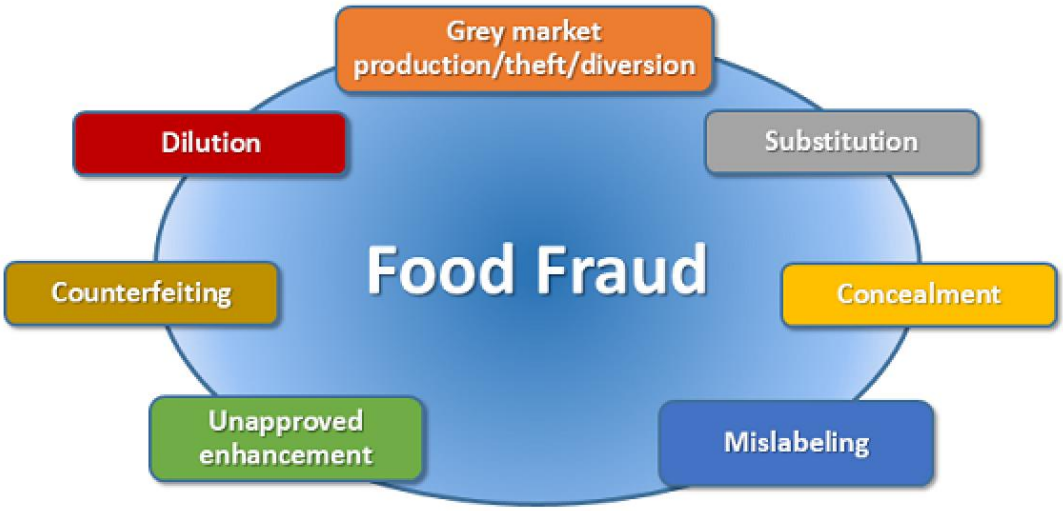

Fig. 6.1. Types of food fraud (Food Fraud | Knowledge for policy (europa.eu))

Dilution - mixing a liquid ingredient of high value with a liquid of lower value.

Substitution - replacing an ingredient, or part of the product, of high value with another ingredient, or part of the product of lower value.

Concealment - hiding the low quality of food ingredients or product.

Mislabelling - placing false claim on packaging for economic gain.

Unapproved enhancement - adding unknown and undeclared materials to food products to enhance the quality attributes.

Counterfeiting - copying the brand name, packaging concept, recipe, processing method, etc. of food products for economic gain.

Grey market production/theft/diversion - sale of excess unreported product.

Products of Plant Origin: Cultivar and Variety Identification

Certain food and feed products may possibly originate from different botanical origin, which influences their applicability in food and feed. For example, dried distillers grains with solubles, which are a by-product from the bioethanol production and mainly used in animal feed, can originate from different cereals, such as maize and wheat. The large variation in the composition can contribute to imbalanced feed formulations.

Products of Animal Origin: Species Identification

Authenticity investigations revealed that in certain countries in 15–39% of the meat products, such as hamburgers and sausages, animal species were not declared on the label. Also, more expensive, more authentic meat can be (partly) substituted with cheaper, less authentic meat tissues or species. For example, different cuts of beef that were interchanged can be analytically distinguished. The horsemeat scandal is a more recent example where beef was (partially) substituted with horsemeat for economic gain.

Food adulteration

An adulterant is a chemical substance, which should not be contained within other substances (e.g. food, beverages) for legal or other reasons. The addition of adulterants is called adulteration.

Adulterated food, according to the Food Code, is food, in which the appearance, taste, composition, or other characters are changed and its quality decreased, but is offered to the consumer as the usual food under a common name or by other false name.

Food is considered adulterated when the food article:

- consists of any filthy, putrid, decomposed or diseased animal or vegetable material;
- is insect infested or unfit for human consumption;
- is prepared, packed or stored under unsanitary conditions;
- contains any poisonous ingredients; has been substituted by any inferior or cheaper substance;
- is packed in a container of any poisonous or deleterious substance;
- has any unpermitted additive or has a permitted additive present in an amount exceeding the prescribed limit.

Notable incidents of adulteration

- In 1987, Beech Nut paid $2.2 million in fines for violating the Federal Food, Drug, and Cosmetic Act by selling artificially flavoured sugar water as apple juice.
- In 1997, ConAgra Foods pled guilty to federal criminal charges that one of its units illegally sprayed water on stored grain to increase its weight and value.
- In 2007, samples of wheat gluten mixed with melamine, presumably to produce artificially inflated results from common tests for protein content, were discovered in many U.S. pet food brands, as well as in human food supply.
- In 2008, significant portions of China's milk supply were found to have been contaminated with melamine. Infant formula produced from melamine-tainted milk killed at least six children and were believed to have harmed thousands of others.
- In 2012, a study in India conducted by the Food Safety Standards Authority of India (FSSAI) across 33 states found that milk in India is adulterated with detergent, fat and even urea, as well diluted with water. Of the 1791 random samples from 33 states, just 31.5% of the samples tested (565) conformed to the FSSAI standards while the rest 1226 (68.4%) failed the test.

Categories of adulteration

- ***Replacement:***

Complete or partial replacement of a food ingredient or a valuable authentic constituent with a less expensive substitute with the intention of circumventing the “origin” and false declaration of the “process”.

- ***Addition:***

Addition of small amounts of non-authenticated substances to mask inferior quality ingredient.

- ***Removal:***

Removal of authentic and valuable constituent without the purchaser’s knowledge.

Reasons of adulteration

When the supply is less than the demand.

To cut down the product costs to meet the market competition.

To earn more profit.

Shortage of authentic ingredients at affordable prices.

Shortage of qualified personnel and lack of modernisation of processing techniques.

Inadequate knowledge of the consequences and associated food safety risks.

Methods for food authentication and adulteration

Chromatographic techniques

Despite their complexity, chromatographic techniques are among the most important methods used in food authentication and adulteration. These techniques are usually classified according to the character of the stationary and the mobile phases, the form of the stationary phase, and the driving forces of separation. Gas chromatography (GC) and high-performance liquid chromatography (HPLC) are the most used techniques.

Spectroscopic techniques

Spectroscopic techniques such as UV-Vis spectrometry, fluorescence, infrared, EN, NMR and stable isotope analysis are widely used in food authentication. These powerful methods, and the computer technology necessary to use them, have only become readily available in recent years, but their use has become a significant feature for the above mentioned techniques.

Enzymes in food authentication

Enzymes are essential constituents of living organisms and are responsible for postharvest and post-mortem changes in foods.

In food products, enzymes have been used in several applications following the release of specific compounds that could characterise the quality of the product. The most relevant examples of enzymes application involved the: (1) determination of the position partition of fatty acids in triglycerides by pancreatic lipase; (2) establishment of the heat treatment intensity used in dairy products by alkaline phosphatase and peroxidase; and (3) quantification of several components in various food products.

DNA-based methods in food authentication

DNA based methods are of increasing importance for the determination of the quality of food products. The polymerase chain reaction (PCR) has been used for the: authentication of meat products, medicinal plant species, fruit juices , milk species in cheeses, and authentication of olive oil; meat species identification; and differentiation of fish species.

Differential scanning calorimetry

Differential scanning calorimetry (DSC) is a thermoanalytical technique in which the difference in the amount of heat required to increase the temperature of a sample and reference is measured as a function of temperature.

Practical work

Food authentication methods – food authenticity databases

Work with authenticity databases (Authenticity databases - FoodAuthenticity document library)

Students will find the most often adulterated food in year 2023 – Students will find 10 adulterated food, they will write authentication method.

Table 6.1. Methods of food adulteration and authenticity

Product	Adulteration	Method

Conclusion

Approved by

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Name, surname, signature

Date

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Theme 7

Chemical safety

Theoretical materials

Chemical substances play an important role in food production and distribution. As food additives, they prolong the shelf life of foods and, as colours and flavourings, they may make foods more attractive. Other chemicals are pharmacologically active and therefore used to fight diseases in farm animals and on crops.

Many raw food materials contain chemicals, which, if consumed in excess, might lead to health problems. Cooking and processing in general can remove or inactivate many chemicals (e.g. protease inhibitors, lectins) that are either directly toxic or inhibit digestion or absorption of nutrients. However, some chemicals have arisen as problems associated with food processing techniques developed in the last 100 years or so, e.g. trans fatty acids resulting from chemical hydrogenation of unsaturated fats, or 3–monochloropropanediol from the chemical hydrolysis of proteins. One recently publicised example of a process-derived chemical hazard in food is the formation of acrylamide in baked products.

Other hazards are contaminants introduced by accident during the production of the raw food materials - sometimes these are unavoidable and sometimes they are, to a greater or lesser extent, caused by poor growing, post-harvest or processing conditions. Mycotoxins produced by moulds on grain or nut products are one example; nitrate accumulation in leafy vegetables, and heavy metal accumulation in seafood are others.

Chemical hazards can be divided into five broad categories:

Inherent ('Natural') toxins

Natural and environmental contaminants

Process and storage-derived contaminants

Deliberately added contaminants

Pesticides and veterinary residues

Natural toxins

These chemicals occur as regular constituents of the food in question (e.g. lectins in kidney beans), or at increased levels as a response of the foodstuff to some sort of stress (e.g. glycoalkaloids in potatoes, an increased production of which can be stimulated when the tuber is exposed to light), and are inherent to the food raw material. There are also some instances of a processing regime potentially releasing a toxin from a nontoxic starting material (as occurs with cyanogenic glycosides in some canned stone fruit).

Lectins

Lectins occur in a wide variety of plants including beans of the Phaseolus genus (e.g. kidney beans and lima beans), broad beans, castor beans, soya beans, lentils, peas, field beans, peanuts, potatoes and cereals, as well as a range of non-food plants.

Raw kidney beans are significantly toxic due to the presence of lectins and must be cooked adequately before consumption.

Glycoalkaloids

Potato glycoalkaloids are a good example of naturally occurring toxins that can and have caused problems when consumed in large quantities, but which we have learned to avoid without too much difficulty.

Oxalates

Oxalic acid and oxalates are widely distributed in plant foods, with the highest levels being found in spinach (0.3-1.2%), rhubarb (0.2-1.3%), tea (0.3-2.0%) and cocoa (0.5-0.9%). Although there is no question that the ingestion of sufficient oxalic acid as crystals or in solution can be fatal, there is considerable debate as to whether serious food poisoning from oxalate is usually due to food.

Natural and Environmental Contaminants

All plants and animals during their lifetime will accumulate various chemicals from their environment. Some of these chemicals, if they are accumulated at high enough levels, might be of toxicological significance to us when we eat the food. Specific examples that are of concern are nitrates in leafy vegetables, heavy metals in various foods, and specific toxins in shellfish. In many cases, the best way to control levels of these unwanted substances is to control the environment in which the food is produced. However, this is generally a long-term control measure and more immediate steps have to be taken to protect human health. These contaminants are divided below into 'natural' (of biological origin) and 'environmental', but they are linked in that the food plant or animal acquires them from its surroundings during its growth.

'Natural' Contaminants

Mycotoxins

Mycotoxins are a group of chemically diverse and naturally occurring substances produced by a range of filamentous fungi or moulds. They have toxic effects on both humans and animals ranging from acute toxicity and death, through reduced egg and milk production, lack of weight gain, impairment or suppression of immune function to tumour formation, cancers and other chronic diseases. The mycotoxins of greatest concern are produced by mould species from three main genera - *Aspergillus, Penicillium* and *Fusarium*.

Aflatoxins

Aflatoxins are produced mainly by some strains of *Aspergillus flavus* and most, if not all, strains of *A. parasiticus*. There are four main aflatoxins, B1, B2, G1 and G2, plus two additional ones that are significant, M1 and M2. The aflatoxins are potent liver toxins in most animals and carcinogens in some, with aflatoxin B1 being the most toxic and carcinogenic. Mould growth and aflatoxin production are greatest in warm temperatures and high humidity, particularly in tropical and sub-tropical regions, mainly on corn (maize), peanuts, cottonseed and tree nuts.

Ochratoxins

Ochratoxins are a group of related compounds produced by Aspergillus ochraceus and related species, as well as Penicillium verrucosum. The main toxin in the group is Ochratoxin A, which causes liver damage in rats, dogs and pigs. Ochratoxins are also teratogenic to mice, rats and chicken embryos, and are now thought to be carcinogenic in humans.

Patulin

Patulin is produced by numerous *Penicillium* and *Aspergillu* species and by *Byssochlamys nivea*. However, the most common producer of patulin is Penicillium expansum, which occurs commonly in rotting apples, as a result of which patulin has frequently been found in commercial apple juice. Patulin is toxic to many biological systems, including bacteria, mammalian cell cultures, higher plants and animals. Its role in causing animal and human disease is unclear, but it is believed to be carcinogenic.

Cyclopiazonic acid (CPA)

Cyclopiazonic acid (CPA) is produced by several moulds which occur on agricultural products or are used in some food fermentations. It also occurs naturally in infected corn (maize) and peanuts. It affects rats, dogs, pigs and chickens, where it may cause anorexia, weight loss, diarrhoea, pyrexia, dehydration and other symptoms. Organs affected include liver, spleen, kidneys, and pancreas. It has the ability to chelate metal ions such as calcium, magnesium and iron, which may be an important mechanism of toxicity.

Zearalenone

Zearalenone (also known as F-2 toxin) is produced by several *Fusarium* species. It occurs naturally in high moisture corn (maize) in late autumn and winter, mainly from the growth of *F. culmorum* in Northern Europe and *F. graminearum* in North America. Production of this and other Fusarium toxins is favoured by high humidity and low temperatures, conditions which often occur in temperate regions during the autumn harvest. It has been found in mouldy hay, high-moisture corn (maize), corn infected before harvest and pelleted feed rations, so it is an important contaminant of animal feed. The involvement of zearalenone in human disease is unconfirmed, but it is regarded as an endocrine disruptor and hence a potential hazard.

Tricothecenes

The tricothecenes are a group of over 20 chemically related toxins produced by several *Fusarium* species. These include deoxynivalenol (DON), T-2 toxin, diacetoxyscirpenal, neosolaniol, nivalenol, diacetylnivalenol, HT2 toxin and fusarenon X. The most commonly occurring of these is deoxynivalenol or DON, which causes vomiting in animals, hence its other name of vomitoxin. It may also be a teratogen and has been found in commodities such as corn (maize) and wheat as well as some processed food products.

Fumonisins

The fumonisins are a group of compounds mainly produced by *Fusarium moniliforme* and *F. proliferatum*. They have been linked to several diseases, including liver cancer and oesophageal cancer in humans.

Moniliformin

Moniliformin is so called because it was first thought to be produced by *F. moniliforme* isolated from corn (maize). However, it has since been shown to be produced mainly by other species of *Fusarium*. It has been shown to be highly toxic in experimental animals, causing rapid death without severe cellular damage.

Shellfish toxins

There are several types of shellfish poisoning including neurotoxic (NSP), diarrhoeic (DSP), paralytic (PSP), amnesic (ASP), and ciguaterra fish poisoning (CFP). Shellfish toxins are not produced by the shellfish themselves, but are accumulated through the ingestion of planktonic dinoflagellates in the diet of the shellfish. The term shellfish generally refers to both marine crustaceans (lobsters, crab, shrimp etc.), and molluscs.

'Environmental' contaminants

Dioxins/Polychlorinated biphenyls (PCBs)

PCBs and dioxins are persistent contaminants with a wide range of chemical structures. They have been found in soil, water, sediment, plants and animal tissue in all parts of the world. Dioxins and PCBs are heterocyclic organic molecules, with PCBs being chlorinated. They have long half-lives in the environment and many have been reported to have toxicological effects in humans. PCBs and dioxins are man-made chemicals used by industry and their release to the environment is generally through by-products of fires and by some manufacturing processes.

Polycyclic aromatic hydrocarbons

Polycyclic aromatic hydrocarbons (PAHs) are a group of compounds comprising two or more fused aromatic rings. Many individual PAHs exist, the most simple of which is naphthalene. A variety of toxic properties have been related to PAH exposure, including the capacity to produce genotoxic and carcinogenic effects in mammals.

Heavy metals

Heavy metals are those with a high atomic mass, including, for example, mercury, cadmium, arsenic and lead, although other metals (e.g. tin) may also be included within this category of contaminant. They are natural components which originate from the earth's crust and are found all over the world. They are toxic in low amounts and have been recognised as a health hazard for many years. There are other routes for metal contamination of products such as migration from packaging (e.g. antimony from plastic bottles, and tin in canned food).

Process-derived contaminants

The production of toxic chemicals in foodstuffs through processing is a recently discovered phenomenon, although historically these chemicals will have always been present. The first three examples below serve to show how unexpected contaminants may arise. In addition, the contamination of food with chemicals from packaging, pesticide and veterinary medicine applications could also loosely be described as process-derived.

Deliberately added contaminants

There is no limit to what chemical contaminants might be deliberately added to foods during manufacture in order to cause harm to the consumer. In most cases, however, the aim is not to cause harm, but to defraud for financial gain. However, potential harm can still result, as evidenced from two of the examples given below.

Illegal or unauthorised dyes

The Sudan I-IV group of chemicals are synthetic azo dyes which have been historically used in industry to colour products such as shoe polish, automotive paints and petroleum derivatives. They are not permitted food colours.

Melamine

Melamine is an industrial chemical found in plastics. It can be combined with formaldehyde to produce melamine resin, a very durable thermosetting plastic used in Formica, and melamine foam, a polymeric cleaning product. The end products include countertops, dry erase boards, fabrics, glues, housewares, guitar saddles, guitar nuts, and flame retardants. Melamine is one of the major components in Pigment Yellow 150, a colourant in inks and plastics. It is also used in the manufacture of plasticisers for concrete.

Pesticides and veterinary residues

Pesticides

Pesticides include chemical and biological products specifically designed to control pests, weeds and diseases, particularly in the production of food. These include insecticides, fungicides, herbicides, rodenticides and molluscicides.

Pesticides are licensed for use against specific target organisms, and their use and application are strictly regulated to control the risks to the operator involved in applying them, and the surrounding environment, and to prevent significant residues being left in or on the food.

Pesticides can be classified by target organism, chemical structure, and physical state. They can be classed as inorganic, synthetic, or biological (biopesticides). Biopesticides include microbial pesticides and biochemical pesticides. Plant-derived pesticides include the pyrethroids, rotenoids, and nicotinoids.

Veterinary residues

The use of medicines used to treat animals raised for food is regulated in a similar manner to that for pesticides used on food crops. There are a wide variety of chemicals for different uses, including:

- Antimicrobials such as sulphadiazine, enrofloxacin, ciprofloxacin, chlortetracycline, amoxicillin and oxytetracycline used to control bacterial diseases.
- Painkillers and anti-inflammatory medicines such as NSAIDs, including ibuprofen and phenylbutazone.
- Dips to control external parasites, including organochlorine or organophosphorus insecticides (see above).
- Wormers to control internal parasites, such as ivermectin.
- Coccidiostats to control protozoal diseases, particularly in poultry, such as nicarbazin.
- Steroids such as boldenone.

Food contact materials (FCMs)

FCMs can be defined as materials that come into contact with food and beverages during food processing, packaging, transport, storage, cooking, or serving. Different types of FCMs, for example, plastics, paper, glass, metal, adhesives, or printing inks, can be used, solely or in combination, to produce food contact articles (FCAs). A typical FCA is food packaging, such as bottles or wraps. However, food service items (e.g. cutlery) as well as food processing equipment (e.g., conveyor belts) or transport vessels also constitute a significant proportion of FCAs overall.

FCMs and, consequently, FCAs, are made of and contain diverse chemical constituents, which can be both intentionally used and non-intentionally present, here collectively referred to as food contact chemicals (FCCs). Under certain conditions, FCCs can be transferred into food, a phenomenon called **migration**.

FCCs can be divided into two groups, intentionally added substances (IASs), i.e. substances that are deliberately used to manufacture FCMs or FCAs, and non-intentionally added substances (NIASs), i.e. substances that have not been added on purpose and do not perform any technical function, but are nonetheless present in the final FCMs or FCAs. NIASs can include impurities, contaminants, reaction by-products and side products, and degradation products.

Theme 8 Food labelling

Theoretical materials

The Food Labelling Information System

The Food Labelling Information System provides a user friendly IT solution which enables its users to select the food and automatically retrieve the mandatory EU labelling indications in 23 EU languages.

EU law on food information to consumers

Regulation (EU) No 1169/2011 on the provision of food information to consumers (FIC Regulation) entered into application on 13 December 2014. The obligation to provide nutrition information applies since 13 December 2016.

This regulation provides in particular clearer and harmonised presentation of allergens (e.g. soya, nuts, gluten, and lactose) for prepacked foods (emphasis by font, style or background colour) in the list of ingredients and mandatory allergen information for non-prepacked foods, including in restaurants and cafes. It also foresees certain nutrition information for the majority of prepacked processed foods, the mandatory origin information for fresh meat from pigs, sheep, goats and poultry and the same labelling requirements for online, distance selling or buying in a shop.

Revision of the regulation on food information to consumers

As part of the **Farm-to-Fork Strategy**, the European Commission announced to revise EU rules on the information provided to consumers. The aim of revising the FIC Regulation is to ensure better labelling information to help consumers make healthier and more sustainable food choices and tackle food waste, by proposing to:

- introduce harmonised **mandatory front-of-pack nutrition labelling** and set **nutrient profiling criteria** to restrict claims made on foods;
- extend **mandatory origin** or provenance information for certain products;
- revise the rules on **date marking** ('use by' and 'best before' dates)

Food supplements

As an addition to a normal diet, food business operators market food supplements, which are concentrated sources of nutrients (or other substances) with a nutritional or physiological effect. Such food supplements can be marketed in "dose" form, such as pills, tablets, capsules, liquids in measured doses, etc.

The objective of the harmonised rules on those products in **Directive 2002/46/EC** is to protect consumers against potential health risks from those products and to ensure that they are not provided with misleading information.

With respect to the safety of food supplements, the Directive lays down a harmonised list of vitamins and minerals that may be added for nutritional purposes in food supplements

(in **Annex I** to the Directive). **Annex II** of the Directive contains a list of permitted sources (vitamin and mineral substances) from which those vitamins and minerals may be manufactured.

Levels of vitamins and minerals in food supplements

Directive 2002/46/EC on food supplements envisages the setting of the maximum and minimum amounts of vitamins and minerals in supplements via the Standing Committee on Plants, Animals, Food and Feed (PAFF Committee) procedure.

Practical work

Labelling - food labelling information system

Students will work with PC.

Students will work with Food Labelling Information System, they will choose the food category and they will write: name of food, the list of ingredients, the date of minimum durability and special storage conditions.

Work with Food Labelling Information System: Food Labelling Information System (europa.eu).

Table 8.1. Food labelling

Food category	Name of food	List of ingedients	Minimum durability	Storage conditions

Conclusion

Approved by

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Name, surname, signature

Date

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Theme 9

Novel food

Theoretical materials

Novel food is defined as food that was not consumed to any significant degree in the EU before 15 May 1997 when the first novel food legislation entered into force. Novel food can be newly developed, innovative food or food produced using new technologies and production processes, as well as food traditionally eaten outside of the EU.

Request for a novel food authorisation

Application procedure

Food business operators can place a novel food on the European Union market only after the Commission has processed an application for the authorisation of a novel food, and has adopted an implementing act authorising the placing on the market of a novel food and updating the Union list.

Implementing Regulation (EU) 2017/2469 has also been adjusted by Commission Implementing Regulation (EU) 2020/1772 to accommodate those changes. These new provisions are applicable to applications submitted from 27 March 2021.

If the novel food is liable to have an effect on human health, the Commission will request the European Food Safety Authority (EFSA) to carry out a risk assessment.

EFSA will adopt its opinion in 9 months from the date of receipt of a valid application from the Commission.

Within the seven months from the date of the publication of the EFSA's opinion, the Commission shall submit to the Standing Committee on Plants, Animals, Food and Feed a draft implementing act authorising the placing on the market of a novel food and updating the Union list.

Once the act receives a favourable vote from the Standing Committee and is adopted and published by the Commission, the novel food can be lawfully placed on the European Union market.

The authorisation covers:

The authorisation and entry for a novel food in the Union list includes, where appropriate:

- Specifications,
- Conditions of use,
- Additional specific labelling requirements,
- Post-market monitoring requirements.

Nanomaterials in food

The term ‘nano’ (from the Greek word for ‘dwarf’) is the term use to describe those materials that have at least one external dimension that measures 100 nanometers (1 nanometer = 1 billionth of a meter). As an example, a human hair has approximately between 80 000 and 100 000 nanometers (nm.).

Nanomaterial - “any intentionally produced material that has one or more dimensions of the order of 100 nm or less or that is composed of discrete functional parts, either internally or at the surface, many of which have one or more dimensions of the order of 100 nm or less, including structures, agglomerates or aggregates, which may have a size above the order of 100 nm but retain properties that are characteristic of the nanoscale”.

The fact that nanomaterials may exhibit different characteristics than their non-nano conventional forms may also be indicative of different behaviour in biological systems leading to different hazard profiles and resulting risks for human health and the environment.

The Novel Food nanomaterial definition is similar to the general definition of Commission Recommendation C(2022)3689 but mainly differs in that:

1. it specifically refers to and defines ‘engineered nanomaterials’;
2. it does not include a percentage threshold for the content in particles of less than 100 nm above which materials are to be classified as nanomaterials. Moreover, Commission Recommendation C(2022)3689 sets that threshold at 50% of the total particles in a given material to have one or more dimension below 100 nm for the material to be classified as a nanomaterial.

Properties that are characteristic of the nanoscale (dimensions measured in nanometres) include:

- those related to the large specific surface area of the materials considered; and/or
- specific physico-chemical properties that are different from those of the non-nanoform of the same material.

Practical work

Novel Food status Catalogue

Work with novel food catalogue (Food and Feed Information Portal Database | FIP (europa.eu))

Searching for novel foods in the catalogue.

Students will work with novel food catalogue - they will look for new foods or food ingredients and characterize them.

Conclusion

Approved by

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Name, surname, signature

Date

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Theme 10

Sanitation in food industry

Theoretical materials

Definitions

CLEANING: The removal of soil particles from surfaces by mechanical, manual or chemical methods.

SANITISING: The treatment of a cleaned surface with a chemical or physical agent to destroy disease/spoilage causing organisms. Reduces the total vegetative cell population to a safe level.

DISINFECTING: Destruction of all vegetative state organisms.

STERILISING: The complete destruction of all organisms, including spores.

DIRTY: A surface that is not clean.

Sanitation practices in food operating

There are a number of precautions that must be taken before production, during production and at the end of production in order to destroy physical, chemical and biological damages in food. These precautions must be carry out during manufacturing, otherwise hygienic product can't be achievement.

Sanitation before production

There is a need for a structure which is free from physical, chemical and biological pollution sources, with hygienic production conditions and has a suitable technological infrastructure in order to produce reliable and quality food. Before the manufacturing process gets started, all materials which are used for in the manufacturing process and the manufacturing yard must be cleaned periodically.

All "food contact surface areas" including the floor in the environment where food is processed, the processing channels, the walls, all kinds of tools, machinery and equipment that come into contact with foodstuffs must be thoroughly cleaned regularly before the start of each work day to protect food from contamination. The cleanliness of the ambient air should also be controlled in the workplace where microbiological contamination is important.

Equipment that does not have a contact surface with food should also be cleaned periodically. Raw and heat-treated products must be prepared in separate rooms or on benches.

Precautions to be taken during the production

If foodstuffs are not processed using appropriate methods and techniques, the following situations can arise:

● Taste, colour, consistency and appearance become undesirable.

● The nutritional value is lost.

● The hygiene quality is lost. It is a condition that can cause health problems and food poisoning.

● It causes the producer to lose market share and reputation.

Preventive measures should be taken to prevent contamination of foodstuffs in the food processing area. For this purpose, protective clothing should be provided and kept for the visitors who should comply with all rules laid down for employees.

Precautions to be taken after the production

Cleaning is the prevention of tools, equipment and various surface dirt and food debris that come into contact with food and turn them into growth area for microorganisms. Cleaning is the reduction of visible dirt and debris as well as all of the invisible microorganisms to the point where they are not killed or harmful.

All materials which are being used during manufacturing process must be cleaned and disinfected periodically to make sure there is no any particular nor microorganism from the last process for purifying new product from the source of dirtiness. For this purpose, a control chart should be prepared at the end of the work in the field of production, these prepared schedules and forms should be filled in by the relevant persons and checked by supervisors.

Elements of cleaning and sanitising

There are many different ways to clean and sanitise equipment. These include the use of clean-in-place (CIP) systems, foaming, clean-out-of-place (COP), spraying, high pressure and manual systems. No matter which kind of cleaning and sanitising is selected, there are basic issues that must be considered.
These are summarised using the acronym TACT WINS.

T – Time	W – Water
A – Action	I – Individual
C – Concentration	N – Nature
T – Temperature	S – Surface

Time: The time required to properly clean depends on many factors including, but not limited to, the method of cleaning, the dirt and the type of equipment.

Action: This is the energy required to properly clean a surface. Action brings the cleaning compounds into contact with the dirt and enhances their removal.

Concentration: To properly clean surfaces, the processor must use the correct cleaning compound at the proper concentration. What is needed depends upon factors such as the nature of the soil, water hardness and the surface being cleaned.

Temperature: The temperature at which detergents are used affects their efficacy. Each cleaner has an optimum temperature range at which it should be used.

Water: Water is the universal solvent. The first step in cleaning is to rinse with water in order to remove gross dirt from the surface and away from the equipment. Water is also used to carry the detergents on to the surface and to carry away the soil.

Individual: Who will do the cleaning? Each person assigned to cleaning must be properly trained on each and every cleaning procedure that they will be conducting.

Nature: What products are being manufactured in each plant will determine the kind of dirt that must be removed. There are five basic kinds of soils the food industry must deal with: fats/grease, proteins, minerals, sugars and complex carbohydrates.

Surface: What is the equipment that is being cleaned made of? The most common material is stainless steel, but one sees plastics in various shapes and forms, rubber, and other metals.

Theme 11

Disinfection methods

Theoretical materials

The aim of disinfection is therefore to further reduce the surface population of viable microorganisms, by the removal or destruction, and/or to prevent surface microbial growth during the inter-production period.

Whilst there are many chemicals with biocidal properties, some common disinfectants are not used in food applications because of safety or taint problems, e.g. phenolics or metal-ion-based products. In addition, other disinfectants are used to a limited extent only in chilled food manufacture and/or for specific purposes, e.g. peracetic acid, biguanides, formaldehyde, glutaraldehyde, organic acids, ozone, chlorine dioxide, bromine and iodine compounds.

Of the acceptable chemicals, therefore, the most commonly used products for open and closed surface disinfection are:

- **chlorine-releasing components;**
- **quaternary ammonium compounds (QACs);**
- **amphoteric compounds;**
- **alcohols;**
- **peracetic acid.**

Chlorine is the cheapest disinfectant and is available as hypochlorite (or occasionally as chlorine gas) or in slow-release forms (e.g. chloramines, dichlorodimethylhydantoin). Hypochlorous acid, the disinfectant active, is produced when all of these chlorine sources are added to water.

Hypochlorous acid has a wide range of activity, including against spores, and is relatively inexpensive. However, it is readily inactivated by organic matter, and may be viewed by some as having an adverse effect on the environment. Chlorine compounds in the undiluted form are corrosive to equipment, can be hazardous to health and should always be handled with care and at the correct concentrations.

QACs (or Quats) are amphipolar, cationic detergents, derived from substituted ammonium salts with a chlorine or bromine anion. Although having little effect on spores, they are both relatively environmentally and operative friendly. It should be noted that certain alkaline compounds (anionic wetting agents) can reduce the bactericidal action of QACs.

A**mphoterics** are based on the amino acid glycine, often incorporating an imidazole group. They share similar activities and benefits with the quaternary ammonium compounds. Amphoterics are known to have good detergent/sterilising properties. They are used for manual cleaning, since they are non-corrosive and non-irritant to skin.

Alcohols are most active in the 60–70% range, rapidly lose effectiveness if diluted out of this range, and can be formulated into wipe and spray-based products. Alcohol products are used on a small, local scale because of their well-recognised health and safety issues.

Peracetic acid, which provides a rapid, broad-spectrum kill, works on the oxidation principle through the reaction with the components of cell membranes. It is particularly effective against spores. It is one of a family of acid disinfectants which are considered to be toxicologically safe and biologically active.

Physical methods of dry sanitation

Dry saturated steam (DSS), superheated steam (SHS), and hot air are examples of dry sanitisation methods. Usually, DSS with moisture content <5.0% at ≤100°C is applied until 85 °C for at least 1 minute, while SHS uses temperatures above the steam saturation point at atmosphere pressure. In fact, longer exposure time may be necessary to sanitise large areas/equipment using dry heat, for example, 170 °C/60 minutes or 150°C/150 minutes. The mechanism of action involves the denaturation of proteins, oxidative damage to free radicals, and dehydration of microbial cells.

Ultraviolet light

UV light is a nonionising radiation with a wavelength (ƛ) shorter than visible light. The range is subdivided into UV-A (315–400 nm), UV-B (280–315 nm), and UV-C (100–280 nm). The most important criterion of UV sanitisation is the total radiation received by the contact surface during treatment, known as the fluence (J/m^2). The mechanism of action involves photothermal impact caused by heating of the surface by the absorption of UV energy and the photochemical effect from the absorption of UV light by the pyrimidine and purine bases of the nucleic acid and nucleoprotein. UV-C light (254 nm) has been widely used in the food industry for water, air, and surface sanitisation.

Pulsed light

This technology consists of a sequence of white light pulses (200–1100 nm) with a broad and extremely short spectrum and with high energy, containing approximately 54% of UV (200–400 nm), 20% infrared, and 26% of visible light radiation, which is produced by pulses of xenon lamps. Its mechanism of action is close to that of UV light; it reaches the DNA of micro-organisms and inactivates the repair system, leading to irreversible damage and death. The effectiveness of PL depends on various factors, including the type of

micro-organism, the light matrix, the pulse frequency, the distance between the light source and the target, and the arrangement of the PL system.

Practical work

Examples of disinfection. Choosing the appropriate disinfectant

Write 5 chemical disinfectants, give advantages disadvantages and applications

Table 11.1.

Characterisation of selected disinfectants

Disinfectant	Advantages	Disadvantages	Application

Conclusions

Approved by

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Name, surname, signature

Date

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Theme 12 Sanitation program

Theoretical materials

An effective cleaning and sanitation program prevents contamination of a food from the hazards that can be present on equipment, food contact surfaces, and in the general premises by:

- reducing biological hazards such as pathogenic microorganisms,
- removing physical hazards like glass, plastic or metal,
- removing chemical hazards such as allergens and chemicals used for sanitising and maintenance of the equipment.

Taking steps to reduce the presence of microorganisms also prevents contamination of a food with spoilage microorganisms. This can result in a food of higher quality and a longer shelf life.

The methods of cleaning and sanitation depend on the size and complexity of the food business.

Roles and responsibilities

Food businesses are responsible for complying with the law. They demonstrate compliance by ensuring that the commodities and processes for which they are responsible meet regulatory requirements. If a written Preventive Control Plan (PCP) is required, the food business develops a PCP with supporting documents, monitors and maintains evidence of its implementation, and verifies that all control measures are effective.

Cleaning and sanitation program

There are **three steps** used in the development of a Cleaning and Sanitation Programme:

1. **Gather key information**
    - this includes: who, where, what, when and how to clean and sanitise. Because this information will form the basis of the Cleaning and Sanitation Programme, the more detailed the information, the more effective the program will be.
2. **Develop templates for records**
    - when completed, these records provide evidence that the cleaning and sanitising activities have been completed and are effective.

Step 1. Gather key information needed to develop the Cleaning and sanitation programme

- What method of cleaning and sanitising is required? For example:

    - for clean-in-place (CIP), equipment is cleaned by an accepted in-line CIP system,
    - for clean-out-of-place (COP), equipment is disassembled for hand cleaning,
    - dry-cleaning, where no water or liquids are used, procedures involve activities such as vacuuming.
- Are special equipment or utensils needed to clean and sanitise? If so, how are they to be used?
- Will gloves, safety goggles, aprons or other personal protective equipment be worn? Are there other protective measures to be taken in to prevent food or food contact surface contamination?
- What are the procedures for taking equipment apart for cleaning and sanitising as well as re-assembling it after cleaning and sanitising? Identify any parts that will require special attention.
- What measures will be taken to protect food or packaging materials from contamination during cleaning and sanitising activities? Is cleaning done during or post processing?
- What types of materials (for example, fat, protein, sugar stone, mineral deposits) will have to be removed from equipment surfaces during cleaning and sanitising activities?

Who?

- Identify all persons or positions that will be responsible for cleaning and sanitising activities.

Where?

- Identify each room or area required to be cleaned and sanitised.

What?

- For the rooms or areas to be cleaned and sanitised, specify:
    - The type and concentration of cleaning compounds and sanitisers and cleaning tools used,
    - All equipment, including utensils, structures and surfaces such as food contact surfaces, walls, floors, drains, ceilings and overhead assemblies to be cleaned and sanitised.

When?

- Choose the frequency of cleaning and sanitising based on the risk of contamination of the food, area, room, type of equipment, food contact surfaces and structures. For instance, will cleaning and sanitising be done daily, weekly, monthly, yearly, or at another frequency?

- If cleaning and sanitation is taking place during production, specify at what point during the production and what precautions are in place to prevent contamination of food.

How?

- Provide step-by-step details on how the cleaning and sanitising is to be performed.
- Identify procedures to be followed to make sure the activities are conducted in a manner so that food or food contact surfaces are not contaminated.
- Identify any general housekeeping, such as sweeping and tidying up that will help in maintaining the establishment, facilities, equipment and conveyances in a clean and sanitary condition.

Include any special instructions required in the cleaning and sanitation process, for example:

- set up instructions for CIP systems, for example, moving piping lines or opening and closing certain valves,
- pre-rinse instructions,
- cleaning and sanitising chemicals to be used and their rotation,
- chemical mixing and handling instructions,
- appropriate chemical concentrations as per product labels,
- temperature of water or cleaning solutions,
- solution pressures,
- surface contact time…

Evidence of effectiveness

Next obtain evidence that the cleaning and sanitising procedures conducted are effective.

Step 2. Develop templates for records

Cleaning and sanitising activities should be recorded on a standardised form that indicates:

- who is responsible for the cleaning and sanitising,
- cleaning and sanitising activities that have to be completed,
- chemicals used, solution temperatures, chemical concentrations,
- date and time,
- verification that activities have been satisfactorily completed.

Step 3. Implement the cleaning and sanitation programme

Once the Cleaning and Sanitation Programme has been determined to be effective and the people who will be doing the cleaning and sanitising have been trained to perform their assigned duties, the sanitation programme is now ready to be put into action.

Practical work

Preparing of Sanitation program

Prepare a cleaning and sanitation programme for food service facilities.

Table 12.1.

List of all cleaning and sanitising agents instructions for mixing

Cleaning or Sanitising Agent and Concentration	Instructions for mixing

Table 12.2.

Cleaning and sanitizing requirements

Item/Area to be Cleaned/Sanitised	Procedure and Concentration Used	Frequency

Table 12.3.

List of pest control measures/pesticides in use

Name Pest Control Measure/ Pesticide	Intended Use	Storage Requirements

Table 12.4.

Cleaning schedule

Cleaning schedule					
AREA	Daily	Weekly	Monthly	Annual	Other (specify)
Kitchen					
Walls / Ceiling					
Storage Areas					
Staff Washrooms					
Work Surfaces					
Floor					
Equipment					
Walk-in Cooler/Freezer					
Inside Fridges/Freezers					

Grill/Fume Hood					
Under/Behind Equipment					
Dishwasher					
Miscellaneous					
Cutting Boards					
Meat Slicers					
Microwaves					
Garbage Cans					
Laundry					
Mixers					
Dining area					
Walls/Ceiling Public					
Tables/Chairs					
Servers Station					
Washroom					

Theme 13

Microbial biofilms in food industry

Theoretical materials

Biofilm refers to microorganisms of complex, sessile communities seen affixed to a surface or fixed firmly in an extracellular matrix aggregates. They are a microbial mass on the interfaces, and they remain as microbial contamination origin in medical field and other industries, especially in food processing industry.

Biofilm formation/development

Biofilm is an assemblage of cells of microorganisms, usually embedded in a matrix of bacterial self-produced extracellular polymeric substances (EPSs), which is permanently connected with a surface.

(1) Planktonic microorganisms are initially approaching a surface in an aqueous medium for attachment (Donlan, 2002);

(2) permanent sticking based on the generation of microorganism-mediated EPSs, as polyhydroxy groups in EPSs colonise bacteria to the surface via hydrogen bonding (Kjelleberg et al., 2007);

(3) monolayer microcolonies formation on the surfaces that are fixed as a result of replication by initial colonisers (Guzmán-Soto et al., 2021) and advancement of the biofilm into a three-dimensional disposition by affixing debris from the environment that is adjacent and by exerting new planktonic bacteria (Guzmán-Soto et al., 2021);

(4) lastly expansion or dispersion in which sessile, matrix-encased biofilm cells change to planktonic bacteria that freely swim through quorum sensing (QS) or a cell-to-cell signalling mechanism by active and passive processes (Webb, 2007);

(5) the cycle begins again.

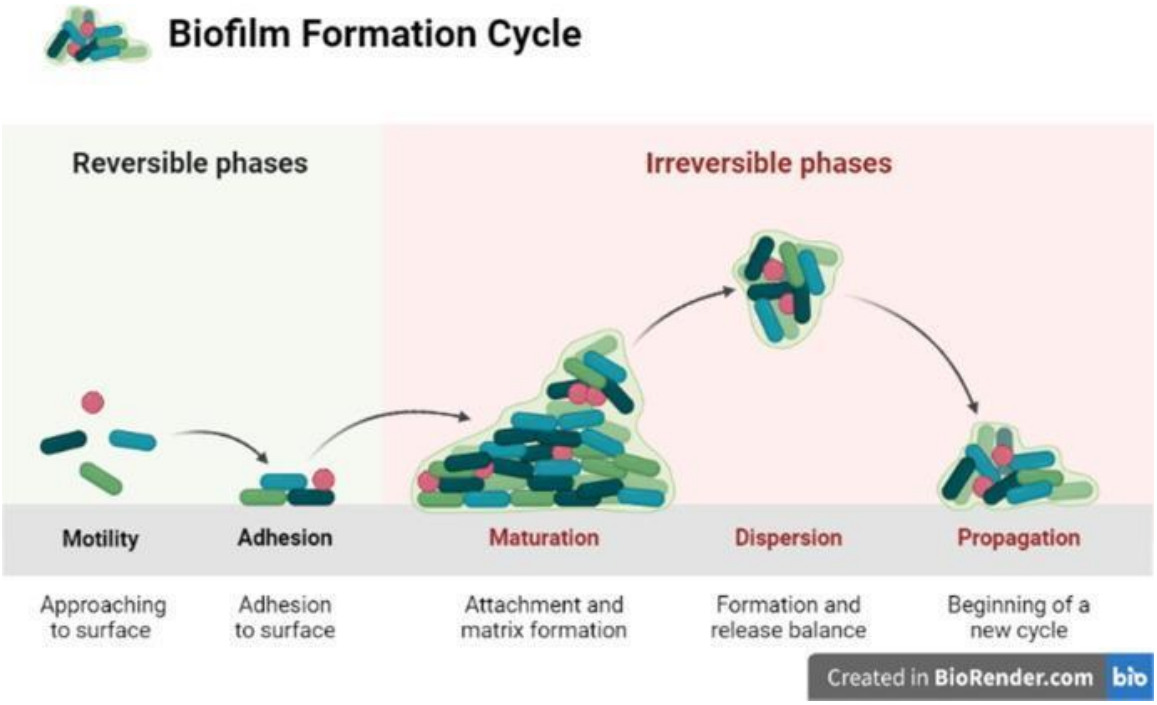

Fig. 1. Biofilm development stages (Olanbiwoninu and Popoola, 2023)

Formation of biofilms in the food industry

In the food industry, usually the surfaces and equipment with food and non-food-contact are regularly colonised by microorganisms that can form biofilms. The extracellular matrix formed during biofilm production is mainly a collection of polysaccharides, such as exogenous DNA or proteins, cellulose. This matrix plays an important role in adhering to hard surfaces (meat, fruit, bones, food industry equipment, etc.). The powerful tenacity of these biofilms in the food industry is as a result of the structural role of the extracellular matrix, which produces complex gradients regarding oxygen diffusion and nutrients, having enzymes (extracellular) used for the purpose of nutrition. This shields the cells embedded against compounds that are toxic and permits for the movement of cell communication molecules.

Control strategies

In the food industry, both physical and chemical approaches have been studied to inhibit bacterial biofilms. Previous studies have proven that mechanical treatment such as clean-in-place cannot remove all of the bacterial cells, while chemical treatment has some contributions to eliminate bacterial cells and inhibit biofilm formation. It was found that sodium hypochlorite (NaClO) acts as a potential disinfectant capable of inhibiting bacteria, while, the bacteria proliferation may happen under higher concentrations of disinfectants, which created conditions for the biofilm formation.

Physical techniques for biofilm cleaning

Ultrasound (US)

As a chemical-free approach, ultrasonic sterilisation presents potential utility for inactivating bacteria and preserving nutritional composition. Furthermore, it is a more environmentally friendly method of cleaning surfaces in the food industry. It was reported that direct-contact low-frequency ultrasound treatment could reduce the biofilm cell density of *S.aureus* by approximately 70%.

Ultraviolet (UV)

As a conventional technique, ultraviolet irradiation has been used to remove biofilms in the food and medical fields for decades. It has prominent advantages in having broad antimicrobial capability and is free of chemical residues. UV wavelengths from 200 to 300 nm, especially ∼260 nm, could effectively damage cell nucleic acid molecules, leading to cell inactivation and biofilm dispersion.

Magnetic fields with magneto-materials

With the rapid development of biofilm resistance, developing new antimicrobial approaches that are more efficient and faster acting is urgent. Magnetic fields combined with magneto-materials are considered as next-generation technologies for biofilm cleaning. Magneto-materials can easily penetrate the cell membrane and lead to cell lysis under the influence of magnetic fields, which makes them more efficient for biofilm elimination.

Chemical addition for biofilm removal

Compared to various physical methods, the addition of biochemical substances is more convenient and economical. Chemical disinfectants such as surfactins, antibiotics and natural compounds extracted from plants exhibit strong biofilm inhibition capability. Here, we will mainly describe two different chemicals, amino acids and vitamins, as representatives of spices and nutrient fortifiers for biofilm inhibition. These two additives exhibit extraordinary biofilm inhibitory capability and are almost of no harm to food safety compared to other chemical sanitisers.

Table 13.1.

Other food additives and some essential oil inhibit biofilm formation.

Substances	Inhibited microorganism	Source	Application
L-carvone	*Hafnia alvei*	Caraway	Spices
Cinnamaldehyde	*Pseudomonas fluorescens*	Cinnamon	Chewing gum
Caffeine	*Pseudomonas aeruginosa*	Coffee bean	Beverage

Substances	Inhibited microorganism	Source	Application
Tyrosol	*Candida albicans*	Olive	Flavouring agent
D-galactose	*Fusobacterium nucleatum*	Milk	Flavouring agent
Zeaxanthin	*Pseudomonas aeruginosa*	Corn	Colorant
Lemon essential oil	*Klebsiella pneumoniae*	Lemon	Promoting digestion
Ginger essential oil	*Klebsiella rbinoscleromatis*	Ginger	Promoting digestion
Litsea cubeba essential oil	*Staphylococcus aureus*	Litsea cubeba	Spices

Theme 14

Genetically modified organisms

Theoretical materials

Genetic modification is a biological technique that effects alterations in the genetic machinery of all kinds of living organisms. GMO is defined as follows by WHO (World Health Organisation): “Organisms (i.e. plants, animals or microorganisms) in which the genetic material (DNA) has been altered in a way that does not occur naturally by mating and/or natural recombination”.

There are three major challenges we are facing that motivate our resort to the new technology for help:

1. Expansion of population.
2. Decrease in arable land.
3. Bottleneck of conventional and modern breeding.

Benefits of GM foods

Agronomic benefits

For the period 1996–2013, it is estimated that biotechnology was responsible for additional global production of 138 million tonnes of soybeans, 274 million tonnes of corn, 21.7 million tonnes of cotton lint, and 8 million tons of canola. If those biotechnologies had not been available, to maintain the equivalent production levels would have required an increment of 11% of the arable land in the US, or 32% of the cereal area in the EU.

Economic benefits

From 2006 to 2012, the global increase in farm income from GM food had reached $116 billion, almost triple that of previous 10 years. It is estimated that about 42% of the economic gain was from the increased yield due to advanced genetics and resistance to pests and weeds. The decreased costs of production (e.g. from the reduced pesticide and herbicide usage) contributed the remaining 58%.

Modification of the chemical composition in food

Some genetic modifications are specifically targeted to enrich certain nutrients or substances having high therapeutic and pro-health value, including vitamins A, C, E, unsaturated fatty acids, alimentary cellulose and probiotics. The aforementioned “Golden Rice” is a significant example. It ameliorates malnutrition in an effective and economic way.

Improvement in food processing

The GM technology can also be employed to facilitate food processing. A notable achievement is the “Flavr Savr” tomatoes. They were produced by the Californian company, Calgene, in 1992. The genetic alteration consists of introduction of an antisense gene, which suppresses the enzyme polygalacturonase; the consequence is the slow down in ripening of tomatoes thus allowing for longer shelf life.

Products for therapeutic purposes

Genetic engineering techniques enable the expression of viral or bacterial antigens in the edible portion of plant cells. A variety of crops (e.g. rice, maize, soybean and potatoes) are under study as potential bearers of edible vaccines against different infections, including Escherichia coli toxins, rabies virus, Helicobacter pylori bacteria, and type B viral hepatitis.

Potential risks of GM foods

Health risks associated with GM foods

Three major health risks potentially associated with GM foods are: toxicity, allergenicity and genetic hazards. These arise from three potential sources, the inserted gene and their expressed proteins per se, secondary or pleiotropic effects of the products of gene expression, and the possible disruption of natural genes in the manipulated organism.

Environmental risks

There is evidence that genetically modified plants appear to interconnect with their state. During the last 40 years, investigations have attempted to establish a correlation between

the natural tendency of evolving humans and its impact on individuals' welfare. To look at whether there is a connection requires an investigation of its degree and any hidden components, integrating knowledge and methods from different disciplines.

Resistance to antibiotics

In the processes of genetic modification, antibiotics are frequently used, typically as selection markers, to distinguish successfully transformed bacteria from those in which the transfecting genes did not take hold. Thus, the machinations to genetically modify an organism carries the risk of transferring the genes of antibiotics resistance into the benign bacteria comprising the microflora of human and animal gastrointestinal tracts, or, worse yet, to pathogenic bacteria harboured by the consumer of GM a food, because bacteria, good and bad, are quite capable of shuttling useful genes – like those that protect them from nasty antibiotics – around by horizontal transfer between species.

Theme 15 Detection of contamination

Theoretical materials

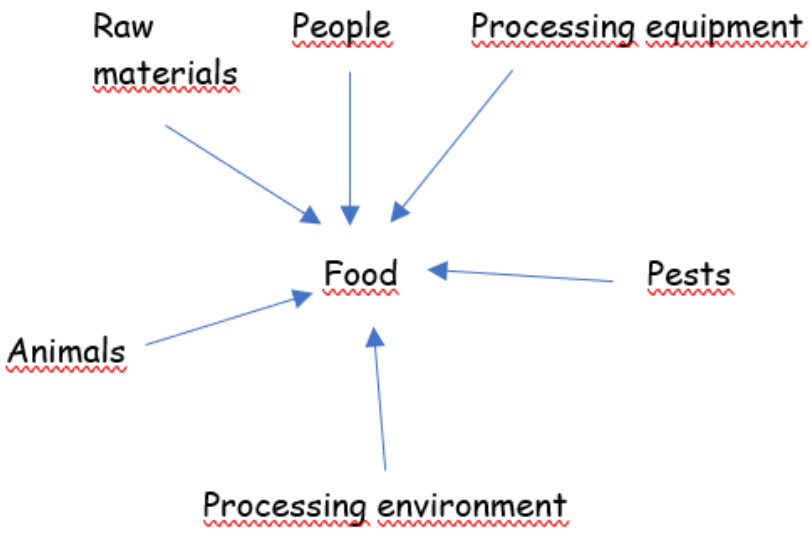

Fig. 15.1. Sources of contamination in food industry (Griffith, 2015).

Cross contamination - the process of contaminating a previously uncontaminated food or food surface,

- prevention of cross-contamination - integration of food safety management procedures,

Table 15.1.

Typical stages in a cleaning programme (Griffith, 2016).

Stage		Function	Reason
1	Preclean	Remove loose food or dirt, scrape, vacuum, etc.	Improve efficiency of later stages, allows detergent access to more firmly adhering residues
		Rinse with water to remove smaller, soluble food particles	
2	Main clean	Removes more firmly adhering food residue, grease or dirt	Improves efficiency of later stages. Presence of dirt/ residue/grease reduces the efficacy of disinfectants
		Usually detergents used to emulsify food particles and reduce surface tension	
3	Rinse	Removes detergent and emulsified/dissolved dirt and grease	Improves efficiency of disinfection, minimizes any reactions between cleaning chemicals. Prevents microorganisms being redeposited on surfaces
4	Disinfect	Further reduction in the number of microorganisms	Minimizes risk of cross-contamination, increases product shelf-life and safety
5	Final rinse	Removes traces of disinfectant	Minimizes risk of disinfectant contaminating the food
6	Dry	Air dry or use disposable materials to minimize recontamination	Residual moisture provides an opportunity for any remaining microorganisms to grow and survive and increase the risk of cross-contamination (transfer rates)
7	Additional Optional terminal disinfection	Ozone, hydrogen peroxide vapor, chlorine dioxide	Used as additional disinfection step to try to eliminate any residual or persistent pathogens or spoilage organisms

Cleaning - removing of contaminants from surfaces, but it can also reduce the number of microorganisms.

The aim of **disinfection** is the elimination of disease-causing or spoiling microorganisms - prevention of recontamination.

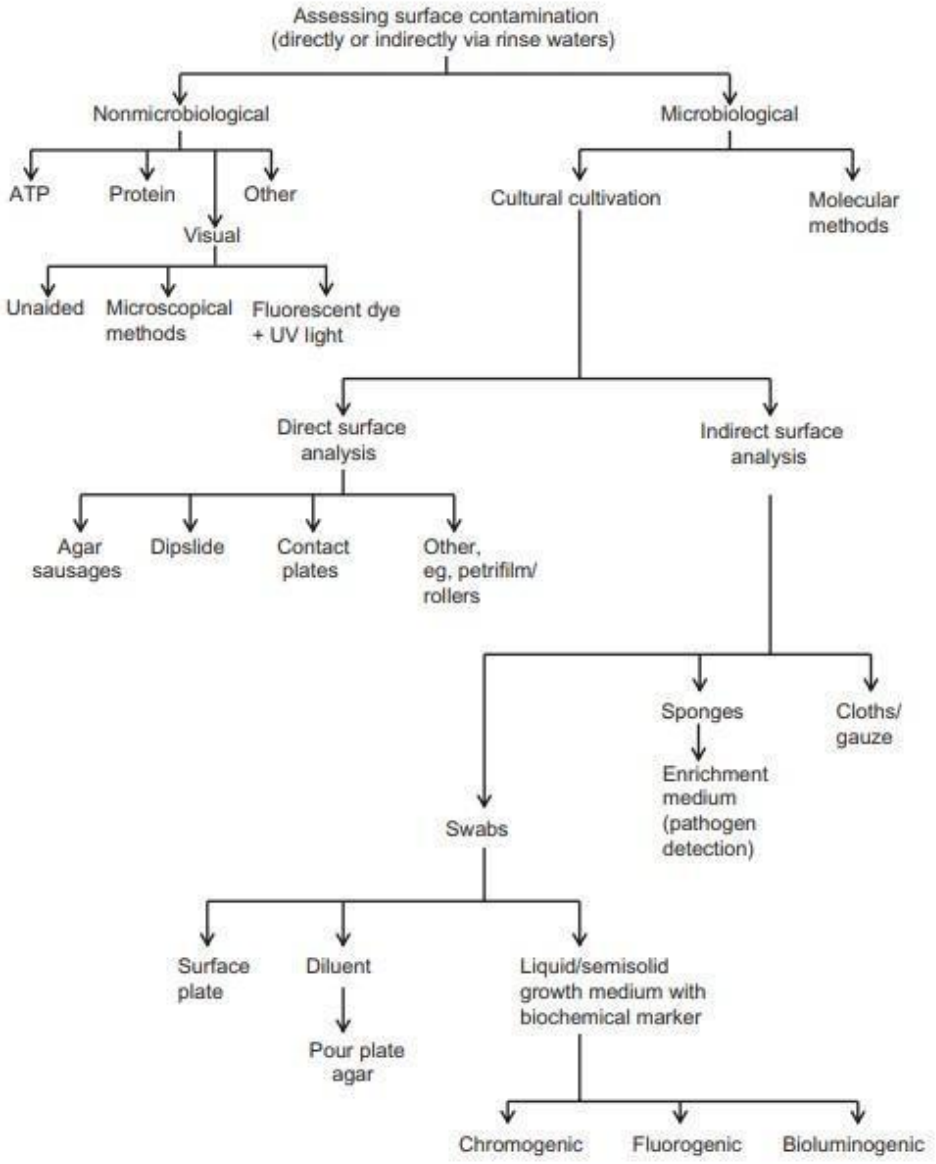

Fig.15.2. Methods for assessing surface cleanliness/contamination (Griffith, 2016).

NON-MICROBIOLOGICAL METHODS

ATP Bioluminescence

Adenosine triphosphate (ATP) is present in all living cells. It is present in viable microorganisms and in most foods and their residues.

ATP can be determined through a bioluminescence reaction using the oxidation of luciferin in the presence of the enzyme luciferase.

The intensity of the emitted light is determined in the luminometer chamber and is expressed in relative luminance units (RLU).

ATP is found in many, but not necessarily all, foods. For example, ATP is present in some fresh food, while other food, especially highly processed foods, contain very little ATP.

Fig. 15.3. Work with the luminometer **(**Hygenia SystemSURE Plus ATP Monitor (qasupplies.com)

MICROBIOLOGICAL METHODS

The main microbiological methods used in the food industry include the **swab, dipslide, imprint.**

Qualitative determination - pathogens.

Semi-quantitative determination - hygiene indicators.

Nutrient medium - solid, liquid.

Table 15.2.

Comparison of the main microbiological methods for hygiene monitoring (Verran and Redfern, 2016)

Methods	Advantages	Disadvantages
Swabbing	Widely used and accepted Can be qualitative (types of organisms) and semiquantitative Any shape, size, or surface area can be tested. Newer short time bioluminogenic tests with minimal equipment requirements now available	No universally agreed protocol Methods, media, etc. vary widely Incubation and sterilization facilities needed or external contract laboratory. Staff with some microbiological training needed Poor recovery especially dry surfaces. Poor reproducibility Motile organisms can cover surfaces of agar
Contact plate	Direct contact with surface Better reproducibility than swabbing Fixed relatively small area Can be bought preprepared Availability in variety of media	Flat surfaces only Motile organisms can cover surface of agar Possible agar residue on surface Lids can become detached in transport, although one make with a lockable lid is available Incubation and sterilization disposal facilities needed Can only estimate surface populations that produce countable colonies on the plate
Dipslide	Direct contact with surface Better reproducibility than swabbing Fixed area/narrow shape, relatively small surface area Can be bought preprepared in a variety of media Different media on reverse side of paddle if required Minimal incubation facilities needed (portable) Can be used to test rinse water Sealed unit with screw cap Longer shelf-life Paddle can be hinged for easier use	Flat surfaces only Motile organisms can cover surface of agar Incubation and sterilization disposal facilities needed Possible agar residue on surface Can only estimate surface populations that produce countable colonies on the plate

Indirect microbiological methods

Swabbing

The oldest and most commonly used method of controlling the level of hygiene.

Swabbing is widely used in industry to assess surface contamination, although not for larger surface areas and as a reference for comparison with other methods. Overall recovery can be seen as a function of the removal of microorganisms from the test surface, their release from the swab and their subsequent ability to grow.

Techniques/variables that improve one element of the swabbing process may adversely affect another. One study showed protocols that improved removal, and adversely affected release. Optimum overall recovery may therefore be a trade-off or compromise between different components of the whole process.

All-in-one medium

A swab, after testing a surface, is returned to its accompanying culture tube containing a liquid or semisolid agar incorporating an indicator system.

The results are semi-quantitative in that the number of bacteria is not recorded but the time taken for the indicator to change colour is a measure of the original microbial load.

Nonspecific media – determination of general aerobic colonies.

Selective media – determination of indicator microorganism or pathogens.

Sponges

Sponges work on a similar principle to swabbing, in that microorganisms are removed, released, and cultivated.

Recovery is by wiping a compressed sterile sponge (e.g. cellulose acetate) of varying sizes over the test surface.

Sponges may be pre-moistened or require the addition of a wetting agent. After inoculation the sponge is returned to a sterile packet and transported to a laboratory.

After the addition of a suitable diluent to the envelope, usually followed by agitation/stomaching, the released organisms can be counted.

Direct microbiological methods

All direct microbiological methods involve contact of sterile agar with a controlled surface.

Microorganisms are directly transferred to the surface of the agar and after an appropriate incubation period, the microorganisms multiply and form colonies that are visible and can be counted. In general, this approach is best for smooth, flat surfaces.

Contact plates

- they resemble small plastic Petri dishes with a lid,
- dishes contain agar,
- an imprint is made from the surface,
- contact plates are incubated for 24-48 hours depending on the group of microorganisms.

Dipslide

- agar immersion, plating, and contact slides,
- they comprise a double-sided hinged paddle with a neutral or selective agar, attached to both sides,
- the paddle is contained within a transparent cylindrical tube,
- the dipslide is removed, then pressed onto the surface to be tested, replaced back into the tube and resulting colony growth counted.
- they can also be used for counting the number of organisms in liquid samples of food, water, or rinse water.

Petrifilm plates

Small, thin films coated with nutrients and gelling agents. After wetting the film with 1 mL of deionised water to rehydrate the growth medium, it can be used to provide a surface count.

Using Petrifilm plates, an impression is made from the controlled area, and after cultivation, the grown colonies are counted.

Direct agar contact methods have a number of advantages and disadvantages compared with traditional swabbing.

Advantages - ease of use, generally lower costs, and better recovery and repeatability.

Disadvantages - more suited to flat surfaces and on very contaminated surfaces overgrowth can occur.

Molecular methods

Molecular methods amplify specific parts of a microorganism's nucleic acid to a detectable level.

Techniques include polymerase chain reaction (PCR), reverse transcriptase (RT-PCR), and nucleic acid sequence-based amplification (NASBA).

One potential disadvantage is that such techniques often do not distinguish between living microorganisms and noninfective nucleic acid and therefore only indicate that at some stage the organism was present on that surface.

Laboratory work

Detection of contamination – swabs

Supplies: sterile swabs, distilled water, cultivation media for determining total viable counts (TVC) and coliform bacteria (CB), test tubes, automatic pipette.

Procedure

- perform a swab from selected surfaces (plastic, ceramics, and stainless steel),

- the swabs are infused in tubes with distilled water, dilution: 10^{-1},

- pipette 1 mL from each test tube onto Petri dishes and fill with cultivation media,

- cultivation in thermostat at temperature: TVC - 30 °C, 48 hours, CB - 37 °C, 24 hours,

- after cultivation - colony counting,

- expression of results – in log CFU/cm^2.

Results

Table 15.3.

Results of microbial contamination of different materials obtained by swabs

Surface	TVC (log CFU/cm^2)	CB (log CFU/cm^2)
Plastic		
Stainless steel		
Glass …		

Conclusions

Approved by

_____
Name, surname, signature

Date

_____

Laboratory work

Detection of contamination - Petrifilm plates

Supplies: Petrifilm plates for determining of TVC and CB, peptone solution, automatic pipette.

Procedure

- activation of Petrifilm plates - pipette 1 mL of peptone solution on each Petrifilm plate,

- let set for 10 minutes at room temperature,

- make an imprint from the tested material using a Petrifilm plate,

- cultivation in thermostat at temperature: TVC - 30 °C, 48 hours, CB - 37 °C, 24 hours,

- after cultivation - colony counting.

Results

Table 15.4.

Results of microbial contamination of different materials obtained by Petrifilm plates

Surface	TVC (log CFU/cm^2)	CB (log CFU/cm^2)
Plastic		
Stainless steel		
Glass …		

Conclusions

Approved by

_____

Name, surname, signature

Date

_____

Theme 16

Pest control in food industry

Theoretical materials

Pest management

The presence of pests in any food handling premises is unacceptable.

The risks posed by pests include:

• The spread of disease – pathogens are transferred from the gut or external surface of the pest.

• Damage to property.

• Contamination of work surfaces and foodstuffs.

• Adverse public opinion and loss of reputation.

• Prosecution and closure.

• Poor staff relations.

The objective of the Pest Management Programme should be to prevent, as far as practicable, the introduction of pests onto the site and to reduce the conditions that may encourage their presence.

Rodents destroy property, spread disease, compete for human food sources, and are aesthetically displeasing. Rodent-associated diseases affecting humans include plague, murine typhus, leptospirosis, rickettsialpox, and rat-bite fever. The three primary rodents of concern to the homeowner are the Norway rat (*Rattus norvegicus*), roof rat (*Rattus rattus*), and the house mouse (*Mus musculus*). The term "commensal" is applied to these rodents, meaning they live at people's expense.

The first of four basic strategies for controlling rodents is to eliminate food sources. To accomplish this, it is imperative for the homeowner or occupant to do a good job of solid waste management. This requires proper storing, collecting, and disposing of refuse.

The second strategy is to eliminate breeding and nesting places. This is accomplished by removing rubbish from near the home, including excess lumber, firewood, and similar materials.

The third strategy is to construct buildings and other structures using rat-proofing methods. Tactics for rodent exclusion include building or covering doors and windows with metal. Rats can gnaw through wooden doors and windows in a very short time to gain entrance.

The first three strategies—good sanitation techniques, habitat denial, and rat proofing—should be used initially in any rodent management program. Should they fail, the ***fourth***

strategy is a killing programme, which can vary from a family cat to the professional application of rodenticides.

Determination of infestation

Rats and mice are nocturnal animals. Because they tend to be inactive during daylight hours, their presence is not always immediately detected. The presence of faecal droppings is one of the obvious signs of rodent infestation.

Control

Control of rodents, especially rats, is difficult because of their ability to adapt to the environment. The most effective method of rodent control is proper sanitation.

Without effective sanitation practices, poisons and traps will provide only a temporary reduction in a rodent population.

Prevention of entry

Protection against rats is accomplished most effectively through the elimination of all possible entrances. Poorly fitting doors and improper masonry around external pipes can be flashed or covered with metal or filled with concrete to block entry of rodents.

Elimination of rodent shelters

Crowded storage rooms with poor housekeeping provide sheltered areas for rodents

to build nests and reproduce. Rodents thrive in areas where garbage and other refuse are placed.

Eradication

The more effective methods of eradicating rodents are poisoning, gassing, trapping, and ultrasonic devices.

Poisoning

Poisoning is an effective method of eradication; however, precautions are necessary

because poison baits are hazardous if ingested by humans. Examples of rodenticides

are the anticoagulants, such as 3-(α acetonylfurfuryl)-4-hydroxycoumarin (fumarin), 3-(α

acetonylbenzyl)-4-hydroxycoumarin (warfarin), 2-pivaloyl-1,3-indandione (pival), brodifacoum, bromodiolone, and chlorophacinone. These multi-dose poisons must be consumed several times before death occurs and accidental consumption of poisoned bait does cause danger.

The multiple-dose anticoagulants (chronic poisons), although safer than most other poisons, should be prepared and applied according to instructions. The ideal locations for

application are along rodent runways and near feeding sites. Fresh bait should be put out daily for at least 2 weeks to ensure that the poison is effective.

Tracking powder

These compounds kill rats or, in the case of nontoxic powders, identify their presence and number. These powders may contain an anticoagulant or a single-dose poison.

Gassing

This technique should be used only if other eradication methods are not effective. If this approach is necessary, rodent burrows should be gassed with a compound such as methyl bromide only by a professional exterminator or a thoroughly trained employee. Rodent burrows should not be gassed if they are less than 6 m from a building because burrows can extend under a closely located building.

Trapping

This is a slow but generally safe method of rodent eradication. Traps and bait stations should be tamper resistant so that non-target animals cannot get into them and placed at right angles to rodent runways, with the baited or trigger end toward the wall. Food that appeals to rodents can be used as bait.

Ultrasonic Devices

This eradication method uses sound waves that are supposed to repel the entry of rodents into areas where the device is installed. The most appropriate time to hit rodents with noise is when they first arrive.

INSECT INFESTATION

Arthropod pests are projected to cause post-harvest losses between 8 and 25% in

developed countries and 70 to 75% in developing countries. These losses are attributable to pest consumption and contamination.

Cockroaches

Cockroaches have become well adapted to living with and near humans, and their resilience is legendary. In light of these facts, cockroach control may become a homeowner's most difficult task because of the time and special knowledge it often involves. The cockroach is considered an allergen source and an asthma trigger for residents. Although little evidence exists to link the cockroach to specific disease outbreaks, it has been demonstrated to carry Salmonella typhimurium, Entamoeba histolytica, and the poliomyelitis virus. Cockroaches are primarily nocturnal. Daytime sightings may indicate potentially heavy infestations.

Detection

Cockroaches may be found in any location where food is being processed, stored, prepared, or served. These insects tend to hide and lay eggs in dark, warm, difficult-to-clean areas. Their favourite harbourages are small spaces in and between equipment and shelves, and under shelf liners. When cockroaches need food that is not in these areas or when they are forced out by other cockroaches, they come out into the light. One of the easiest methods of checking for cockroach infestation is to enter a darkened production or storage area and turn on the lights. Also, a strong, oily odour that arises from a substance given off by certain glands of this insect can indicate the presence of cockroaches.

Control

Control of this pest in food establishments should be a continuous operation through effective sanitation and the use of chemicals. The most important form of control is effective sanitation. These pests require food, water, and a sheltered hiding place.

Infestation is reduced through filling cracks in floors and walls with caulking or other sealants.

The use of chemical control should follow sanitary practices. Chemical control can be handled through a pest control operator, but integrated chemical control and sanitary practices can be more effective and more economical.

Because insects such as cockroaches become inactive at approximately 5 ºC, refrigerated storage and refrigeration of other areas will reduce infestation. Cockroach control is usually based on the use of baits and bait stations, fungi, and possible nematodes. **Diazinon** offers potential for the control of cockroaches. **Amidinohydrozone (Dursban)** has been developed and sold as a bait, and can be effective against cockroaches that resist other poisonous compounds, but the use of this insecticide indoors is not acceptable.

A residual insecticide such as **diazinon** sprayed in hiding places is considered effective if these pests have not developed a resistance to this compound. This compound is sometimes supplemented with a **pyrethrin**-based non-residual insecticide to force the insects from the hidden areas to the sprayed area, where improved contact with the insecticide can occur.

Other compounds, such as flowable **microencapsulated diazinon**, are available for the control of cockroaches and other insects through spot, crack, or crevice treatment, but not for application in food handling areas. The liquid pesticide, cyfluthrin, a parathyroid-class chemical is as a nerve toxin that kills insects.

Four management strategies exist for controlling cockroaches. The first is **prevention.** This strategy includes inspecting items being carried into the home and sealing cracks and crevices in kitchens, bathrooms, exterior doors, and windows. Structural modifications would include weather stripping and pipe collars. The second strategy is **sanitation.** This denies cockroaches food, water, and shelter. These efforts include quickly cleaning food particles from shelving and floors; timely washing of dinnerware; and routine cleaning under refrigerators, stoves, furniture, and similar areas. If pets are fed indoors, pet food should be stored in tight containers and not left in bowls overnight. Litter boxes should be cleaned routinely. Access should be denied to water sources by fixing leaking plumbing, drains, sink traps, and purging clutter, such as papers and soiled clothing and rags. The third strategy is **trapping.** Commercially available cockroach traps can be used to capture roaches and serve as a monitoring device. The most effective trap placement is against vertical surfaces, primarily corners, and under sinks, in cabinets, basements, and floor drains. The fourth strategy is **chemical control.** The use of chemicals typically indicates that the other three strategies have been applied incorrectly.

Other insects

The most common of the seasonal insects in foodservice and food processing plants are

flies. The most populous varieties of flies associated with these establishments are the house fly and the fruit fly. The house fly (Musca domestica), which is found throughout the world, is an even greater pest than the cockroach. It is a pest to all segments of the community, transmitting a variety of pathogenic organisms to humans and their food. Examples are human disease such as typhoid, dysentery, infantile diarrhoea, and streptococcal and staphylococcal infections. Flies transmit diseases primarily because they feed on animal and human wastes and collect these pathogenic microorganisms on the feet, mouth, wings, and gut. These pathogens are deposited when the fly crawls on food or in the fly excrement.

House flies are more abundant in the late summer and fall because the population has

been building rapidly during the warm weather. When adult flies enter buildings for food and shelter, these pests generally remain. Flies are most active in a 12 to 35 ºC environment. Below 6 ºC they are inactive, and below -5 ºC death can occur within a few hours. Heat paralysis sets in at approximately

40 ºC, and death can occur at 49 ºC. Therefore, the most effective means of controlling the fly population is to prevent them from entering processing

INSECT DESTRUCTION

Pesticides

Pests should be destroyed without chemicals, if possible, because of the controversy and potential danger of pesticides. However, if these techniques are ineffective, it is necessary to use pesticides. To ensure the proper and effective application of pesticides, the use of a professional pest control company should be considered. Restricted pesticides should be applied by a commercial applicator.

Residual insecticides are applied to obtain insecticidal effects for an extended period of time. In residual treatment, the chemicals are normally applied in spots or cracks and crevices. Some residual insecticides cannot legally be used in food areas.

Another method of residual application of insecticides is crack and crevice treatment. Small amounts of insecticides are applied to cracks and crevices where insects hide or in areas where these pests may enter buildings for example, expansion joints between the various elements of construction and between equipment and floors.

Non-residual insecticides are applied for the control of insects only during the time of treatment and are applied either as contact or as space treatments. Contact treatment is the application of a liquid spray for an immediate insecticidal effect. Contact refers to the actual touching of the pests. This treatment method should only be used when there is a high probability that the spray will touch the pests. In space treatment, foggers, vapour dispensers, or aerosol devices are used to disperse insecticides into the air. This technique can control flying insects and crawling insects in the exposed area.

The following chemicals are common fumigants for insects:

● ***Phosphine****:* The principal active compound in this fumigant is aluminium phosphide, which is usually contained in a permeable package or in pellets. This method of use permits controlled contact

of the phosphine with moisture in the air to release hydrogen phosphide (phosphine), the active ingredient. This gas is very flammable. Instructions provided for use and storage provided by the supplier should be followed.

● ***Methyl bromide****:* This nonflammable fumigant is widely used. Methyl bromide penetrates effectively and acts as a respiratory toxin, apparently absorbed through the insect's cuticle. Regulators have evaluated this fumigant and it appears that it will be phased out in the future.

● ***Ethylene oxide****:* This non-residual fumigant is normally mixed with carbon dioxide in a ratio of 1:9 (by weight) to reduce flammability and explosiveness.

This insecticide, most frequently used for stored commodities, should be applied through a professional pest control operator.

● ***Carbonyl sulfide****:* This compound has been found to be toxic to a large number of species of stored-product insects. It has been patented as a fumigant for the control of insects and mites in post-harvest commodities. Carbonyl sulphide has many characteristics indicating that it could replace methyl bromide or phosphine, or both, under some circumstances. It is environmentally friendly, with good penetration and aeration characteristics. It is versatile, being toxic in short exposure periods or for a longer exposure time. This fumigant shows no adverse effects on seed germination and is an effective fumigant for other commodities.

Other Chemical Methods of Insect Control

Other potential methods of insect control include the use of *baits*. Baits are a combination of insect-attracting foods, such as sugar, and an insecticide. Although baits are not always as convenient to use as other methods, they can be effective in controlling inaccessible areas of ant and cockroach infestations and in reducing outside fly populations. Because baits are poisonous food, special precautions should be exercised in their use and storage. Commercial dry granular baits should be scattered thinly over feeding surfaces daily, or as needed, to provide initial knockdown and control of populations. Granular fly baits are satisfactory for outdoor use only. Liquid baits consist of an insecticide in water with an attractant such as sugar, corn syrup, or molasses. They may be applied to walls, ceilings or floors frequented by flies using a sprayer or watering can. Fly bait should be used regularly during the summer months to control population growth.

Mechanical methods

None of the conventional devices to control insects mechanically is especially effective. Fly swatters are contaminated and spread insect carcasses and parts when being used, so they should not be permitted in food processing, storage, preparation, or sales areas. A viable mechanical device for the control of insects is the air curtain, which not only reduces cold air loss in a refrigerated facility but also protects against insect and dust entry into food establishments.

Air curtains can be used for personnel doors and entrances large enough for loading trucks or for the passage of large equipment. Air curtains are most effective if the area being protected is under positive air pressure. The equipment is normally mounted outside and above the opening to be protected.

Insect light traps

One of the safest and most effective methods of fly control is the use of insect light traps. This technique does not have the potential hazard of toxic sprays.

Sticky traps

These traps can consist of sticky flypaper, pieces of waterproofed cord, or flat pieces of plastic covered with a slow-drying adhesive. Yellow plastic strips with a sticky coating will catch a wide variety of flying insects. Some sticky traps contain pheromones so that a

specific insect species can be caught. Light trap models use a low-voltage electric pulse to stun the insects, which then fall down onto the glue board. This approach reduces the production of insect fragments and does not create the bug zapping sound generated by the electrocution traps.

Biological Control

The use of biological control is frequently incorporated into integrated pest management (IPM) programmes (discussed near the end of this chapter). One of the most widely used biological control schemes for the control of phytophagous insects is the development and incorporation of host plant resistance. Resistance is attained through the use of plant species that are known to be refractory to attack. One of the promising techniques is the incorporation of gene splicing and recombinant DNA manipulation, which is being investigated universally.

Pheromone traps

Pheromones are chemical substances emitted by insects to communicate with others of the same species. Types of pheromones include sex attractant, aggregation, fear, and territorial boundary markers. Natural and synthetic sex attractant pheromones lure male insects into sticky traps where they become permanently trapped and die. Chemical attractants are now being used to control fruit flies.

Pheromones traps can be used in pest management for:
1. *Detection and monitoring*. Information such as the presence, location, and the amount of species can determine when appropriate action should be taken (i.e. pesticide application).

2. *Mass trapping*. Larger traps with a larger quantity of pheromone can be incorporated to catch insects.

3. *Confusion*. Sex pheromones can confuse the mating instincts of male insects preventing them from locating females.

The use of pheromones in pest management offers the following advantages.

1. *Economy*. A small amount is required and traps are easy to use.

2. *Species specific*. A pheromone used to attract a specific species does not attract or harm beneficial species.

3. *Non-poisonous*. No known safety hazards exist to humans or other animals.

4. *No insect resistance*. Sex attractants.

Theme 17

Personal hygiene

Theoretical materials

Food handlers can transmit bacteria causing illness. In fact, humans are the major source of food contamination. Their hands, breath, hair, and perspiration contaminate food, as can their unguarded coughs and sneezes, which can transmit microorganisms capable of causing illness.

Employee Hygiene

Ill employees should not come into contact with food or equipment and utensils used in the processing, preparation, and serving of food. Human illnesses that may be transmitted through food are diseases of the respiratory tract, such as common cold, sore throat, pneumonia, scarlet fever, tuberculosis, and trench mouth; intestinal disorders; dysentery; typhoid fever; and infectious hepatitis. In many illnesses, the disease-causing microorganisms may remain with the person after recovery. A person with this condition is known as a carrier. When employees become ill, their potential as a source of contamination increases.

Skin

Improper hand washing and infrequent bathing increases the amount of microorganisms dispersed with the dead cell fragments. Contamination results in shortening the product's shelf life or in foodborne illness.

Foodborne illness may occur if a food handler is a carrier of Staphylococcus aureus or Staphylococcus epidermis, two of the predominant bacterial species normally present on the skin. These organisms are present in the hair follicles and in the ducts of sweat glands. They are capable of causing abscesses, boils, and wound infections following surgical operations. As secretions occur, perspiration from the eccrine gland, as well as sebum (a fatty material seated into hair follicles) contains bacteria from the gland and subsequently deposits them on the skin surface, with subsequent reinfection.

Fingers

Bacteria may be picked up through the hands touching dirty equipment, contaminated food, clothing, or other areas of the body. When this occurs, the employees should use a hand-dip sanitiser to reduce the transfer of contamination. Plastic gloves can be a solution.

Jewellery

To reduce safety hazards in an environment containing machinery, jewellery should not be worn in food processing or foodservice areas. Also, it may be contaminated and fall into food.

Hair

Microorganisms (especially staphylococci) are found on hair. Employees who scratch their heads should use the hand dip before handling food and should wear a head covering. The necessity for wearing hair coverings in food processing areas should be considered a condition of employment for all new employees and should be made known at the time when they are hired.

Mouth

Many bacteria are found in the mouth and on the lips. During a sneeze, some of the bacteria

are transferred to the air and may land on food being handled. Furthermore, smoking should be prohibited while working. Various disease-causing bacteria, as well as viruses, are also found in the mouth, especially if an employee is ill. These microorganisms can be transmitted to other individuals, as well as to food products, when one sneezes.

The intrinsic factors that affect microbial contamination by people are as follows:

1. Location on the body. The composition of the normal microbiota varies depending on the body area. The face, neck, hands, and hair contain a higher proportion of transient microorganisms and a higher bacterial density.

2. Age. The microbial population changes as a person matures.

3. Hair.

4. pH. The pH of the skin is affected through the secretion of lactic acid from the sweat glands, bacterial production of fatty acids, and diffusion of carbon dioxide through the skin.

5. Nutrients.

Carriers are divided into three groups:

1. Convalescent carriers. People who, after recovering from an infectious disease, continue to harbour the causative organism for a variable length of time, usually less than 10 weeks.

2. Chronic carriers. People who continue to harbour the infectious organism indefinitely, although they do not show symptoms of the disease.

3. Contact carriers. People who acquire and harbour a pathogen through close contact with an infected person, but do not develop the disease.

Hand Washing

Microorganisms found on the hand surfaces may be transient bacteria or resident bacteria. Transient bacteria are picked up accidentally by food handlers and are transient in that they are present on the hands only temporarily (e.g., *E. coli*). Residual microorganisms permanently reside on the hand surfaces and are the normal or resident microflora of the skin (e.g., *Staphylococcus*

epidermidis).

The first line of defence against disease is frequent and effective hand washing by food handlers. Approximately 38% of food contamination is attributable to improper hand washing. The most effective method to ensure effective hand washing is through motivation, reinforcement, incentives, and modelling through supervisors and managers practicing appropriate hand washing.

These practices should be conducted to ensure personal hygiene:
1. Physical health should be maintained and protected through the practice of proper nutrition and physical cleanliness.
2. Illness should be reported to the employer before working with food so that work adjustments can be made to protect food from the employee's illness or disease.
3. Hygienic work habits should be developed to eliminate potential food contamination.
4. During the work shift, hands should be washed after using the toilet, handling garbage or other soiled materials, handling uncooked muscle foods, egg products, or dairy products, handling money, smoking, coughing, or sneezing.
5. Personal cleanliness should be maintained by daily bathing and the use of deodorants, washing hair at least twice a week, cleaning fingernails daily, using a hat or hair net while handling food,
and wearing clean underclothing and uniforms.
6. Employees' hands should not touch foodservice equipment and utensils. Disposable gloves should be used when contact is necessary.
7. Rules such as "no smoking" should be followed, and other precautions related to potential contamination should be taken.

Role of Employees

Food processing and foodservice firms should protect their employees and consumers

from workers with diseases or other microorganisms of public health concern that can affect the wholesomeness or sanitary quality of food.

Theme 18

HACCP system

Theoretical materials

HACCP System implementation

Elements of a Food Safety Management System (FSMS)

Prior to the application of the HACCP-based procedures to any business, the food business operator (FBO) should have implemented the prerequisite programmes. Compliance with the procedures of regulations are the prevention and preparedness pillars of each FSMS and are needed to develop HACCP-based procedures.

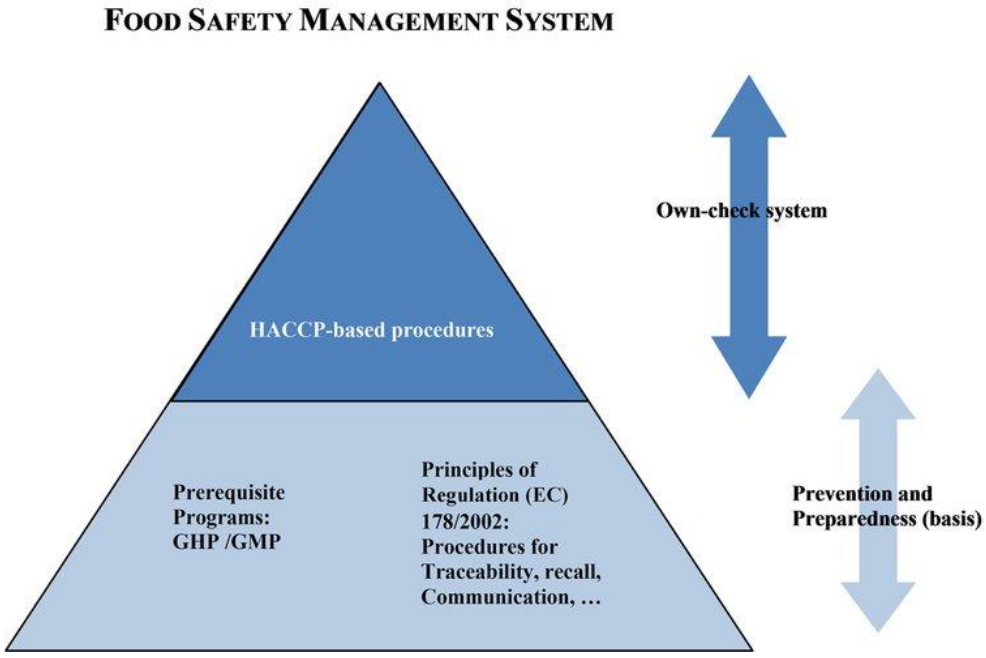

Fig. 18.1 Food safety management system (ISO 22000:2018)

Preliminary activities prior to the implementation of the HACCP plan are as follows:

- Assembly of a multidisciplinary HACCP team,
- Description of the product(s) at the end of process (called hereafter 'end product'),
- Identification of intended use,

- Construction of a flow diagram (description of manufacturing process),
- On-site confirmation of flow diagram,
- Assembly of a multidisciplinary HACCP team.

This team, which involves all parts of the food business concerned with the product, should include the whole range of specific knowledge and expertise appropriate to the product under consideration, its production (manufacture, storage, and distribution), its consumption and the associated potential hazards and should also involve, as much as possible, the higher levels of management. The team should get the full support of the management who should consider themselves as the owner of the HACCP plan and the overall FSMS.

Where necessary, the team should be assisted by specialists who will help it to solve its difficulties as regards assessment and control of critical points.

The team may include specialists and technicians:

- who understand the biological, chemical or physical hazards connected with a particular product group,
- who have responsibility for, or are closely involved with, the technical process of manufacturing the product under study,
- who have a working knowledge of the hygiene and operation of the process plant and equipment,
- any other person with specialist knowledge of microbiology, hygiene or food technology.

One person may fulfil several or all of these roles, provided that all relevant information is available to the team and is used to ensure that the system developed is reliable. Where expertise is not available in the establishment, advice should be obtained from other sources (consultancy, guides of good hygiene practices, etc. not excluding other companies of the same group (at sectorial or association level) where expertise is available).

- Description of the product(s) at the end of process (called hereafter 'end product')

A full description of the end product should be drawn up, including relevant safety information such as:

- origin of ingredients/raw materials, which may help identify certain hazards,
- composition (e.g. raw materials, ingredients, additives, possible allergens etc.),
- structure and physico-chemical characteristics (e.g. solid, liquid, gel, emulsion, moisture content, pH, water activity, etc.),
- processing (e.g. heating, freezing, drying, salting, smoking, etc. and to what extent),
- packaging (e.g. hermetic, vacuum, modified atmosphere) and labelling,
- storage and distribution conditions, including transport and handling
- required shelf life (e.g. 'use by date' or 'best before date'),
- instructions for use,
- any microbiological or chemical criteria applicable.

Identification of intended use

The HACCP team should also define the normal or expected use of the product by the customer and by the consumer target groups for which the product is intended. In specific cases, the suitability of the product for particular groups of consumers, such as institutional caterers, travellers, etc. and for vulnerable groups of the population may have to be considered.

Construction of a flow diagram (description of manufacturing process)

Whatever format is chosen, all steps involved in the process should be studied in sequence and presented in a detailed flow diagram.

All processes (from receiving the raw materials to placing the end product on the market) including delays during or between steps, should be mentioned together with sufficient technical data that is relevant for food safety, such as temperature and the duration of heat treatment.

Types of data may include but are not limited to:

- plan of working premises and ancillary premises,

- equipment layout and characteristics,
- sequence of all process steps (including the incorporation of raw materials, ingredients or additives and delays during or between steps),
- technical parameters of operations (in particular time and temperature, including delays),
- flow of products (including potential cross-contamination),
- segregation of clean and dirty areas (or high/low risk areas).

On-site confirmation of flow diagram

After the flow diagram has been drawn up, the HACCP team should confirm it on site during operating hours. Any observed deviation must result in an amendment of the original flow diagram to make it accurate.

In small enterprises, HACCP/FSMS activities might be carried out by one person who is (temporarily or regularly) assisted by external expertise. Where external expertise is used, it is essential that there is sufficient ownership of the FSMS by the food business itself. FBOs using this route should make sure that they know how the system works and how it is being applied to their business and that their staff is suitably trained to ensure effective implementation.

When there is no processing or other manufacturing (e.g. cutting, wrapping), the description of the product can be limited to information available on the label (prepacked food) or other information on the food extracted from reliable websites. Unless specifically targeted to certain consumers (e.g. baby food), the intended use can be considered as consumption by the general public.

The nature of the business will define the complexity of the required flow diagram, which might be very simple in certain businesses.

HACCP System

Hazard analysis and critical control points, or HACCP, is a systematic preventive approach to food safety from biological, chemical, and physical hazards in production processes that can cause the finished product to be unsafe and designs measures to reduce these risks to a safe level. In this manner, HACCP attempts to avoid hazards rather than attempting to inspect finished products for the effects of those hazards. The HACCP system can be used at all stages of a food chain, from food production and preparation processes including packaging, distribution, etc. The Food and Drug Administration (FDA) and the United States Department of Agriculture (USDA) require mandatory HACCP

programmes for juice and meat as an effective approach to food safety and protecting public health. Meat HACCP systems are regulated by the USDA, while seafood and juice are regulated by the FDA. All other food companies in the United States that are required to register with the FDA under the Public Health Security and Bioterrorism Preparedness and Response Act of 2002, as well as firms outside the US that export food to the US, are transitioning to mandatory hazard analysis and risk-based preventive controls (HARPC) plans.

It is believed to stem from a production process monitoring used during World War II because traditional "end of the pipe" testing on artillery shells' firing mechanisms could not be performed, and a large percentage of the artillery shells made at the time were either duds or misfiring. HACCP itself was conceived in the 1960s when the US National Aeronautics and Space Administration (NASA) asked Pillsbury to design and manufacture the first foods for space flights. Since then, HACCP has been recognised internationally as a logical tool for adapting traditional inspection methods to a modern, science-based, food safety system. Based on risk-assessment, HACCP plans allow both industry and government to allocate their resources efficiently by establishing and auditing safe food production practices. In 1994, the organisation International HACCP Alliance was established, initially to assist the US meat and poultry industries with implementing HACCP. As of 2007, its membership spread over other professional and industrial areas.

HACCP has been increasingly applied to industries other than food, such as cosmetics and pharmaceuticals. This method, which in effect seeks to plan out unsafe practices based on science, differs from traditional "produce and sort" quality control methods that do nothing to prevent hazards from occurring and must identify them at the end of the process. HACCP is focused only on the health safety issues of a product and not the quality of the product, yet HACCP principles are the basis of most food quality and safety assurance systems. In the United States, HACCP compliance is regulated by 21 CFR part 120 and 123. Similarly, FAO and WHO published a guideline for all governments to handle the issue in small and less developed food businesses.

History

In the early 1960s, a collaborated effort between the Pillsbury Company, NASA, and the U.S. Army Laboratories began with the objective to provide safe food for space expeditions. People involved in this collaboration included Herbert Hollander, Mary Klicka, and Hamed El-Bisi of the United States Army Laboratories in Natick, Massachusetts, Paul A. Lachance of the Manned Spacecraft Center in Houston, Texas, and Howard E. Baumann representing Pillsbury as its lead scientist.

To ensure that the food sent to space was safe, Lachance imposed strict microbial requirements, including pathogen limits (including E. coli, Salmonella, and Clostridium botulinum).[5] Using the traditional end product testing method, it was soon realised that almost all of the food manufactured was being used for testing and very little was left for actual use. Therefore, a new approach was needed.

NASA's own requirements for critical control points (CCP) in engineering management would be used as a guide for food safety. CCP derived from failure mode and effects analysis (FMEA) from NASA via the munitions industry to test weapon and engineering system reliability. Using that information, NASA and Pillsbury required contractors to identify "critical failure areas" and eliminate them from the system, a first in the food industry then. Baumann, a microbiologist by training, was so pleased with Pillsbury's experience in the space programme that he advocated for his company to adopt what would become HACCP at Pillsbury.

Soon, Pillsbury was confronted with a food safety issue of its own when glass contamination was found in farina, a cereal commonly used in infant food. Baumann's leadership promoted HACCP in Pillsbury for producing commercial foods, and applied to its own food production. This led to a panel discussion at the 1971 National Conference on Food Protection that included examining CCPs and good manufacturing practices in producing safe foods. Several botulism cases were attributed to under-processed low-acid canned foods in 1970–71. The United States Food and Drug Administration (FDA) asked Pillsbury to organise and conduct a training programme on the inspection of canned foods for FDA inspectors. This 21-day programme was first held in September 1972 with 11 days of classroom lecture and 10 days of canning plant evaluations.[5] Canned food regulations (21 CFR 108, 21 CFR 110, 21 CFR 113, and 21 CFR 114)[6] were first published in 1969. Pillsbury's training programme, which was submitted to the FDA for review in 1969, entitled "Food Safety through the Hazard Analysis and Critical Control Point System" was the first use of the acronym HACCP.

HACCP was initially set on three principles, now shown as principles one, two, and four in the section below. Pillsbury quickly adopted two more principles, numbers three and five, to its own company in 1975. It was further supported by the National Academy of Sciences (NAS) when they wrote that the FDA inspection agency should transform itself from reviewing plant records into an HACCP system compliance auditor.

Over the period 1986 to 1990, a team consisting of National Sea Products and the Department of Fisheries and Oceans developed the first mandatory food inspection programme based on HACCP principles in the world. Together, these Canadian innovators

developed and implemented a Total Quality Management Programme and HACCP plans for all their groundfish trawlers and production facilities.

A second proposal by the NAS led to the development of the National Advisory Committee on Microbiological Criteria for Foods (NACMCF) in 1987. NACMCF was initially responsible for defining HACCP's systems and guidelines for its application and were coordinated with the Codex Alimentarius Committee for Food Hygiene, that led to reports starting in 1992 and further harmonisation in 1997. By 1997, the seven HACCP principles listed below became the standard.

A year earlier, the American Society for Quality offered their first certifications for HACCP Auditors.[8] First known as Certified Quality Auditor-HACCP, they were changed to Certified HACCP Auditor (CHA) in 2004.

HACCP expanded in all realms of the food industry, going into meat, poultry, seafood, dairy, and has spread now from the farm to the fork.

HAZARD ANALYSIS (PRINCIPLE 1)

The steps in creating the risk analysis are as follows:

- **Listing of relevant hazards**
- **Control measures**

LISTING OF RELEVANT HAZARDS

A hazard is a biological, chemical or physical agent in, or condition of, food or feed with the potential to cause an adverse health effect (2).

All major potential biological, chemical or physical hazards that may be reasonably expected to occur at each process step (including production, acquisition, storage, transport and handling of raw materials and ingredients and delays during manufacture) should be identified and listed. It may be useful to consult external source of information (e.g. the Rapid Alert System for Food and Feed).

The HACCP team should next conduct a hazard analysis to identify which hazards are of such a nature that their elimination or reduction to acceptable levels is essential to the production of a safe food (end product).

In conducting the hazard analysis, the following should be:

- the likelihood of occurrence of hazards and severity of their adverse health effects;

- the qualitative and/or quantitative evaluation of the presence of hazards;
- the survival or multiplication of pathogenic micro-organisms and unacceptable generation of chemicals in intermediate products, end products, production line or line environment;
- the production or persistence in foods of toxins or other undesirable products of microbial metabolism, chemicals or physical agents or allergens;
- the contamination (or recontamination), of a biological (micro-organisms, parasites), chemical or physical nature, of raw materials, intermediate products or end products.

Example of a hazard analysis – (semi-quantitative) risk evaluation procedure

- Based on FAO/WHO: Risk characterisation of microbiological hazards in food and on Quality management systems in the food industry.
- The risk level is defined by the severity or the effect of the hazard in relation to the probability in which the hazard can occur in the end product if the considered (specific) control measures are not present or are failing – taking into consideration the next steps in the process where an elimination or reduction to an acceptable level is possible, and taking into consideration the already correctly implemented PRPs.
- **P = Probability=** the probability that the hazard is occurring in the end product, if the considered specific control measures are not present or are failing – taking into consideration the next steps in the process where an elimination or reduction to an acceptable level is possible and taking into consideration the already correctly implemented PRPs.
- **E = Effect=** the effect or the severity of the hazard related to human health.

Table 18.1.

Example of a hazard analysis – (semi-quantitative) risk evaluation procedure

RISK LEVEL (R = P x E): SCALE 1 TO 7

PROBABILITY	High	4	4	5	6	7
	Real	3	3	4	5	6
	Small	2	2	3	4	5
	Very small	1	1	2	3	4
			1	2	3	4
			Limited	Moderate	Serious	Very serious
			EFFECT			

Probability

1 = very small

- Theoretical chance – the hazard never occurred before;
- There is a next step in the production process which will eliminate or reduce the hazard to an acceptable level (e.g. pasteurization, fermentation);
- The control measure or the hazard are of such a nature that when the control measure is failing, no production is possible any more or no useful end products are produced (e.g. too high a concentration of colorants as additives);
- It is a very limited and/or local contamination.

2 = small

- The probability that due to failing or absence of the PRPs the hazard will occur in the end product is very limited;

- The control measures for the hazard are of a general nature (PRPs) and these are well implemented in practice;

3 = real

- Failing or lacking of the specific control measure does not result in the systematic presence of the hazard in the end product but the hazard can be present in a certain percentage of the end product in the associated batch.

4 = high

- Failure or absence of the specific control measure will result in a systematic error, there is a high probability that the hazard is present in all end products of the associated batch.

Effect (or severity)

1 = limited

- There is no problem for the consumer related to food safety (nature of hazard e.g. paper, soft plastic, large size foreign materials);
- The hazard can never reach a dangerous concentration (e.g. colorants, S. aureus in a frozen food where multiplication to higher counts is highly unlikely or cannot happen because of storage conditions and cooking).

2 = moderate

- No serious injuries and/or symptoms or only when exposed to an extremely high concentration during a long period of time;
- A temporary but clear effect on health (e.g. small pieces).

3 = serious

- A clear effect on health with short-term or long-term symptoms which results rarely in mortality (e.g. gastro-enteritis);
- The hazard has a long-term effect; the maximal dose is not known (e.g. dioxins, residues of pesticides, mycotoxins, …).

4 = very serious

- The consumer group belongs to a risk category and the hazard can result in mortality;
- The hazard results in serious symptoms from which mortality may result;

- Permanent injuries.

Determination of CCPs and oPRPs when considered relevant

Risk levels 1 & 2: no specific actions, control covered by PRPs.

Risk levels 3 & 4: possible oPRPs. Additional question to be answered by the HACCP team: Is the general control measure(s) as described in the Pre Requisite Program's (PRPs) enough as monitoring for the identified risk?

- If YES: PRP
- If NO: oPRP

Risk levels 5, 6 and 7: CCP or if no measurable critical limit exists this may be an oPRP (e.g. controlling an allergen).

CCPs are the points in a production process where a continuous/batch wise control via a specific control measure is required to eliminate or to reduce the hazard to an acceptable level. The monitoring must be demonstrable and a record must be kept. In the case of a breach of the critical limit, a corrective action towards product and process is necessary.

oPRPs are points in the production process with a smaller food safety risk or where no measurable limits exists. These points can be controlled via more elaborated general basic control measures belonging to the PRPs e.g. more frequent control, recording etc. Due to a regular control and adaptation of the process/product requirements these risks can be considered as controlled. An immediate corrective action towards the product is not required. Examples of oPRPs include:

- Raw material reception → sampling plan for verification of safety/hygiene approaches by suppliers.
- Cross-contamination between batches for allergens → intermediate cleaning and check by adenosine triphosphate (ATP) measurements.
- Contamination of food in high care area → mouth masks and extra protection of personnel, weekly hand hygiene check.

Alternative/simplified approach

The same approach is used in a simpler way, for example:

- Risk levels 1 to 5 instead of 1 to 7 by using 3 instead of 4 subdivisions of the probability and effect (subdivisions 3 and 4 are merged).

- oPRPs are not included when identifying 'intermediate' risk, but only differentiation is made between hazards that can be controlled by PRPs only and those requiring a CCP.

CONTROL MEASURES

The FBO should consider and describe what control measures, if any, can be applied for each hazard.

Control measures are those actions and activities that can be used to prevent hazards, eliminate them or reduce their impact or likelihood of occurrence to acceptable levels. Many preventive control measures are part of PRPs and are intended to avoid contamination from the production environment (e.g. personnel, pest, water, maintenance). Other control measures aiming at reduction or elimination of hazards are more specifically linked to particular production process e.g. pasteurisation, fermentation and may result in the establishment of CCPs or operational PRPs.

More than one control measure may be required to control an identified hazard e.g. pasteurisation controlled by time, temperature and flow rate of the fluid and more than one hazard may be controlled by one control measure e.g. pasteurisation or controlled heat treatment may provide sufficient assurance of reduction of the level of several pathogenic micro-organisms such as *Salmonella* and *Listeria*.

Control measures should be validated.

Control measures should be supported by detailed procedures and specifications to ensure their effective implementation.

IDENTIFICATION OF CRITICAL CONTROL POINTS (CCP) (Principle 2)

The identification of a CCP requires a logical approach. Such an approach can be facilitated by the use of a decision tree or other methods, according to the knowledge and experience of the HACCP team.

The identification of CCPs has two consequences for the HACCP team which should then:

- ensure that appropriate control measures are effectively designed and implemented. In particular, if a hazard has been identified at a step where control is necessary for product safety and no control measure exists at that step, or at any other further on in the production process, then the product or process should be modified at that step or at an earlier or later stage, to include a control measure;
- establish and implement a monitoring system at each CCP.

Each process step identified in the flow diagram should be considered in sequence. At each step, the decision tree and/or risk evaluation should be applied to each hazard that may be reasonably expected to occur or be introduced and each control measure identified. Application should be flexible, considering the whole manufacturing process in order to avoid, whenever possible, unnecessary CCPs. Training in the application of a method to identify CCPs is recommended.

Fig.18.2. Critical control point - detection of foreign bodies

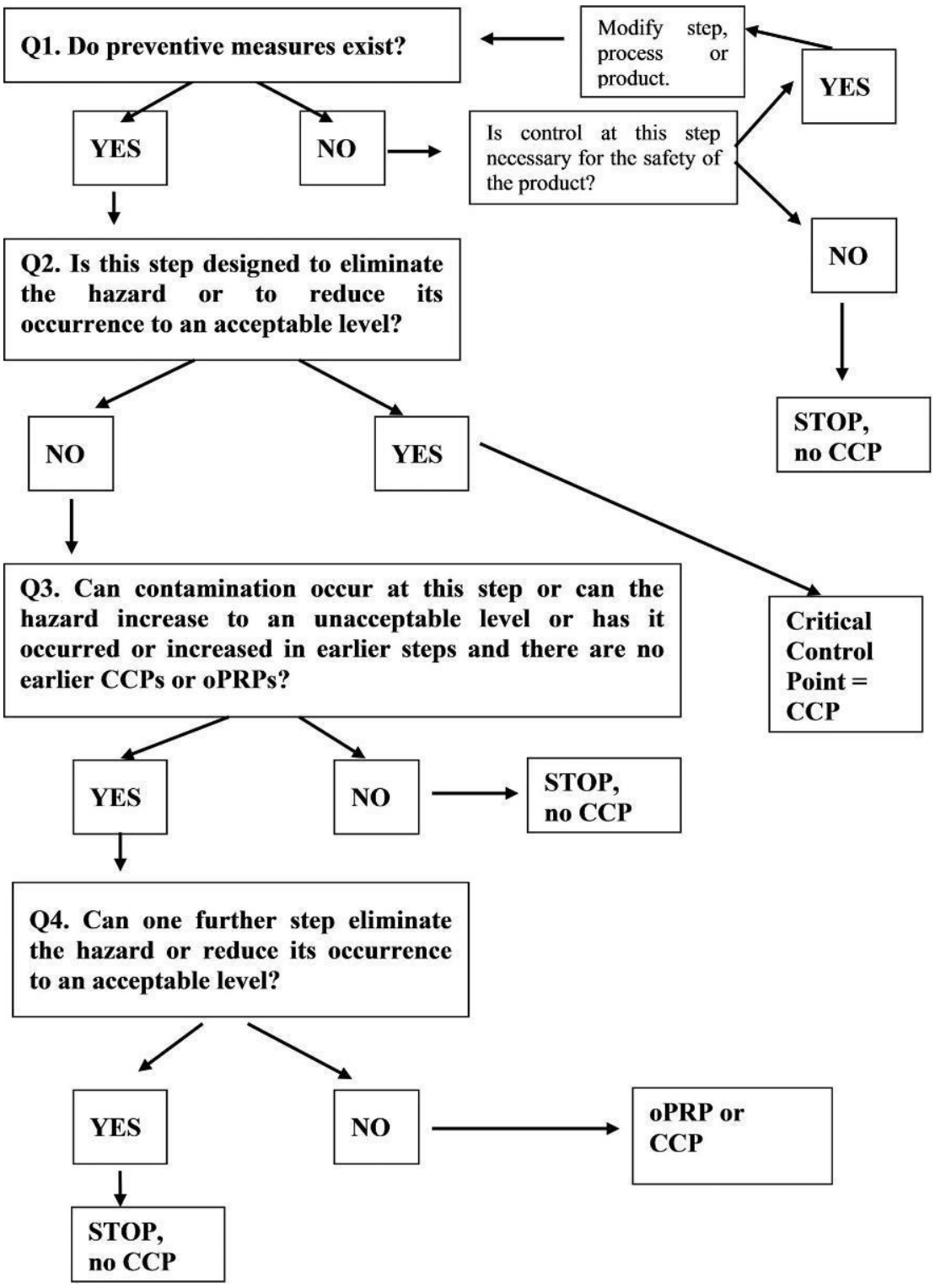

Fig.18.3. Examples of a decision tree to identify critical control points (CCPs).

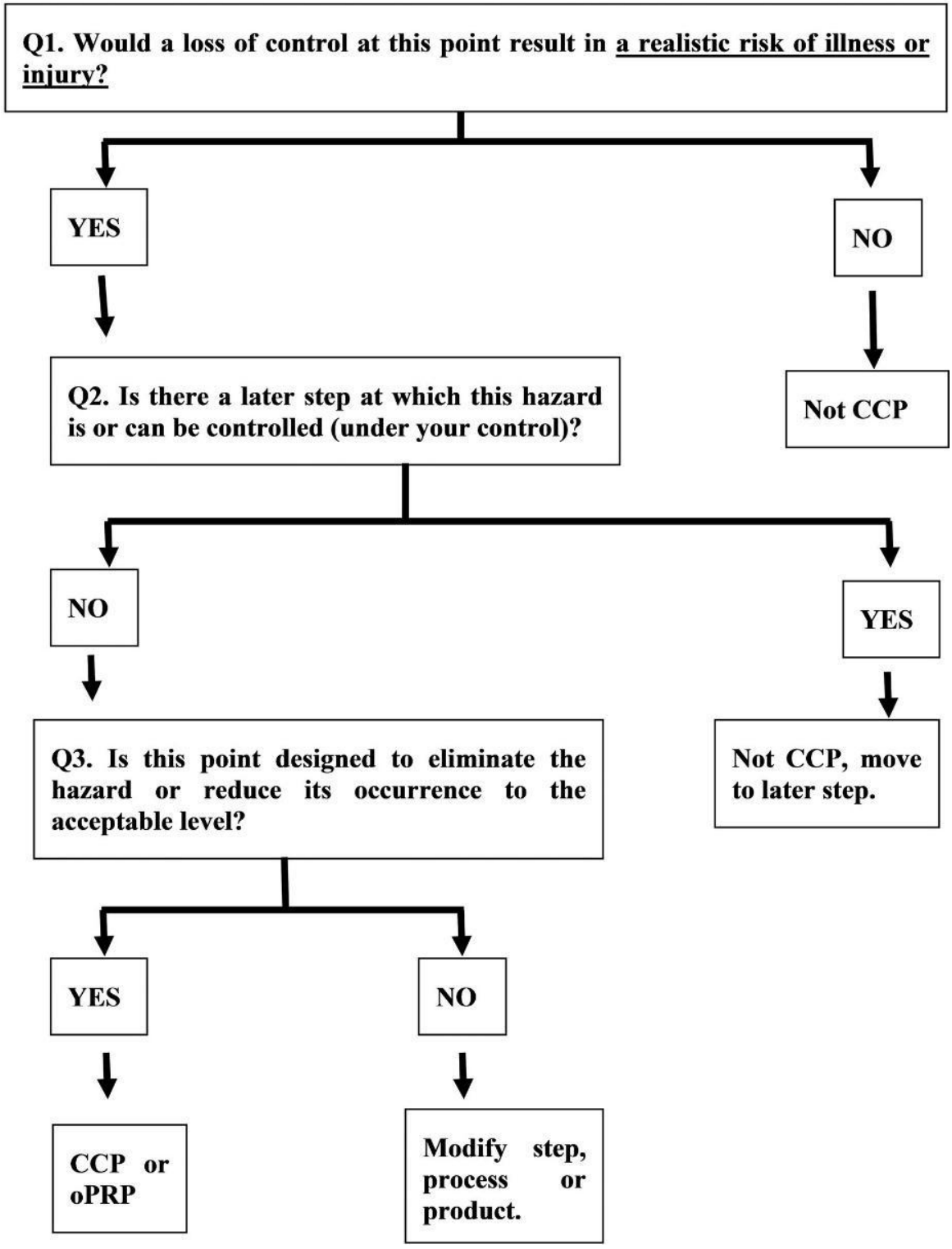

Fig.18.4. Example of simplified decision tree

The hazard analysis may identify different levels of risks for each process step:

- For lower risk levels it can be concluded that, if robust PRPs are in place, these PRPs are sufficient to control the hazards.
- For intermediate levels of risks identified, 'intermediate' measures can be proposed, such as operational PRPs.

oPRPs are PRPs that are typically linked to the production process and are identified by the hazard analysis as essential, in order to control the likelihood of the introduction, survival and/or proliferation of food safety hazards in the product(s) or in the processing environment. Similarly to CCPs, operational PRPs include measurable or observable action criteria or action limits (but targets rather than critical limits), monitoring of the implementation of control measures, monitoring records and corrective actions if needed. Examples are:

- Control of washing process of vegetables (e.g. by frequency of wash water refreshment to avoid microbial cross-contamination, mechanical action in the water to remove physical hazards as stones, pieces of wood).
- Control of blanching process for the deep freezing industry (time/temperature).

Washing and blanching processes can usually not be considered as CCPs because neither provides full elimination of the microbial hazards nor reduction to an acceptable level can be achieved or is at the objective. However, they will impact the microbial load of the processed products.

- More intensive cleaning and disinfection in high care areas, more strict personal hygiene in high care areas, for example in packaging areas of ready to eat food.
- More severe incoming check upon reception of raw materials if supplier is not guaranteeing the desired quality/safety level (e.g. mycotoxins in spices).
- Control of allergens by a sanitation programme.

- For high level of risks, which are not controlled by PRPs or oPRPs, CCPs should be established.

Table 18.2.

Comparison of PRPs, oPRPs and CCPs (ISO 22000:2018)

Type of control measure	PRP	OPRP	CCP
Scope	Measures related to creating the environment for safe food: measures impacting food suitability and safety.	Measures related to the environment and/or product (or combination of measures) to prevent contamination, or to prevent, eliminate or reduce hazards to an acceptable limit in the end product. These measures are implemented after the implementation of PRPs.	
Relation to hazards	Not specific to any hazard.	Specific to each hazard or group of hazards.	
Determination	Development based on: ✓ Experience, ✓ Reference documents (guides, scientific publications, …), ✓ Hazard or hazard analysis.	Based on the hazard analysis taking PRPs into account. CCPs and oPRPs are product and/or process specific.	
Validation	Not necessarily carried out by FBO. (i.e.: cleaning products manufacturer has validated the efficiency of the product and determined product spectrum and instructions of use – FBO has to follow instructions and keep technical specifications of product).	Validation has to be carried out (in many cases, guides to good practice provide guidance on a validation methodology or gives ready to use validation material).	
Criteria	/	Measurable or observable criteria.	Measurable critical limit.
Monitoring	Where relevant and feasible.	Monitoring of the implementation of control measures: usually recorded.	
Loss of control: Corrections/corrective actions	Corrective actions and/or corrections on the implementation of PRPs where relevant.	Corrective actions on the process. Possible corrections on the product (case by case). Records kept.	Pre-set corrections on the product. Possible corrective actions on the process. Records kept.
Verification	Scheduled verification of implementation.	Scheduled verification of implementation, verification of achievement of planned hazard control.	

Summary of examples on flexibility for certain FBOs

Activity	Flexibility
1 Prerequisites programs	— Exclusions from scope of Regulations (EC) No 852/2004 and (EC) No 853/2004 — Less descriptive PRPs for primary production and associated operations — Less descriptive PRPs for movable and/or temporary premises, … — Exclusion of most retailers from the scope of Regulation (EC) No 853/2004 — Possible adaptation under national law for use of traditional methods, FBOs in regions with geographic constraints and for any establishment as regards construction lay-out and equipment — Use of generic sectorial guides for good hygiene practice
2 Preliminary HACCP activities	— No permanent HACCP team, one person responsible for HACCP/FSMS — Use of existing product information (label, internet) — Simple flow diagram
3 Hazard analysis and CCP identification	— Simplified decision trees or (semi-)quantitative risk evaluation methods — Pre-determination of hazards from generic HACCP guide or a generic hazard analysis only. — No need for detail on the nature of the hazards. — Similar products can be grouped.

CCP identified / **No CCP identified**

4 Critical limits	— Pre-determined limits from legislation, scientific opinions, … — No need for fixing numerical values	Low risks: Activities 1 to 3 are considered as compliance with the HACCP-based procedures Intermediate risks: compliance might require oPRPs
5 Monitoring procedure	— Regular visual observation instead of continuous recording — Use of check lists with boxes to tick in case of compliance — Use of standard processing procedures	
6 Verification and validation	— Verify that monitoring is done by checking the records or checking actual monitoring, like checking that measuring temperature is done according the procedures and guides. — Use of results from analyses as validation/Analysing the products against criteria	
7 Documents and records	— Use of generic guides as documentation — Only records on non-compliance and corrective actions	

Fig.18.5. Example Hazard analysis and identification of CCPs (ISO 22000:2018).

Several simplified methods have been described to carry out the hazards analysis and identify possible CCPs e.g. simplified decision trees and semi-quantitative risk evaluation methods.

In certain cases, due to the nature of the food business and the food that is handled by it, a (generic) hazard analysis may demonstrate that no very significant hazard has been identified and therefore there is no need for CCPs. In this case all food hazards can be controlled by the implementation of the PRPs only or in combination with the application of certain oPRPs. It must however be stressed that flexibility on the hazard analysis is not directly linked to the size of the establishment and is not appropriate even when the business is small e.g.:

- when there is a high likelihood of failure in the method of processing such as canning, vacuum packing,
- food production for vulnerable groups of consumers,
- allergen controls in products declared to be allergen free.

For certain categories of food businesses with very identical, standardised and limited handling of the food (e.g. retail shops), it may be possible to pre-determine hazards that need to be controlled. Guidance on such hazards and on the control thereof can be addressed in a generic HACCP guide or a generic hazard analysis only.

In certain cases, due to the nature of the food business and the food that is handled by it, the hazard analysis may demonstrate that significant hazards do not exist and there are no control measures, which could be categorised as CCPs. In these cases oPRPs are the control measures.

In small businesses it may suffice that the hazard analysis in the HACCP plan describes in a practical and simple way the methods to control hazards without necessarily entering into detail on the nature of the hazards. Such analysis should nevertheless cover all significant hazards in a business and should clearly define procedures to control these hazards and the corrective action to be taken in case of problems.

CRITICAL LIMITS AT CCPs (Principle 3)

Each control measure associated with a critical control point should give rise to the specification of critical limits.

Critical limits correspond to the extreme values acceptable with regard to product safety. They separate acceptability from unacceptability. They are set for observable or measurable parameters which can demonstrate that the critical point is under control. They should be based on substantiated evidence that the chosen values will result in process control.

Examples of such parameters include temperature, time, pH, moisture content, amount of additive, preservative or salt, sensory parameters such as visual appearance or texture, etc.

In some cases, to reduce the likelihood of exceeding a critical limit due to process variations, it may be necessary to specify more stringent levels (i.e. target levels) to assure that critical limits are observed.

Critical limits should be validated and should have clear, specific values.

Critical limits may be derived from a variety of sources. When not taken from regulatory standards or from guides of good hygiene practices, the HACCP team should ascertain their validity relative to the control of identified hazards at CCPs.

Critical limits at CCPs can be established on the basis of:

- Experience (best practice);
- International documentation for a number of operations, e.g. canning of food, pasteurisation of liquids etc. for which internationally accepted standards (*Codex Alimentarius*) exist; critical limits can also be established;
- Guides to good practice on this specific issue;
- Scientific publications;
- EU legislation, EFSA opinions.

The requirement to establish a critical limit at a CCP does not always imply that a numerical value must be fixed. This is in particular the case where monitoring procedures are based on visual observation e.g.:

- The faecal contamination of carcases in a slaughterhouse,
- The boiling temperature of liquid food,

- The change of physical properties of food during processing (e.g. cooking of food).

MONITORING PROCEDURES AT CCPs (Principle 4)

An essential part of HACCP-based procedures is a program of observations or measurements performed at each CCP to ensure compliance with specified critical limits.

Observations or measurements must be able to detect loss of control at CCPs and provide information in time for corrective action to be taken.

Where possible, process adjustments should be made when monitoring results indicate a trend towards loss of control at a CCP. The adjustments should be made before a deviation occurs (the critical limit is not met). Data derived from monitoring must be evaluated by a designated and experienced person with knowledge and authority to carry out corrective actions when indicated.

Observations or measurements can be made continuously or intermittently. When observations or measurements are not continuous, it is necessary to establish a frequency of observations or measurements which provides information in time for corrective actions to be taken.

The HACCP plan should describe the methods, the frequency of observations or measurements and the recording procedure for monitoring at CCPs:

- who is to perform monitoring and checking,
- when monitoring and checking is performed,
- how monitoring and checking is performed.

The frequency of monitoring should be risk based e.g. depending on the likelihood of hazard occurrence in the product, the volume of production, the distribution of the product, the potential consumers, the number of workers directly handling the product.

Records associated with monitoring CCPs must be signed by the person(s) doing the monitoring and when records are verified by staff of the company responsible for reviewing.

Monitoring is not only achieved by measuring. Monitoring may, in many cases, be a simple procedure, e.g.:

- A regular visual verification of the temperature of cooling/freezing/heating facilities using a thermometer;

- A visual observation to monitor whether the correct de-hiding procedure is being applied during slaughter where this part of the slaughter process has been identified as a critical control point for preventing carcase contamination;
- A visual observation to verify whether a food preparation submitted to a particular heat treatment has the correct physical properties reflecting the level of heat treatment (e.g. boiling or to making sure food is steaming hot all the way through).

Monitoring should be as frequent as necessary to ensure that critical limits and targets are permanently met. It should confirm that the critical limit or target is not exceeded. The type of CCP determines the frequency of monitoring. Monitoring of a CCP can in some cases occur intermittently, e.g. in a case of reduced frequency of monitoring after prolonged period of good results.

Standard processing procedures can be used:

- Certain foods may sometimes be processed in a standard way using standard calibrated equipment, e.g. certain cooking operations, roasting chicken etc. Such equipment ensures that the correct time/temperature combination is respected as a standard operation. The cooking temperature of the product then needs not to be systematically measured if it is ensured that the equipment is functioning properly, that the required time/temperature combination is respected and that the necessary controls for that purpose are carried out (and corrective action taken where necessary).
- In restaurants, food is prepared in accordance with well-established culinary procedures. This implies that measurements (e.g. food temperature measurements) need not be carried out systematically if the established procedures are followed.

CORRECTIVE ACTIONS (Principle 5)

For each CCP, corrective actions should be planned in advance by the HACCP team, so that they can be taken without hesitation when monitoring indicates a deviation from the critical limit.

Such corrective actions should include:

- proper identification of the person(s) responsible for the implementation of the corrective action,
- means and action required to correct the observed deviation,
- action(s) (sometimes called 'corrections' to differentiate from other corrective actions) to be taken with regard to products that have been manufactured during the period when the process was out of control,
- written record of measures taken indicating all relevant information (for example: date, time, type of action, actor and subsequent verification check).

Monitoring may indicate that preventive measures (PRPs or their robustness) or the process and its CCPs shall have to be reviewed if corrective actions for the same procedure have to be taken repeatedly.

VERIFICATION (AND VALIDATION) PROCEDURES (Principle 6)

The HACCP team should specify the methods and procedures to be used for determining if the HACCP-based procedures are working correctly. Methods for verification may include in particular random sampling and analysis, reinforced analysis or tests at selected critical points, intensified analysis of intermediate or end products, surveys on actual condition during storage, distribution and sale and on actual use of the product.

The frequency of verification should be sufficient to confirm that HACCP-based procedures are working effectively. The frequency of verification shall depend on the characteristics of the business (output, number of employees, nature of the food handled), the monitoring frequency, the accuracies of the employees, the number of deviations detected over time and the hazards involved.

Verification procedures may include:

- Audits of HACCP-based procedures and their records,
- Inspection of operations (people compliance),
- Confirmation that CCPs monitoring is implemented and maintained,
- Review of deviations and product dispositions; corrective actions taken with regard to the product.

The frequency of verification will greatly influence the amount of recheck or recall required in case a deviation exceeding the critical limits has been detected. Verification should comprise all of the following elements, but not necessarily all at the same time:

- check on the correctness of the records and analysis of deviations,
- check on the person monitoring processing, storage and/or transport activities,
- physical check on the process being monitored,
- calibration of instruments used for monitoring.

Verification should be carried out by someone other than the person who is responsible for performing the monitoring and corrective actions. Where certain verification activities cannot be performed in house, verification should be performed on behalf of the business by external experts or qualified third parties.

At the start of a process or in case of a change, validation activities should be carried out and should gather evidence to confirm the efficacy of all elements of the HACCP plan. Such evidence includes scientific publications, in-house testing, predictive microbiology,

demonstrating that the critical limits set, will, if adhered to, result in the intended effect on the hazard (no growth, reduction). Additional guidance and examples of validation activities are in CAC/GL 69-2008.

Examples of changes that may require re-validation include:

- change in raw material or in product, processing conditions (factory layout and environment, process equipment, cleaning and disinfection programme),
- change in packaging, storage or distribution conditions,
- change in consumer use,
- receipt of any information on a new hazard associated with the product.

Where necessary, such a review must result in the amendment of the procedures laid down. The changes should be fully incorporated into the documentation and record-keeping system in order to ensure that accurate up-to-date information is available.

Validation, verification or monitoring?

- **Validation:** evidence before the start (or change) of a process demonstrating that the considered control measures (PRPs, oPRPs or CCPs) are effective when correctly applied and will be protective of human health e.g. evidence that the targeted hazard does not grow to an unacceptable level at the proposed critical limit of storage temperature.
- **Monitoring:** ongoing (real-time) collection of information at the step where the control measure is applied e.g. the continuous or intermittent monitoring of the storage temperature.
- **Verification:** periodic activity to demonstrate that the desired outcome has indeed been reached e.g. sampling and testing of the food to evaluate the presence of the targeted hazard below the acceptable threshold by storage at a certain temperature.

Example 1: milk pasteurisation

- Validation: before production activities: Experimental proof that the process used will heat milk to 72 °C for 15 seconds and will destroy *Coxiella burnetti*. Calibrated probes, microbiological tests and predictive microbiology can be used.
- Monitoring: during production activities: System (time – temperature – pressure – volume throughput) which will enable the companies to see that the critical limit (72 °C for 15 seconds) is attained during process.

- Verification: fixed frequency per year: Periodic microbiological tests on the end product, regular check of temperature of the pasteuriser with calibrated probes.

Example 2: Fermentation of dry cured sausages

- Validation: pH, water activity, time/temperature combination, not allowing *Listeria monocytogenes* to grow by predictive modelling or by challenge testing;
- Monitoring during fermentation: measurement of pH, weight loss, time period, temperature, humidity of fermentation chamber, *L. monocytogenes* sampling in fermentation environment;
- Verification: *L. monocytogenes* sampling plan in the end product.

Verification may in many cases be a simple procedure by which it is possible to check that monitoring is done in a proper way in order to achieve a required food safety level.

Simple verification procedures may include:

- physical audit or check on the monitoring;
- physical audit or check on the monitoring records including the checking of corrective actions whenever a non-compliance or exception reporting has been recorded.

Generic HACCP guides should include examples of necessary verification procedures, and when standard processes are concerned, there should be a validation of the considered control measures on the targeted hazards as well. The validation of the HACCP plan and activities of the FBO can focus on the sampling and testing of the food to evaluate the presence of the targeted hazards.

DOCUMENTATION AND RECORD KEEPING (Principle 7)

Efficient and accurate record keeping is essential to the application of HACCP-based procedures. HACCP-based procedures should be documented in the HACCP-plan and continuously supplemented by records on findings.

Documentation and record keeping should be appropriate to the nature and size of the operation and sufficient to assist the business to verify that the HACCP-based procedures are in place and being maintained.

Documents and records should be kept for a sufficient period of time beyond the shelf life of the product for traceability purposes, for the regular revision of the procedures by the FBO and to allow the competent authority to audit the HACCP-based procedures.

Expert developed HACCP guidance materials (e.g. sector-specific HACCP guides) may be utilised as part of the documentation, provided that those materials reflect the specific food operations of the business. Documents should be signed by a responsible reviewing official of the company.

Recommended documentation includes:

- PRPs applied, working instructions, standard operational procedures, control instructions;
- Description of the preparatory stages (before 7 principles);
- Hazard analysis;
- CCP (+/- oPRPs) identification;
- Critical limit determination;
- Validation activities;
- Corrective actions anticipated;
- Description of planned monitoring and verification activities (what, who, when);
- Record forms;
- Modifications to the HACCP-based procedures;
- Supporting documents (generic guides, scientific evidence).

A systematic, integrated approach can be taken by using worksheets for the development of the HACCP plan as provided in the Annex to CAC/RCP 1-1969, Diagram 3. Starting from the flow diagram, at each step of processing the potential hazards are described, relevant control measures (PRPs) listed, CCPs identified (if appropriate based on the hazards analysis) along with their critical limits, monitoring procedures, corrective actions and available records.

Record examples are:

- Outcome of CCP monitoring activities;
- Observed deviations and executed corrective actions;
- Outcome of verification activities.

Records should be kept for an appropriate period of time. That period should be long enough to ensure information to be available in case of an alert that can be traced back

to the food in question. For certain foods the date of consumption is certain. For instance, in food catering, consumption takes place shortly after the time of production. For food for which the date of consumption is uncertain, records should be kept for a reasonably short period after the expiry date of the food. Records are an important tool for the competent authorities to allow verification of the proper functioning of the food businesses' FSMS.

A simple record-keeping system can be effective and easily communicated to employees. It may be integrated into existing operations and may use existing paperwork, such as delivery invoices and checklists to record, for example, product temperatures.

This section refers to HACCP related documentation only and not to other documentation on issues such as stock management, traceability etc.

HACCP-based procedures, documents and records must be commensurate to the nature and the size of the food business.

As a general rule, the need for HACCP-related record keeping should be well-balanced and can be limited to what is essential with regard to food safety. It is important to consider that recording is necessary but not the goal in itself.

HACCP related documentation includes:

- Documents on the HACCP-based procedures appropriate for a particular food business, and
- Records on measurements and analysis carried out.

Taking into account the above, the following general guidelines could be used:

- Where generic HACCP guides exist, documentation on hazard analysis, CCP determination, critical limit determination, possible modification of the FSMS and validation activities can be substituted for individual documentation on HACCP-based procedures. Such guides could also clearly indicate where there is a need for records and the period of time during which records must be kept.
- In particular in the case of visual monitoring procedures, it may be considered to limit the need for establishing a record only to measurements of non-compliance (e.g. failure of equipment to maintain the correct temperature) that are detected.
- Carrying out monitoring effectively is in general more important than recording it. Therefore, flexibility on the recording could be more easily accepted than flexibility concerning the monitoring itself (e.g. its frequency).

- In particular for small businesses keeping the right temperature is far more important than actually recording it.

Taking into account the above, the following general guidelines could be used:

- Where generic HACCP guides exist, documentation on hazard analysis, CCP determination, critical limit determination, possible modification of the FSMS and validation activities can be substituted for individual documentation on HACCP-based procedures. Such guides could also clearly indicate where there is a need for records and the period of time during which records must be kept.
- In particular in the case of visual monitoring procedures, it may be considered to limit the need for establishing a record only to measurements of non-compliance (e.g. failure of equipment to maintain the correct temperature) that are detected.
- Carrying out monitoring effectively is in general more important than recording it. Therefore, flexibility on the recording could be more easily accepted than flexibility concerning the monitoring itself (e.g. its frequency).
- In particular for small businesses keeping the right temperature is far more important than actually recording it.

Taking into account the above, the following general guidelines could be used:

- The records of non-compliance should include the corrective action that has been taken. The use of a diary or a checklist might be a suitable way of record keeping in such cases. FBOs can simply tick boxes to indicate how they act or provide more detailed information by writing in text boxes how they comply with a control point. Daily record-keeping is based on confirming opening and closing checks with a tick and a signature to confirm that safe methods have been followed. When a box ticking approach is used, only problems or changes to procedures are recorded in more detailed additional writing (i.e. exception reporting).
- (Generic) models regarding auto-control documents should be provided by stakeholders' organisations or competent authorities. These should be easy to use, understandable and simple to implement.
- A x-weekly review of methods only requires completing a check list of activities and possible impact on safe methods.

Although EU legislation does not provide for critical limits at critical control points, microbiological criteria can be used in validation and verification of HACCP-based procedures and other food hygiene control measures, as well as for the verification of the

correct functioning of these control measures. For a particular operation or type of food, the guides to good practice can refer to these limits and the HACCP-based procedure can be formatted in such a way as to ensure that these limits are met.

Theme 19

Preparation of the HACCP plan

Practical work 1

1. Assignment for students: Product description (specification) as part of the HACCP plan

Objective of the assignment:

Prepare a detailed product description (specification) that will be part of the HACCP (Hazard Analysis and Critical Control Points) plan. This description is essential for ensuring food safety and product quality.

Instructions:

1. **Product selection:**
    - Choose a specific food product to describe. This can be any product, such as dairy products, meat and meat products, baked goods, beverages, etc.
2. **Basic information:**
    - Product name.
    - Product description (characteristics, appearance, taste, smell).
    - Photo of the product (if possible).
3. **Ingredients:**
    - Detailed list of all ingredients in the product, including additives and preservatives.
    - Proportion of each ingredient.
4. **Nutritional information:**
    - Energy value (kJ/kcal).
    - Content of proteins, fats, carbohydrates, fibre, salt, and other relevant components.
5. **Allergens:**
    - List of potential allergens present in the product.
6. **Production process:**
    - Brief description of the production process.
    - Key steps in the production process, including Critical Control Points (CCPs).
7. **Packaging:**
    - Type and material of the packaging.
    - Size and weight of the package.
    - Labelling – what the label must include.

8. **Storage and distribution:**
    - Storage conditions (temperature, humidity, etc.).
    - Shelf life.
    - Distribution method (transport conditions, logistics).
9. **Target group:**
    - Intended consumer group (children, adults, people with food intolerances, etc.).
10. **Risks and preventive measures:**
    - Identification of possible risks associated with the product (biological, chemical, physical).
    - Description of preventive measures to minimise these risks.

Report format:

- Prepare the report using a text editor (e.g. Microsoft Word, Google Docs).
- Follow the structure and order of points listed above.
- The total length of the report should be at least 5 pages (A4), font Times New Roman, size 12, line spacing 1.5.

Evaluation criteria:

- Completeness and detail of information.
- Clarity and comprehensibility of the description.
- Accuracy and relevance of the provided data.
- Creativity and presentation (including photos and visual elements).

Submit your work electronically to [email address] or through the platform [name of the platform] by the specified deadline.

2. Assignment for students: creating a flowchart for a selected food product

Objective of the Assignment:

Develop a flowchart for a selected food product based on the provided technological process using symbols according to ISO 9004 – 4.

Instructions:

1. **Selection of a food product:**
    - Choose a specific food product that will be the subject of your flowchart. This can be any product, such as bread, dairy products, meat and meat products, beverages, etc.
2. **Technological process:**

- Study the provided technological process for the selected product. Identify all the main steps and sub-steps in the production process.

3. **Use of symbols according to ISO 9004 – 4:**
   - Use appropriate symbols from ISO 9004 – 4 to denote each step in the technological process. The symbol set includes:
     - Oval: Start and end of the process
     - Parallelogram: Input control
     - Rectangle: Process operation
     - Hexagon: Decision point
     - Wavy line: Storage
     - Circle with a red border: Inspection
4. **Creating the flowchart:**
   - Create the flowchart using suitable software (e.g. Microsoft Visio, Google Drawings, Lucidchart) or manually on paper.
   - Ensure correct use of symbols according to ISO 9004 – 4.
   - Make the flowchart clear and unambiguous.
5. **Design of the flowchart:**
   - The flowchart should include all key steps from the receipt of raw materials to the final product.
   - Each step should be labelled with the appropriate symbol and a brief description (e.g., "Receipt of raw materials," "Mixing ingredients," "Baking," "Quality control").

Format and Submission:

- **Format:** The flowchart can be submitted in PDF, JPEG, or PNG format, or as a physical drawing (in case of a hand-drawn chart).
- **Submission:** Upload the file to the platform [name of the platform] or submit the physical drawing in class.
- **Submission deadline:** [Provide a specific date]

Evaluation criteria:

- Correct use of symbols according to ISO 9004 – 4.
- Completeness and detail of the flowchart.
- Clarity and aesthetics of the flowchart.
- Logical sequence of steps and clarity of descriptions.

Conclusion

This assignment will help you understand the importance of flowcharts in the food industry and their role in ensuring product quality and safety according to ISO standards.

Approved by

_____

Name, surname, signature

Date

_____

Practical work 2

Assignment for students: risk analysis/preventive measures and risk management level determination

Objective of the assignment:

Prepare a risk analysis and determine preventive measures and the level of risk management for the following items according to the specified methodology.

Items for risk analysis:

1. **Disinfectants used in operation (chlorine-based):**
    - **Objective:** Assess the risks associated with the use of chlorine-based disinfectants in the operation.
    - **Preventive measures:** Identify and describe preventive measures to control the risks.
        - Proper storage of disinfectants in labelled, secure containers.
        - Use of personal protective equipment (PPE) by staff.
        - Regular training on the safe handling and use of disinfectants.
        - Emergency procedures for spills or accidental exposure.
    - **Risk management level:** Determine the appropriate level of control for handling and using disinfectants.
        - High level of control: Frequent audits, strict adherence to safety protocols, and comprehensive training.
2. **Wooden pallets for packing finished product (powdered sugar):**
    - **Objective:** Analyse the risks associated with using wooden pallets for packing powdered sugar.
    - **Preventive measures:** Suggest preventive measures to manage risks.
        - Regular inspection and maintenance of pallets to ensure they are clean and free from contaminants.
        - Use of pallet covers to protect the product from dust and debris.
        - Storing pallets in dry, clean areas to prevent mould growth.
    - **Risk management level:** Assess the level of control needed to manage risks.
        - Moderate level of control: Routine checks, proper storage practices, and cleanliness standards.
3. **Packaging and labelling of vegetable mix (celery, carrot):**
    - **Objective:** Evaluate the risks in the packaging and labelling process of the vegetable mix.
    - **Preventive Measures:** Identify measures to mitigate risks.
        - Accurate labelling to include all ingredients and allergens.
        - Ensuring that packaging materials are clean and food-safe.

        - Training staff on proper packaging and labelling techniques to avoid cross-contamination.
    - **Risk management level:** Define the level of control required to ensure safety and compliance.
        - High level of control: Regular verification of labels, stringent hygiene protocols, and training.
4. **Production personnel of baby food:**
    - **Objective:** Assess the risks related to the personnel involved in the production of baby food.
    - **Preventive measures:** Propose preventive measures.
        - Regular health checks and hygiene training for all staff.
        - Implementation of strict personal hygiene protocols (e.g. handwashing, use of hairnets and gloves).
        - Monitoring compliance with hygiene standards through regular inspections.
    - **Risk management level:** Determine the level of control needed for ensuring the safety of baby food production.
        - High level of control: Continuous monitoring, frequent training sessions, and strict enforcement of hygiene rules.

Format and submission:

- **Format:** The analysis should be prepared in a structured report format (e.g. Microsoft Word, Google Docs).
- **Submission:** Upload the document to the platform [name of the platform] or submit a printed copy in class.
- **Submission Deadline:** [Provide a specific date].

Evaluation Criteria:

- Completeness and detail of the risk analysis.
- Appropriateness and effectiveness of the preventive measures.
- Accuracy in determining the risk management level.
- Clarity and organisation of the report.

Conclusion

This assignment will help you understand the importance of risk analysis and management in the food industry, ensuring the safety and quality of food products.

Approved by

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Name, surname, signature

Date

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Practical work 3

Assignment for students: Incorporate monitored indicators into the HACCP plan (part A, part B)

Objective of the assignment:

Incorporate the monitored indicators into the final HACCP plan (part A, part B) for the following processes:

1. Shock freezing to a temperature of -18°C or below.
2. Receiving pork halves into the meat processing plant.
3. Detection of foreign particles in baby food products.

Instructions:

1. **Shock freezing to -18 °C or below:**
    - **Process:** Shock freezing
    - **Monitored indicators:** Temperature during the freezing process
    - **Critical limits:** Temperature must be maintained at -18 °C or below
    - **Monitoring:**
        - **What:** Temperature of the freezing chamber
        - **How:** Use of a calibrated thermometer
        - **Frequency:** Continuous monitoring with a data logger, manual checks every 4 hours
        - **Who:** Designated quality control staff
    - **Corrective actions:**
        - Adjust settings of the freezer if temperature rises above -18 °C
        - Investigate and document the cause of the deviation
        - Reprocess or discard affected products if necessary
    - **Record keeping:** Temperature logs
    - **Verification procedures:** Regular calibration of thermometers, review of temperature logs
2. **Receiving pork halves into the meat processing plant:**
    - **Process:** Receiving pork halves
    - **Monitored indicators:** Temperature of pork halves upon receipt, visual inspection
    - **Critical limits:** Temperature must be at or below 4 °C
    - **Monitoring:**
        - **What:** Temperature of pork halves
        - **How:** Use of a calibrated thermometer
        - **Frequency:** At the time of delivery
        - **Who:** Receiving staff

    - **Corrective actions:**
        - Reject pork halves if temperature is above 4 °C
        - Document the non-compliance and notify the supplier
    - **Record keeping:** Delivery temperature logs, non-compliance reports
    - **Verification procedures:** Periodic review of delivery logs, calibration of thermometers
3. **Detection of foreign particles in baby food products:**
    - **Process:** Detection of foreign particles
    - **Monitored indicators:** Presence of foreign particles
    - **Critical limits:** Zero tolerance for foreign particles
    - **Monitoring:**
        - **What:** Baby food products
        - **How:** Use of metal detectors and visual inspections
        - **Frequency:** Continuous monitoring with metal detectors, visual inspections at packaging
        - **Who:** Quality control staff
    - **Corrective actions:**
        - Halt production if foreign particles are detected
        - Investigate and remove the source of contamination
        - Reprocess or discard affected products
    - **Record keeping:** Detection logs, corrective action reports
    - **Verification procedures:** Regular testing of metal detectors, review of detection logs

Format and submission:

- **Format:** Complete the provided HACCP plan templates (Part A and Part B) with the information above.
- **Submission:** Upload the completed templates to the platform [name of the platform] or submit a printed copy in class.
- **Submission deadline:** [Provide a specific date].

Evaluation Criteria:

- Completeness and accuracy of the information in the HACCP plan templates.
- Appropriateness and effectiveness of the monitoring procedures and corrective actions.
- Clarity and organisation of the completed templates.

Conclusion:

This assignment will help you understand the critical aspects of incorporating monitored indicators into the HACCP plan to ensure food safety and compliance with regulatory standards.

Approved by

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Name, surname, signature

Date

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Practical work 4

Assignment for students: Creating a universal working checklist for evaluating the HACCP system and its principles

Objective of the assignment:

Create a universal working checklist to evaluate the HACCP (Hazard Analysis and Critical Control Points) system and all its principles. Then, use this checklist to audit an existing HACCP system.

Instructions:

1. **Understanding HACCP principles:**
    - Review the seven principles of HACCP:
        1. Conduct a hazard analysis.
        2. Determine critical control points (CCPs).
        3. Establish critical limits.
        4. Establish monitoring procedures.
        5. Establish corrective actions.
        6. Establish verification procedures.
        7. Establish record-keeping and documentation procedures.
2. **Creating the checklist:**
    - Design a comprehensive checklist that covers all seven principles of HACCP.
    - Include specific questions and criteria for each principle to ensure a thorough evaluation.
    - Ensure the checklist is detailed enough to cover various aspects of the HACCP system, such as documentation, process controls, and corrective actions.
3. **Components of the checklist:**
    - **Section 1: Hazard analysis**
        1. Are potential hazards identified for each step of the process?
        2. Is there a risk assessment for each identified hazard?
        3. Are preventive measures in place for each hazard?
    - **Section 2: Critical control points (CCPs)**
        1. Are CCPs identified correctly in the process?
        2. Are the CCPs documented and clearly defined?
        3. Are there control measures in place for each CCP?
    - **Section 3: Critical limits**

1. Are critical limits established for each CCP?
2. Are the critical limits measurable and specific?
3. Are the limits based on scientific data or regulatory standards?

- **Section 4: Monitoring procedures**

1. Are monitoring procedures defined for each CCP?
2. Is the frequency of monitoring adequate to ensure control?
3. Are the monitoring records maintained properly?

- **Section 5: Corrective actions**

1. Are corrective actions defined for deviations from critical limits?
2. Are staff trained on how to implement corrective actions?
3. Are corrective actions documented and reviewed?

- **Section 6: Verification procedures**

1. Are verification activities defined and performed regularly?
2. Is there a review of records and monitoring data?
3. Are validation activities conducted to ensure the HACCP plan is effective?

- **Section 7: Record-keeping and documentation**

1. Are all records and documents related to the HACCP plan maintained?
2. Are records easily accessible and properly stored?
3. Is there a documentation procedure in place?

4. **Using the checklist:**
   - Select an existing HACCP system to evaluate.
   - Use the created checklist to conduct a thorough audit of the HACCP system.
   - Document the findings of the audit, noting any areas of compliance and non-compliance.
5. **Report preparation:**
   - Prepare a report summarising the audit findings.
   - Include an assessment of the overall effectiveness of the HACCP system.
   - Provide recommendations for improvements based on the audit results.

Format and submission:

- **Format:** The checklist should be prepared in a structured format (e.g. Microsoft Word, Google Docs) and the audit report should follow a formal report structure.
- **Submission:** Upload the checklist and audit report to the platform [name of the platform] or submit printed copies in class.
- **Submission Deadline:** [Provide a specific date].

Evaluation criteria:

- Completeness and detail of the checklist.
- Thoroughness and accuracy of the audit using the checklist.
- Clarity and organisation of the audit report.
- Practicality and effectiveness of the recommendations provided.

Conclusion

This assignment will help you understand the critical aspects of evaluating and auditing HACCP systems, ensuring food safety and compliance with regulatory standards.

Approved by

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Name, surname, signature

Date

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Practical work 5

Assignment for students: Creating a record template for HACCP

Objective of the assignment:

Create a record template for two monitoring activities as part of the HACCP (Hazard Analysis and Critical Control Points) plan. The activities are:

1. Measurement of temperature and humidity in a dry storage.
2. Receiving and inspection of food items in the operation.

Instructions:

1. **Measurement of temperature and humidity in a dry storage:**
    - **Record title:** Measurement of Temperature and Humidity in Dry Storage
    - **Document number:** [Assign a unique number]
    - **Subject of monitoring:** Temperature and humidity levels
    - **Monitoring procedure:**
        - Use a calibrated thermometer and hygrometer to measure temperature and humidity.
        - Record readings at the specified times.
    - **Frequency of monitoring:** Twice daily (morning and afternoon)
    - **Limit:**
        - Temperature: 10 °C to 21 °C
        - Humidity: 50% to 60%
    - **Procedure in case of non-compliance:**
        - If temperature or humidity is outside the limits, notify the supervisor immediately.
        - Take corrective actions such as adjusting the HVAC system.
        - Document the corrective actions taken.
    - **Recorded data:**
        - Date
        - Time
        - Temperature reading
        - Humidity reading
        - Initials of the person who recorded the data
    - **Approval:**

        - Date of approval
        - Name and signature of the person who approved the record

2. **Receiving and inspection of food items:**
    - **Record title:** Receiving and Inspection of Food Items
    - **Document number:** [Assign a unique number]
    - **Subject of monitoring:** Quality and safety of received food items
    - **Monitoring procedure:**
        - Inspect food items upon arrival for any signs of spoilage, damage, or contamination.
        - Check the temperature of perishable items using a calibrated thermometer.
        - Verify the items against the purchase order and delivery note.
    - **Frequency of monitoring:** Every delivery
    - **Limit:**
        - Perishable items should be at or below 5 °C.
        - No signs of spoilage, damage, or contamination.
    - **Procedure in case of non-compliance:**
        - Reject items that do not meet the quality and safety standards.
        - Document the issues and notify the supplier.
        - Record the corrective actions taken.
    - **Recorded Data:**
        - Date
        - Time
        - Supplier name
        - Items received
        - Temperature of perishable items
        - Condition of items (pass/fail)
        - Initials of the person who recorded the data
    - **Approval:**
        - Date of approval
        - Name and signature of the person who approved the record

Template format:

- Prepare the template using a text editor (e.g. Microsoft Word, Google Docs).
- Follow the structure and details provided above.
- Include tables or sections for recording data, ensuring clarity and ease of use.

Evaluation Criteria:

- Completeness and accuracy of the template.
- Clarity and usability of the template.
- Adherence to the provided structure and details.

Approved by

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Name, surname, signature

Date

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Theme 20

Food safety management system

Theoretical materials

Food safety management systems – introduction, basic terms and definitions, process principle (1 h)

Introduction

0.1 General

The adoption of a food safety management system (FSMS) is a strategic decision for an organisation that can help to improve its overall performance in food safety. The potential benefits to an organisation of implementing a FSMS based on this document are: a) the ability to consistently provide safe foods and products and services that meet customer and applicable statutory and regulatory requirements; b) addressing risks associated with its objectives; c) the ability to demonstrate conformity to specified FSMS requirements.

This document employs the process approach (see 0.3), which incorporates the Plan-Do-Check-Act (PDCA) cycle (see 0.3.2) and risk-based thinking (see 0.3.3). This process approach enables an organisation to plan its processes and their interactions. The PDCA cycle enables an organisation to ensure that its processes are adequately resourced and managed, and that opportunities for improvement are determined and acted on. Risk-based thinking enables an organisation to determine the factors that could cause its processes and its FSMS to deviate from the planned results, and to put in place controls to prevent or minimise adverse effects.

In this document, the following verbal forms are used: — “shall” indicates a requirement; — “should” indicates a recommendation; — “may” indicates a permission; — “can” indicates a possibility or a capability.

“NOTES” provide guidance in understanding or clarifying the requirements in this document.

0.2 FSMS Principles

Food safety is related to the presence of food safety hazards at the time of consumption (intake by the consumer). Food safety hazards can occur at any stage of the food chain. Therefore, adequate control throughout the food chain is essential. Food safety is ensured through the combined efforts of all the parties in the food chain. This document specifies the requirements for a FSMS that combines the following generally recognized key elements: — interactive communication; — system management; — prerequisite programmes; — hazard analysis and critical control point (HACCP) principles.

In addition, this document is based on the principles that are common to ISO management system standards. The management principles are: — customer focus; —

leadership; — engagement of people; — process approach; — improvement; — evidence-based decision making; — relationship management.

0.3 Process approach

0.3.1 General

This document adopts a process approach when developing and implementing a FSMS and improving its effectiveness to enhance production of safe products and services while meeting applicable requirements. Understanding and managing interrelated processes as a system contributes to the organisation's effectiveness and efficiency in achieving its intended results. The process approach involves the systematic definition and management of processes, and their interactions, so as to achieve the intended results in accordance with the food safety policy and strategic direction of the organisation. Management of the processes and the system as a whole can be achieved using the PDCA cycle, with an overall focus on risk-based thinking aimed at taking advantage of opportunities and preventing undesirable results. The recognition of the organisation's role and position within the food chain is essential to ensure effective interactive communication throughout the food chain.

0.3.2 Plan-Do-Check-Act cycle

The PDCA cycle can be described briefly as follows:

Plan: establish the objectives of the system and its processes, provide the resources needed to deliver the results, and identify and address risks and opportunities; **Do:** implement what was planned; **Check:** monitor and (where relevant) measure processes and the resulting products and services, analyse and evaluate information and data from monitoring, measuring, and verification activities, and report the results; **Act:** take actions to improve performance, as necessary.

In this document, and as illustrated in Figure 1, the process approach uses the concept of the PDCA cycle at two levels. The first covers the overall frame of the FSMS (Clause 4 to Clause 7 and Clause 9 to Clause 10). The other level (operational planning and control) covers the operational processes within the food safety system as described in Clause 8. Communication between the two levels is therefore essential.

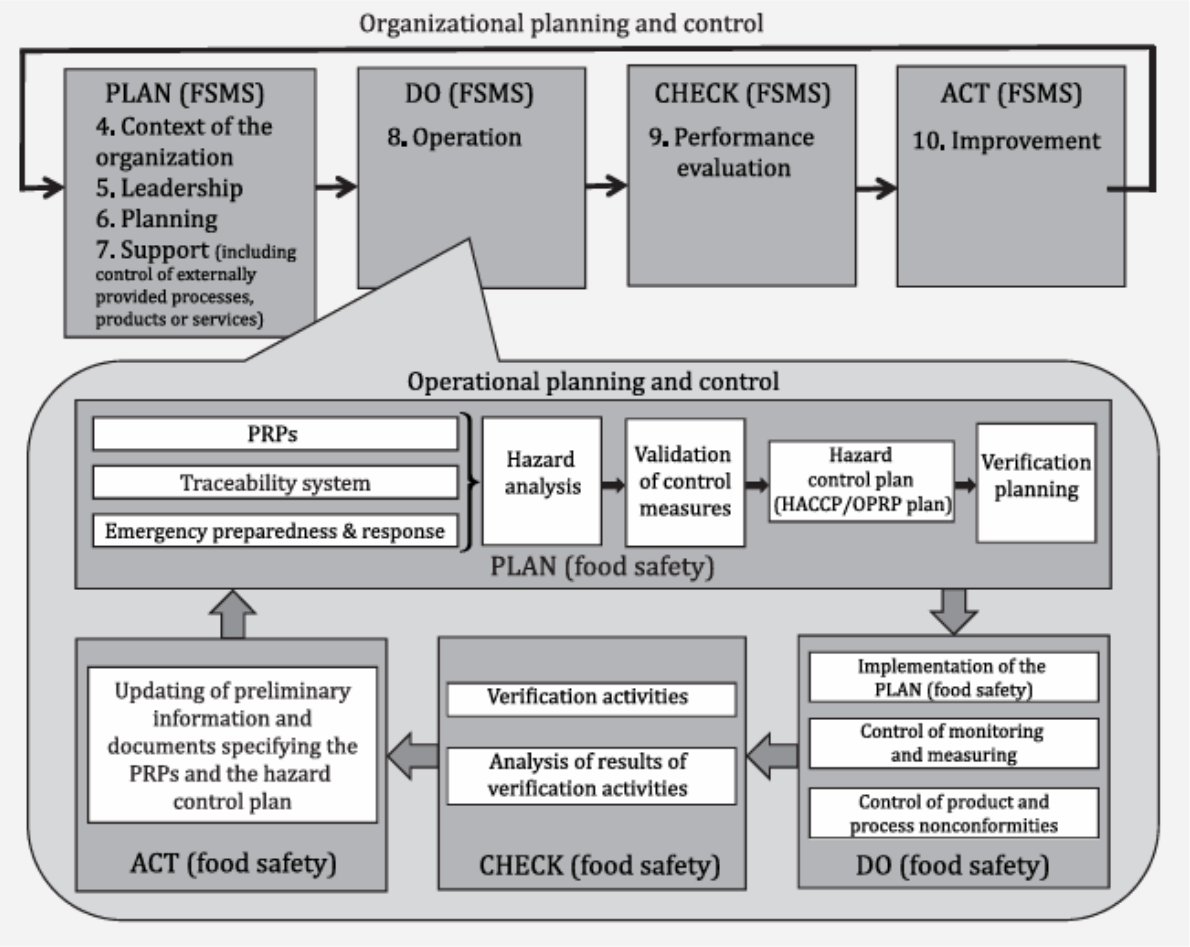

Fig. 20.1. Illustration of the Plan-Do-Check-Act cycle at the two levels (ISO 22000:2018)

0.3.3 Risk-based thinking

0.3.3.1 General

Risk-based thinking is essential for achieving an effective FSMS. In this document, risk-based thinking is addressed on two levels, organisational (see 0.3.3.2) and operational (see 0.3.3.3), which is consistent with the process approach described in 0.3.2.

0.3.3.2 Organisational risk management

Risk is the effect of uncertainty, and any such uncertainty can have positive or negative effects. In the context of organisational risk management, a positive deviation arising from a risk can provide an opportunity, but not all positive effects of risk result in opportunities. To conform to the requirements of this document, an organisation plans and implements actions to address organisational risks (Clause 6). Addressing risks establishes a basis for increasing the effectiveness of the FSMS, achieving improved results, and preventing negative effects.

0.3.3.3 Hazard analysis — operational processes

The concept of risk-based thinking based on the HACCP principles at the operational level is implicit in this document. The subsequent steps in HACCP can be considered as the necessary measures to prevent hazards or reduce hazards to acceptable levels to ensure food is safe at the time of consumption (Clause 8). Decisions taken in the application of HACCP should be based on science, free from bias and documented. The documentation should include any key assumptions in the decision-making process.

0.4 Relationship with other management system standards

This document has been developed within the ISO high-level structure (HLS). The objective of the HLS is to improve alignment between ISO management system standards. This document enables an organisation to use the process approach, coupled with the PDCA cycle and risk-based thinking, to align or integrate its FSMS approach with the requirements of other management systems and supporting standards. This document is the core principle and framework for FSMSs and sets out the specific FSMS requirements for organisations throughout the food chain. Other guidance related to food safety, specifications and/or requirements specific to food sectors can be used together with this framework. In addition, ISO has developed a family of associated documents. These include documents for: — prerequisite programmes (ISO/TS 22002 series) for specific sectors of the food chain; — requirements for auditing and certification bodies; — traceability.

ISO also provides guidance documents for organisations on how to implement this document and related standards. Information is available on the ISO website.

Food Safety Management Systems — requirements for any oOrganisation in the food chain

1. Scope

This document specifies requirements for a food safety management system (FSMS) to enable an organisation that is directly or indirectly involved in the food chain: a) to plan, implement, operate, maintain and update a FSMS providing products and services that are safe, in accordance with their intended use; b) to demonstrate compliance with applicable statutory and regulatory food safety requirements; c) to evaluate and assess mutually agreed customer food safety requirements and to demonstrate conformity with them; d) to effectively communicate food safety issues to interested parties within the food chain; e) to ensure that the organisation conforms to its stated food safety policy; f) to demonstrate conformity to relevant interested parties; g) to seek certification or registration of its FSMS by an external organisation, or make a self-assessment or self-declaration of conformity to this document.

All requirements of this document are generic and are intended to be applicable to all organisations in the food chain, regardless of size and complexity. Organisations that are directly or indirectly involved include, but are not limited to, feed producers, animal food producers, harvesters of wild plants and animals, farmers, producers of ingredients, food manufacturers, retailers, and organisations providing food services, catering services,

cleaning and sanitation services, transportation, storage and distribution services, suppliers of equipment, cleaning and disinfectants, packaging materials and other food contact materials.

This document allows any organisation, including small and/or less developed organisations (e.g. a small farm, a small packer-distributor, a small retail or food service outlet) to implement externally-developed elements in their FSMS.

Internal and/or external resources can be used to meet the requirements of this document.

2. Normative references

There are no normative references in this document.

3. Terms and definitions

For the purposes of this document, the following terms and definitions apply. ISO and IEC maintain terminological databases for use in standardisation at the following addresses: — ISO Online browsing platform: available at https://www.iso.org/obp — IEC Electropedia: available at http://www.electropedia.org

- **Acceptable level:** of a food safety hazard not to be exceeded in the end product provided by the organisation.
- **Action criterion** measurable or observable specification for the monitoring of an OPRP.
  - Note 1 to entry: An action criterion is established to determine whether an OPRP remains in control, and distinguishes between what is acceptable (criterion met or achieved means the OPRP is operating as intended) and unacceptable (criterion not met nor achieved means the OPRP is not operating as intended).
- **Audit**: systematic, independent and documented process for obtaining audit evidence and evaluating it objectively to determine the extent to which the audit criteria are fulfilled Note 1 to entry: An audit can be an internal audit (first party) or an external audit (second party or third party), and it can be a combined audit (combining two or more disciplines).
  - Note 2 to entry: An internal audit is conducted by the organisation itself, or by an external party on its behalf.
  - Note 3 to entry: “Audit evidence” and “audit criteria” are defined in ISO 19011.
  - Note 4 to entry: Relevant disciplines are, for example, food safety management, quality management or environmental management.
- **Competence:** ability to apply knowledge and skills to achieve intended results conformity fulfilment of a requirement.

- **Contamination**: introduction or occurrence of a contaminant including a food safety hazard in a product or processing environment continual improvement recurring activity to enhance performance.
- **Control measure:** action or activity that is essential to prevent a significant food safety hazard or reduce it to an acceptable level.
  - Note 1 to entry: See also significant food safety hazard.
  - Note 2 to entry: Control measure(s) is (are) identified by hazard analysis.
- **Correction action:** to eliminate a detected nonconformity
  - Note 1 to entry: A correction includes the handling of potentially unsafe products and can therefore be made in conjunction with a corrective action.
  - Note 2 to entry: A correction may be, for example, reprocessing, further processing and/or elimination of the adverse consequences of the nonconformity (such as disposal for other use or specific labelling).
- **Corrective action:** action to eliminate the cause of a nonconformity and to prevent recurrence.
  - Note 1 to entry: There can be more than one cause for a nonconformity.
  - Note 2 to entry: Corrective action includes cause analysis.
- **Critical control point CCP**: step in the process at which control measure(s) is (are) applied to prevent or reduce a significant food safety hazard to an acceptable level, and defined critical limit(s) and measurement enable the application of corrections.
- **Critical limit:** measurable value which separates acceptability from unacceptability Note 1 to entry: Critical limits are established to determine whether a CCP remains in control. If a critical limit is exceeded or not met, the products affected are to be handled as potentially unsafe products. [SOURCE: CAC/RCP 1-1969, modified — the definition has been modified and Note 1 to entry has been added].
- **Documented information**: information required to be controlled and maintained by an organisation and the medium on which it is contained
  - Note 1 to entry: Documented information can be in any format and media, and from any source.
  - Note 2 to entry: Documented information can refer to: — the management system, including related processes; — information created in order for the organisation to operate (documentation); — evidence of results achieved (records).
- **Effectiveness:** extent to which planned activities are realized and planned results achieved.

- **End product**: product that will undergo no further processing or transformation by the organisation.
  - Note 1 to entry: A product that undergoes further processing or transformation by another organisation is an end product in the context of the first organisation and a raw material or an ingredient in the context of the second organisation.
- Feed single or multiple product(s), whether processed, semi-processed or raw, which is (are) intended to be fed to food-producing animals
  - Note 1 to entry: Distinctions are made in this document between the terms food, feed, and animal food:
  — food is intended for consumption by humans and animals, and includes feed and animal food;
  — feed is intended to be fed to food-producing animals;
  — animal food is intended to be fed to non-food-producing animals, such as pets.
- **Flow diagram:** schematic and systematic presentation of the sequence and interactions of steps in the process.
- **Food substance**: (ingredient), whether processed, semi-processed or raw, which is intended for consumption, and includes drink, chewing gum and any substance which has been used in the manufacture, preparation or treatment of "food" but does not include cosmetics or tobacco or substances (ingredients) used only as drugs
  - Note 1 to entry: Distinctions are made in this document between the terms food, feed and animal food:
  — food is intended for consumption by humans and animals, and includes feed and animal food;
  — feed is intended to be fed to food-producing animals; — animal food is intended to be fed to non-food-producing animals, such as pets. [SOURCE: CAC/GL 81-2013, modified
  — The word "human" has been deleted.].
- **Animal food**: single or multiple product(s), whether processed, semi-processed or raw, which is (are) intended to be fed to non-food-producing animals Note 1 to entry: Distinctions are made in this document between the terms food, feed and animal food:
  — food is intended for consumption by humans and animals, and includes feed and animal food;
  — feed is intended to be fed to food-producing animals;
  — animal food is intended to be fed to non-food-producing animals, such as pets
- **Food chain**: sequence of the stages in the production, processing, distribution, storage and handling of a food and its ingredients, from primary production to

consumption.
Note 1 to entry: This includes the production of feed and animal food.
Note 2 to entry: The food chain also includes the production of materials intended to come into contact with food or raw materials.
Note 3 to entry: The food chain also includes service providers.

- **Food safety:** assurance that food will not cause an adverse health effect for the consumer when it is prepared and/or consumed in accordance with its intended use
  - Note 1 to entry: Food safety is related to the occurrence of food safety hazards in end products and does not include other health aspects related to, for example, malnutrition.
  - Note 2 to entry: It is not to be confused with the availability of, and access to, food ("food security").
  - Note 3 to entry: This includes feed and animal food. [SOURCE: CAC/RCP 1-1969, modified — the word "harm" has been changed to "adverse health effect" and notes to entry have been added].
- **Food safety hazard:** biological, chemical or physical agent in food with the potential to cause an adverse health effect.
  - Note 1 to entry: The term "hazard" is not to be confused with the term "risk" which, in the context of food safety, means a function of the probability of an adverse health effect (e.g. becoming diseased) and the severity of that effect (e.g. death, hospitalisation) when exposed to a specified hazard.
  - Note 2 to entry: Food safety hazards include allergens and radiological substances.
  - Note 3 to entry: In the context of feed and feed ingredients, relevant food safety hazards are those that can be present in and/or on feed and feed ingredients and that can through animal consumption of feed be transferred to food and can thus have the potential to cause an adverse health effect for the animal or the human consumer. In the context of operations other than those directly handling feed and food (e.g. producers of packaging materials, disinfectants), relevant food safety hazards are those hazards that can be directly or indirectly transferred to food when used as intended.
  - Note 4 to entry: In the context of animal food, relevant food safety hazards are those that are hazardous to the animal species for which the food is intended. [SOURCE: CAC/RCP 1-1969, modified — the phrase "or condition of" has been deleted from the definition and notes to entry have been added].
- **Interested party:** (preferred term) stakeholder (admitted term) person or organisation that can affect, be affected by, or perceive itself to be affected by a

decision or activity 3.24 lot defined quantity of a product produced and/or processed and/or packaged essentially under the same conditions.
- Note 1 to entry: The lot is determined by parameters established beforehand by the organisation and may be described by other terms, e.g. batch.
- Note 2 to entry: The lot may be reduced to a single unit of product. [SOURCE: CODEX STAN 1, modified — Reference to "and/or processed and/or packaged" has been included in the definition and notes to entry have been added].

- **Management system**: set of interrelated or interacting elements of an organisation to establish policies and objectives and processes to achieve those objectives.
  - Note 1 to entry: A management system can address a single discipline or several disciplines. - Note 2 to entry: The system elements include the organisation's structure, roles and responsibilities, planning and operation.
  - Note 3 to entry: The scope of a management system may include the whole of the organisation, specific and identified functions of the organisation, specific and identified sections of the organisation, or one or more functions across a group of organisations.
  - Note 4 to entry: Relevant disciplines are, for example, a quality management system or an environmental management system.
- **Measurement process:** to determine a value.
- **Monitoring**: determining the status of a system, a process or an activity.
  - Note 1 to entry: To determine the status, there may be a need to check, supervise or critically observe.
  - Note 2 to entry: In the context of food safety, monitoring is conducting a planned sequence of observations or measurements to assess whether a process is operating as intended.
  - Note 3 to entry: Distinctions are made in this document between the terms validation, monitoring and verification:
  — validation is applied prior to an activity and provides information about the capability to deliver intended results;
  — monitoring is applied during an activity and provides information for action within a specified time frame;
  — verification is applied after an activity and provides information for confirmation of conformity.
- **Nonconformity**: non-fulfilment of a requirement.
- **Objective:** result to be achieved.
  - Note 1 to entry: An objective can be strategic, tactical, or operational.
  - Note 2 to entry: Objectives can relate to different disciplines (such as financial,

health and safety, and environmental goals) and can apply at different levels (such as strategic, organisation-wide, project, product and process).
- Note 3 to entry: An objective can be expressed in other ways, e.g. as an intended outcome, a purpose, an operational criterion, as a FSMS objective, or by the use of other words with similar meaning (e.g. aim, goal, or target).
- Note 4 to entry: In the context of FSMS, objectives are set by the organisation, consistent with the food safety policy, to achieve specific results.

- **Operational prerequisite programme OPRP**: control measure or combination of control measures applied to prevent or reduce a significant food safety hazard to an acceptable level, and where action criterion and measurement or observation enable effective control of the process and/or product.
- **Organisation**: person or group of people that has its own functions with responsibilities, authorities and relationships to achieve its objectives.
  - Note 1 to entry: The concept of organisation includes, but is not limited to sole-trader, company, corporation, firm, enterprise, authority, partnership, charity or institution, or part or combination thereof, whether incorporated or not, public or private.
- **Outsource**:, verb make an arrangement where an external organisation performs part of an organisation's function or process.
  - Note 1 to entry: An external organisation is outside the scope of the management system, although the outsourced function or process is within the scope.
- **Performance:** measurable result.
  - Note 1 to entry: Performance can relate either to quantitative or qualitative findings.
  - Note 2 to entry: Performance can relate to the management of activities, processes, products (including services), systems or organisations.
- **Policy:** intentions and direction of an organisation as formally expressed by its top management.
- **Prerequisite programme PRP**: basic conditions and activities that are necessary within the organisation and throughout the food chain to maintain food safety.
  - Note 1 to entry: The PRPs needed depend on the segment of the food chain in which the organisation operates and the type of organisation. Examples of equivalent terms are: good agricultural practice (GAP), good veterinary practice (GVP), good manufacturing practice (GMP), good hygiene practice (GHP), good production practice (GPP), good distribution practice (GDP) and good trading practice (GTP).

- **Process:** set of interrelated or interacting activities that transform inputs to outputs.
- **Product**: output that is a result of a process.
  - Note 1 to entry: A product can be a service.
- **Requirement**: need or expectation that is stated, generally implied or obligatory.
  - Note 1 to entry: "Generally implied" means that it is custom or common practice for the organisation and interested parties that the need or expectation under consideration is implied.
  - Note 2 to entry: A specified requirement is one that is stated, for example in documented information.
- **Risk**: effect of uncertainty.
  - Note 1 to entry: An effect is a deviation from the expected – positive or negative.
  - Note 2 to entry: Uncertainty is the state, even partial, of deficiency of information related to, understanding or knowledge of, an event, its consequence, or likelihood.
  - Note 3 to entry: Risk is often characterised by reference to potential "events" (as defined in ISO Guide 73:2009, 3.5.1.3) and "consequences" (as defined in ISO Guide 73:2009, 3.6.1.3), or a combination of these.
  - Note 4 to entry: Risk is often expressed in terms of a combination of the consequences of an event (including changes in circumstances) and the associated "likelihood" (as defined in ISO Guide 73:2009, 3.6.1.1) of occurrence.
  - Note 5 to entry: Food safety risk is a function of the probability of an adverse health effect and the severity of that effect, consequential to (a) hazard(s) in food, as specified in the Codex Procedural Manual.
- **Significant food safety hazard:** food safety hazard, identified through the hazard assessment, which needs to be controlled by control measures.
- **Top management:** person or group of people who directs and controls an organisation at the highest level.
  - Note 1 to entry: Top management has the power to delegate authority and provide resources within the organisation.
  - Note 2 to entry: If the scope of the management system covers only part of an organisation, then top management refers to those who direct and control that part of the organisation.
- **Traceability:** ability to follow the history, application, movement and location of an object through specified stage(s) of production, processing and distribution
  - Note 1 to entry: Movement can relate to the origin of the materials, processing history or distribution of the food.
  - Note 2 to entry: An object can be a product, a material, a unit, equipment, a

service, etc. [SOURCE: CAC/GL 60-2006, modified — Notes to entry have been added].

- **Update:** immediate and/or planned activity to ensure application of the most recent information.
  - Note 1 to entry: Update is different from the terms “maintain” and “retain”:
  — “maintain” is to keep something on-going/to keep in good condition;
  — “retain” is to keep something that is retrievable.
- **Validation**: obtaining evidence that a control measure (or combination of control measures) will be capable of effectively controlling the significant food safety hazard.
  - Note 1 to entry: Validation is performed at the time a control measure combination is designed, or whenever changes are made to the implemented control measures.
  - Note 2 to entry: Distinctions are made in this document between the terms validation, monitoring and verification:
  — validation is applied prior to an activity and provides information about the capability to deliver intended results;
  — monitoring is applied during an activity and provides information for action within a specified time frame;
  — verification is applied after an activity and provides information for confirmation of conformity
- **Verification**: confirmation, through the provision of objective evidence, that specified requirements have been fulfilled.
  - Note 1 to entry: Distinctions are made in this document between the terms validation, monitoring and verification:
  — validation is applied prior to an activity and provides information about the capability to deliver intended results;
  — monitoring is applied during an activity and provides information for action within a specified time frame;
  — verification is applied after an activity and provides information for confirmation of conformity.

Food safety management system – Context of the organisation, leadership, planning, support, operation, performance evaluation, improvement (5 h)

4. Context of the organisation

4.1 Understanding the organisation and its context

The organisation shall determine external and internal issues that are relevant to its purpose and that affect its ability to achieve the intended result(s) of its FSMS. The organisation shall identify, review and update information related to these external and internal issues.

NOTE 1: Issues can include positive and negative factors or conditions for consideration.

NOTE 2: Understanding the context can be facilitated by considering external and internal issues, including, but not limited to, legal, technological, competitive, market, cultural, social and economic environments, cybersecurity and food fraud, food defence and intentional contamination, knowledge and performance of the organisation, whether international, national, regional or local.

4.2 Understanding the needs and expectations of interested parties

To ensure that the organisation has the ability to consistently provide products and services that meet applicable statutory, regulatory and customer requirements with regard to food safety, the organisation shall determine: a) the interested parties that are relevant to the FSMS; b) the relevant requirements of the interested parties of the FSMS.

The organisation shall identify, review and update information related to the interested parties and their requirements.

4.3 Determining the scope of the food safety management system

The organisation shall determine the boundaries and applicability of the FSMS to establish its scope. The scope shall specify the products and services, processes and production site(s) that are included in the FSMS. The scope shall include the activities, processes, products or services that can have an influence on the food safety of its end products.

When determining this scope, the organisation shall consider: a) the external and internal issues referred to in 4.1; b) the requirements referred to in 4.2.

The scope shall be available and maintained as documented information.

4.4 Food Safety Management System

The organisation shall establish, implement, maintain, update, and continually improve a FSMS, including the processes needed and their interactions, in accordance with the requirements of this document.

5. Leadership

5.1 Leadership and commitment

Top management shall demonstrate leadership and commitment with respect to the FSMS by: a) ensuring that the food safety policy and the objectives of the FSMS are established and are compatible with the strategic direction of the organisation; b) ensuring the integration of the FSMS requirements into the organisation's business processes; c) ensuring that the resources needed for the FSMS are available; d) communicating the importance of effective food safety management and conforming to the FSMS requirements, applicable statutory and regulatory requirements, and mutually agreed customer requirements related to food safety; e) ensuring that the FSMS is evaluated and maintained to achieve its intended result(s) (see 4.1); f) directing and supporting persons to contribute to the effectiveness of the FSMS; g) promoting continual improvement; h) supporting other relevant management roles to demonstrate their leadership as it applies to their areas of responsibility.

NOTE: Reference to "business" in this document can be interpreted broadly to mean those activities that are core to the purposes of the organisation's existence.

5.2 Policy

5.2.1 Establishing the food safety policy

Top management shall establish, implement, and maintain a food safety policy that: a) is appropriate to the purpose and context of the organisation; b) provides a framework for setting and reviewing the objectives of the FSMS; c) includes a commitment to satisfy applicable food safety requirements, including statutory and regulatory requirements and mutually agreed customer requirements related to food safety; d) addresses internal and external communication; e) includes a commitment to continual improvement of the FSMS; f) addresses the need to ensure competencies related to food safety.

5.2.2 Communicating the Food Safety Policy

The food safety policy shall: a) be available and maintained as documented information; b) be communicated, understood, and applied at all levels within the organisation; c) be available to relevant interested parties, as appropriate.

5.3 Organisational roles, responsibilities, and authorities

5.3.1 Top management shall ensure that the responsibilities and authorities for relevant roles are assigned, communicated, and understood within the organisation. Top management shall assign the responsibility and authority for: a) ensuring that the FSMS conforms to the requirements of this document; b) reporting on the performance of the FSMS to top management; c) appointing the food safety team and the food safety team leader; d) designating persons with defined responsibility and authority to initiate and document action(s).

5.3.2 The food safety team leader shall be responsible for: a) ensuring the FSMS is established, implemented, maintained, and updated; b) managing and organising the work of the food safety team; c) ensuring relevant training and competencies for the food

safety team (see 7.2); d) reporting to top management on the effectiveness and suitability of the FSMS.

5.3.3 All persons shall have the responsibility to report problem(s) with regards to the FSMS to identified person(s).

6. Planning

6.1 Actions to address risks and opportunities

6.1.1 When planning for the FSMS, the organisation shall consider the issues referred to in 4.1 and the requirements referred to in 4.2 and 4.3 and determine the risks and opportunities that need to be addressed to: a) give assurance that the FSMS can achieve its intended result(s); b) enhance desirable effects; c) prevent, or reduce, undesired effects; d) achieve continual improvement.

NOTE: In the context of this document, the concept of risks and opportunities is limited to events and their consequences relating to the performance and effectiveness of the FSMS. Public authorities are responsible for addressing public health risks. Organisations are required to manage food safety hazards (see 3.22) and the requirements related to this process that are laid down in Clause 8.

6.1.2 The organisation shall plan: a) actions to address these risks and opportunities; b) how to:

1. integrate and implement the actions into its FSMS processes;
2. evaluate the effectiveness of these actions.

6.1.3 The actions taken by the organisation to address risks and opportunities shall be proportionate to: a) the impact on food safety requirements; b) the conformity of food products and services to customers; c) requirements of interested parties in the food chain.

NOTE 1: Actions to address risks and opportunities can include: avoiding risk, taking risk in order to pursue an opportunity, eliminating the risk source, changing the likelihood or consequences, sharing the risk, or accepting the presence of risk by informed decision.

NOTE 2: Opportunities can lead to the adoption of new practices (modification of products or processes), using new technology and other desirable and viable possibilities to address the food safety needs of the organisation or its customers.

6.2 Objectives of the Food Safety Management System and planning to achieve them

6.2.1 The organisation shall establish objectives for the FSMS at relevant functions and levels. The objectives of the FSMS shall: a) be consistent with the food safety policy; b) be

measurable (if practicable); c) take into account applicable food safety requirements, including statutory, regulatory and customer requirements; d) be monitored and verified; e) be communicated; f) be maintained and updated as appropriate.

The organisation shall retain documented information on the objectives for the FSMS.

6.2.2 When planning how to achieve its objectives for the FSMS, the organisation shall determine: a) what will be done; b) what resources will be required; c) who will be responsible; d) when it will be completed; e) how the results will be evaluated.

6.3 Planning of changes

When the organisation determines the need for changes to the FSMS, including personnel changes, the changes shall be carried out and communicated in a planned manner. The organisation shall consider: a) the purpose of the changes and their potential consequences; b) the continued integrity of the FSMS; c) the availability of resources to effectively implement the changes; d) the allocation or re-allocation of responsibilities and authorities.

7. Support

7.1 Resources

7.1.1 General

The organisation shall determine and provide the resources needed for the establishment, implementation, maintenance, update, and continual improvement of the FSMS. The organisation shall consider: a) the capability of, and any constraints on, existing internal resources; b) the need for external resources.

7.1.2 People

The organisation shall ensure that persons necessary to operate and maintain an effective FSMS are competent (see 7.2). Where the assistance of external experts is used for the development, implementation, operation, or assessment of the FSMS, evidence of agreement or contracts defining the competency, responsibility, and authority of external experts shall be retained as documented information.

7.1.3 Infrastructure

The organisation shall provide the resources for the determination, establishment, and maintenance of the infrastructure necessary to achieve conformity with the requirements of the FSMS.

NOTE: Infrastructure can include: — land, vessels, buildings, and associated utilities; — equipment, including hardware and software; — transportation; — information and communication technology.

7.1.4 Work Environment

The organisation shall determine, provide, and maintain the resources for the establishment, management, and maintenance of the work environment necessary to achieve conformity with the requirements of the FSMS.

NOTE: A suitable environment can be a combination of human and physical factors such as: a) social (e.g. non-discriminatory, calm, non-confrontational); b) psychological (e.g. stress-reducing, burnout prevention, emotionally protective); c) physical (e.g. temperature, heat, humidity, light, air flow, hygiene, noise).

These factors can differ substantially depending on the products and services provided.

7.1.5 Externally developed elements of the Food Safety Management System

When an organisation establishes, maintains, updates, and continually improves its FSMS by using externally developed elements of an FSMS, including PRPs, the hazard analysis, and the hazard control plan (see 8.5.4), the organisation shall ensure that the provided elements are: a) developed in conformance with the requirements of this document; b) applicable to the sites, processes, and products of the organisation; c) specifically adapted to the processes and products of the organisation by the food safety team; d) implemented, maintained, and updated as required by this document; e) retained as documented information.

7.1.6 Control of externally provided processes, products, or services

The organisation shall: a) establish and apply criteria for the evaluation, selection, monitoring of performance, and re-evaluation of external providers of processes, products, and/or services; b) ensure adequate communication of requirements to the external provider(s); c) ensure that externally provided processes, products, or services do not adversely affect the organisation's ability to consistently meet the requirements of the FSMS; d) retain documented information of these activities and any necessary actions as a result of the evaluations and re-evaluations.

7.2 Competence

The organisation shall: a) determine the necessary competence of person(s), including external providers, doing work under its control that affects its food safety performance and effectiveness of the FSMS; b) ensure that these persons, including the food safety team and those responsible for the operation of the hazard control plan, are competent

on the basis of appropriate education, training, and/or experience; c) ensure that the food safety team has a combination of multi-disciplinary knowledge and experience in developing and implementing the FSMS (including, but not limited to, the organisation's products, processes, equipment, and food safety hazards within the scope of the FSMS); d) where applicable, take actions to acquire the necessary competence, and evaluate the effectiveness of the actions taken; e) retain appropriate documented information as evidence of competence.

NOTE: Applicable actions can include, for example, the provision of training to, the mentoring of, or the re-assignment of currently employed persons; or the hiring or contracting of competent persons.

7.3 Awareness

The organisation shall ensure that all relevant persons doing work under the organisation's control shall be aware of: a) the food safety policy; b) the objectives of the FSMS relevant to their task(s); c) their individual contribution to the effectiveness of the FSMS, including the benefits of improved food safety performance; d) the implications of not conforming with the FSMS requirements.

7.4 Communication

7.4.1 General

The organisation shall determine the internal and external communications relevant to the FSMS, including: a) on what it will communicate; b) when to communicate; c) with whom to communicate; d) how to communicate; e) who communicates.

The organisation shall ensure that the requirement for effective communication is understood by all persons whose activities have an impact on food safety.

7.4.2 External communication

The organisation shall ensure that sufficient information is communicated externally and is available for interested parties of the food chain. The organisation shall establish, implement, and maintain effective communications with: a) external providers and contractors; b) customers and/or consumers, in relation to:

1. product information related to food safety, to enable the handling, display, storage, preparation, distribution, and use of the product within the food chain or by the consumer;
2. identified food safety hazards that need to be controlled by other organisations in the food chain and/or by consumers;
3. contractual arrangements, enquiries, and orders, including their amendments;

4. customer and/or consumer feedback, including complaints; c) statutory and regulatory authorities; d) other organisations that have an impact on, or will be affected by, the effectiveness or updating of the FSMS.

Designated persons shall have defined responsibility and authority for the external communication of any information concerning food safety. Where relevant, information obtained through external communication shall be included as input for management review (see 9.3) and for updating the FSMS (see 4.4 and 10.3). Evidence of external communication shall be retained as documented information.

7.4.3 Internal Communication

The organisation shall establish, implement, and maintain an effective system for communicating issues having an impact on food safety. To maintain the effectiveness of the FSMS, the organisation shall ensure that the food safety team is informed in a timely manner of changes in the following: a) products or new products; b) raw materials, ingredients, and services; c) production systems and equipment; d) production premises, location of equipment, and surrounding environment; e) cleaning and sanitation programmes; f) packaging, storage, and distribution systems; g) competencies and/or allocation of responsibilities and authorisations; h) applicable statutory and regulatory requirements; i) knowledge regarding food safety hazards and control measures; j) customer, sector, and other requirements that the organisation observes; k) relevant enquiries and communications from external interested parties; l) complaints and alerts indicating food safety hazards associated with the end product; m) other conditions that have an impact on food safety.

The food safety team shall ensure that this information is included when updating the FSMS (see 4.4 and 10.3). Top management shall ensure that relevant information is included as input to the management review (see 9.3).

7.5 Documented information

7.5.1 General

The organisation's FSMS shall include: a) documented information required by this document; b) documented information determined by the organisation as being necessary for the effectiveness of the FSMS; c) documented information and food safety requirements required by statutory, regulatory authorities, and customers.

NOTE: The extent of documented information for an FSMS can differ from one organisation to another due to: — the size of the organisation and its type of activities, processes, products, and services; — the complexity of processes and their interactions; — the competence of persons.

7.5.2 Creating and updating

When creating and updating documented information, the organisation shall ensure appropriate: a) identification and description (e.g. a title, date, author, or reference number); b) format (e.g. language, software version, graphics) and media (e.g. paper, electronic); c) review and approval for suitability and adequacy.

7.5.3 Control of documented information

7.5.3.1 Documented information required by the FSMS and by this document shall be controlled to ensure: a) it is available and suitable for use, where and when it is needed; b) it is adequately protected (e.g. from loss of confidentiality, improper use, or loss of integrity).

7.5.3.2 For the control of documented information, the organisation shall address the following activities, as applicable: a) distribution, access, retrieval, and use; b) storage and preservation, including preservation of legibility; c) control of changes (e.g. version control); d) retention and disposition.

Documented information of external origin determined by the organisation to be necessary for the planning and operation of the FSMS shall be identified, as appropriate, and controlled. Documented information retained as evidence of conformity shall be protected from unintended alterations.

NOTE: Access can imply a decision regarding the permission to view the documented information only, or the permission and authority to view and change the documented information.

8. Operation

8.1 Operational planning and control

The organisation shall plan, implement, control, maintain, and update the processes needed to meet requirements for the realisation of safe products, and to implement the actions determined in 6.1, by: a) establishing criteria for the processes; b) implementing control of the processes in accordance with the criteria; c) keeping documented information to the extent necessary to have the confidence to demonstrate that the processes have been carried out as planned.

The organisation shall control planned changes and review the consequences of unintended changes, taking action to mitigate any adverse effects, as necessary. The organisation shall ensure that outsourced processes are controlled (see 7.1.6).

8.2 Prerequisite programmes (PRPs)

8.2.1 The organisation shall establish, implement, maintain, and update PRP(s) to facilitate the prevention and/or reduction of contaminants (including food safety hazards) in the products, product processing, and work environment.

8.2.2 The PRP(s) shall be: a) appropriate to the organisation and its context with regard to food safety; b) appropriate to the size and type of the operation and the nature of the products being manufactured and/or handled; c) implemented across the entire production system, either as programmes applicable in general or as programmes applicable to a particular product or process; d) approved by the food safety team.

8.2.3 When selecting and/or establishing PRP(s), the organisation shall ensure that applicable statutory, regulatory, and mutually agreed customer requirements are identified. The organisation should consider: a) the applicable part of the ISO/TS 22002 series; b) applicable standards, codes of practice, and guidelines.

8.2.4 When establishing PRP(s) the organisation shall consider: a) construction, layout of buildings, and associated utilities; b) layout of premises, including zoning, workspace, and employee facilities; c) supplies of air, water, energy, and other utilities; d) pest control, waste and sewage disposal, and supporting services; e) the suitability of equipment and its accessibility for cleaning and maintenance; f) supplier approval and assurance processes (e.g. raw materials, ingredients, chemicals, and packaging); g) reception of incoming materials, storage, dispatch, transportation, and handling of products; h) measures for the prevention of cross contamination; i) cleaning and disinfecting; j) personal hygiene; k) product information/consumer awareness; l) others, as appropriate.

Documented information shall specify the selection, establishment, applicable monitoring, and verification of the PRP(s).

8.3 Traceability system

The traceability system shall be able to uniquely identify incoming material from the suppliers and the first stage of the distribution route of the end product. When establishing and implementing the traceability system, the following shall be considered as a minimum: a) relation of lots of received materials, ingredients, and intermediate products to the end products; b) reworking of materials/products; c) distribution of the end product.

The organisation shall ensure that applicable statutory, regulatory, and customer requirements are identified. The organisation shall verify and test the effectiveness of the traceability system.

NOTE: Where appropriate, the verification of the system is expected to include the reconciliation of quantities of end products with the quantity of ingredients as evidence of effectiveness.

8.4 Emergency preparedness and response

8.4.1 General

Top management shall ensure procedures are in place to respond to potential emergency situations or incidents that can have an impact on food safety which are relevant to the role of the organisation in the food chain. Documented information shall be established and maintained to manage these situations and incidents.

8.4.2 Handling of emergencies and incidents

The organisation shall: a) respond to actual emergency situations and incidents by:

1. ensuring applicable statutory and regulatory requirements are identified;
2. communicating internally;
3. communicating externally (e.g. suppliers, customers, appropriate authorities, media); b) take action to reduce the consequences of the emergency situation, appropriate to the magnitude of the emergency or incident and the potential food safety impact; c) periodically test procedures where practical; d) review and, where necessary, update the documented information after the occurrence of any incident, emergency situation, or tests.

NOTE: Examples of emergency situations that can affect food safety and/or production are natural disasters, environmental accidents, bioterrorism, workplace accidents, public health emergencies, and other accidents, e.g. interruption of essential services such as water, electricity, or refrigeration supply.

8.5 Hazard control

8.5.1 Preliminary steps to enable hazard analysis

8.5.1.1 General

To carry out the hazard analysis, preliminary documented information shall be collected, maintained, and updated by the food safety team. This shall include, but not be limited to: a) applicable statutory, regulatory, and customer requirements; b) the organisation's products, processes, and equipment; c) food safety hazards relevant to the FSMS.

8.5.1.2 Characteristics of raw materials, ingredients, and product contact materials

The organisation shall ensure that all applicable statutory and regulatory food safety requirements are identified for all raw materials, ingredients, and product contact materials. The organisation shall maintain documented information concerning all raw materials, ingredients, and product contact materials to the extent needed to conduct the hazard analysis (see 8.5.2), including the following, as appropriate: a) biological, chemical, and physical characteristics; b) composition of formulated ingredients, including additives and processing aids; c) source (e.g. animal, mineral, or vegetable); d) place of origin (provenance); e) method of production; f) method of packaging and delivery; g) storage conditions and shelf life; h) preparation and/or handling before use or processing; i) acceptance criteria related to food safety or specifications of purchased materials and ingredients appropriate to their intended use.

8.5.1.3 Characteristics of End Products

The organisation shall ensure that all applicable statutory and regulatory food safety requirements are identified for all the end products intended to be produced. The organisation shall maintain documented information concerning the characteristics of end products to the extent needed to conduct the hazard analysis (see 8.5.2), including information on the following, as appropriate: a) product name or similar identification; b) composition; c) biological, chemical, and physical characteristics relevant for food safety; d) intended shelf life and storage conditions; e) packaging; f) labelling relating to food safety and/or instructions for handling, preparation, and intended use; g) method(s) of distribution and delivery.

8.5.1.4 Intended Use

The intended use, including reasonably expected handling of the end product and any unintended use but reasonably expected mishandling and misuse of the end product, shall be considered and shall be maintained as documented information to the extent needed to conduct the hazard analysis (see 8.5.2). Where appropriate, groups of consumers/users shall be identified for each product. Groups of consumers/users known to be especially vulnerable to specific food safety hazards shall be identified.

8.5.1.5 Flow diagrams and process steps

8.5.1.5.1 Flow diagrams

The food safety team shall prepare flow diagrams that provide an overview of the processes within the scope of the FSMS. These diagrams shall include: a) the sequence and interaction of the steps in the operation; b) any outsourced processes and outsourced product or service providers; c) the functions and processes, including PRPs, that occur within the scope of the FSMS; d) where raw materials, ingredients, intermediate products, and end products enter and leave the system; e) where end products, intermediate products, by-products, and waste are released or removed.

8.5.1.5.2 On-site confirmation of flow diagrams

The food safety team shall confirm on-site the accuracy of the flow diagrams, update the flow diagrams where appropriate, and retain them as documented information.

8.5.1.5.3 Description of processes and process environment

The food safety team shall describe, to the extent needed to conduct the hazard analysis: a) the layout of premises, including food and non-food handling areas; b) processing equipment and contact materials, processing aids, and flow of materials; c) existing PRPs, process parameters, control measures (if any) and/or the strictness with which they are applied, or procedures that can influence food safety; d) external requirements (e.g. from statutory and regulatory authorities or customers) that can impact the choice and the strictness of the control measures.

The variations resulting from expected seasonal changes or shift patterns shall be included as appropriate. The descriptions shall be updated as appropriate and maintained as documented information.

8.5.2 Hazard analysis

8.5.2.1 General

The food safety team shall conduct a hazard analysis, based on the preliminary information, to determine the hazards that need to be controlled. The degree of control shall ensure food safety and, where appropriate, a combination of control measures shall be used.

8.5.2.2 Identification of Hazards

8.5.2.2.1 The organisation shall identify and list the food safety hazards reasonably expected to occur in relation to the type of product, type of process, and actual processing conditions. The organisation shall seek information from staff and external experts who are familiar with the product and/or processes in other facilities.

NOTE 1: This may include information from the sources referred to in 8.5.1.

NOTE 2: Statutory and regulatory requirements can include food safety objectives (FSOs). The Codex Alimentarius Commission defines FSOs as “The maximum frequency and/or concentration of a hazard in a food at the time of consumption that provides or contributes to the appropriate level of protection (ALOP).”

8.5.2.2.2 The organisation shall identify step(s) (e.g. receiving raw materials, processing, distribution, and delivery) at which each food safety hazard can be present, be

introduced, increase, or persist. When identifying hazards, the organisation shall consider: a) the stages preceding and following in the food chain; b) all steps in the flow diagram; c) the process equipment, utilities/services, process environment, and persons.

8.5.2.2.3 The organisation shall determine the acceptable level in the end product of each food safety hazard identified, whenever possible. When determining acceptable levels, the organisation shall: a) ensure that applicable statutory, regulatory, and customer requirements are identified; b) consider the intended use of end products; c) consider any other relevant information.

The organisation shall maintain documented information concerning the determination of acceptable levels and the justification for the acceptable levels.

8.5.2.3 Hazard assessment

The organisation shall conduct, for each identified food safety hazard, a hazard assessment to determine whether its prevention or reduction to an acceptable level is essential. The organisation shall evaluate each food safety hazard with regard to: a) the likelihood of its occurrence in the end product prior to application of control measures; b) the severity of its adverse health effects in relation to the intended use (see 8.5.1.4).

The organisation shall identify any significant food safety hazards. The methodology used shall be described, and the result of the hazard assessment shall be maintained as documented information.

8.5.2.4 Selection and categorization of control measure(s)

8.5.2.4.1 Based on the hazard assessment, the organisation shall select an appropriate control measure or combination of control measures that will be capable of preventing or reducing the identified significant food safety hazards to defined acceptable levels. The organisation shall categorise the selected identified control measure(s) to be managed as OPRP(s) (see 3.30) or at CCPs (see 3.11). The categorisation shall be carried out using a systematic approach. For each of the control measures selected, there shall be an assessment of the following: a) the likelihood of failure of its functioning; b) the severity of the consequence in the case of failure of its functioning; this assessment shall include:

1. the effect on identified significant food safety hazards;
2. the location in relation to other control measure(s);
3. whether it is specifically established and applied to reduce the hazards to an acceptable level;
4. whether it is a single measure or is part of a combination of control measure(s).

8.5.2.4.2 In addition, for each control measure, the systematic approach shall include an assessment of the feasibility of: a) establishing measurable critical limits and/or

measurable/observable action criteria; b) monitoring to detect any failure to remain within critical limit and/or measurable/observable action criteria; c) applying timely corrections in case of failure.

The decision-making process and results of the selection and categorisation of the control measures shall be maintained as documented information. External requirements (e.g. statutory, regulatory, and customer requirements) that can impact the choice and the strictness of the control measures shall also be maintained as documented information.

8.5.3 Validation of control measure(s) and combinations of control measures

The food safety team shall validate that the selected control measures are capable of achieving the intended control of the significant food safety hazard(s). This validation shall be done prior to implementation of control measure(s) and combinations of control measures to be included in the hazard control plan (see 8.5.4) and after any change therein (see 7.4.2, 7.4.3, 10.2, and 10.3). When the result of validation shows that the control measure(s) is (are) not capable of achieving the intended control, the food safety team shall modify and re-assess the control measure(s) and/or combination(s) of control measure(s).

The food safety team shall maintain the validation methodology and evidence of capability of the control measure(s) to achieve the intended control as documented information.

NOTE: Modification can include changes in control measure(s) (i.e. process parameters, rigour and/or their combination) and/or change(s) in the manufacturing technologies for raw materials, end product characteristics, methods of distribution, and intended use of the end products.

8.5.4 Hazard control plan (HACCP/OPRP plan)

8.5.4.1 General

The organisation shall establish, implement, and maintain a hazard control plan. The hazard control plan shall be maintained as documented information and shall include the following information for each control measure at each CCP or OPRP: a) food safety hazard(s) to be controlled at the CCP or by the OPRP; b) critical limit(s) at CCP or action criteria for OPRP; c) monitoring procedure(s); d) correction(s) to be made if critical limits or action criteria are not met; e) responsibilities and authorities; f) records of monitoring.

8.5.4.2 Determination of critical limits and action criteria

Critical limits at CCPs and action criteria for OPRPs shall be specified. The rationale for their determination shall be maintained as documented information. Critical limits at CCPs shall be measurable. Conformance with critical limits shall ensure that the acceptable level is not exceeded. Action criteria for OPRPs shall be measurable or

observable. Conformance with action criteria shall contribute to the assurance that the acceptable level is not exceeded.

8.5.4.3 Monitoring systems at CCPs and for OPRPs

At each CCP, a monitoring system shall be established for each control measure or combination of control measure(s) to detect any failure to remain within the critical limits. The system shall include all scheduled measurements relative to the critical limit(s). For each OPRP, a monitoring system shall be established for the control measure or combination of control measure(s) to detect failure to meet the action criterion. The monitoring system, at each CCP and for each OPRP, shall consist of documented information, including: a) measurements or observations that provide results within an adequate time frame; b) monitoring methods or devices used; c) applicable calibration methods or, for OPRPs, equivalent methods for verification of reliable measurements or observations (see 8.7); d) monitoring frequency; e) monitoring results; f) responsibility and authority related to monitoring.

8.6 Updating the information specifying the PRPs and the hazard control plan

Following the establishment of the hazard control plan, the organisation shall update the following information, if necessary: a) characteristics of raw materials, ingredients, and product-contact materials; b) characteristics of end products; c) intended use; d) flow diagrams and descriptions of processes and process environment.

The organisation shall ensure that the hazard control plan and/or the PRP(s) are up to date.

8.7 Control of monitoring and measuring

The organisation shall provide evidence that the specified monitoring and measuring methods and equipment in use are adequate for the monitoring and measuring activities related to the PRP(s) and the hazard control plan. The monitoring and measuring equipment used shall be: a) calibrated or verified at specified intervals prior to use; b) adjusted or re-adjusted as necessary; c) identified to enable the calibration status to be determined; d) safeguarded from adjustments that would invalidate the measurement results; e) protected from damage and deterioration.

The results of calibration and verification shall be retained as documented information. The calibration of all the equipment shall be traceable to international or national measurement standards; where no standards exist, the basis used for calibration or verification shall be retained as documented information. The organisation shall assess the validity of the previous measurement results when the equipment or process environment is found not to conform to requirements. The organisation shall take appropriate action in relation to the equipment or process environment and any product affected by the non-conformance. The assessment and resulting action shall be maintained as documented information. Software used in monitoring and measuring within the FSMS shall be validated by the organisation, software supplier, or third party

prior to use. Documented information on validation activities shall be maintained by the organisation and the software shall be updated in a timely manner. Whenever there are changes, including software configuration/modifications to commercial off-the-shelf software, they shall be authorized, documented, and validated before implementation.

NOTE: Commercial off-the-shelf software in general use within its designed application range can be considered to be sufficiently validated.

8.8 Verification related to PRPs and the hazard control plan

8.8.1 Verification

The organisation shall establish, implement, and maintain verification activities. The verification planning shall define purpose, methods, frequencies, and responsibilities for the verification activities. The verification activities shall confirm that: a) the PRP(s) are implemented and effective; b) the hazard control plan is implemented and effective; c) hazard levels are within identified acceptable levels; d) input to the hazard analysis is updated; e) other actions determined by the organisation are implemented and effective.

The organisation shall ensure that verification activities are not carried out by the person responsible for monitoring the same activities. Verification results shall be retained as documented information and shall be communicated. Where verification is based on testing of end product samples or direct process samples and where such test samples show nonconformity with the acceptable level of the food safety hazard (see 8.5.2.2), the organisation shall handle the affected lot(s) of product as potentially unsafe (see 8.9.4.3) and apply corrective actions in accordance with 8.9.3.

8.8.2 Analysis of results of verification activities

The food safety team shall conduct an analysis of the results of verification that shall be used as an input to the performance evaluation of the FSMS (see 9.1.2).

8.9 Control of product and process non-conformities

8.9.1 General

The organisation shall ensure that data derived from the monitoring of OPRPs and at CCPs are evaluated by designated persons who are competent and have the authority to initiate corrections and corrective actions.

8.9.2 Corrections

8.9.2.1 The organisation shall ensure that when critical limits at CCP(s) and/or action criteria for OPRPs are not met, the products affected are identified and controlled with regard to their use and release. The organisation shall establish, maintain, and update documented information that includes: a) a method of identification, assessment, and correction for affected products to ensure their proper handling; b) arrangements for review of the corrections carried out.

8.9.2.2 When critical limits at CCPs are not met, affected products shall be identified and handled as potentially unsafe products (see 8.9.4).

8.9.2.3 Where action criteria for an OPRP are not met, the following shall be carried out: a) determination of the consequences of that failure with respect to food safety; b) determination of the cause(s) of failure; c) identification of the affected products and handling in accordance with 8.9.4.

The organisation shall retain results of the evaluation as documented information.

8.9.2.4 Documented information shall be retained to describe corrections made on non-conforming products and processes, including: a) the nature of the non-conformity; b) the cause(s) of the failure; c) the consequences as a result of the non-conformity.

8.9.3 Corrective actions

The need for corrective actions shall be evaluated when critical limits at CCP(s) and/or action criteria for OPRPs are not met. The organisation shall establish and maintain documented information that specifies appropriate actions to identify and eliminate the cause of detected non-conformities, to prevent recurrence, and to return the process to control after a non-conformity is identified. These actions shall include: a) reviewing nonconformities identified by customer and/or consumer complaints and/or regulatory inspection reports; b) reviewing trends in monitoring results that can indicate loss of control; c) determining the cause(s) of non-conformities; d) determining and implementing actions to ensure that non-conformities do not recur; e) documenting the results of corrective actions taken; f) verifying corrective actions taken to ensure that they are effective.

The organisation shall retain documented information on all corrective actions.

8.9.4 Handling of potentially unsafe products

8.9.4.1 General

The organisation shall take action(s) to prevent potentially unsafe products from entering the food chain, unless it can demonstrate that: a) the food safety hazard(s) of concern is (are) reduced to the defined acceptable levels; b) the food safety hazard(s) of concern will be reduced to identified acceptable levels prior to entering the food chain; or c) the product still meets the defined acceptable level(s) of the food safety hazard(s) of concern despite the nonconformity.

The organisation shall retain products that have been identified as potentially unsafe under its control until the products have been evaluated and the disposition has been determined. If products that have left the control of the organisation are subsequently determined to be unsafe, the organisation shall notify relevant interested parties and initiate a withdrawal/recall (see 8.9.5). The controls and related responses from relevant interested parties and authorisation for dealing with potentially unsafe products shall be retained as documented information.

8.9.4.2 Evaluation for release

Each lot of products affected by the nonconformity shall be evaluated. Products affected by failure to remain within critical limits at CCPs shall not be released, but shall be handled in accordance with 8.9.4.3.

8.9.4.3 Disposition of Nonconforming Products

Products that are not acceptable for release shall be: a) reprocessed or further processed within or outside the organisation to ensure that the food safety hazard is reduced to acceptable levels; or b) redirected for other use as long as food safety in the food chain is not affected; or c) destroyed and/or disposed as waste.

Documented information on the disposition of nonconforming products, including the identification of the person(s) with approving authority, shall be retained.

8.9.5 Withdrawal/Recall

The organisation shall be able to ensure the timely withdrawal/recall of lots of end products that have been identified as potentially unsafe, by appointing competent person(s) having the authority to initiate and carry out the withdrawal/recall. The organisation shall establish and maintain documented information for: a) notifying relevant interested parties (e.g. statutory and regulatory authorities, customers and/or consumers); b) handling withdrawn/recalled products as well as products still in stock; c) performing the sequence of actions to be taken.

Withdrawn/recalled products and end products still in stock shall be secured or held under the control of the organisation until they are managed in accordance with 8.9.4.3. The cause, extent, and result of a withdrawal/recall shall be retained as documented information and reported to top management as input for the management review (see 9.3). The organisation shall verify the implementation and effectiveness of withdrawals/recalls through the use of appropriate techniques (e.g. mock withdrawal/recall or practice withdrawal/recall) and retain documented information.

9 Performance evaluation

9.1 Monitoring, measurement, analysis, and evaluation

9.1.1 General

The organisation shall determine: a) what needs to be monitored and measured; b) the methods for monitoring, measurement, analysis, and evaluation, as applicable, to ensure valid results; c) when the monitoring and measuring shall be performed; d) when the results from monitoring and measurement shall be analysed and evaluated; e) who shall analsze and evaluate the results from monitoring and measurement.

The organisation shall retain appropriate documented information as evidence of the results. The organisation shall evaluate the performance and the effectiveness of the FSMS.

9.1.2 Analysis and evaluation

The organisation shall analyse and evaluate appropriate data and information arising from monitoring and measurement, including the results of verification activities related to PRPs and the hazard control plan (see 8.8 and 8.5.4), the internal audits (see 9.2), and external audits. The analysis shall be carried out: a) to confirm that the overall performance of the system meets the planned arrangements and the FSMS requirements established by the organisation; b) to identify the need for updating or improving the FSMS; c) to identify trends which indicate a higher incidence of potentially unsafe products or process failures; d) to establish information for planning of the internal audit programme related to the status and importance of areas to be audited; e) to provide evidence that corrections and corrective actions are effective.

The results of the analysis and the resulting activities shall be retained as documented information. The results shall be reported to top management and used as input to the management review (see 9.3) and the updating of the FSMS (see 10.3).

NOTE: Methods to analyse data can include statistical techniques.

9.2 Internal audit

9.2.1 The organisation shall conduct internal audits at planned intervals to provide information on whether the FSMS: a) conforms to:

1. the organisation's own requirements for its FSMS;
2. the requirements of this document; b) is effectively implemented and maintained.

9.2.2 The organisation shall: a) plan, establish, implement, and maintain (an) audit programme(s), including the frequency, methods, responsibilities, planning requirements, and reporting, which shall take into consideration the importance of the processes concerned, changes in the FSMS, and the results of monitoring, measurement, and previous audits; b) define the audit criteria and scope for each audit; c) select competent auditors and conduct audits to ensure objectivity and the impartiality of the audit process; d) ensure that the results of the audits are reported to the food safety team and relevant management; e) retain documented information as evidence of the implementation of the audit programme and the audit results; f) make the necessary correction and take the necessary corrective action within the agreed time frame; g) determine if the FSMS meets the intent of the food safety policy (see 5.2) and objectives of the FSMS (see 6.2).

Follow-up activities by the organisation shall include the verification of the actions taken and the reporting of the verification results.

NOTE: ISO 19011 provides guidelines for auditing management systems.

9.3 Management review

9.3.1 General

Top management shall review the organisation's FSMS at planned intervals to ensure its continuing suitability, adequacy, and effectiveness.

9.3.2 Management review input

The management review shall consider: a) the status of actions from previous management reviews; b) changes in external and internal issues that are relevant to the FSMS, including changes in the organisation and its context (see 4.1); c) information on the performance and the effectiveness of the FSMS, including trends in:

1. result(s) of system updating activities (see 4.4 and 10.3);
2. monitoring and measurement results;
3. analysis of the results of verification activities related to PRPs and the hazard control plan (see 8.8.2);
4. nonconformities and corrective actions;
5. audit results (internal and external);
6. inspections (e.g. regulatory, customer);
7. the performance of external providers;
8. the review of risks and opportunities and of the effectiveness of actions taken to address them (see 6.1);
9. the extent to which objectives of the FSMS have been met; d) the adequacy of resources; e) any emergency situation, incident (see 8.4.2) or withdrawal/recall (see 8.9.5) that occurred; f) relevant information obtained through external (see 7.4.2) and internal (see 7.4.3) communication, including requests and complaints from interested parties; g) opportunities for continual improvement.

The data shall be presented in a manner that enables top management to relate the information to stated objectives of the FSMS.

9.3.3 Management review output

The outputs of the management review shall include: a) decisions and actions related to continual improvement opportunities; b) any need for updates and changes to the FSMS, including resource needs and revision of the food safety policy and objectives of the FSMS.

The organisation shall retain documented information as evidence of the results of management reviews.

10. Improvement

10.1 Nonconformity and corrective action

10.1.1 When a nonconformity occurs, the organisation shall: a) react to the nonconformity and, as applicable:

1. take action to control and correct it;
2. deal with the consequences; b) evaluate the need for action to eliminate the cause(s) of the nonconformity, in order that it does not recur or occur elsewhere, by:
3. reviewing the nonconformity;
4. determining the causes of the nonconformity;
5. determining if similar nonconformities exist, or could potentially occur; c) implement any action needed; d) review the effectiveness of any corrective action taken; e) make changes to the FSMS, if necessary.

Corrective actions shall be appropriate to the effects of the nonconformities encountered.

10.1.2 The organisation shall retain documented information as evidence of: a) the nature of the nonconformities and any subsequent actions taken; b) the results of any corrective action.

10.2 Continual improvement

The organisation shall continually improve the suitability, adequacy, and effectiveness of the FSMS. Top management shall ensure that the organisation continually improves the effectiveness of the FSMS through the use of communication (see 7.4), management review (see 9.3), internal audit (see 9.2), analysis of results of verification activities (see 8.8.2), validation of control measure(s) and combination(s) of control measure(s) (see 8.5.3), corrective actions (see 8.9.3), and FSMS updating (see 10.3).

10.3 Update of the Food Safety Management System

Top management shall ensure that the FSMS is continually updated. To achieve this, the food safety team shall evaluate the FSMS at planned intervals. The team shall consider whether it is necessary to review the hazard analysis (see 8.5.2), the established hazard control plan (see 8.5.4), and the established PRPs (see 8.2). The updating activities shall be based on: a) input from communication, external as well as internal (see 7.4); b) input from other information concerning the suitability, adequacy, and effectiveness of the

FSMS; c) output from the analysis of results of verification activities (see 9.1.2); d) output from management review (see 9.3).

System updating activities shall be retained as documented information and reported as input to the management review (see 9.3).

Theme 21

Management systems – documentation

Practical work food safety management system – documentation

Documentation of the integrated food safety management system

- **Integrated management system:** A management system created by integrating two or more management systems.
- It is possible to integrate the following management systems: a) Quality Management System (ISO 9001: 2015), b) Quality Management System of Testing and Calibration Laboratories (ISO 17025: 2017), c) Food Safety Management System (ISO 22000: 2018, or another), d) Environmental Management System (ISO 14001: 2015), e) Occupational Health and Safety Management System (STN ISO 45001: 2019).

Within the integrated management system, each system must function not only independently but also in relation to each other and in the context of the company's strategy and policy. PAS 99:2012 – Specification of common management system requirements as a framework for integration serves as a tool for integrating management systems. This standard is based on the PDCA cycle principle.

Objectives of integrating management systems:

- Streamlining processes.
- Clarifying processes.
- Preventing process duplication.
- Creating a comprehensive documentation structure.

Procedure for creating and integrating management systems

- Comparing ISO standard requirements.
- Identifying common requirements.
- Identifying organisational processes.
- Creating a process map.
- Creating a documentation structure.
- Creating first-level documents (company policy, company objectives, integrated management system manual).
- Creating second-level documents (rules, guidelines, record templates, etc.).
- Creating rules (organisational rules, work rules, wage rules).

- Creating guidelines (e.g. production process management, personnel, maintenance, procurement, marketing, etc.).
- Creating third-level documents (plans, procedures, etc.).

Comparing ISO standard requirements

ISO standard requirements often overlap; thus, they can be integrated and further developed in a single common documentation to prevent duplicate documents with the same content.

When comparing ISO standards, it is necessary to identify: a) common requirements, b) different requirements.

Some ISO standards contain cross-references between common elements of other ISO standards. These requirements can be developed in one place in the documentation. However, there is not always full agreement between common elements of ISO standards. It is necessary to consider specific requirements of each ISO standard used and integrate them into the documentation.

When integrating multiple management systems, it is appropriate to create an integrated management system manual. Creating a management system manual according to ISO 9001 is no longer mandatory, but it may be a specific requirement of some technical standards or private standards (e.g., BRC Global Standard for Food Safety).

Integrated management system manual

The manual should include the following sections:

- Title page (logo, address, code, document number and name, prepared by, reviewed by, approved by with dates and signatures, issue effective date, copy number)
- Content
- Purpose of the document
- Terms
- Abbreviations
- Company profile
    - Company history
    - Information from the business register
    - Production assortment
- Description of processes occurring in the company
    - Process map
    - Management processes
    - Support processes
    - Main (key) processes

- Coverage of standard requirements (tables for each standard)
- Attachments
- Distribution list
- Change list

The header of each page should include: logo, company address, document type, document name, document code and number, issue number, page number out of total pages, document validity.

Integration of Management Systems

This involves creating a uniform documentation structure for different management systems. Documentation can contain references and can refer to other documents. When creating references to other documents, it is necessary to avoid document duplication.

Identifying Organisational processes

- **Managerial (control):** Elements of corporate governance or decisions by corporate management.
- **Key (main, executive):** Activities serving to create added value.

Creating a process map.

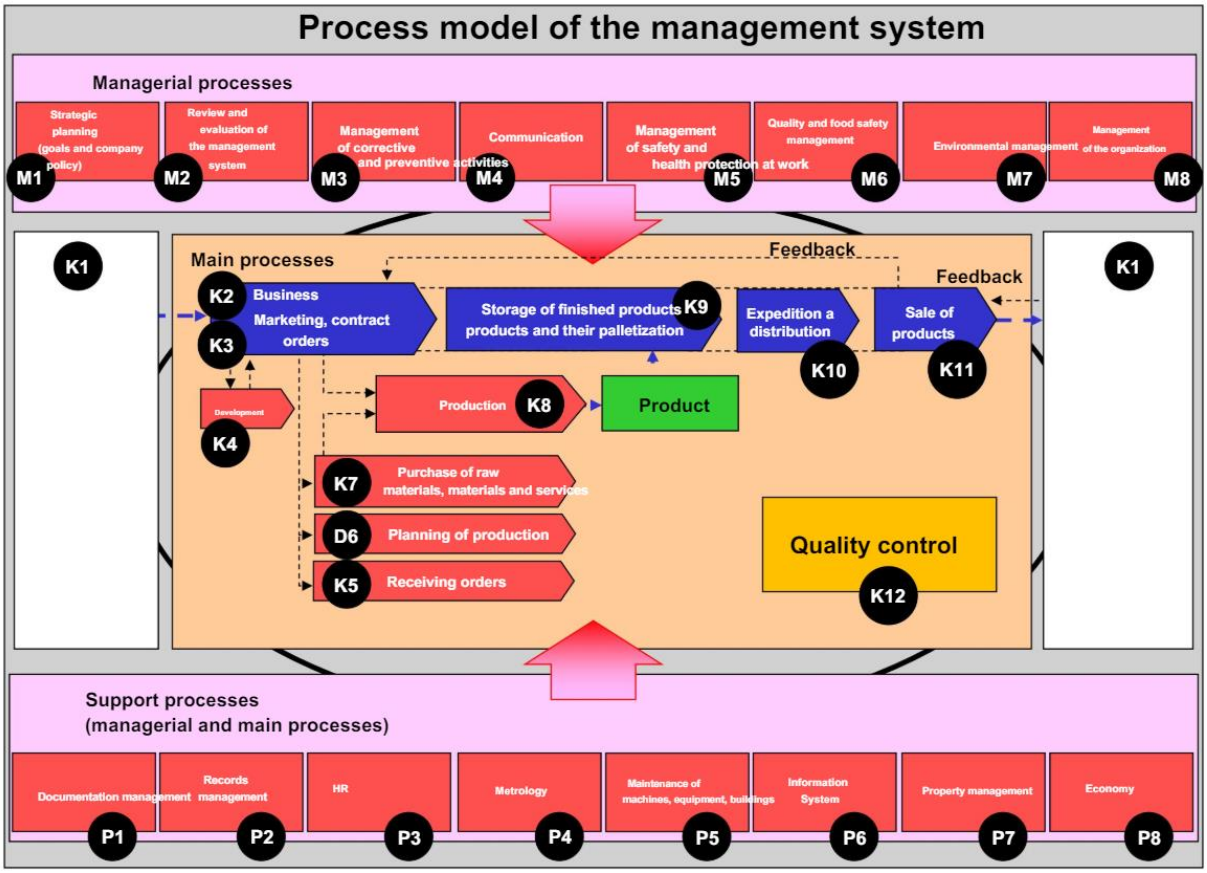

Fig.21.1 Process model of the management system (Zajác, 2020)

Processes can be arranged in a table or illustrated using a flowchart and included in the integrated management system manual. The process structure varies in different types of food businesses. Examples of processes are listed below. It is recommended to label and number individual processes and sub-processes:

Managerial processes

- M1 Organisational management,
- M2 Planning,
- M3 Communication management,
- M4 Occupational health and safety management,
- M5 Food safety management,
- M6 Environmental management,
- M7 Quality management,
- M8 Corrective and preventive actions management,
- M9 Verification and evaluation of the integrated management system.

Support Processes

- P1 Documentation management,
- P2 Record management,
- P3 Human resources,
- P4 Metrology,
- P5 Maintenance,
- P6 Information system management,
- P7 Property management,
- P8 Economics (accounting, orders management),
- P9 Transport (subcontracted); own transport can also be classified among main processes.

Key (Main) processes

- K1 Customer orientation and customer satisfaction survey,
- K2 Commercial activity and marketing,
- K3 Contracting and sales,
- K4 Development,
- K5 Order receipt,
- K6 Production planning,
- K7 Procurement,
- K8 Production,
- K9 Product storage,
- K10 Dispatch and distribution,
- K11 Product sales,
- K12 Quality control.

Process representation in documents

Processes are recommended to be processed in documents in the form of flowcharts, indicating all steps, decisions, and references to documents, forms, and records.

The documentation of a Food Safety and Quality Management System (FSQMS) is a comprehensive set of documents that define and guide the processes, procedures, and policies necessary to ensure food safety and quality within an organisation. The documentation serves as a framework for implementing, maintaining, and improving food safety and quality practices. It typically includes the following levels and types of documentation:

1. First Level: policy and objectives

- **Company policy:** This is a high-level document outlining the organisation's commitment to food safety and quality, including objectives and strategic direction.

- **Quality and food safety policy:** This document states the organisation's commitment to producing safe and high-quality food products.
- **Management system manual:** A comprehensive document that describes the structure of the management system, its scope, processes, and interactions.

2. Second Level: procedures and guidelines

- **Organisational guidelines:** Detailed documents that provide specific instructions on how various processes should be conducted to ensure food safety and quality.
- **Standard operating procedures (SOPs):** These outline the step-by-step instructions for performing routine operations in compliance with safety and quality standards.
- **Records:** Documents that record the results of various processes and activities, such as inspection records, maintenance logs, and training records.
- **Laws and regulations:** Documentation of applicable legal and regulatory requirements that the organisation must comply with.
- **Technical standards and functional diagrams:** Documents and diagrams that provide technical details and specifications relevant to food safety and quality.

3. Third level: Work instructions and detailed procedures

- **Technical documentation:** Includes contracts, technical documents, and specific standards relevant to food safety and quality.
- **Plans:** Detailed plans such as marketing plans, financial plans, investment plans, and production plans.
- **Procedures:** Specific procedures related to technological processes, work activities, control measures, and calibration methods.

Specific examples of documentation components:

- **Hazard Analysis and Critical Control Points (HACCP) Plan:** A detailed plan that identifies critical control points in the food production process and outlines measures to control food safety hazards.
- **Good Manufacturing Practices (GMP):** Documentation that defines the practices required to conform to guidelines recommended by agencies that control the authorisation and licensing of the manufacture and sale of food.
- **Corrective and Preventive Actions (CAPA):** Procedures and records for identifying and addressing any deviations from food safety and quality standards.

Objectives of FSQMS documentation:

- **Ensure compliance:** To meet statutory, regulatory, and customer-specific requirements.
- **Improve processes:** To streamline and clarify processes, avoiding duplication and enhancing efficiency.
- **Facilitate communication:** To provide a clear communication framework within the organisation and with external stakeholders.

- **Support audits and certification:** To facilitate internal and external audits and help achieve certification or registration of the FSQMS.

Key Benefits:

- **Consistency:** Ensures consistent production of safe and high-quality food products.
- **Accountability:** Establishes clear responsibilities and authorities within the organisation.
- **Continuous improvement:** Provides a basis for continuous improvement through regular review and updating of the system.

By maintaining comprehensive documentation, organisations can effectively manage food safety and quality, ensuring that all processes are well-defined, monitored, and continuously improved. This ultimately helps in protecting consumer health, complying with legal requirements, and maintaining customer trust and satisfaction.

Example of document structure

LOGO

Company name and address

D 1 – 1

Directive title

Edition No.: 1	Valid from:	Print number:

Prepared by:	Reviewed by:	Approved:
A date:	A date:	A date:
Signature:	Signature:	Signature:

TABLE OF CHANGES					
Change:	Valid from:	Chapter:	Page:	Changed:	Approved:

Distribution list and familiarization with the document:

Print number	Function	Name and surname	A date	Signature
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				

By signing, I confirm that I have received the document, that I have familiarized myself with its content and that I understand it.

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Automatic content, do not delete or edit any things in it

1. Purpose of the document

This directive sets out responsibilities, rules for the preparation and use of documents and records in the company **Name and address of the company**.

This directive serves as a model document for the creation of other documents.

Documenting the quality management system is intended to:

- description of individual processes so that they can be carried out uniformly and unambiguously
- transparency and elimination of duplicate processes
- explanation of the purpose for which the process is carried out
- determination of duties, competencies and responsibilities in the performance of individual processes

Documents must be commented on, checked, then approved by the responsible person before they are issued and, if necessary, regularly updated. Documents must be simple, legible and easily identifiable. Revisions and corrections must be marked in the document.

Edit the purpose of the document.

1.1 Scope of validity

This directive is binding for all users listed in the switchboard. Edit scope of validity.

1.2 Related documents

1.2.1 Internal documents

PK - Company quality **manual Name** and **address** of the company.
D XX-XX Internal audits
D XX-XX Non-compliance management, corrective and preventive measures
D XX-XX Registration and shredding procedure

Edit the list of internal documents that are directly related to this directive, or list the documents to which the directive refers.

1.2.2 External documents

STN EN ISO 9000 Quality management system - glossary
STN EN ISO 9001 Quality management system - requirements
IFS International Food Standard 6

Edit the list of external documents that are directly related to this directive, or list the documents to which the directive refers.

1.3 Concepts and definitions

Concept, definition	Explanation
Document	A document that describes information in the form of processes.
External document	Document used in **Company name and address**, issued by an external organization - e.g. Ministry of Health of the Slovak Republic, Ministry of Health of the Slovak Republic, Veterinary Administration of the Slovak Republic, EC
Workflow	A specified method of performing an activity or process
Guidelines	A document that guides the execution of activities
Record	It is evidence that describes achieved results or performed activities
Directive	A document setting out the method and responsibilities for the performance of activities forming part of quality management
Quality manual	Document describing the organization's quality management system
Document management	Rules established to ensure the handling of documentation

Modify terms and definitions used in this directive.

1.4 Abbreviations and symbols

In short Definition Concept	Explanation
IKD	Identification code of the document
MP	Managerial process
HP	The main process
PP	Supporting process

Adjust list abbreviations used in the directive

2. Process description

2.1 Flow chart

Draw a flowchart here

2.2 Comment

KP 2 Production

KP 2-1 Production planning

Responsibility: XX (use the uniform abbreviations listed in the documentation and records management document!!!)

Here comes the text, a brief description of the subprocess. Here comes the text, a brief description of the subprocess. Here comes the text, a brief description of the subprocess. Here comes the text, a brief description of the subprocess. Here comes the text, a brief description of the subprocess.

Process names and numbering can be derived from the process model!
Briefly describe the individual processes (sub-processes) listed in the process diagram.

3. Additional guidelines and instructions

- Indicate guidelines and instructions if they exist and cannot be included in sub-processes.
- If they do not exist, state: This directive does not contain additional guidelines and instructions
- In no case do not remove point 3 for the sake of uniformity of chapter numbering within all guidelines!

4. Amendment procedure

The inspection of this directive is carried out once a year on 15.12.

Controls are recorded by the manager on the title page with a pen. After five years from the issuance of the directive, or in case of organizational changes in the company, a new directive will be issued.

Any changes in this directive are submitted to the DG via MK , which accepts or rejects them and approves them in the final form after discussion by the management of our company.

Changes are recorded in each printout on the Change Sheet:

5. List of attachments

Annex no. 1 Name

If the directive does not contain annexes, state:

This directive does not contain annexes.

Practical work

Food safety management system – Solving practical tasks

Task No. 1: Analysis of the processes in a food company.

Create a process model of the management system with the indication of managerial, main, and supporting processes according to the requirements of norms and standards: ISO 9001, ISO 22000, IFS, BRC, and TFMS. Students work in pairs and create a process model for a designated food operation that follows the principles of the PDCA process approach and the requirements of technical norms and standards. The exercise is intended for students to understand the organisation's context and think about the relationships between individual processes.

Output: Process model of the food company management system. Picture: A diagram consisting of several processes.

Process model of the food company management system

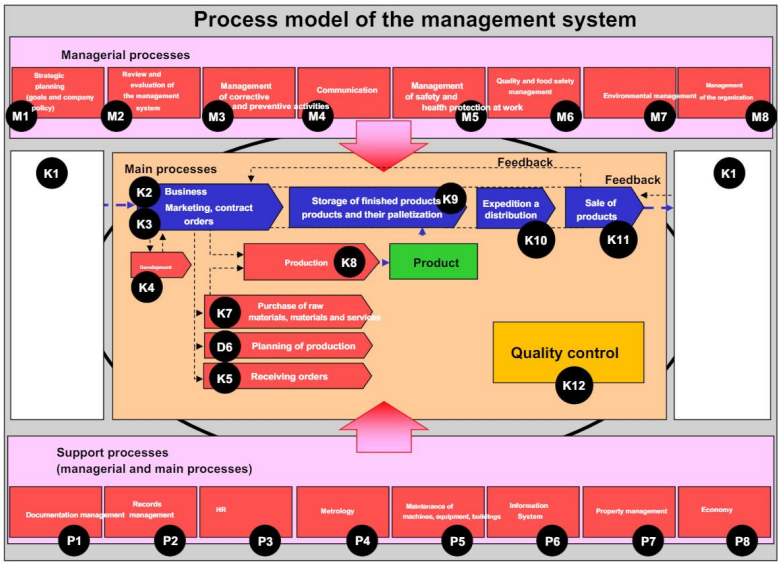

Fig. 21.2 Process model of the food company management system (Zajác, 2020)

1. Managerial Processes

These are processes that involve strategic planning, leadership, and overall management of the food safety and quality management systems.

1. **Strategic planning and leadership (M1)**
    - Establishing company policies, objectives, and strategic direction.

- Ensuring commitment to food safety and quality standards.
- Periodic review and updating of policies and objectives.

2. **Risk management (M2)**
    - Identifying, assessing, and managing risks related to food safety and quality.
    - Implementing preventive measures and corrective actions.
3. **Management review (M3)**
    - Regular review of the FSQMS by top management.
    - Evaluating performance and effectiveness of the management systems.
    - Decision-making for continuous improvement.
4. **Internal audits (M4)**
    - Planning and conducting internal audits.
    - Reporting audit findings and implementing corrective actions.

2. Main processes

These are core activities directly related to the production and delivery of safe and high-quality food products.

1. **Product development (K1)**
    - Research and development of new food products.
    - Ensuring new products meet safety and quality standards.
2. **Procurement (K2)**
    - Sourcing and purchasing raw materials and ingredients.
    - Supplier evaluation and approval.
3. **Production (K3)**
    - Manufacturing processes to produce safe and high-quality food.
    - Implementation of HACCP plans and GMP.
4. **Quality control (K4)**
    - Inspection and testing of raw materials, in-process products, and finished goods.
    - Ensuring products meet predefined quality standards.
5. **Storage and distribution (K5)**
    - Proper storage of raw materials, in-process items, and finished products.
    - Ensuring safe and hygienic transportation and distribution.
6. **Customer service and feedback (K6)**
    - Handling customer inquiries and complaints.
    - Collecting and analysing customer feedback for continuous improvement.

3. Supporting processes

These processes support the main and managerial processes by providing necessary resources and infrastructure.

1. **Human resources (P1)**

- Recruitment, training, and development of employees.
- Ensuring staff competencies in food safety and quality.

2. **Documentation and record control (P2)**
    - Managing and maintaining documentation related to FSQMS.
    - Ensuring records are accurate and up-to-date.
3. **Maintenance (P3)**
    - Maintaining equipment and facilities to ensure they are in good working condition.
    - Preventive maintenance and calibration of equipment.
4. **Information technology (P4)**
    - Managing IT infrastructure and systems.
    - Ensuring data security and integrity.
5. **Finance and budgeting (P5)**
    - Financial planning and management.
    - Allocating resources for food safety and quality initiatives.
6. **Marketing and sales (P6)**
    - Promoting food products.
    - Managing sales and distribution channels.

2. To create the company policy.

Read the requirements in ISO standards and private food safety standards. Prepare a company policy document. Integrate the requirements of different standards into this policy.

Output: Company policy

Standard requirements related to the company policy

ISO 9001:2015

5.2 Policy

5.2.1 Development of quality policy

Top management must develop, implement, and maintain a quality policy that: i) is suitable for the purpose, for the context of the organisation, and its strategic direction; j) provides a framework for setting quality objectives; k) contains a commitment to comply with applicable requirements; l) contains a commitment to continuous improvement of the quality management system.

5.2.2 Quality Policy Communication

The quality policy must be: g) available and maintained as documented information; h) communicated, understood, and applied in the organisation; i) if necessary, available to the relevant interested parties.

ISO 22000

5.2 Food safety policy

The organisation's top management must define, document, and communicate its food safety policy. Top management of the organisation must ensure that the food safety policy: e) is appropriate to the organisation's role in the food chain; f) meets the requirements of technical standards and laws, as well as the safety requirements mutually agreed with the customer; k) is communicated, implemented, and maintained at all levels of the organisation; l) is reviewed for its continuing suitability (see 5.8); m) adequately addresses communication (see 5.6); n) is supported by measurable targets.

IFS 8

1. Governance and commitment

1.1 Policy

1.1.1* The senior management shall develop, implement, and maintain a corporate policy, which shall include, at a minimum:

- food safety, product quality, legality, and authenticity;
- customer focus;
- food safety culture;
- sustainability.

This corporate policy shall be communicated to all employees and shall be broken down into specific objectives for the relevant departments. Objectives about food safety culture shall include, at a minimum, communication about food safety policies and responsibilities, training, employee feedback on food safety-related issues, and performance measurement.

1.1.2 All relevant information related to food safety, product quality, legality, and authenticity shall be communicated effectively and in a timely manner to the relevant personnel.

BRC 8

1.1 Senior management commitment and continuous improvement

Essential requirements

Higher management must prove that it is fully committed to performance requirements of global safety standards for food and processes that will facilitate continuous improvement in food safety and quality management.

Provisions of the requirement

1.1.1 The workplace must have documented principles supporting its intention to fulfil obligations of producing safe and legal products with the prescribed quality and a responsible approach to customers. These principles shall be:

- signed by the person with the main responsibilities for the workplace,
- communicated to all workers.

The company shall have a documented policy which states the company's intention to meet its obligation to produce safe and legal products to the specified quality and its responsibility to its customers. This shall be:

- signed by the person with overall responsibility for the site,
- communicated to all staff.

Company food safety and quality policy

1. Introduction

- **Purpose:** Briefly state the purpose of the policy, emphasising the organisation's commitment to food safety and quality.
- **Scope:** Define the scope of the policy, including the areas of the business it covers (e.g. production, processing, distribution).

2. Commitment to food safety and quality

- **Statement of commitment:** A clear statement from top management expressing the commitment to maintaining high standards of food safety and quality.
- **Legal and regulatory compliance:** Commitment to comply with all relevant food safety and quality regulations, standards, and customer requirements.

3. Food safety and quality objectives

- **Objectives:** Outline specific, measurable objectives aimed at ensuring food safety and quality (e.g. reducing incidents of contamination, achieving customer satisfaction).
- **Continuous improvement:** Commitment to the continuous improvement of the food safety and quality management system.

4. Roles and responsibilities

- **Top management:** Define the roles and responsibilities of top management in supporting and implementing the policy.
- **Food safety and quality team:** Outline the roles of the food safety and quality team, including the Food Safety Team Leader.
- **Employees:** Highlight the responsibilities of all employees in maintaining food safety and quality standards.

5. Implementation and maintenance

- **Training and competence:** Ensure that all employees are adequately trained and competent in food safety and quality practices.
- **Communication:** Describe the methods for communicating the food safety and quality policy and objectives within the organisation and to relevant stakeholders.
- **Documentation and records:** Commitment to maintaining up-to-date documentation and records to support food safety and quality activities.

6. Hazard Analysis and Critical Control Points (HACCP)

- **HACCP Implementation:** Outline the implementation of the HACCP plan to identify, evaluate, and control food safety hazards.
- **Critical Control Points:** Define the critical control points (CCPs) and the measures taken to monitor and control these points.

7. Good Manufacturing Practices (GMP)

- **GMP Standards:** Commitment to adhering to Good Manufacturing Practices to ensure the production of safe and high-quality food products.

8. Corrective and preventive actions

- **Nonconformities:** Procedures for handling nonconformities related to food safety and quality.
- **Corrective actions:** Steps to identify, document, and address the root cause of nonconformities.
- **Preventive actions:** Measures to prevent the recurrence of nonconformities.

9. Review and Evaluation

- **Management review:** Regular review of the food safety and quality policy by top management to ensure its continued suitability and effectiveness.
- **Performance evaluation:** Monitoring, measurement, analysis, and evaluation of the performance of the food safety and quality management system.

10. Conclusion

- **Reaffirmation of commitment:** A closing statement reaffirming the organisation's commitment to food safety and quality.
- **Approval:** Signature of the top management representative responsible for the policy.

Example policy statement:

Introduction: Our company is dedicated to producing safe, high-quality food products. This policy outlines our commitment to food safety and quality, the scope of our management system, and the responsibilities of all employees in maintaining these standards.

Commitment: We are committed to complying with all relevant food safety and quality regulations, standards, and customer requirements. Our top management supports this policy and ensures that adequate resources are provided for its implementation and maintenance.

Objectives: Our food safety and quality objectives include achieving zero contamination incidents, ensuring customer satisfaction, and continuously improving our management system.

Responsibilities: All employees are responsible for adhering to food safety and quality standards. The Food Safety Team Leader coordinates the implementation of our HACCP plan, and top management oversees the overall effectiveness of our management system.

Implementation: We provide regular training to our employees, maintain up-to-date documentation, and communicate our policy to all stakeholders. Our HACCP plan identifies critical control points, and we follow Good Manufacturing Practices to ensure product safety and quality.

Review: This policy is reviewed annually by top management to ensure its effectiveness and relevance. Performance evaluations are conducted regularly to monitor and improve our food safety and quality management system.

3. Create the selected directive for the food safety management system

Students will create a directive for the management of the production process. As part of this task, they must adhere to the principles of creating documentation creation and the formal structure of the documentation of the quality and food safety management system. When developing the directive, they analyse the sub-processes of the production management process, such as **(production planning, provision of employees, raw materials, packaging material, preparation of the technological line, start of production, inter-operation control, output control, and end of production)**. When creating the directive, they follow an already created process model. They describe how individual sub-processes will be performed, considering and integrating the requirements of technical norms and standards. The exercise is intended for students to learn how to create a quality and food safety management system.

Output: Document - management system directive: Management of the production process.

Approved by

_____

Name, surname, signature

Date

_____

Theme 22
Legislative requirements for food of animal and plant origin

Theoretical materials

Hygiene rules for food of animal origin

Food business operator general obligations

Operators must use only potable water (or 'clean water' in some circumstances) to remove surface contamination, unless alternatives are approved by the European Commission.

Products must be prepared and handled in establishments which need to be at least registered, but often approved.

Products must have a health mark or other approved identification mark.

Products from outside the EU must satisfy at least EU requirements, demonstrated by the listing of authorised countries and establishments; in addition, products must be accompanied by certificates.

Meat, including domestic ungulates (bovine, porcine, ovine and caprine species); poultry and lagomorphs (farmed birds, rabbits, hares and rodents); farmed and wild game; minced meat, meat preparations and mechanically separated/recovered meat; and meat products. The rules include requirements for:

- transporting live animals to slaughterhouses;
- slaughterhouses and cutting plants;
- slaughter hygiene and hygiene during cutting and boning;
- emergency slaughter (outside slaughterhouses) and slaughter on the farm;
- temperature requirements during processing and storage;
- training of hunters in health and hygiene;
- handling of wild game (large and small).

Fishery products, seawater and freshwater fish, including crustaceans and molluscs, whether wild or farmed. The rules apply to thawed, unprocessed fishery products and fresh fishery products. Among others, products must meet requirements for:

- fishing, freezer and factory vessels;
- hygienic and careful handling and landing procedures;
- control of parasites;
- cooking, cooling, shelling and shucking of crustaceans and molluscs;
- health standards and freshness;

- toxins harmful to humans; and
- wrapping, packaging, storage and transport.

Raw milk and **milk products** must come from animals that are:

- in good general health;

- showing no symptoms of infectious diseases communicable to humans through milk; and

- from herds free from brucellosis and tuberculosis.

There are also requirements for:

- premises and equipment;
- hygiene during milking, collection and transport;
- temperature and heat treatment; and
- wrapping, packaging, labelling and identification marking.

Eggs and **egg products** must be:

- kept clean, dry, in an odour-free environment, protected from shocks and direct sun;
- stored and transported at a temperature suitable for optimal conservation;
- delivered to the consumer within 21 days of laying.

Food safety risk associated with foods of plant origin

Consumers include foods of plant origin in their diet because they want to eat healthy. However, what many consumers do not realise is that consumption of these foods may pose a food safety risk. Foods contaminated with unacceptable levels of pathogenic micro-organisms, chemicals, or physical hazards can result in severe health and economic effects for consumers and society. Foods of plant origin are those derived from plants which include:

• produce (fruits and vegetables),
• sprouts,
• culinary herbs,
• nuts,
• edible fungi,
• maple and honey products,
• grain products.

Factors affecting food safety

Environment: Foods of plant origin are typically grown in fields exposed to organisms that are present naturally in the environment (excluding: from soil, irrigation water, wildlife, etc.). Good agricultural practices (GAPs) help reduce the risks associated with these products but cannot guarantee a product free from pathogenic micro-organisms.
Post harvesting: Improper post-harvest handling may contribute further contamination. Inadequate product storage conditions may also allow pathogenic micro-organisms that are present to multiply.
Processing: There is an increased demand for fresh cut produce including fruit trays, bagged salads and cut vegetables. Processing (peeling or cutting) fruits and vegetables increases the risk of contamination by breaking the natural outer barrier of the fruit and releasing juices which provides nutrients for pathogenic micro-organisms to grow, if present. These processes also involve product handling by personnel and/or equipment that if not hygienic can be a source of contamination.

Inappropriate storage: Sales and consumption of ready-to-eat grain products has also increased. These grains rarely have a treatment to reduce the microbial load and may be a concern if stored or used under conditions that promote the growth of pathogenic micro-organisms (excluding: mould producing mycotoxins).

The safety of food products must be ensured by using a preventative approach, including the implementation of good agriculture and manufacturing practices (GAP, GMP) and hazard analysis critical control point (HACCP).

Laboratory works

Laboratory examination of milk and dairy products

Salt detection test in milk

Salt or sugar is used to mask extraneous water added to milk or to elevate total solids in milk. it is important to detect presence of salt in milk.

Method

Apparatus and reagents required

- Test tubes
- 5% potassium chromate
- 0.1N silver nitrate
- Milk sample

Procedure

Take 2.0 mL of milk in a test tube

Add 1.0 mL of 5% potassium chromate to the milk

Add 2.0 mL of 0.1N silver nitrate to the test tube

Results

Appearance of red precipitate indicates the absence of dissolved chloride in milk.

Appearance of yellow colour indicates presence of dissolved chloride.

Starch detection test in milk

Starch is sometimes added to adulterate milk. Starch being cheaper, is sometimes added in the milk by adulterators.

Apparatus and reagents required

- Test tube
- 1% Iodine solution
- Milk sample

Procedure

Take 3 mL milk in a test tube, boil and cool under tap water.

Add a drop of 1% Iodine solution.

Results

Presence of starch is indicated by the appearance of a blue colour, which disappears when the sample is boiled and re-appears on cooling.

Microbiological analysis

Total viable count (TVC) in milk

Total plate count results reflect the number of colonies that can emerge under the given physical and chemical conditions (atmosphere, temperature, pH, available nutrients, and presence of growth inhibitory compounds).

Materials Required

• Diluent: 0.1% Peptone or Phosphate buffer (90 or 99 mL, 9 mL)

• Media: Plate count agar (PCA) medium (pH 7.0 at 25 °C); autoclaved at 121 °C for 15 minutes

• Pestle and mortar, Petri dishes, pipettes, incubator

Procedure

Sampling: Collect the sample randomly from entire lot. According to FSSAI sampling, 5 sachets (500 mL) of samples will be collected from entire lot. Sample will be stored at refrigeration temperature (2-7 °C) until analysis.
Preparation of the test sample: 100-150 mL of the sample will be poured into the sterile sample bottle from each sachet. Opened sachets will be sealed and kept at refrigeration temperature (2-7 °C).
Serial dilution and plating
Mark the tubes and Petri dishes for batch no., sample no., parameter, dilution etc.
Pipette out 10 or 11 mL of sample from sample bottle into 90 or 99 mL
of diluent bottle (1:10 dilution).
Pipette out 1 mL of diluted sample from 1:10 dilution bottle into 9 mL of diluent tube.
Subsequently go for further dilutions if required by pipetting out from previous dilution into 9 mL of diluent tube.
Pour the PCA (50 °C) medium into the plates and allow it to solidify.
Incubate the plates at 35 ± 2 °C for 48–72 hrs.

Counting and calculation

After incubation, retain dishes containing not more than 300 colonies at two consecutive dilutions. It is necessary that one of these dishes contains at least 15 colonies. Calculate the number N of micro-organisms per millilitre or per gram of product, depending on the case, using the following equation:

$$N = \frac{\Sigma C}{(n1 + 0.1n2)d}$$

Where,

- ∑C is the sum of colonies counted on all the dishes retained;
- n1 is the number of dishes retained in the first dilution;
- n2 is the number of dishes retained in the second dilution;
- d is the dilution factor corresponding to the first dilution.

Round the result calculated to two significant figures. Take as the result the number of micro-organisms per millilitre or per gram of product, expressed as a number between 1.0 and 9.9 multiplied by 10 x where x is the appropriate power of 10.

Results

Table 22.1.

Results of microbiological analysis of milk

Sample	TVC (log CFU/ml)
Milk	

Conclusion

Approved by

_____

Name, surname, signature

Date

_____

Laboratory works

Laboratory examination of meat products

Determination of salt content in the meat products

Apparatus and reagents required:

- water,
- potassium chromate (K_2CrO_4),
- silver nitrate ($AgNO_3$),
- beaker,
- burette.

Procedure

Weigh 2 g of the sample, cut into small pieces.

Pour 100 mL of warm water, mix for 5 minutes.

Add 5 mL of potassium chromate to the solution.

Pour $AgNO_3$ into the burette.

Titrate to a pale pink permanent colour. You should read off the used ml of $AgNO_3$.

Calculation:

Content of NaCl (%)

$$X = \frac{a}{2}$$

where,

a – consumption of $AgNO_3$

Determination of the total viable counts (TVC) of coliform bacteria (CB) in meat products

Materials Required:

- distilled water,
- pipette,
- cultivation media,
- Petri dishes

Procedure

- weigh 5 g of the sample,

- add 45 mL of distilled water, a dilution of 10-1 is created.
- prepare a 10^{-2} dilution.
- pipette + mL from both dilution to Petri dishes
- pour the PCA (50 °C) medium to determination of TVC and VRBL medium to determination of CB into the plates and allow it to solidify.

Incubate the plates at 30 ± 2 °C for 48–72 hrs (determination of TVC) and at 37 ± 2 °C for 24–48 hrs (determination of CB)

Counting and Calculation

After incubation, retain dishes containing not more than 300 colonies at two consecutive dilutions. It is necessary that one of these dishes contains at least 15 colonies. Calculate the number N of micro-organisms per millilitre or per gram of product, depending on the case, using the following equation:

$$N = \frac{\Sigma C}{(n1 + 0.1n2) \times d}$$

where,

- ∑C is the sum of colonies counted on all the dishes retained;
- n_1 is the number of dishes retained in the first dilution;
- n_2 is the number of dishes retained in the second dilution;
- d is the dilution factor corresponding to the first dilution.

Results

Table 22.2. Results of microbiological analysis of meat products

Sample	TVC (log CFU/g)	CB (log CFU/g)
Ham		
Sausages		
Pate…		

Conclusion

Approved by

_____

Name, surname, signature

Date

_____

Co-funded by the European Union

OFINU

Open Food Innovation University (OFINU)

Study module

“New Food Product Development”

WORKBOOK

for students

2024

Summary

The workbook is elaborated within the project “Open Food Innovation University" (OFINU), being in implementation with support of the European Union Erasmus+ Programme.

Overall objective of the project - to modernise food innovation and technology related higher education in Uzbekistan and Tajikistan, thereby increasing the quality and ensuring relevance of the higher education to the needs of the socio-economic growth of the countries concerned and especially of their regions.

Full partners:

- Lead partner: Latvia University of Life Sciences and Technologies
- Uzbekistan: Samarkand Agro-innovations and Research University, Andijan Institute of Agriculture and Agro-technologies
- Tajikistan: Technological University of Tajikistan, Kulob Institute of Technology and Innovation Management, Isfara Branch of the Technological University of Tajikistan
- Slovakia: Slovak University of Agriculture in Nitra

Associated partners in Uzbekistan:

- A group of companies "AGROMIR"
- "Navigul" MCHJ QK
- “Samarqand don mahsulotlari” JC (Samarkand grain products)

Associated partners in Tajikistan:

- CJSC “Combinati Shiri Dushanbe”
- LTD "Orion Rustam"
- Association of Entrepreneurs of Khatlon

The project implementation period: 01/02/2024 - 31/01/2027.

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Partner universities and their academic staff, involved in the development of the study course:

P1 LBTU. Latvia University of Life Sciences and Technologies

Dace Klava Dr. sc. ing. Asoc. professor - dace.klava@lbtu.lv

Emīls Kozlinskis - Orkla Biscuit Production, Product and Development department manager, emils.kozlinskis@gmail.com

Evita Straumite Dr. sc. ing. Assoc. professor - evita.straumite@lbtu.lv

P2 SAMARU. Samarka and Agroinnovations and Research University

Khusniddin Pardaev PhD - pardayev2@gmail.com

Shukrullo Muratov PhD - muratovshukrullo1@gmail.com

Ravshan Kalandarov MSc. Senior Lecturer - qalanravshan@gmail.com

Fotima Saydullaeva MSc. Senior Lecturer - foti.9292@gmail.com

Iroda Baymuradova MSc. - baymuradovairoda07@gmail.com

Elnara Devletshaeva MSc. Assistant teacher - elnaradevletshayeva@gmail.com

RahmatilloTashmanov PhD - tashmanovraxmatillo@gmail.com

Temurbek Mikhliev MSc, Assistant teacher - mixliyevt@gmail.com

Babur Eshonkulov PhD - b.eshonqulov0201@gmail.com

Anvar Shamsiev PhD - anvarshams07@gmail.com

P3 AIAA. Andijan Institute of Agriculture and Agro-technologies

Muhammad Zahiriddin Zaynobiddinov MSc, Senior Lecturer - mr.zaynobiddinov@gmail.com

Mashhurbek Tojidinov - mashhurbek1212@gmail.com

Kholdarov Shukhratjon MSc, Assistant teacher) - shuhratxoldarov7777@gmail.com

Dekhkonova Shakhnozaxon MSc, Assistant teacher - sahnozadehkonova49@gmail.com

P4 TUT. Technological University of Tajikistan

Shuhratjon Nazarov PhD in Tech. Sc., Assistant Professor – nazarovshuhratjon@gmail.com

Azimjon Khushmatov PhD in Tech. Sc., Assistant Professor - azimdzonkhushmatov@gmail.ru

Sitora Sodiqova Senior Lecturer - ssodiqova871@gmail.com

P5 KITIM. Kulob Institute of Technology and Innovation Management

Bobokhon Qurbonzoda PhD in Tech. Sc., Assistant Professor - qurbonzodabobokhon@gmail.com

Bahrom Nabotov Senior Lecturer - nabotovbahrom@gmail.com

P6 BTUTI. Branch of the Technological University of Tajikistan in the city of Isfara

Sirojiddin Boboev Senior Lecturer - sirozhiddinboboev76@gmail.com

Mirzomaruf Boboev Senior Lecturer - mirzomarufboboev@gmail.com

Hoshimjon Abdulloev PhD in agriculture - abdulloevhosimjon8480@gmail.com

Navoiddin Nosirov PhD in jurisprudence - nnavoiddin@gmail.com

Taskina Karomaddinova Assistant - Karomadinovataskina@gmail.com

P7 SUA. Slovak University of Agriculture in Nitra

Eva Ivanišová Ing. PhD. - eva.ivanisova@uniag.sk

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Theme of the study course

The study module includes three parts: Idea Generation, Prototype Development and Commercialisation. To ensure the full implementation of the module, lecturers with knowledge in new product development management, food technologies and processes, as well as marketing and sales specialists participate in it.

Learning methods

In the implementation of the module, the teachers use the learner-centred approach, which empowers students to take charge of their own learning, leading to increased engagement and motivation. The use of digital tools for interactive learning has made classes more dynamic and accessible - students can access learning materials from anywhere, leading to increased flexibility and convenience. Interactive methods, such as seminars, methods used for providing laboratory and practical work (individually, group work, discussions, and re–training). An innovative method - Hackathon - will be used to consolidate the acquired knowledge and to create prototypes of new products - for the problems raised by food production.

During the study of the module, student groups work practically and follow the new product development process from idea concept to sales plan. New product development pilots are carried out by each student team in the product group of their interest, which is agreed upon at the beginning of the implementation of the module.

COURSE SCHEDULE

Thematic Study Plan for module "New Food Product Development"

Date, Time	Study form	Topic	Lecturer
Theme 1. Role of innovation in science and entrepreneurship			
Day 1	Lecture (1h)	Introduction to the course, participants and awareness of innovation.	Assoc. prof. D. Klava
	Lecture (3h)	Innovation, types of innovation and their differences. Innovation in a European and global context. Role of development of new products in food industry and research institutes. Development of new products in research centres and their role in the development of the food production sector. The European Union support system for innovation development, differences with local market approach. Transfer of knowledge and technology in a collaborative model science - production - science. Process of developing new products in a food production company. Role of innovation in product life cycle and business development. Strategic and conceptual modelling of new products in a company. **HW** Tendencies in Food industries and Food science – each student finds and describes 5 new trends and creates a presentation.	Assoc. prof. D. Klava Dr. sc. ing. E. Kozlinskis
Theme 2. Idea generation			
Day 2	Seminar (4h)	Discussion about new trends in food industries in a European and global context.	Dr. sc. ing. E. Kozlinskis Assoc. prof. D. Klava
	Lecture (1h)	New product development process - idea, prototype, development, and commercialisation. Creative thinking methods and their application in new product	

		development. Implementing a conceptual approach to new product development.	
	Practical work (2h)	Group work - develop a product concept.	
Day 3	Lecture (1h)	Consumer role in the new product development process. Business Model Canva as tools for idea development.	Assoc. prof. D. Klava
	Practical work (2h)	Consumer profile development. Evaluate consumer need and value of new products using Business Model Canva.	
	Practical work (4h)	Ideas generation techniques. Using Ideas generation techniques e.g. b rainstorming, analogical reasoning, random name, etc. for new ideas.	Assoc. prof. D. Klava
Day 4	Practical work (4h)	Evaluation and selection of ideas. Description of ideas.	Assoc. prof. D. Klava
	Lecture (2h)	Architecture and design of the new idea, appropriately of actuality in the food industry. Prototyping techniques and methods used in development stages. **HW** New product architecture and design development.	
Day 5	Seminar (1h)	Presentation and discussion of new product design.	Assoc. prof. D. Klava

	Lecture (2h)	Food product sensory properties (appearance, aroma, taste, consistency / structure) as food design elements. Identification of consumer expectations, needs and benefits. Consumer methods for food product sensory evaluation (line scale, hedonic scale, CATA, RATA, Just about Right, Mapping/Napping u.c.).	Assoc. prof. E. Straumīte
	Practical work (2h)	Sensory evaluation methods used in consumer studies. **HW** - Study of scientific articles about sensory evaluation methods used in consumer studies.	
	Seminar (1h)	A discussion about sensory evaluation methods used in consumer studies.	Assoc. prof. E. Straumīte
	Lecture (1h)	Emotions in creating and choosing new products. Principles of organisation of sensory evaluation (definition of aim, selection of samples, selection of panellists, etc.). Sensory claims as a provider of information to the consumer. Food Pairing.	
Theme 3. Product development			
Day 6	Lecture (3h)	Product development process. Developing the required documentation for the new product. Intellectual property rights protection.	Assoc. prof. D. Klava
	Practical work (5h)	Developing technology documents.	
Day 7	Practical work (5h)	Develop a label and packaging sample for the new product.	Assoc. prof. Evita Straumīte
	Seminar (2h)	Presentation of packaging and label sample.	
Day 8	Practical work	The prototype evaluation phase. Developing, testing and finalising prototypes.	Assoc. prof. D. Klava

	(4h)		
	Seminar (2h)	A discussion about the product's technological documentation.	
Theme 4. Commercialisation			
Day 9	Lecture (4h)	The commercialisation phase of new products. Product sales strategy. Integrated marketing for sales.	Assoc. prof. D. Klava
	Practical work (3h)	Communication elements for marketing. **HW** Development of a plan of sales activities for the new product.	
Day 10	Practical work (4h)	Content of marketing communication. Marketing activities plan.	Assoc. prof. D. Klava
	Seminar (3h)	A discussion about marketing activities plan.	
Theme 5. Evaluation of new product development process.			
Day 11	Lecture (2h)	SWOT analysis for new product development. Risk identification and evaluation. Using criticism to improve your product.	Assoc. prof. D. Klava
	Practical work (4h)	SWOT analysis for project evaluation.	
	Seminar (2h)	A discussion about SWOT analysis.	
Theme 6. Hackathon "InnoFood"			
Day 12 (24h)	Hackathon "**InnoFood**" - to solve a problem or identify new opportunities for food industry.		

Theme 1

Role of innovation in science and entrepreneurship

Theoretical materials

Innovation — a new development introduced into civil circulation or used for one's own needs, the application of which in practice ensures the achievement of a significant socio-economic effect.

I**nnovative infrastructure —** a set of enterprises, organisations, institutions, their associations of any form of ownership, carrying out material and technical, financial, organisational and methodological, information, consulting and other support for innovative activity.

An innovative project — a set of measures that provide for deadlines, performers, sources of funding and the formation of an appropriate infrastructure for the creation of new developments.

Innovative activity — activity aimed at the creation of new developments, as well as ensuring their transfer and implementation in the production sector.

State order for the creation of innovations — an assignment for the performance of an innovative project at the expense of the State budget of the Republic of Uzbekistan and other sources not prohibited by law.

Transfer of technologies — a set of measures aimed at transferring a new development from the sphere of its reception (development) to the sphere of practical application.

A new product development — is the result of intellectual activity (new or improved technology, service and organisational and technical solution of a production, administrative, commercial or other nature), which has signs of novelty compared to existing analogues, practical applicability and the ability to ensure the achievement of a significant socio-economic effect when use in practice.

Product development is both an exciting and difficult endeavour. From initial ideation to research and prototyping, no two product launches are the same. However, there’s a general process that can help you get started with the product development process.

The product development process describes the six steps needed to take a product from initial concept to final market launch. This includes identifying a market need, researching the competition, ideating a solution, developing a product roadmap, and building a minimum viable product (MVP).

The product development process has evolved in recent years and is now commonly used by dividing each step into six separate phases. This helps to better organise the process and break individual deliverables into smaller tasks.

Basic principles of innovative activity

The basic principles of innovative activity are:

- freedom of innovative activity,
- ensuring equal access to state support for innovative activity,
- publicity and targeting of state support for innovative activity,
- promoting the development of competition,
- free exchange of information,
- legal protection of intellectual property objects created as a result of innovative activity,
- no harm to the life and health of citizens, and the environment.

Practical work

Trends in food industries and food science

The aim of the practical work is to pay attention to the latest trends in the overall food ecosystem. Look in more detail at the latest scientific research directions and find 3-5 insights for future work.

Task. Each student finds and describes 5 new tendencies and creates a presentation (max. 7 slides). At the end, select 3 insights for new product development.

Materials

Where to find information:
https://www.scopus.com/search/form.uri?display=basic#basic
https://www.sciencedirect.com/
https://www.effost.org/default.aspx
https://www.innovamarketinsights.com/trends/top-food-trends-2024

Results

1.

2.

3.

4.

5.

Conclusion (3 insights from trends for new product development)

Approved by _____
Name, Surname, signature

Date _____

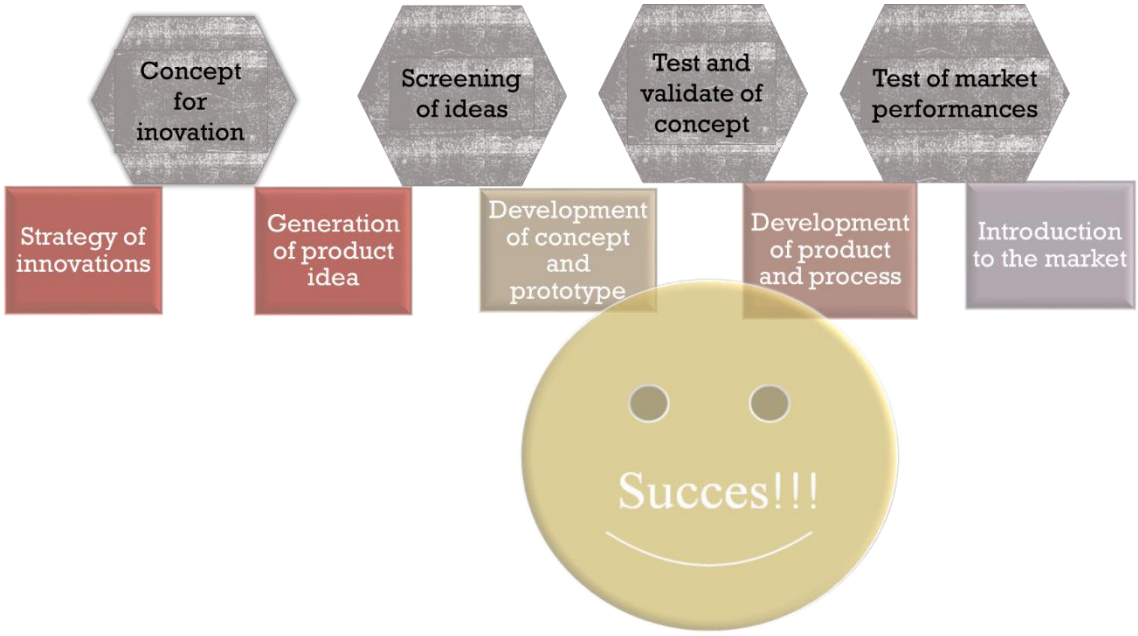
Theme 2

Idea Generation

Theoretical materials

Development of new products is a process that consists of several stages (Fig. 2.1.). The basic stages are strategy of innovation, idea generation, prototyping, product development, and commercialisation. Food companies' capacity for innovation stems from an innovation system: a coherent set of interdependent processes and structures that dictates how the company searches for novel problems and solutions, synthesises ideas into a business concept and product designs, and selects which projects get funded. Individual best practices involve trade-offs.

Figure 2.1. New product development process.



Strategy of Innovations - development of an innovation strategy involves the deliberate development of a plan for the development of new products, including market analysis, customer preferences, competitors, technological progress, in order to achieve business goals. The initial stage of the product development process begins by generating new product ideas. This is the product innovation stage, where you brainstorm product concepts based on customer needs, concept testing, and market research.
It's a good idea to consider the following factors when initiating a new product concept:

- Target market: your target market is the consumer profile you're building your product for. These are your potential customers. It is important to identify this at the

beginning so you can build your product concept around your target market from the start.

- Existing products: when you have a new product concept, it's a good idea to evaluate your existing product portfolio. Are there existing products that solve a similar problem? Or does a competitor offer a product that doesn't allow for market share? And if yes, is your new concept different enough to be viable? Answering these questions can ensure the success of your new concept.
- Functionality: while you don't need a detailed report of the product functionality just yet, you should have a general idea of what functions it will serve. Consider the look and feel of your product and why someone would be interested in purchasing it.
- SWOT analysis: analysing your product strengths, weaknesses, opportunities, and threats early in the process can help you build the best version of your new concept. This will ensure your product is different from the competitors' products and solves a market gap.
- SCAMPER method: to refine your idea, use brainstorming methods like SCAMPER, which involves substituting, combining, adapting, modifying, putting to another use, eliminating, or rearranging your product concept.

To validate a product concept, consider documenting ideas in the form of a business case. This will allow all team members to have a clear understanding of the initial product features and the objectives of the new product launch.

Once you've completed the business case and discussed your target market and product functionality, it's time to define the product. This is also referred to as scoping or concept development, and focuses on refining the product strategy.

During this stage, it's important to define specifics including:

- Business analysis: a business analysis consists of mapping out distribution strategy, ecommerce strategy, and a more in-depth competitor analysis. The purpose of this step is to begin building a clearly defined product roadmap.
- Value proposition: the value proposition is what problem the product is solving. Consider how it differs from other products in the market. This value can be useful for market research and for developing your marketing strategy.
- Success metrics: it's essential to clarify success metrics early so you can evaluate and measure success once the product is launched. Are there key metrics you want to look out for? These could be basic KPIs like average order value, or something more specific like custom set goals relevant to your organisation.
- Marketing strategy: once you've identified your value proposition and success metrics, begin brainstorming a marketing strategy that fits your needs. Consider which channels you want to promote your product on—such as social media or a blog post. While this strategy may need to be revised depending on the finished product, it's a good idea to think about this when defining your product to begin planning ahead of time.

Once these ideas have been defined, it's time to begin building your minimum viable product (MVP) with initial prototyping.

Every company must develop procedures that provide for how new products are introduced so that it is a planned process. In the development of new products, special Research and Development services are created in companies, or a new product development team is formed in smaller companies. The team includes:

- Technologist,
- Engineering,
- Marketing specialist,
- Financial specialist,
- Managing director.

Development of a concept for a new product - concept design is to illustrate how to turn an idea into scalable and pragmatic business opportunities. A concept defines, from a business perspective, how the idea can be realised by considering technical solutions, organisational and business changes and ecosystem implications. Concept development process (Fig. 2.2.).

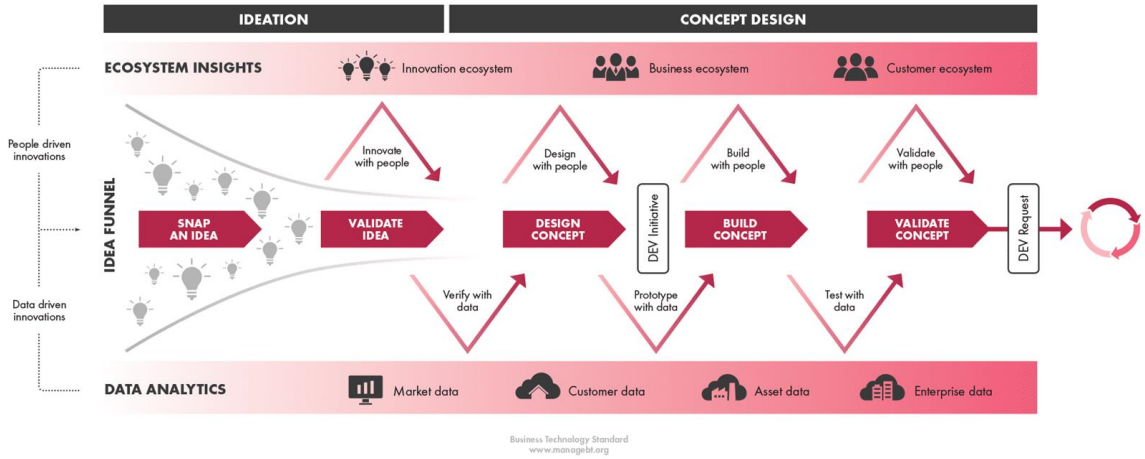


Figure 2.2. Concept development process for new product development.
https://www.managebt.org/book/demand/innovations-and-concepts

Sensory analysis and consumer research are important tools in innovation and new product development (NPD), from design to commercialisation. Innovation is necessary for companies to maintain their market position and attract new consumers. Sensory analysis techniques have evolved considerably in recent decades, from more traditional techniques (discriminator and descriptive analysis or preference and hedonic tests) towards more novel and faster techniques (check-all-that apply, napping, flash profile, temporal dominance of sensations, etc.), with outstanding application at the different stages of NPD. In addition to the application of these techniques, knowing how the consumer interacts with a food product in the different stages (purchase, ingestion, etc.) is essential to better understand and be able to measure consumer attitudes, emotions, and behaviour. Important practical applications have been reported on the development of different novel, functional and

enhanced products (meat, fish, biscuits, yogurt, porridge, hybrid meat, molecular products, etc.), which helps to increase knowledge in this field.

Sensory analysis determines the properties (appearance, aroma, taste, flavour, texture, etc.) of a product or food through the senses (sight, smell, taste, touch and hearing) of the humans. This type of analysis has been used for centuries for the purpose of accepting or rejecting food products. Historically, it was considered a methodology that complements technological and microbiological safety when assessing the quality of food. However, its important evaluation and impact in recent decades has placed it as one of the most important methodologies for innovation and application to ensure final product acceptance by consumers.

Key components of new food product sensory design are:

1. Visual appearance (Sight)

Colour: the colour of food can influence perceived flavour and freshness. For instance, bright colours are often associated with fresh and ripe produce.

Presentation: the arrangement and garnishing of food can enhance its visual attractiveness.

2. Aroma (Smell)

Aroma: the smell of food plays a crucial role in flavour perception. Aroma compounds should be carefully selected and balanced to evoke the desired response.

Freshness indicators: aroma can indicate freshness and quality, especially in products like meat, milk, fish, baked goods, coffee, and herbs.

3. Flavour (Taste)

Flavour balance: the good balance of sweet, sour, salty, bitter, umami, spice and other is very important. Complex flavour profiles can be crafted to provide a satisfying taste and aftertaste experience.

Flavour release: Understanding how flavours are released during consumption can help in designing products that have a lasting and evolving taste.

4. Texture / Consistency (touch)

Mouthfeel: the physical sensation of food in the mouth, including creaminess, crunchiness, temperature, pain, and chewiness, affects overall satisfaction.

Consistency: Consistent texture from batch to batch ensures reliable quality.

5. Sound

Sound of consumption: the sound food makes when consumed, such as the crunch of a crisp snack, can enhance the eating experience and signal freshness or quality.

Sensory methods in consumer research are crucial for understanding how consumers perceive and interact with food products. These methods help in gathering insights into consumer preferences, acceptance, and behaviour, which in turn guide product development, marketing strategies, and quality control. Traditional sensory techniques, such as discrimination, descriptive, preference, and hedonic tests, which are still widely used today, have evolved into newer, faster, and more complete techniques:

a) Just about Right (JAR) method - helps in product optimization by identifying attributes that need adjustment to meet consumer expectation.
b) Check-all-that-Apply (CATA) - provides a quick and broad understanding of consumer perceptions and product characteristics.

c) Rate-all-that-Apply (RATA) - provides a quick and broad understanding of consumer perceptions of product sensory properties intensity and product characteristics.
d) Mapping (M) and Napping (N).
e) Temporal dominance of sensations (TDS) - the time series data used in sensory analysis and give information about temporal characteristics of a food product.
f) Time intensity test - it captures the dynamic changes in the perception of a sensory attribute over time.
g) Preference ranking test - consumers need to rank a set of products based on their preference.
h) Home use tests (HUT) - to evaluate product performance in a real-life setting. Consumers use the product in their own homes for a specified period and provide feedback on their experience. This test provides realistic insights into product acceptance, usage patterns, and potential improvements.

Practical work

Develop Product Concept

Task. Using a context map and developing a product concept and development plan.

Methods

Using the context map, in each part write key words about new product concept. Discuss and develop concept description (Fig.2.3).

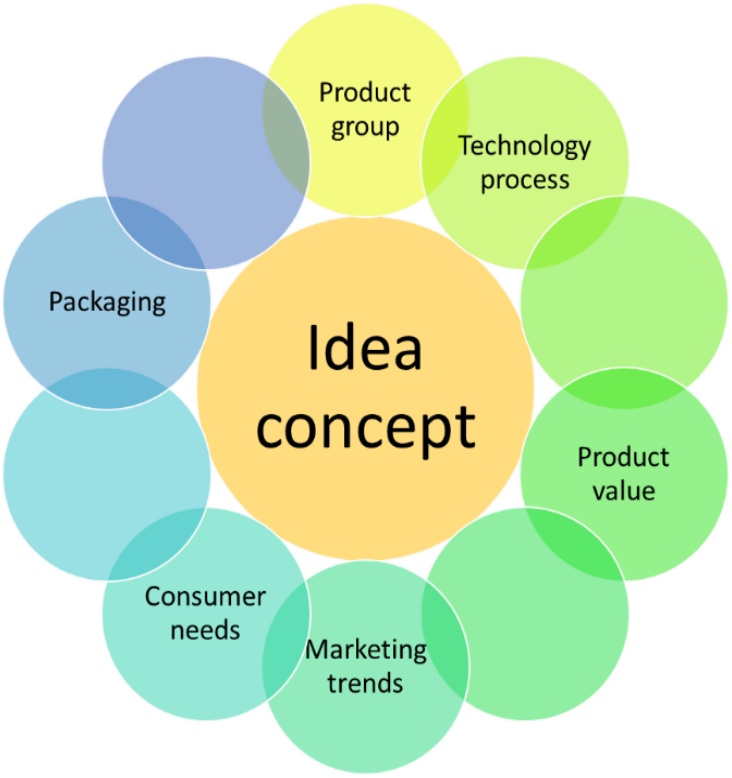
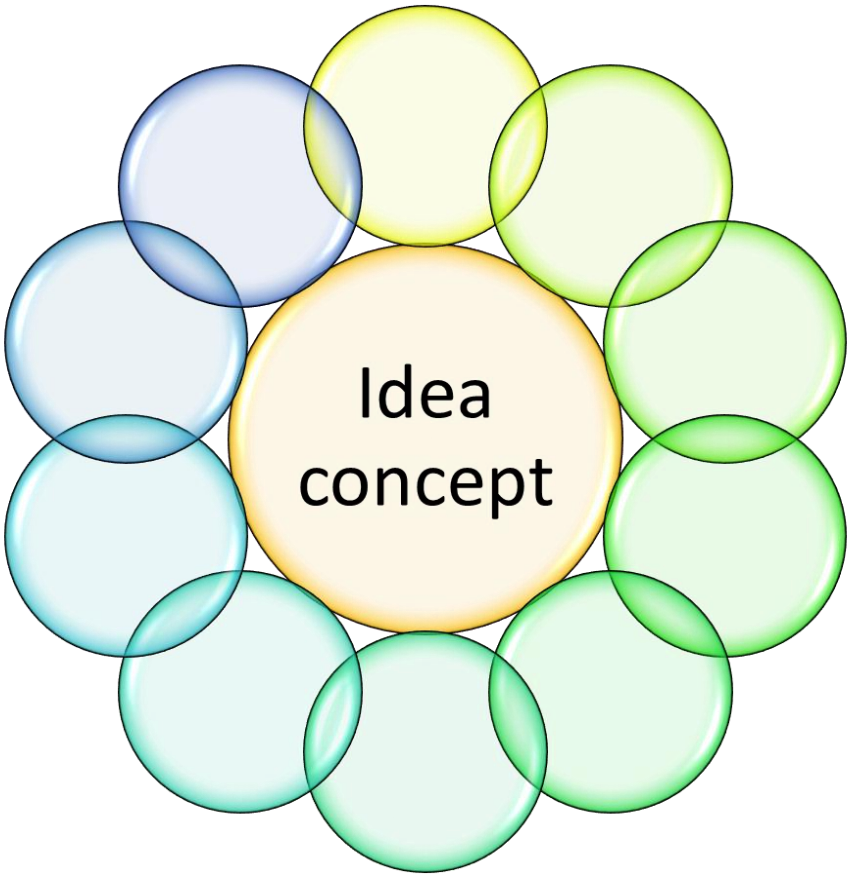


Figure 2.3. Product Context map

Results



Description of product development concept

Approved by _____

Name, Surname, signature

Date _____

Practical work

Consumer profile development

Task. Consumer profile development for a new product development. Evaluate consumer needs and value of new products using Business Model Canva.

Methods

https://jamboard.google.com/d/1Oig4vUtbYgJOXoUZP2ty25SNBM4U7SCsQRwHHn8RDxU/viewer?f=7 or https://miro.comor PDF documents Consumer profile

Results

Consumer portfolio.

Approved by _____

Name, Surname, signature

Date _____

Practical work Ideas generation techniques

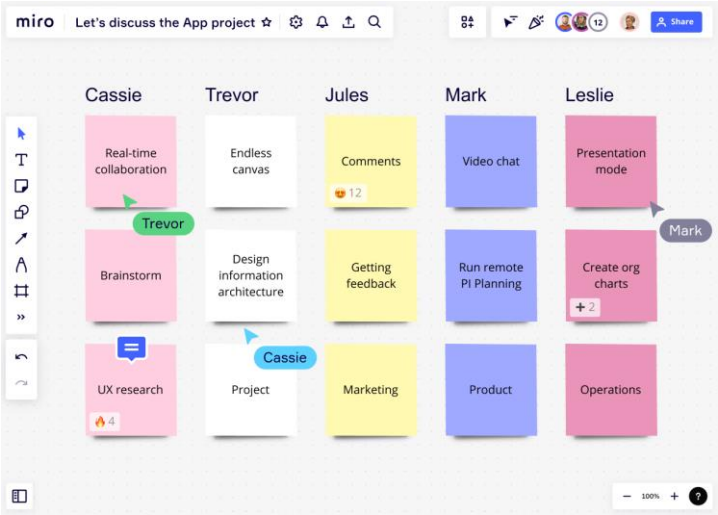
Task. Using ideas generation techniques (also creative thinking methods) e.g. brainstorming, analogical reasoning, random name, etc. for new ideas generation.
Important!

- No criticism
- Unusual ideas are welcome
- Combine and improve ideas

Methods

Brainstorm
<u>Rules for brainstorm method:</u>
Defined problem -

- Generate ideas (time 5 min)
- Form criteria for solving ideas
- Estimate ideas



A list of ideas (min. 20 ideas)

Analogies

Rules for analogies method:

- Define the problem
- Choose a natural object or picture that you will use to search for analogies
- Make associations and ideas
- Generate Ideas

Use this picture for Ideas Generation.

Write down what associations arise when looking at the picture.

A list of Ideas (min 10)

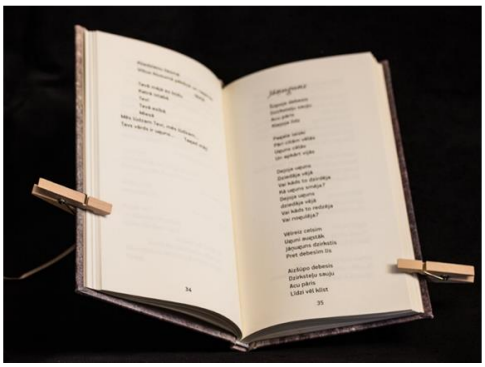
Random word

<u>Rules for Analogies method:</u>

- Define the problem
- Choose a poet book for a random word search
- Make associations and generate ideas
- Create min 10 ideas

Focuss (problem area)	Random word for ideas	Ideas

Look for the random word in books, articles or booklets



Write down what associations arise when you hear or read the chosen word.

A list of Ideas (min 10)

Results

Collect all ideas in a table 2.1.

Table 2.1.

List of Ideas (Min 40)

No.	Idea (short title)	Description of Idea

Approved by _____

Name, Surname, signature

Date _____

Practical work

Evaluation and Selection of ideas

1. Evaluation and selection of ideas 1 stage. Describe the ideas according to the previously developed concept.

Methods

HOW - NOW - WOW

Ideas from Table 2.1 – evaluate them in four categories using 4 categories from Figure 2.4.

Impossible – not able to realise

HOW - Ideas for the future, we can plan for next year

WOW - really innovative, creative ideas, but not implemented in our company

NOW - Ideas for development at this time

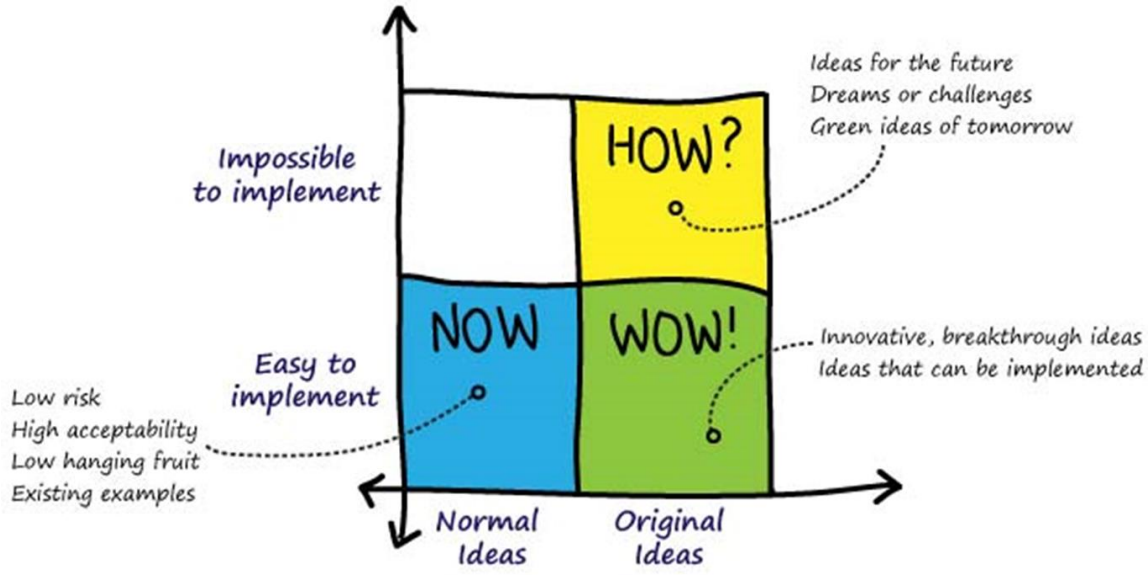


Figure 2.4. Method How – Now – Wow
https://gamestorming.com/how-now-wow-matrix/

Results Collect no more than 5 ideas for next evaluation step from NOW or WOW categories.

2. Evaluation and selection of ideas from the last task using the score sheet screening method. Describe the best idea according to the previously developed concept.

Score sheets for screening of ideas

In order to evaluate ideas using the scoring method (Table 2.2.), you need to set criteria and choose a scoring scale. The criteria are set by the product development team, choosing the most important ones, for example - technological possibilities, innovation aspect, engineering solutions, market capacity, etc. The rating scale can be chosen from 1 to 10 points; however, it should be noted that the value of each point must be defined. For example, 1- not relevant, 2- almost not relevant, 3- partially relevant, 4- relevant, 5- current;

Table 2.2

Score sheets for screening of ideas

Selection criteria	Idea 1	Idea 2	Idea 2	Idea 3
Product innovation				
Technical capability				
Development time/ development cost				
Marketability				
Competition				
Total Score				

If you cannot get one super idea for product development, you can vote in the new product development team.

Conclusion

Description of Idea_____

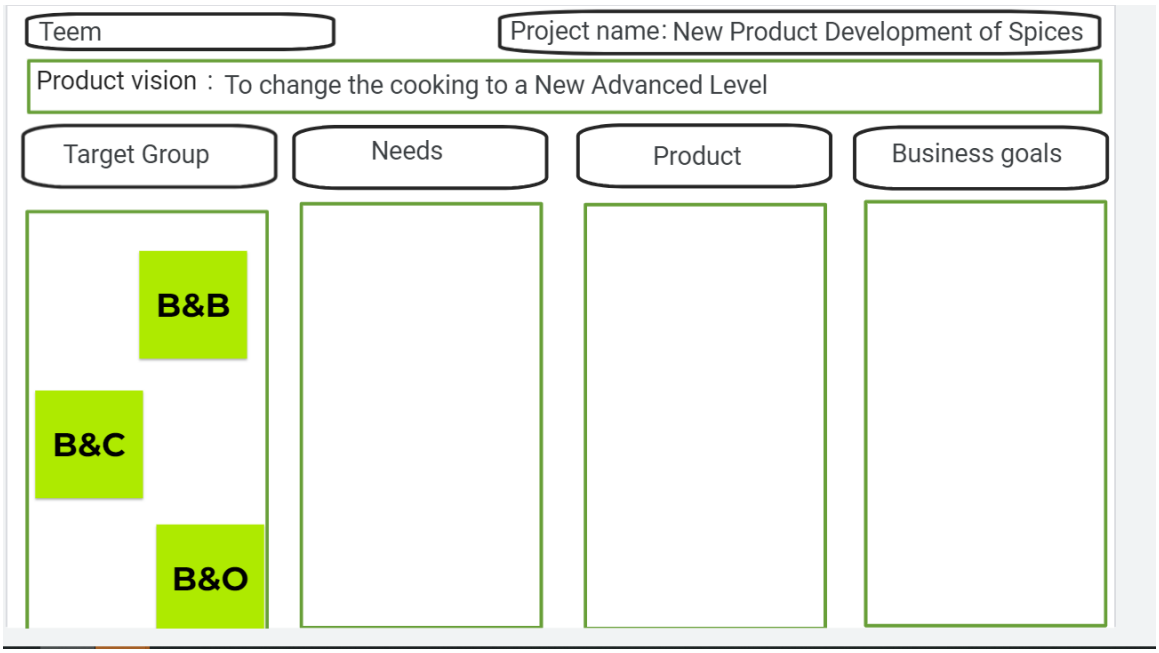
_____

_____

_____

Specific description of Idea fill table 2.3.

Table 2.3.
Specific description of table



Description of Project Target	
Name of product	
Description of idea	
Design of product	
Mass/volume of product	
Size of product	

Structure of product	
Form or shape of product	
Tasty and aroma	
Packaging	
Shelf life of product	
Important factors for new product development	
Product advantage from consumer viewpoint	
Competition of product	
Consumer target group	
Strategy of price	

Home Work (HW) -new product architecture and design (picture, colour palate, size etc.)

Approved by _____

Name, Surname, signature

Date _____

Practical work

Sensory evaluation methods used in consumer studies

Practical work task - to test the ability of evaluators using the smell and basic taste test.

1. To recognise the sample's aroma and fill worksheet 2.1. Aroma test.

Worksheet 2.1.

Aroma test

***NAME, SURNAME*_____**

DATE **_____**

TRAY NO. **_____**

Check the test samples presented by smelling them and write the sample code to the corresponding aroma description.

Do not repeat the smelling process more than 3 times!!!

Sample code	*Aroma*	*Right / Wrong*
	caraway	
	vinegar	
	mint	
	mushrooms	
	coffee	

Sample code	*Aroma*	*Right / Wrong*
	bitter almond	
	apple	
	smoked products	
	peach	
	mustard	

	cinnamon	
	vanillin	

	nuts	
	garlic	

2. To recognise the basic tastes (sweet, sour, salty, bitter and umami) in water solutions and fill worksheet 2.2.

Worksheet 2.2

Basic taste test

NAME, SURNAME_____

DATE ***_____***

TRAY NO. ***_____***

With this test, we want to find out if you can identify five basic tastes – sweet, salty, sour, bitter and umami.

Take the sample in the mouth so that the liquid covers the surface of the tongue. Determine the taste.

The mouth should be rinsed with distilled water after tasting each sample.

Take your time when tasting the samples!

Sample code	***Taste***	***Right / Wrong***

3. To evaluate the intensity of sensory properties for food products and fill worksheet 2.3.

Worksheet 2.3.

12 cm LINE SCALE (INTENSITY OF SENSORY PROPERTIES)

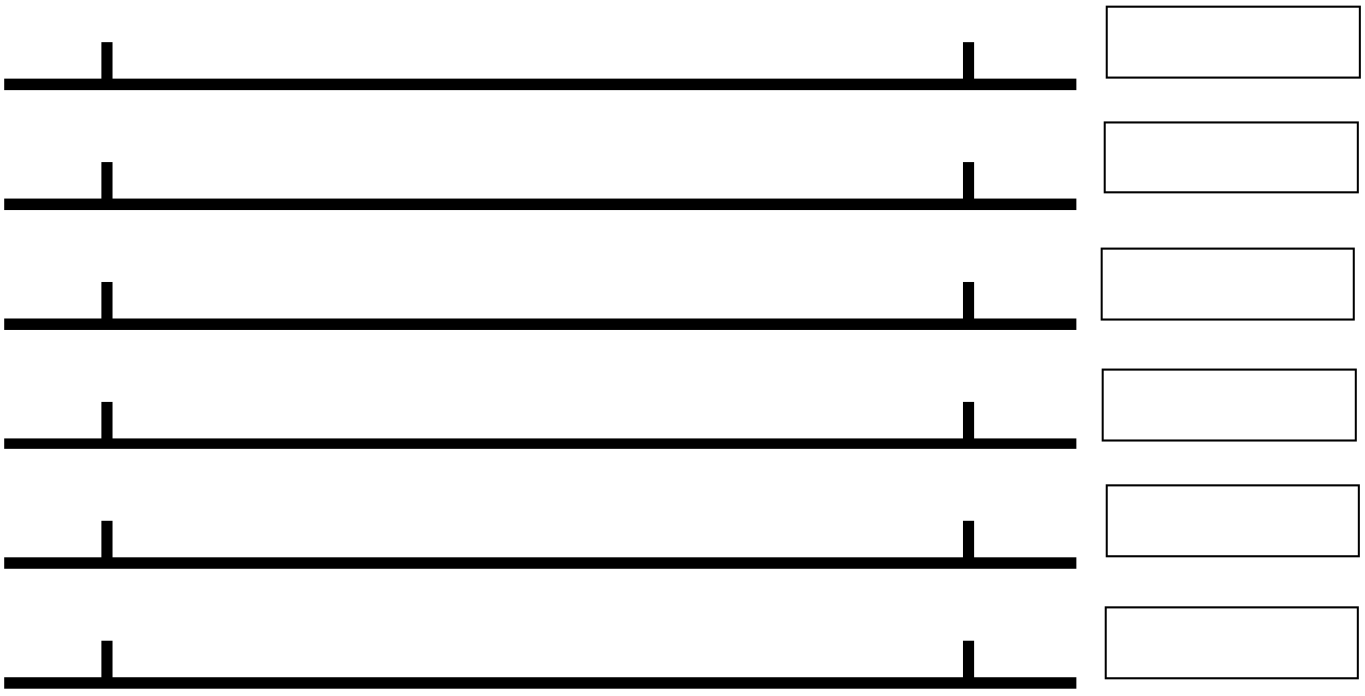
***NAME, SURNAME*_____**

DATE **_____**

TRAY NO. **_____**

Select and write in the rectangles (on the right hand side of the scale) the sensory properties that are specific to these products.

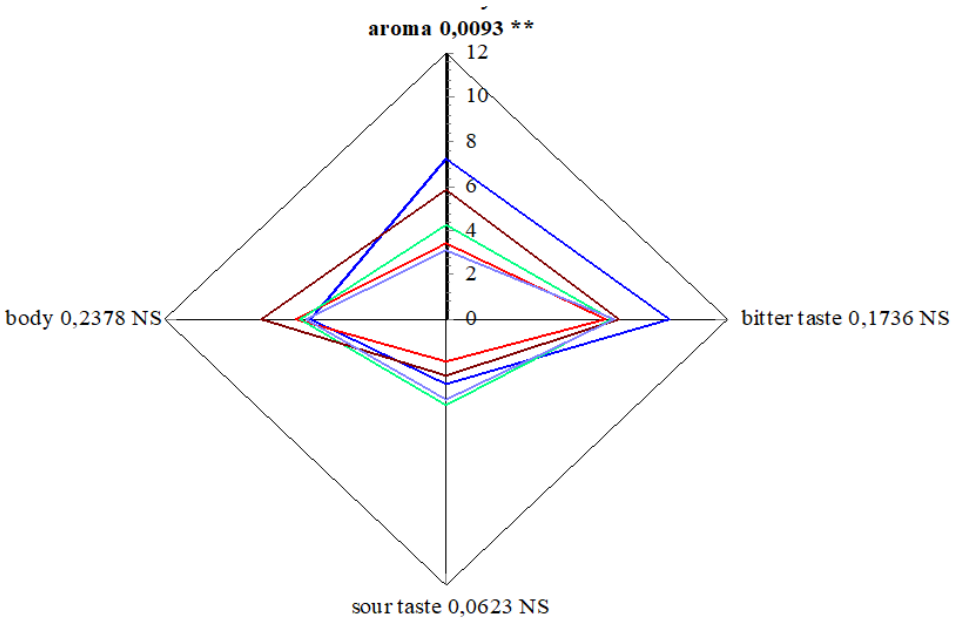
Please mark the intensities of the presented product samples on the Line scale and write the sample number below the marking.



Results

Prepared sensory properties profile of analysed food products.

Example


aroma 0,0093 **
12
10
8
6
4
2
0
body 0,2378 NS
bitter taste 0,1736 NS
sour taste 0,0623 NS

4. To evaluate the acceptability of sensory properties for food products using Just about Right method and 7-point Hedonic scale and fill worksheet 2.4 and 2.5.

Worksheet 2.4.

JAR (Just about Right) test

***NAME, SURNAME*_____**

DATE **_____**

TRAY NO. **_____**

Select and write in the introduction part and from left to right-hand side of the scale the sensory properties that are specific to these products.

Please, evaluate the sensory properties (_____, _____, _____, _____, _____) of _____ samples using JAR (Just About Right) test.

Please, indicate your opinion about _____ sensory properties, marking the squared box that matches your preference and liking.

_____
sample code

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

_____
sample code

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

_____
sample code

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

_____
sample code

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

	much too little	too little	just about right	too much	much too much

Worksheet 2.5.

7-point Hedonic scale

Please, evaluate overall liking of _____ samples!

_____
sample code

dislike very much	dislike moderately	dislike slightly	neither like nor dislike	like slightly	like moderately	like very much

_____
sample code

dislike very much	dislike moderately	dislike slightly	neither like nor dislike	like slightly	like moderately	like very much

_____
sample code

dislike very much	dislike moderately	dislike slightly	neither like nor dislike	like slightly	like moderately	like very much

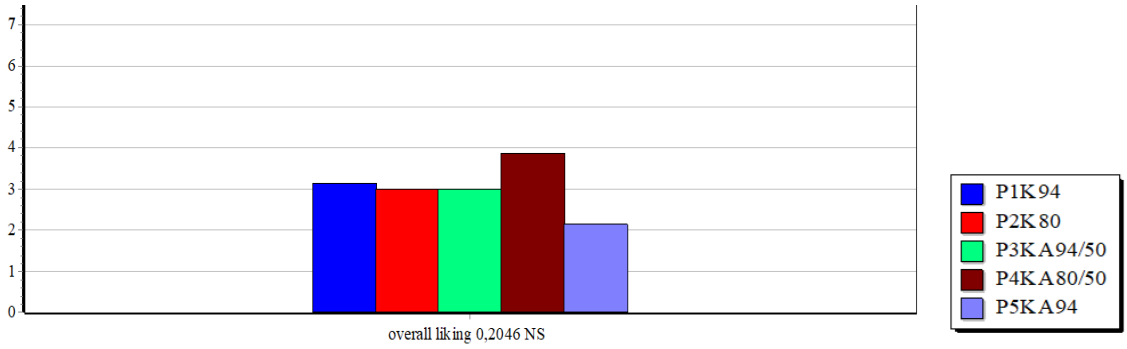
_____
sample code

dislike very much	dislike moderately	dislike slightly	neither like nor dislike	like slightly	like moderately	like very much

Results

1. Collect the obtained data from the JAR method (worksheet 2.4.) - much too little (-2), too little (-1), just about right (0), too much (1), much too much (2).
2. Collect the obtained data from the 7-point Hedonic scale (worksheet 2.5.)- dislike very much (1), dislike moderately (2), dislike slightly (3), neither like nor dislike (4), like slightly (5), like moderately (6) and like very much (7).
3. Prepare a graph with obtained data from 7-point Hedonic scale!

Example:



Conclusions

Approved by _____

Name, Surname, signature

Date _____

Theme 3

Product development

Theoretical materials

After a product idea, the next step is to better prototype and develop the idea. During the prototyping stage, your team will intensively research and document the product by creating a more detailed business plan and constructing the product.
These early-stage prototypes might be as simple as a drawing or a more complex computer render of the initial design. These prototypes help you identify areas of risk before you create the product.
During the prototyping phase, you will work on specifics like:

- Feasibility analysis- the next step in the process is to evaluate your product strategy based on feasibility. Determine if the workload and estimated timeline are possible to achieve. If not, adjust your dates accordingly and request help from additional stakeholders.
- Market risk research- it's important to analyse any potential risks associated with the production of your product before it's physically created. This will prevent the product launch from being derailed later on. It will also ensure you communicate risks to the team by documenting them in a risk register.
- Development strategy- Next, you can begin working through your development plan. In other words, know how you'll be assigning tasks and the timeline of these tasks. One way you can plan tasks and estimate timeline is by using the critical path method.

During the initial design phase, project stakeholders work together to produce first prototype of the product. The design should be created with the target audience in mind and complement the key functions of your product.

A successful product design may take several iterations to get just right, and may involve communicating with distributors in order to source necessary materials.
To produce the initial design, you will need:

- Ingredients - raw materials play an important role in designing the first prototype. Raw materials in the development of new products must be specially evaluated, as they must be available regularly, also in large quantities. The value and seasonality of local products, as well as food safety issues, should be taken into account.
- Recipes and technologies - technologies must correspond to the latest trends and be economically available to both producers and consumers.
- Connect with stakeholders - it's important to keep tight communication during the design phase to verify your initial design is on the right track. Share weekly or daily progress reports to share updates and get approvals as needed.

- Receive initial feedback: when the design is complete, ask senior management and project stakeholders for initial feedback. You can then revise the product design as needed until the final design is ready to be developed and implemented.

Once the design is approved and ready to be handed off, move on to the validation phase for final testing before launching the product.

Validation and testing

To go live with a new product, you first need to validate and test it. This ensures that every part of the product—from development to marketing—is working effectively before it's released to the public.

To ensure the quality of your product, complete the following:

- Concept development and testing - you may have successfully designed your prototype, but you'll still need to work through any issues that arise while developing the concept. This could involve software development or the physical production of the initial prototype. Test functionality by enlisting the help of team members and beta testers to ensure the quality of the development.
- Front-end testing- during this stage, test the front-end functionality for risks with development code or consumer-facing errors. This includes checking the ecommerce functionality and ensuring it's stable for launch.
- Test marketing - before you begin producing your final product, test your marketing plan for functionality and errors. This is also a time to ensure that all campaigns are set up correctly and ready to launch.

Once your initial testing is complete, you're ready to begin producing the final product concept and launch it to your customer base.

Practical work

Developing technological documentation

1. Prepare recipe and technology process for new product production.
Description of technology process and quality control of new product.
Develop a recipe and technological documentation for_____,
calculate for 10 pcs. of the finished product.
Recipes and technological documentation should be made in the given forms. Describe in detail the preparation of the product, as well as represent it in the form of a technological scheme.

Results

TECHNOLOGICAL DOCUMENTATION

RECIPE

Losses, %		**Ingredients, their characteristics**	**Amount of raw materials 10 pieces of the finished product, g**	
technical	**heat treatment**		**Gross**	**Net**
Product				
St/p outcome, y				
	Roast, %			
Product output, kg				
Filling				
St/p outcome, y				
Product decoration				
St/p outcome, y				
Total output of product st/p, y				

Dry loss, %	
Total gross income, y	
Output of 1 piece, g	

TECHNOLOGICAL INSTRUCTION

Pre-treatment	
Processing	
Implementation	
Quality indicators of the product	

Approved by _____

Name, Surname, signature

Date _____

Practical work

Label and packaging design for the new product

The purpose of the work is to develop a label and packaging design for a new type of food product. Practical tasks - to develop a sample label and packaging for the new product.

Recommendations for analysis and development of a new product label and packaging

To create a food packaging design, you need to have knowledge in many areas of food production. Without knowledge of the properties of raw materials and the product, its production technology, the characteristics of packaging materials and consumer preferences, it is difficult to count on creating an attractive packaging design.

The positive impact of packaging on product perception is recognised by most manufacturers. Therefore, the company management is now allocating significant funds to improve the packaging of their product. And these costs pay off in a short period of time.

In order for food packaging to help make the product more unique and recognisable, you should take care of its design. Having entrusted the design of food packaging to professionals, the manufacturers themselves need to clearly understand what they want from the designer, and the specific direction in which they expect the new product to be promoted. This includes the creation of a completely new brand, the development of new packaging for the food products, and its creative design - everything that is so necessary for a domestic manufacturer and seller in the process of maintaining their brand.

When paying attention to the design of food packaging, we must not forget about its shape. It is known that the original form of packaging plays an important role in attracting buyers. The knowledge in the field of technical production and the intricacies of industrial design allows us to develop just such packaging for food products, the shape of which will correspond to both the characteristics of the product and the style of the company itself.

Another significant point in packaging design is corporate identity, including a logo and brand name. This tool for establishing contact with the consumer helps to effectively position the product and its manufacturer.

The logo plays a significant role in creating a food brand. When creating a logo, it is important not only to take into account the customer’s desire to stand out from competitors, but to play on the association with the brand in such a way as to emphasise the nature of the product being produced.

A brand today is not just a legally registered symbol of a manufacturer or product, containing comprehensive information about it. It is a living image of a product or company. The more

vivid and immediate a given image becomes, the more likely it is that it will penetrate the minds of consumers and stand out among competing brands.

To create a label design and a product as a whole, you can use various methods and tools. Original and generally accepted techniques for organising shape and colour, drawing, computer modelling and analysis based on general approaches and principles of design. The main thing is a creative approach to the implementation of a visual representation of your product idea.

The packaging must contain the necessary information for the consumer, taking into account its placement in accordance with the requirements of legislation on the safety of product and packaging materials.

Good packaging and label design is a sign of a quality product that can sell itself. A well-developed design can provoke a purchase in a few minutes. At the same time, development should be carried out not only in strict accordance with the ideology and corporate style of the brand. Understanding the price niche, the belonging of the created image to the product category, and the certainty of the place of sale for the developer is necessary.

Methods

1. Conduct an analytical review of the literature and legislation in different countries on advances in the field of industrial design of labels and packaging for food products.

2. Based on the review of the main characteristics of the new product and your aesthetic ideas, develop a creative label design for your product.

3. Develop a packaging layout for a new product, taking into account the placement of necessary information for the consumer in accordance with legislation requirements.

Results

Prepared food product packaging design according to legislation and added sensory product claims.

Description of the proposed packaging design solution.

Offers (design image).

Approved by _____

Name, Surname, signature

Date _____

Practical work

The prototype evaluation phase. Developing, testing and finalising prototypes

1. Developed evaluation protocols for prototype tests.
2. Evaluate prototypes using developed tests – examples in worksheet 3.1. and 3.2.
3. Developed samples of prototype.

Results

Table 3.1.

Recipe's evaluation protocol

Ingredients	Amount of ingredients, kg				
	Prototype 1	Prototype 2	Prototype 3	Prototype 4	Final

Table 3.2

Prototype evaluation protocol

	Sensory properties			Textural properties		Picture
	Taste	Aroma	Visual	Texture	Viscosity	
Prototype 1						
Prototype 2						
Prototype 3						
Prototype 4						
Final Version						

Worksheet 3.1.

CATA (*Check all that Apply*)

Please write words that describe_____!

Sensory attributes
Appearance, colour
Structure
Taste, aftertaste

Please check the sensory attributes which are characteristics of the _____ sample.

Worksheet 3.2.

Sensory attributes	Sample code				
	123	261	431	183	795
Appearance, colour					
Structure					
Taste and aftertaste					

Conclusion

1. Final recipe

2. Workflow of technological processing

3. Quality parameters of products

4. Design of packaging and labelling

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Date _____

Theme 4

Commercialisation

Theoretical materials

The commercialisation process of a new product involves several stages from its conceptualisation to its launch into the market. Here's a general overview of the typical steps involved:

1. Market research: market research is conducted to gather insights into customer needs, preferences, and buying behaviour. This helps in refining the product concept and identifying target market segments.
2. Business analysis: a thorough analysis of the potential financial viability of the product is conducted. This includes assessing costs, pricing strategies, sales forecasts, and potential returns on investment.
3. Prototype development and testing: a prototype of the product is developed to test its functionality, design, and usability. Feedback from testing is used to make necessary improvements and refinements.
4. Marketing strategy development: a comprehensive marketing strategy is formulated to create awareness, generate interest, and drive demand for the new product. This may include branding, advertising, promotions, and distribution channels.
5. Sales and distribution: channels for distributing the product are identified and partnerships with retailers, distributors, or online platforms are established. Sales strategies and tactics are developed to reach target customers effectively.
6. Launch: the product is officially launched into the market. This may involve a launch event, press releases, and other promotional activities to create buzz and generate initial sales.
7. Post-launch evaluation and iteration: after the product is launched, its performance is monitored closely. Feedback from customers, sales data, and market trends are analysed to evaluate the product's success and identify areas for improvement. Iterations and adjustments may be made based on this feedback to optimise the product and its marketing strategy.

Each of these steps requires careful planning, coordination, and execution to ensure a successful commercialization process and a smooth transition from product development to market launch.

The content of marketing communication refers to the specific messages and information conveyed to the target audience through various communication channels. Effective marketing communication content should be relevant, compelling, and tailored to resonate with the audience's needs, preferences, and interests. Here are some key components of marketing communication content:

1. Value proposition: clearly communicate the unique value proposition of the product or service—what sets it apart from competitors and why it's valuable to the target audience.

2. Product features and benefits: highlight key features and benefits of the product or service, emphasising how it solves a problem or fulfils a need for the customer.
3. Brand storytelling: share the brand's story, values, and mission to create an emotional connection with the audience and differentiate the brand in the market.
4. Visual elements: incorporate visually appealing elements such as images, graphics, videos, and infographics to enhance engagement and convey information more effectively.
5. Call to action (CTA): include a clear and compelling call to action prompting the audience to take the desired action, whether it's making a purchase, signing up for a newsletter, or contacting the company.
6. Targeted messaging: tailor the messaging to different segments of the target audience based on demographics, psychographics, behaviour, or other relevant criteria to ensure relevance and resonance.
7. Customer testimonials and reviews: incorporate testimonials, reviews, case studies, or success stories from satisfied customers to build credibility and trust in the brand.
8. Social proof: showcase social proof indicators such as user-generated content, social media followers, or industry awards to reinforce the brand's credibility and popularity.
9. Educational content: Provide valuable information, tips, or educational content related to the industry, product usage, or solving customer problems to position the brand as a trusted authority and resource.
10. Personalisation: use personalisation techniques to address the audience by name, tailor content based on past interactions or preferences, and create a more personalised and relevant experience.
11. Consistency across channels: ensure consistency in messaging, tone, and branding across different communication channels—whether it's social media, email marketing, website content, or advertising—to maintain brand coherence and recognition.
12. Feedback and engagement: encourage two-way communication by inviting feedback, responding to comments and inquiries, and fostering engagement with the audience to build relationships and loyalty over time.

Creating a marketing activities plan involves outlining the specific tactics and strategies that will be implemented to achieve the marketing objectives outlined in the overall marketing plan. Here's a general framework for developing a marketing activities plan:

1. Set clear objectives: define specific, measurable objectives that align with the overall marketing goals. These objectives should be realistic, time-bound, and relevant to the target audience.
2. Identify target audience: clearly define the target audience segments based on demographics, psychographics, behaviour, or other relevant criteria. Understanding the audience's needs, preferences, and pain points is crucial for tailoring marketing activities effectively.
3. Choose marketing channels: select the most appropriate marketing channels to reach the target audience based on their preferences and behaviour. This may include a mix

of online and offline channels such as social media, email marketing, content marketing, advertising, events, public relations, and more.

4. Develop messaging and content: create compelling messaging and content that resonates with the target audience and communicates the brand's value proposition effectively. Tailor the messaging and content to each marketing channel and audience segment for maximum impact.
5. Allocate budget and resources: determine the budget and resources required for each marketing activity, taking into account factors such as channel costs, production expenses, personnel, and any other associated costs.
6. Timeline and schedule: establish a timeline and schedule for implementing each marketing activity, ensuring that deadlines are realistic and achievable. Consider seasonal trends, industry events, and other external factors that may impact timing.
7. Implementation plan: Outline the specific steps and tasks required to execute each marketing activity, including responsibilities, deadlines, and dependencies. Assign roles and responsibilities to team members or external partners as needed.
8. Measurement and evaluation: define key performance indicators (KPIs) and metrics to track the success of each marketing activity. Establish benchmarks and targets for each KPI, and regularly monitor and evaluate performance to identify areas for improvement.
9. Optimisation and adjustment: continuously optimise and refine marketing activities based on performance data and feedback from the target audience. Adjust strategies, messaging, and tactics as needed to improve results and achieve marketing objectives.
10. Integration and alignment: ensure that marketing activities are integrated and aligned with other departments and initiatives within the organisation, such as sales, product development, customer service, and branding, to maximize effectiveness and consistency.
11. Risk management: identify potential risks and challenges that may impact the success of marketing activities, and develop contingency plans to mitigate these risks proactively.
12. Review and reporting: regularly review and report on the progress and results of marketing activities to stakeholders and decision-makers. Use insights gained from performance data to inform future marketing strategies and activities.

Detailed actions aimed for achieving the optimal position in the market should be understood in the company marketing plan. It affects the company's performance, product sales and profits, not production.

The purpose of the marketing plan

- Maintaining the company's position in the market.
- New product development and introduction.
- Coverage of new niches and segments (diversification), etc.

Advantages of developing a **marketing plan** for the company:

1. It determines what part of its funds should be spent on marketing activities.
2. Forms the policy of promotion of specific types of goods and services in the market.

3. Develops a strategy and tactics for working with the target market, including pricing procedures.
4. It helps to increase the income and profit from the sale of certain goods.

Types of the company's marketing plan and the purpose of their preparation.

Marketing plans are classified as follows:

1. Duration - strategic (more than 3 years), tactical (up to 3 years), operational (up to 1 month).
2. Depth of study - detailed or general.
3. Area of operation - target plan, pricing policy, product policy, marketing communications, control and revision, finance.

The structure and content of the company's marketing plan.

A marketing plan is an internal document used by the company's management to make decisions. However, it may take several months to compile, as it requires:

1. Collect information about customers.
2. Study supply and demand in the market.
3. Competitive advantages.
4. Competitive Ratings, etc.

Three to four months are spent on creating a marketing plan: 50% of the time is spent on collecting all the necessary information, 40% on analysis and evaluation, and only 10% is spent on creating the document itself.

When creating a marketing plan, it is recommended to focus on the following structure:

1. *Summary.* This section includes a description of the main points outlined in the marketing plan. Here the goal, the ways to achieve it, and the expected results of the implementation of the plan are determined.
2. *Market overview and forecast.* This section describes the market (size, growth opportunities, trends, characteristics) and shows the specific behaviour of consumers and the competitors in it. Here it is important to show how many competitors there are in the selected segment, what shares they cover and what opportunities exist for the market growth.
3. *SWOT analysis and competitive advantages.* This section analyses the company's strengths and weaknesses, threats and opportunities for its activities.

According to the results of the SWOT analysis, the marketer should determine the following:

- The main competitive advantage of the company.
- Placement of the product in relation to consumers (preferably with a forecast for 3-5 years).
- Tactical measures to take advantage of opportunities and reduce the impact of threats.
- Strategy to fight competitors and increase customer loyalty.

4. *The purpose and tasks of the marketing plan.* The marketing plan should contribute to the development of the business, so it includes business goals for the selected planning period (a month, a year, three years). Only after that, tasks of marketing activities are created.
5. *Marketing mix (marketing-mix).* The basis of any marketing plan is called the marketing mix, which is based on the 5P model for goods and the 7P model for services.

The 5P model. Any marketing activity is built on five components:

- Product - product or product policy - logo and form style, appearance and physical characteristics of the product, product assortment, product quality.
- Price - price or price policy - wholesale and retail price, the procedure for determining the cost of goods, discounts and promotions, price discrimination.
- Place - place of sale or sales policy - selling goods in markets, stores, distribution bases, display of goods, inventory management and logistics.
- Promotion - promotion or advertising policy - advertising strategy, advertising activity, PR activity, event marketing, communication channels, media strategy.
- People - employee motivation policy – motivation, corporate culture, working with loyal customers and VIP customers, feedback.

Thus, when developing a marketing plan, each of the above positions is developed in detail, which allows to form a complete picture of the company's activities in the market.

6. *Operating budget.* Contains a detailed list of costs for marketing activities, which can be presented in tabular form.
7. *Risk assessment.* This part describes the risks that the company may face during the implementation of the marketing plan.

Practical work

Communication elements for marketing

Communication elements are crucial components of a marketing plan and play a significant role in conveying the brand message to the target audience. Here are some key communication elements that can be included in a marketing plan:

1. Brand Identity,
2. Advertising,
3. Public Relations (PR),
4. Digital Marketing,
5. Content Marketing,
6. Sales Promotion,
7. Direct Marketing,
8. Word-of-Mouth Marketing,
9. Internal Communication,
10. Feedback and Customer Service.

1. Identify the line that correctly explains the following terms (Table 4.1.).

Table 4.1.

Communication elements

T/r	Communication elements		Explanation of terms
1	Brand Identity	A	It encompasses a range of online tactics to engage with consumers, including email marketing, content marketing, social media marketing, influencer marketing, and search engine optimization.
2	Advertising	B	This can include blog posts, articles, videos, infographics, whitepapers, e -books, and more.
3	Public Relations (PR)	C	Its tactics are used to stimulate immediate sales or encourage customer loyalty. Examples include discounts, coupons, rebates, contests, giveaways, and loyalty programs.
4	Digital Marketing	C	It can include various channels such as television, radio, print media, outdoor advertising, online advertising (including social media ads, display ads, and search engine marketing), and more.
5	Content Marketing	E	This may include press releases, media interviews, event sponsorships, and community involvement.
6	Sales Promotion	F	This can include direct mail, telemarketing, SMS marketing, and personalised email marketing campaigns.

7	Direct Marketing	G	This includes elements such as the brand name, logo, tagline, and brand colours that help create a distinct identity in the minds of consumers.
8	Word-of-Mouth Marketing	H	This includes responding to customer inquiries, addressing complaints, and soliciting feedback through surveys or social media listening.
9	Internal Communication;	I	This can be achieved through exceptional customer service, referral programs, and user-generated content.
10	Feedback and Customer Service	J	This may include internal newsletters, meetings, training sessions, and employee recognition programs.

2. Divide the students into 3 groups and assign each group to sell some kind of product and give them the task of using the communication elements of marketing. The assessment is based on the correct use of the communication elements of the requirements and the ability to persuade the customer to buy it.

Methods

Brainstorming, case studies, cooperative learning

Students interpret the marketing communication terms given in task 1 in order to strengthen their theoretical knowledge. Then, while performing the tasks given in the 2nd task, they directly test how to sell the product and the effective use of communication elements in a practical exercise based on theoretical knowledge, like a marketer.

Results

Marketing communication elements for a new product commercialisation.

Approved by _____

Name, Surname, signature

Date _____

Practical work

Content of marketing communication

Task. Each student will write down in their notebook which communication methods they intend to use to sell the new product which they believe will be effective, and a group discussion will be held. Students will be evaluated on this basis.

Methods

Flipped classroom method can be used in this lesson. Depending on the rules of the offline classes, 5 or 6 students will give a presentation during the class on what actions can be taken in each marketing communication direction for the new product to move.

Results

Channels of communications

Content of communications

Key words of communications

Approved by _____

Name, Surname, signature

Date _____

Practical work

Marketing activities plan

Creating a marketing activities plan involves outlining the specific tactics and strategies that will be implemented to achieve the marketing objectives outlined in the overall marketing plan.

Methods

Each student team using brainstorming, case studies, cooperative learning will be taught the structure and methods of creating a marketing plan for new product, the 5P marketing-mix model.
Below is a template for writing a marketing plan.

Template for writing a marketing plan.

1. Analysis of market trends and comparison with the 1st homework on trends.

2. Product analysis – value of products, location for sales, price, packaging design.Compare with competitors' products (3-5 products).

3. Choosing a target market. Considering the features of the product and its price, and the main target audience, which will be middle class professionals who monitor their health.

4. Competitive advantages. Analyse competitor's company offers and activities and communication channels, and find different channels and tactics for your marketing activities.

5. Create a strategy for marketing activities.

6. Tactical marketing activities plan**.** Plan and describe marketing communications channels, activities targeted at consumers, and develop content for the marketing plan.

Results

Marketing plan includes:

1. Summary
2. Description of the company and product
3. Goal of the marketing plan (include strategy – Why and How?)
4. Target customers
5. Selling proposition (include competitor analysis)
6. Distribution plan

7. Marketing activities and plan (Table 4.2.)

Table 4.2.

Marketing activities plan

Tasks	Activities	Time sheet / week no.													
		1	2	3	4	5	6	7	8	9	10	11	12	13	14

You can use also digital planner https://miro.com/

Approved by _____

Name, Surname, signature

Date _____

Theme 5

Evaluation of new product development process

Theoretical materials

SWOT stands for Strengths, Weaknesses, Opportunities, and Threats. It is a simple management tool, but it really helps you to grow your business, whether you are just starting a business or growing your company even better.

Strengths are the advantages or strengths of an idea that is owned, which can provide an advantage over competitors. Strengths can be simply mean “What do you currently do or have which is good?”

Weaknesses are characteristics related to the weakness of the company, comparable to competitors, can also be a weakness that is currently considered internal. Defining your weaknesses can be done with the question “What could you do better?”

Opportunities can be classified as opportunities that can be used for an idea to develop.

Threats can be classified as threats that will be faced by project that can hinder its development.

Strengths or Weaknesses evaluation using control questions and a 5-point scale.

Evaluation of value propositions:

- Our value proposition is based on customer research,
- Our value proposition is based on customer needs,
- Our customers are very satisfied,
- Our value proposition is based on our own assumptions,
- Our value proposition partially meets customer needs,
- We have had complaints or returned purchases.

Evaluation of key resources:

- Our main resources are difficult for competitors to replace,
- Resource needs are easily predictable,
- We can get the resources at the right time and in the right amount,
- For competitors, our main resources are easily substitutable,
- Resource needs are difficult to predict,
- It is difficult for us to get the right amount of resources at the right time.

Evaluation of main activities:

- Our main activities are well planned,

- Our main activities are completed on time,
- Activities are delegated to the team as needed,
- Our main activities are spontaneous,
- There are often difficulties in meeting deadlines,
- Execution of activities is based on one person in a team.

Evaluation of key partners:

- We work with partners effectively,
- We have good relationships with key partners,
- Our cooperation is weak and ineffective,
- We tend to be in conflict with key partners.

Customer segment evaluation:

- The outflow of customers to competitors is low,
- Customers are well segmented,
- More and more customers are interested in our product,
- The outflow of customers from competitors is high,
- Customers are not segmented,
- New customers are not interested in our product.

Customer relationship evaluation:

- We have strong customer relationships,
- The selected activities perfectly match the customer segment,
- We pay great attention to attracting new customers,
- We have weak customer relationships,
- The selected activities do not correspond well to the customer segment,
- We do not pay much attention to attracting new customers.

Opportunity evaluation using control questions and a 5-point scale:

- Is there a possibility that an additional service or product can be created for the product?
- Are there opportunities that we can meet the customer's additional needs?
- Is it possible to add value to the product?

Opportunities for resources and activities:

- Is it possible to use cheaper resources?
- Are there any resources that have not yet been used:
- Can we standardise or automate any activities?
- Is it possible to increase the efficiency of activities?
- Could the partner provide additional opportunities in the value proposition?

Opportunities for customer segments and relationships:

- Can we serve new customer segments?
- Can we segment customers more precisely to perform activities more efficiently?

- Can we better align information channels to attract more customers?
- Have we identified non-profit customers?

Threats to value evaluation using control questions and a 5-point scale.

- Are substitute products available on the market?
- Can competitors offer a lower price or better value?

Threats to resources, activities and partners:

- Could we face any barriers to the supply of resources?
- Is the quality of our resources deteriorating?
- Are there any activities that we may have difficulty implementing?
- Is there a risk of losing a partner?
- Is there a risk that the partner will cooperate with competitors?

Threats to customer segments and relationships:

- Is there a possibility that the market will be saturated in the near future?
- Is there increasing competition in the market?
- Is there a possibility that customers will choose the value proposition of the competitors?
- Is there a possibility that any of our customer relationships are compromised?

Practical work SWOT analysis for project evaluation

Determine the strengths, weaknesses, threats and opportunities of the project, evaluate their importance on a 0 - 5 scale and write in the table 4.3.

Results

Table 4.3.

SWOT analysis

Strength	**Weakness**
➢ ➢ ➢	➢ ➢ ➢
Opportunities	**Threats**
➢ ➢ ➢	➢ ➢ ➢

Conclusion

Approved by _____

Name, Surname, signature

Date _____

Theme 6

Hackathon “InnoFood”

Theoretical materials

Hackathon is an innovative and engaging way to empower people with the skills and knowledge needed to succeed in the food industry. These intensive, multi-day collaborative workshops provide an immersive learning experience that encourages creativity, critical thinking, and problem-solving skills. By working together on real-world challenges, participants gain hands-on experience with the principles and practices of STEM and STEAM fields while learning to communicate their ideas effectively and work in interdisciplinary teams.

The hacking track is for participants to dive into problems. Often groups of 2-5 individuals form around a project, such as building a new data visualisation, writing a document, or collaboratively investigating a problem. Participants take out their laptops, connect to power and Wi-Fi, and get working.

Hacking begins with project introductions. Participants that bring projects to the event have an opportunity to briefly (1 minute max) explain what they are working on at the very start of the event so that other participants can join that project. At the end of the event, a wrap-up session gives each project a chance to demonstrate some accomplishments.

Identifying the purpose and goals of the Hackathons.

Working out the reasons for your Hackathons and what you'd like to get out of it is an essential first step in planning a successful event. Here are some steps you can take to help you identify the purpose and goals of your Hackathons:

Determine the audience: the first step in identifying the purpose and goals of your Hackathons is to determine who the event is for. Will it be for students, educators, professionals, or a combination of these groups? Knowing your audience (or your class!) will help you determine the specific goals and objectives of the event.

Identify the problem or challenge: next, you'll need to identify the problem or challenge that your Hackathons will focus on. This should be a real-world issue that is relevant to your audience and can be solved using the skills and knowledge of the participants. You may decide that students should be able to select a challenge that is important to them rather than have one assigned to them, but it is important to provide a structure and framework, such as the UN Sustainable Development Goals, so that they are not paralysed by infinite options.

Define the objectives: once you've identified the problem or challenge, you'll need to define the objectives of your Hackathons. What specific skills or knowledge do you want participants

to gain from the event? Do you want them to develop new products or solutions, learn new technologies, or improve their collaboration and communication skills?

Establish the criteria for success: to ensure that your Hackathons is successful, you'll need to establish criteria for success. What are the specific outcomes you're hoping to achieve? Will you measure success based on the number of new solutions developed, the quality of the solutions, or some other metric? MTF always prioritises personal development in this regard, rather than a scoring system or competitive approach. Success is not when one group of students 'wins', but when all students progress and grow.

Create a timeline: finally, you'll need to create a timeline for your Hackathons. This should include specific milestones, such as the date by which participants must register, the date of the event itself, and the deadline for submitting final solutions. A well-planned timeline will help you stay on track and ensure that your Hackathons runs smoothly.

Once you've done your planning, it's time to design your program, challenges and activities for the participants to engage in during your hackathons. It's not enough to simply provide some technology and ask the students to simply make something - it's important to create a collaborative and fun culture, get the creative juices flowing, and encourage the students to help each other to create the best possible project they can.

Providing opportunities for brainstorming, ideation, and prototyping

Setting up creative opportunities is crucial to the success of the hackathons. Here are some great ways to create opportunities for these activities:

Brainstorming sessions - conduct brainstorming sessions with participants to generate ideas and solutions for the challenge. Encourage participants to think outside the box and come up with as many ideas as possible. Provide a safe and non-judgmental environment for participants to share their ideas.

Design thinking workshops - organise design thinking workshops that help participants understand the problem, empathise with the user, define the challenge, come up with possible solutions, prototype, and test. Design thinking workshops can help participants think creatively and systematically about the problem and come up with innovative solutions. Even an introduction to just the very basic principles of design thinking can have a significant impact on how students creatively approach their challenge.

Idea Stations - set up Idea Stations where participants can use different creative thinking methods for ideation and share their ideas and get feedback from others. Provide tools such as whiteboards, sticky notes, and markers to facilitate idea generation and sharing. Prototyping areas - set up areas where participants can use tools to build and test their ideas.

Collaboration spaces - create collaboration spaces where participants can work together on their ideas. Provide comfortable seating, tables, and power outlets to facilitate collaboration

and productivity. Having a breakout room or quiet workspace can be very helpful for some students.

Mentor sessions - provide mentoring sessions where participants can get feedback and guidance from experts, coaches and facilitators. Mentors can help participants refine their ideas, troubleshoot technical challenges, and provide insights into the industry.

Work in progress presentations - organise 'show-and-tell' sessions where participants can showcase their prototypes and ideas to the rest of the group. This can be a great way to foster collaboration, inspire others, and get feedback on ideas.

By setting up these opportunities, you can create a collaborative and supportive environment that fosters creativity, ideation, and prototyping, and helps participants develop innovative solutions to their challenge.

Methods

Our pedagogical approach is based on the principles of experiential learning, which emphasise the importance of **active engagement**, **reflection**, and **integration of knowledge**. Hackathons are grounded in **constructivist learning theory**, which posits that learning is an active and collaborative process that involves the construction of knowledge and understanding through interaction with the environment and peers.

Results

Create a check list (6.1. table) for Hackathons planning and executing.

Table 6.1.

Check list for Hackathons planning and executing

Activities	Works	Done	Not

Conclusions

Approved by _____

Name, Surname, signature

Date _____

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Open Food Innovation University (OFINU)

Study module

“Academic Writing”

WORKBOOK

for students

2024

Summary

The workbook is elaborated within the project “Open Food Innovation University" (OFINU), being in implementation with support of the European Union Erasmus+ Programme.

Overall objective of the project - to modernise food innovation and technology related higher education in Uzbekistan and Tajikistan, thereby increasing the quality and ensuring relevance of the higher education to the needs of the socio-economic growth of the countries concerned and especially of their regions.

Full partners:
- Lead partner: Latvia University of Life Sciences and Technologies
- Uzbekistan: Samarkand Agro-innovations and Research University, Andijan Institute of Agriculture and Agro-technologies
- Tajikistan: Technological University of Tajikistan, Kulob Institute of Technology and Innovation Management, Isfara Branch of the Technological University of Tajikistan
- Slovakia: Slovak University of Agriculture in Nitra

Associated partners in Uzbekistan:
- A group of companies "AGROMIR"
- "Navigul" MCHJ QK
- “Samarqand don mahsulotlari” JC (Samarkand grain products)

Associated partners in Tajikistan:
- CJSC “Combinati Shiri Dushanbe”
- LTD "Orion Rustam"
- Association of Entrepreneurs of Khatlon

The project implementation period: 01/02/2024 - 31/01/2027.

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TEACHERS

RUTA
GALOBURDA

ZANDA
KRUMA

MIROSLAVA
KAČÁNIOVÁ

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Theme of the study course

The study course is focused on provision of knowledge and development of skills needed for writing and publishing scientific papers, especially for a peer-reviewed scientific journals. The course provides knowledge on types or articles, methods to be used for their elaboration, structure, use of academic vocabulary, as well develops skills to analyse articles, prepare and submit manuscripts, and to present scientific results.

Partner universities and their academic staff, involved in the development of the study course:

P1 Latvia University of Life Sciences and Technologies

Ruta Galoburda - ruta.galoburda@lbtu.lv

Zanda Kruma - zanda.kruma@lbtu.lv

P7 Slovak University of Agriculture in Nitra

Miroslava Kačániová - miroslava.kacaniova@gmail.com

P2 SAMARU. Samarkand Agroinnovations and Research University

Shavkat Hasanov - shavkat_hasanov@hotmail.com

Sherzod Babakholov - sherzod311377@gmail

Azamat Ismailov - azamatismoyilov528@gmail.com

Shakhista Ishniyazova - ishniyazova04@gmail.com

Yigitali Tashpulatov - t.yigitali1981@gmail.com

Kamoliddin Bozorov - k.bozorov84@gmail.com

P3 AIAA. Andijan Institute of Agriculture and Agro-technologies

Bahodirjon Nosirov - bahodirjonn@gmail.com

Murodjon Atajanov - atajanov.aqxai@gmail.com

Sanjarbek Iskandarov - iskandarovsanjarbek1985@gmail.com

Muhammad Zahiriddin Zaynobiddinov - mr.zaynobiddinov@gmail.com

Turgunbay Khalmatov - xturgunboy2@gmail.com

P4 TUT. Technological University of Tajikistan

Khurshed Ikromi - x_teshaev@yahoo.com

Muhabbat Ikromi - ikromimuhabbat983@gmail.com

P6 BTUTI. Branch of the Technological University of Tajikistan in the city of Isfara

Zokirkhoja Soliev - zokir13051975@gmail.com

Learning methods

No.	Themes	Possible methods to be used
1.	Lectures	Presentation of theoretical material by the teacher in front of the audience. Lectures include a theoretical background of academic writing.
2.	Practical works	Use of visual and interactive materials: Presentations, video tutorials, interactive websites. Drafting manuscript following practical guidance of teacher.
3.	Seminars	Presenting prepared poster and oral presentation. Discuss with classmates and teacher.
4.	Independent work	Assignments for independent studies are described with each topic.

Course schedule

Date, Time	Study form	Theme	Lecturer
1. Introduction to article types and publishing			
1st day	Lectures (3 h)	Types of scientific articles. Citation and impact factors. Criteria and tools for journal selection. Thematic area of the journal. Publication costs, funding sources. Instructions for authors. Copyright and its transfer. Article authorship and sequence of authors. Scientific ethics and acknowledgments.	R. Galoburda
	Practical work (2 h)	● Choice of journal for manuscript submission. ● Searchable journal databases available.	R. Galoburda
2. The structure of a scientific article (IMRaD)			
2nd day	Lectures (2 h)	Writing process. The structure of a scientific article (IMRaD). Use of other authors' works. Automatic reference management tools.	R. Galoburda
	Practical work (4 h)	● Analysis of scientific articles. Automatic reference management tools.	R. Galoburda
3. Selection and critical analysis of articles			
3rd day	Lectures (2 h)	Working with databases. Critical analysis of articles.	R. Galoburda
	Practical work / seminar (3 h)	● Preparation of background information for scientific article, making library with possible references. ● Presentation of the selected journals.	R. Galoburda
4. Elements of academic language			
4th day	Lectures (2 h)	The key elements of academic writing. Word choice. English terms and phrases commonly used in academic writing. Paragraph unity and coherence. The most common errors in cases where the language of the manuscript is not the native language of the author.	R. Galoburda
	Practical work / seminar(4 h)	● The use of different terms in English. Error recognition. ● Presentation of the manuscript outline.	R. Galoburda
5. Visual elements for data presentation in manuscript			
5th day 6th day	Lectures (4 h)	Preparation and design of visual material.	Z. Krūma

Date, Time	Study form	Theme	Lecturer
	Practical work (12 h)	● Analysis of possible visual elements from literature. Drafting and preparation of visual elements.	Z. Krūma
6. Preparing, editing, and submitting manuscripts			
7th day	Lectures (3 h)	Preparing, editing, and submitting manuscripts. Editing the manuscript before submission. Language editing. Communication with editors and reviewers. Communication with scientific editor and reviewers. Preparation of the article, CREDiT, back matter, selection of possible reviewers, and cover letter. Second cover letter. Responses to reviewers. Revision, resubmission of manuscript. Language editing, language improvement services. Proofreading approval.	M. Kačániová
	Practical work (4 h)	● Formatting manuscripts according to the publisher's requirements. ● Preparation of cover letter. ● Responding to the reviewer. ● Reviewing manuscripts submitted by other students.	M. Kačániová
7. Presenting scientific results			
8th day	Lectures (2 h)	Poster presentation. Oral presentation.	M. Kačániová
	Practical work / seminar(4 h)	● Poster preparation based on the manuscript. ● Preparation of oral presentation based on the manuscript. ● Presentations.	M. Kačániová

Theme 1

Introduction to article types and publishing

Theoretical materials

Writing and publishing a scientific paper in a peer-reviewed academic journal is a crucial component of research. It offers professional career benefits and provides a significant level of personal satisfaction. According to Meo (2018), there can be various reasons for publishing (Fig. 1.1).

Publishing rules according to Zaumanis (2021)**:**

- publish a lot;
- publish high impact papers;
- co-author efficiently;
- build and online presence;
- prioritise journals over conferences;
- publish open access;
- review others' work.

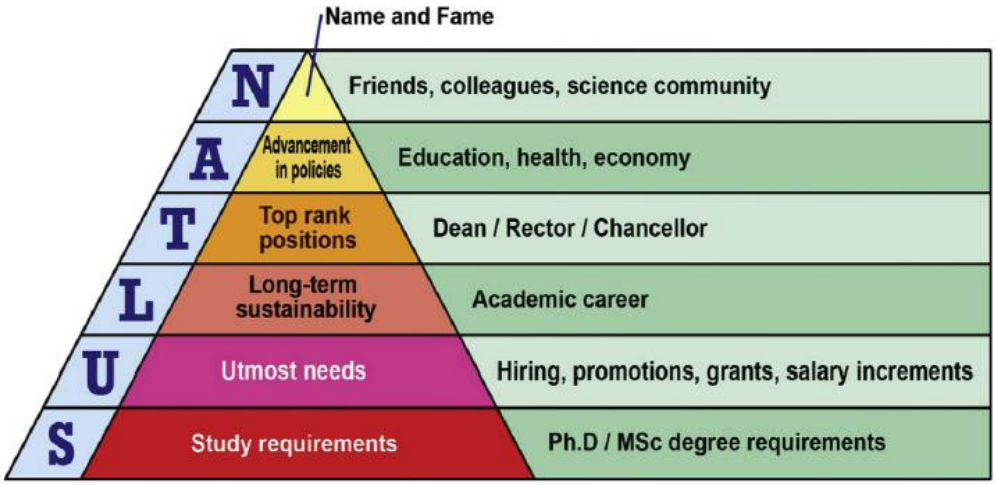

Fig. 1.1 SULTAN'S pyramid: Why researchers publish. (Meo, 2018).

Pre-requisites for a scientific paper

- a well-designed study;
- thorough knowledge about the data and findings;
- early settling of authorship;
- selecting the appropriate journal.

Your manuscript most likely will be accepted if it is within the scope of the journal; describes the research that advances the field; adds to an active research field; is carefully prepared and follows the journal's submission guidelines; uses clear and concise language; follows ethical standards.[1]

There are various types of paper publications (Fig. 1.2), each varying in content, audience, purpose, length, and scope. These include original research, review articles, invited articles, conference proceedings, comments/errata, and press releases (Monavarian, 2021).

Types of scientific journals

- Specific scientific journals. The specific scientific journals are about certain very specific topics or subfields, for example, an astrophysics journal or a journal about cell biology.
- General scientific journals.
- Open-access journals.
- Subscription-based journals.
- Pre-print Journals.

Fig. 1.2 Six major types of paper publications (Monavarian, 2021).

[1] Get your manuscript ready for journal editors. Springer Nature. Accessed on June 16, 2024. Available at: https://beta.springernature.com/pre-submission/what-editors-look-for?journalId=13197

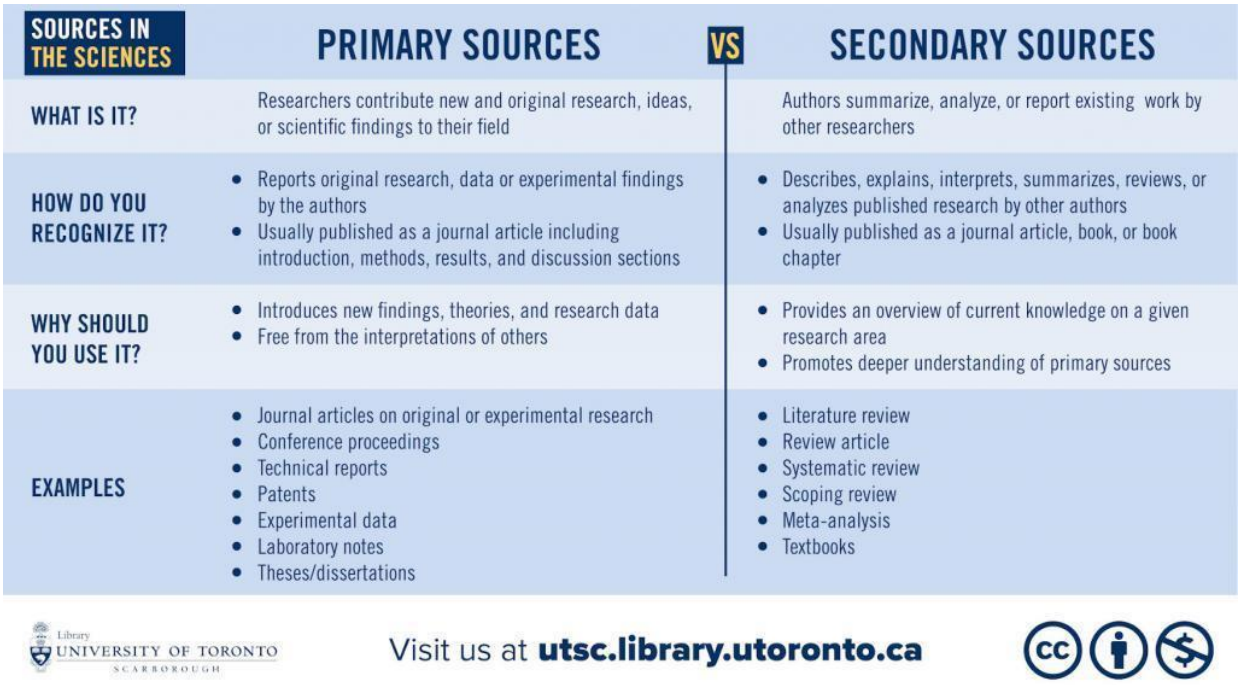

Fig. 1.3 Primary vs. secondary sources in the sciences infographic [2]

Several citation databases exist for the evaluation of journals and researchers (Fig. 1.4).

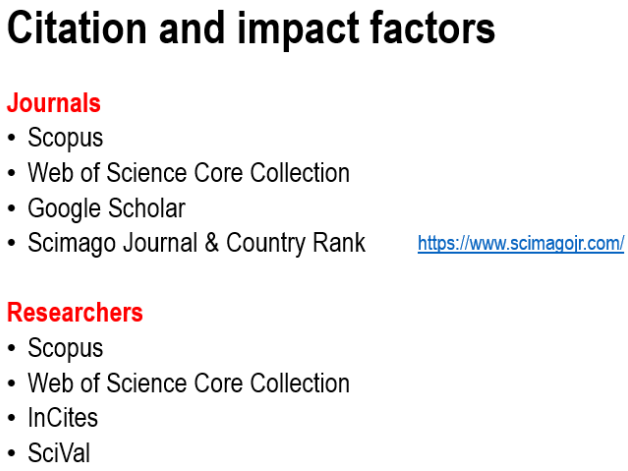

Fig. 1.4 Citation databases with scores for journal and researcher evaluation.

Measuring a journal impact factor

The following metrics are used to understand the impact of a journal:

[2] Types of Sources. University of Toronto, Scarborough. Accessed on June 16, 2024. Available at: https://utsc.library.utoronto.ca/sites/default/public/users/user244/sources_sciences.jpg

- **"CiteScore metrics** – helps to measure journal citation impact. Free, comprehensive, transparent and current metrics calculated using data from Scopus®, the largest abstract and citation database of peer-reviewed literature.
- **SJR** – or SCImago Journal Rank, is based on the concept of a transfer of prestige between journals via their citation links.
- **SNIP** – or Source Normalised Impact per Paper, is a sophisticated metric that accounts for field-specific differences in citation practices.
- **JIF** – or Journal Impact Factor is calculated by Clarivate Analytics as the average of the sum of the citations received in a given year to a journal's previous two years of publications, divided by the sum of "citable" publications in the previous two years.
- **H-index** – Although originally conceived as an author-level metric, the H-index has been being applied to higher-order aggregations of research publications, including journals." [3]

For more information please visit Research metrics and publishing at Monash University library at https://guides.lib.monash.edu/research-metrics-publishing/home.

Researchers' metrics

Researcher's output is measured by number of publications and number of citations, which often is described by Hirsh index (h index). The h-index is defined as the highest number h such that the author or journal has published h papers, each of which has been cited at least h times (Hirsch, 2005). Additional tools for benchmarking author against peers and evaluating institutional productivity worldwide:

- InCites (based on your publications in the Web of Science core collection)
- SciVal (based on your publications in Scopus)[3]

Besides h index h index the following metrics are used:

- FWCI (Field Weighted Citation Impact);
- total number of publications;
- total citations, average citations;
- % of documents cited;
- documents in the top 1%, top 10%;
- % first author publications;
- citer analysis (who is citing you?);
- how quickly are you being cited?

Check if the journal is right for you

Submitting manuscripts to an unsuitable journal is one of the most common reasons for early rejection and publication delays (Ali, 2010). Therefore check the following before submission:

- read the aims and scope on the Journal website;

[3] What is journal Impact Factor? Elsevier Author Services. Accessed on June 16, 2024. Available at: https://scientific-publishing.webshop.elsevier.com/research-process/what-journal-impact-factor/

- consider if researchers in a related field might be interested in your study. If so, a journal that covers a broad range of topics may be best. If only researchers in your field are likely to want to read your study, then a field-specific journal may be best;
- verify if your target journal accepts the type of manuscript you want to publish;
- look beyond the Impact Factor - it's just one measure of a Journal's reputation;
- consider the impact of other work published in the journal and whether your research is of a similar level;
- check if the "time to publication" is suitable to your needs.

Always check the guidelines of your target journal to understand the publishing model and the fees (APC – article processing charge).
Consider the following questions when selecting journal to avoid predatory journals.

- Is the journal visible and recognised?
- Visit the journal's website and read all of it, following every link and noting every claim or the lack thereof.
- Find and read papers published by the journal.

Additionally check Beall's list of potential predatory journals and publishers at https://beallslist.net/.

Open access and subscription publishing model

The primary difference between open access and subscription publications lies in how readers access the content and how the publication is funded. Some subscription journals have an embargo period, after which free access to articles is provided. Some journals are hybrid journals, providing both publication models.

Table 1.1

Open Access vs. subscription publications

	Open Access Publications	**Subscription Publications**
Accessibility	Content is freely available to the public. Anyone with internet access can read, download, and share the articles without a subscription or payment.	Content is available only to subscribers. Readers, or their institutions, must pay for a subscription or purchase individual articles to access the content.
Funding	Often funded through article processing charges (APCs) paid by the authors, their institutions, or funding bodies. Sometimes, open access journals are funded by academic institutions or grants.	Funded primarily through subscription fees paid by individuals or institutions (such as libraries).
Licensing	Articles are typically published under a Creative Commons license, which allows for various degrees of reuse and redistribution.	Articles are generally under more restrictive copyright, limiting how they can be redistributed or reused without permission.

Ethics and copyright

Whether you are just starting your career or are an experienced researcher, you undoubtedly recognise the critical importance of ethical conduct. Issues such as plagiarism, research fraud, and undisclosed conflicts of interest can threaten both scientific integrity and your reputation within the scientific community. Adhering to ethical guidelines is essential for ensuring your work and career stay on the right track. For more details see Elsevier publication "Ethics in Research & Publication" (available at: https://researcheracademy.elsevier.com/uploads/2018-02/ethics_a5_booklet_update260617_web.pdf).

Ethics topics to consider when publishing include the following:[4]

- **"Authorship of the paper:** Authorship should be limited to those who have made a significant contribution to the conception, design, execution or interpretation of the reported study. Transparency about the contributions of authors is encouraged, for example, in the form of a CRediT author statement.
- **Originality and plagiarism:** The authors should ensure that they have written entirely original works, and if the authors have used the work and/or words of others that this has been appropriately cited or quoted.
- **Data access and retention:** Authors may be asked to provide the raw data in connection with a paper for editorial review, and should be prepared to provide public access to such data.
- **Multiple, redundant or concurrent publication:** An author should not, in general, publish manuscripts describing essentially the same research in more than one journal or primary publication. Elsevier does not view the following uses of a work as prior publication: publication in the form of an abstract; publication as an academic thesis; publication as an electronic preprint. **Note:** some society-owned titles and journals that operate double-blind review have different policies on prior publication. Information on prior publication is included within each Elsevier journal's guide for authors.
- **Acknowledgement of sources:** Proper acknowledgment of the work of others must always be given.
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- **Fundamental errors in published works:** When an author discovers a significant error or inaccuracy in his/her own published work, it is the author's obligation to promptly notify the journal editor or publisher, and cooperate with the editor to retract or correct the paper.
- **Reporting standards:** Authors of reports of original research should present an accurate account of the work performed, as well as an objective discussion of its significance.
- **Hazards and human or animal subjects:** Statements of compliance are required if the work involves chemicals, procedures or equipment that have any unusual hazards inherent in their use, or if it involves the use of animal or human subjects.
- **Use of patient images or case details:** Studies on patients or volunteers require ethics committee approval and informed consent, which should be documented in the paper."

Policies and Guidelines by various publishers can be found using the following links.

- Elsevier
  https://beta.elsevier.com/researcher/author/policies-and-guidelines

[4] Policies and Guidelines. Accessed on June 16, 2024. Available at: https://www.elsevier.com/researcher/author/policies-and-guidelines

- John Wiley & Sons
  https://onlinelibrary.wiley.com/page/journal/10970037/homepage/forauthors.html#_4._EDITORIAL_POLICIES
- Taylor and Francis
  https://authorservices.taylorandfrancis.com/editorial-policies/
- Springer
  https://www.springer.com/us/editorial-policies/authorship-principles
- Sage
  https://us.sagepub.com/en-us/nam/publishing-policies

Copyright is a legal entitlement designed to safeguard the interests of creators of diverse works (such as original literary, dramatic, musical, or artistic creations, as well as published editions). It ensures the moral and economic rights of authors, publishers, and other creators. Exceptions to copyright infringement include instances where copying occurs within the scope of fair dealing, under the terms of a licensing agreement, or with the written consent of the copyright holder. Everyone is obligated to adhere to copyright laws and the conditions specified in licenses. Types of Creative Commons Licences are listed in Fig. 1.5. The licences tend to be "more permissive" than licences from commercial publishers, and their basic idea is to permit, and almost encourage, the copying of the works as long as due acknowledgment is given to the original author as its source.

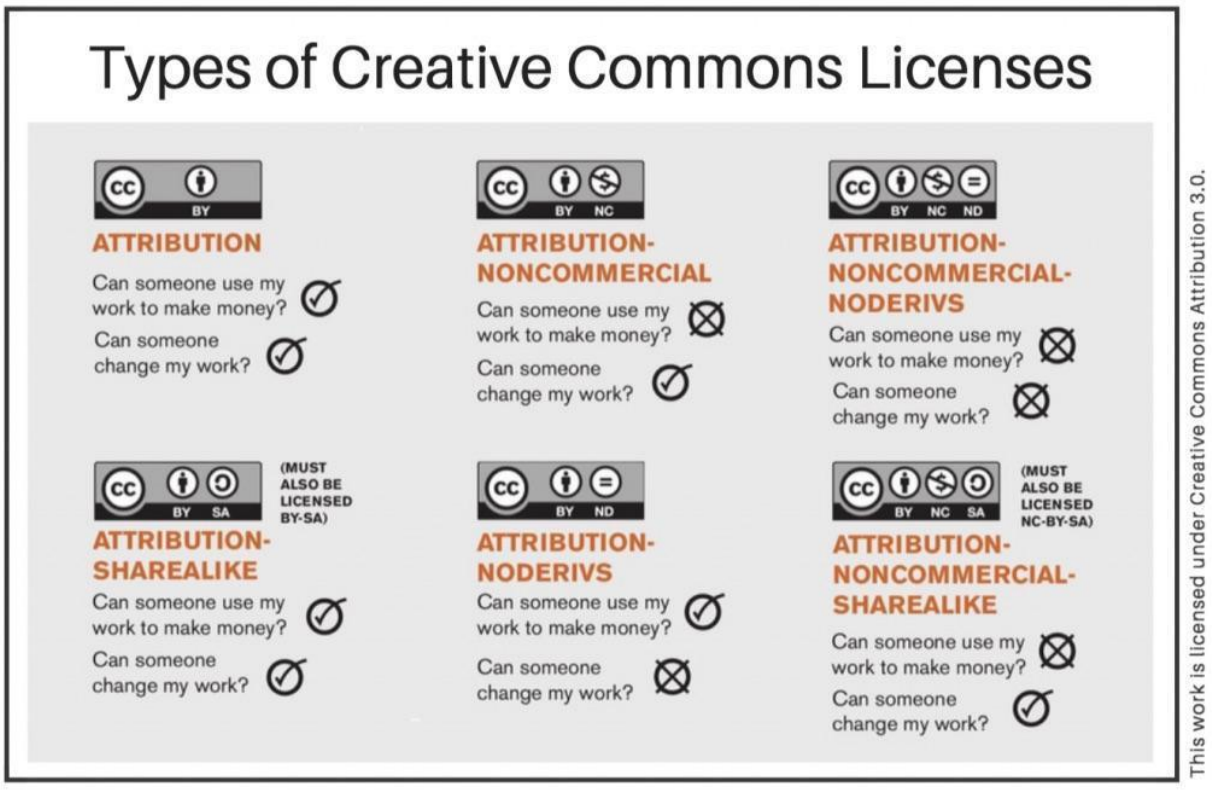

Fig. 1.5 Types of Creative Commons Licences[5]

[5] Copyright & Plagiarism: Copyright Basics. Shaw University Libraries - James E. Cheek Learning Resources Center. Accessed on June 16, 2024. Available at: https://shawu.libguides.com/c.php?g=809408&p=7515551.

The extent of fair dealing is not specified by the legislation. Generally guidelines are whichever is the greater than one chapter or 5% of a book; one article or 5% of an issue of a journal; one paper or 5% of a set of conference proceedings; one case or 5% of a law report.
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Practical work

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https://www.mdpi.com/about/journalselector
https://researcher.life/

- Analyse the selected article
- ✔ Is it original (primary) article, published after peer review?
- ✔ Does it give clear methods description? Is sample size sufficient?
- ✔ Is the aim reached and described in conclusions based on evidence reported in the results and discussion part?
- ✔ Are references up to date?
- ✔ If all above are yes, then go on with active reading.

- **Active reading!** Select one of the five articles, most relevant to your study.
- ✔ See the construction of paragraphs (highlight the topic sentence in introduction and results and discussion part). Write 1-4 word phrases to demonstrate what paragraph is about.
- ✔ Take a note of significant concepts, key terms, questions you may have, contradictions etc.)

Materials

Available searchable databases.

Methods

Define key words to find scientific publications on your topic.

Results

1. **Glossary with useful terms and phrases.**

Example. *Continue with a list of verbs for definition of aim, adding at least ten verbs.*
To establish
To evaluate
To assess ….

Example. *For Academic Phrasebook organisation following subheadings may be used. Add your own phrases found from scientific articles.*

1. *Establishing research territory*
   - *1.1. Considerable research attention has been devoted to _____*
   - *1.2. A number of recent studies have focused on _____*
   - *1.3.*

2. *Describing research gaps*
   - *2.1. There is limited research investigating _____*
   - *2.2. Few attempts have been made to investigate the role of _____*
   - *2.3.*

3. *Stating the aim of the research/study*
   - *3.1. This study was carried out to examine _____*
   - *3.2. This study offers an analysis of _____*
   - *3.3. The aim of this study was to determine the effect of _____*
   - *3.4.*

4. *Literature review*
   - *4.1. A number of scholars have conducted research on _____*
   - *4.2. It is generally agree that _____*
   - *4.3. Current research seems to indicate that _____*
   - *4.4. Numerous researchers have written extensively about _____*
   - *4.5.*

5. *Referencing*
   - *5.1. Smith et al. (2015) argued that ____*
   - *5.2. The study carried out by Smith et al. (2015) revealed that ____*
   - *5.3. Smith et al. (2015) established a link between _____ and _____*

5.4.

6. *Sampling and data collection*
   - *6.1. The survey included a variety of questions on _____*
   - *6.2. The sample for this study was randomly drawn from _____*
   - *6.3. For the purpose of this study _____ was measure with _____*
   - *6.4.*

7. *Data analysis and discussion*
   - *7.1. The correlation between ____ was calculated to evaluate ____*
   - *7.2. Means and standard deviations of _____ are presented in table {X}.*
   - *7.3. A positive correlation was obtained between ____ and ____*
   - *7.4. A possible interpretation of this finding is that _____*
   - *7.5. Future studies will have to focus on _____*
   - *7.6.*

2. Journal list for the manuscript submission

Create a table with three potential journal names for your publication with various publishers, and give key points and rating for your selection (for ideas see a publication at https://digitalcommons.lmu.edu/cgi/viewcontent.cgi?article=1041&context=librarian_pubs). Add more rows if required.

Selection criteria	Journal titles		
	Title 1	Title 2	Title 3
Web search for the journal			
…			

Conclusion

After completing practical and independent work, list the selected journals and justify why you have made this selection.

Approved by _____

Name, Surname, signature

Date _____

Theme 2

The structure of a scientific article (IMRaD)

Theoretical materials

The structure of a scientific article

In scientific article typically there is front matter, article body, and back matter (Fig. 2.1).

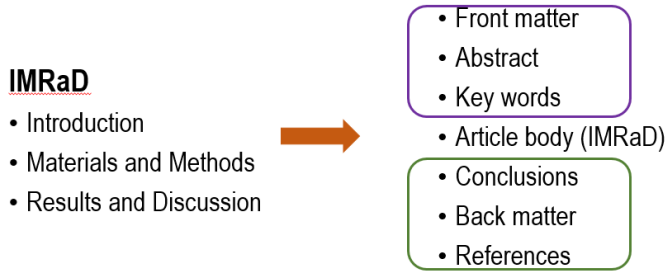


Fig. 2.1 The structure of a scientific article.

Writing research papers involves understanding the structure and roles of different sections. Although the standard format – introduction, methods, results, discussion, and conclusions – provides a framework, it doesn't prevent writers from facing challenges and getting stuck. Therefore it is important to understand the basic components of a scientific paper, which are presented in Fig. 2.2.

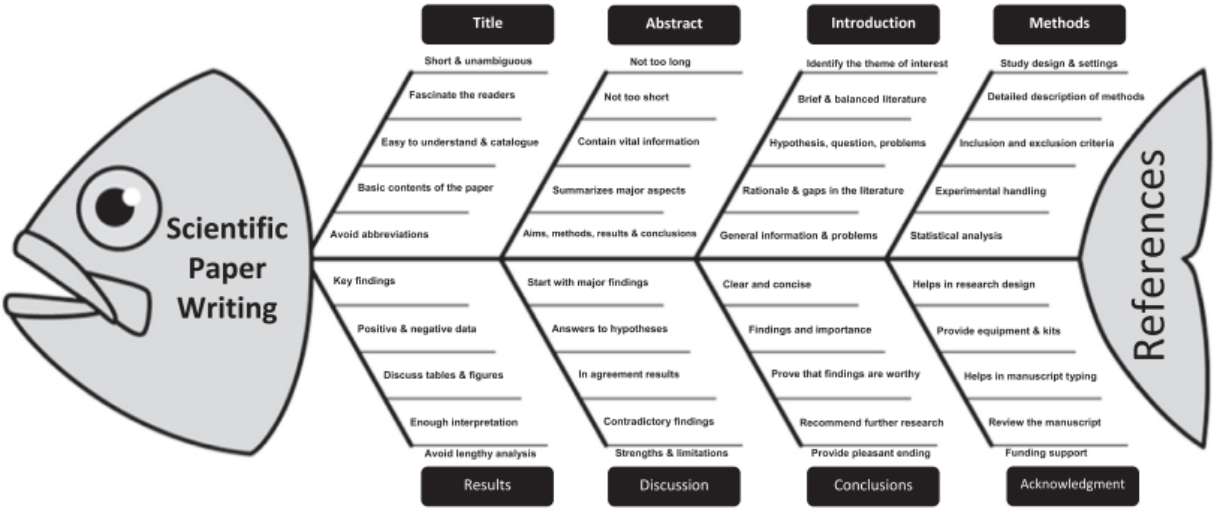
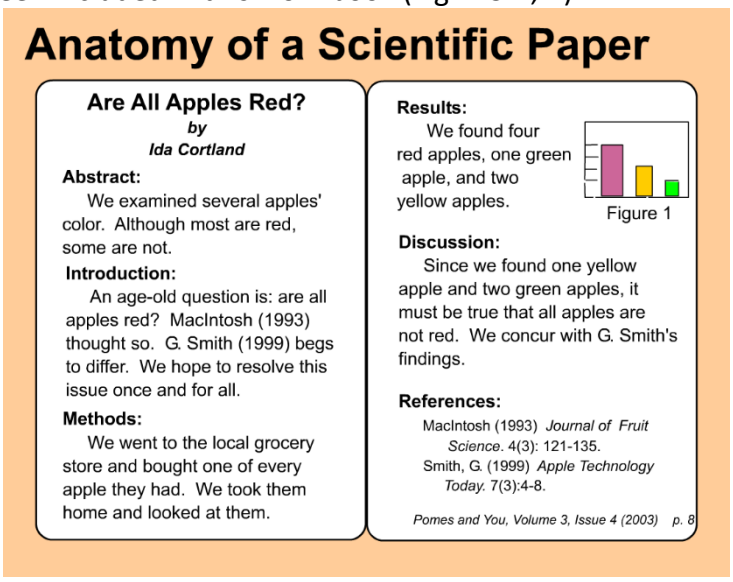
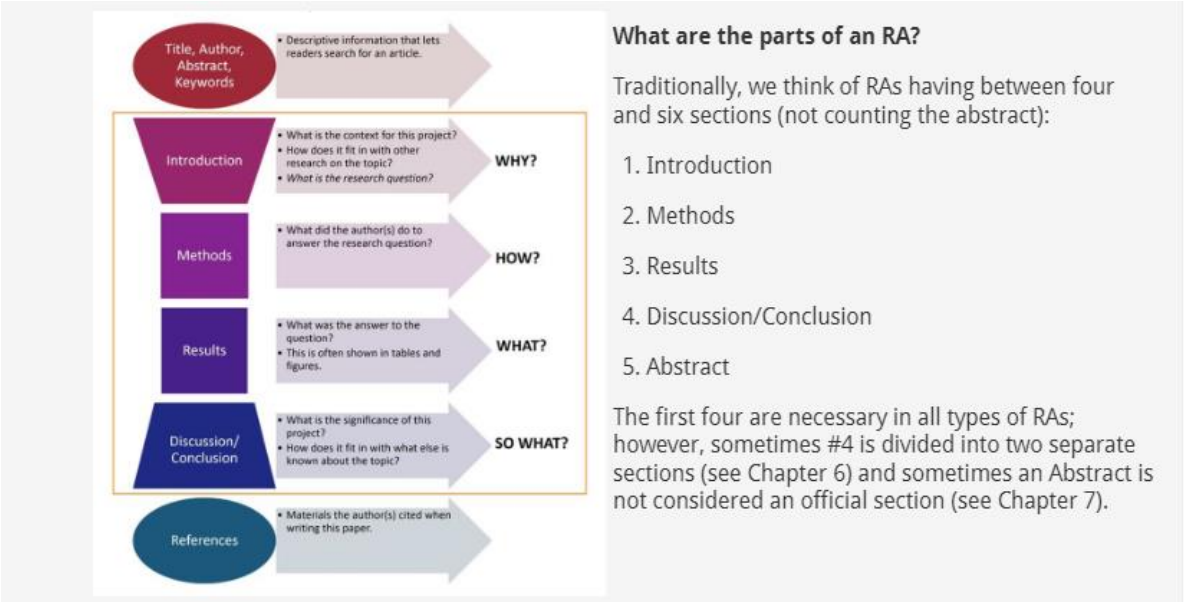


Fig. 2.2 MEO'S Fish Bone Model: Basic components of a scientific paper (Meo, 2018).

Structure of the academic article has been described in many publications, therefore several pictures presenting it have been included in this work book (Fig. 2.3 A, B).



(A)



(B)

Fig. 2.3 Example of the scientific article parts (A) [6] and explanation of the research article parts (B) (Huffman et al., 2023).

The Title of the paper provides a concise first impression. The abstract provides a brief, clear, and concise summary of the entire paper. The introduction explains the paper's purpose, starting broadly and narrowing down to a specific research question. The materials and methods sections, sometimes divided into two parts, detail how the study was conducted. The results section presents key findings objectively, using text, tables, graphs, and statistics in a logical sequence without interpretation. The discussion interprets the results in the context of existing knowledge and explains new insights

[6] Anatomy of a scientific paper, Human Nutrition: Reading Scientific Articles. Windward Community College. Accessed on June 16, 2024. Available at: https://library.wcc.hawaii.edu/nutrition/reading.

gained from the study. The conclusion reinforces the main claims or interpretations and emphasises their significance beyond the paper's scope.[7]
See also Research Paper Outline with Key Sentence Skeleton described by M. Zaumanis https://peerrecognized.com/research-paper-outline-with-key-sentence-skeleton-paper-template/.

Authorship

Authors can be listed:

- in the order of overall contribution of authors to the manuscript,
- often the senior author is the last regardless of his/her contribution,
- in alphabetical order, then the text on equal contribution is added.

One author has to be indicated as the corresponding author. All authors have to agree with the author order and most typically it cannot be changed after manuscript submission (follow COPE protocol, letter signed by all authors).

Unacceptable authorship is misrepresenting a scientist's relationship to their work. Examples of unacceptable authorship:

- 'ghost' authors – article written by somebody not acknowledged as an author (may be paid for writing);
- 'Guest' authors – somebody listed to help increase the chances of publication;
- 'Gift' or 'honorary' authors – their contribution is based solely on a tenuous affiliation with a study;
- mutual support authorship;
- denial of authorship.[8]

In 2015, Learned Publishing featured an article introducing the Contributor Role Taxonomy (CRediT), advocating a broader approach to defining authors' contributions in scholarly publications beyond traditional authorship. The taxonomy proposed a straightforward yet comprehensive framework, enabling authors to transparently and systematically describe their contributions during article submissions, thereby capturing the diversity and specifics of their scholarly output (Allen et al., 2019). For additional details on credit role taxonomy visit Elsevier at https://www.elsevier.com/researcher/author/policies-and-guidelines/credit-author-statement.

Paraphrasing

When writing a paper, you often incorporate information from books, journals, the Internet, and other sources. Your supervisor might advise you to use your own words. This means that even though you are using someone else's information, you cannot use their exact wording. Instead, you must express the same idea differently. This process is known as paraphrasing. For examples of paraphrasing, visit blogspot at https://englishreadingwriting.blogspot.com/p/paraphrasing.html.

[7] Anatomy of a scientific article. CHEM: Intro to Scientific Literature. The Citadel Daniel Library. Accessed on June 16, 2024. Available at: https://library.citadel.edu/c.php?g=615326&p=4280193.

[8] Factsheet. Authorship. (2017) Elsevier. Ethics in Research & Publication. Accessed on June 16, 2024. Available at: https://researcheracademy.elsevier.com/uploads/2018-02/2017_ETHICS_AUTH02.pdf.

Example: If the book you are reading from says, "John Adams, who was involved in winning independence for the United States, was the second President." You cannot write those words in your paper. You cannot even write, "John Adams, a man involved in winning independence for the United States, was its second President." One way that you could re-write it is to say, "The second American President, John Adams, was also influential in gaining freedom for the country."[9]

Copyright

- Copyright is a property right intended to protect the rights of those who create works of various kinds (original literary, dramatic, musical or artistic works, published editions).
- Copyright protects the moral and economic rights of writers, publishers and other creators.
- Copyright exceptions: it is not infringed where limited copying is carried out within the concept of fair dealing, the terms of licensing scheme, written permission from the copyright holder.
- Everybody have obligations to observe copyright law and the terms associated to licences.

Plagiarism

Pun (2021) reported that plagiarism is an increasing issue in academia, especially in colleges and universities. With the internet and technology, it has become easier for authors and students to replicate previous studies instead of creating original content. Many do not realise that using another person's work without proper acknowledgment is plagiarism, effectively stealing or copying someone else's work. This can result in serious repercussions such as disciplinary actions, revocation of academic degrees, job termination, damaged reputations, and loss of research funding. Therefore, it is essential for authors to avoid plagiarism to uphold integrity and achieve a successful academic career.

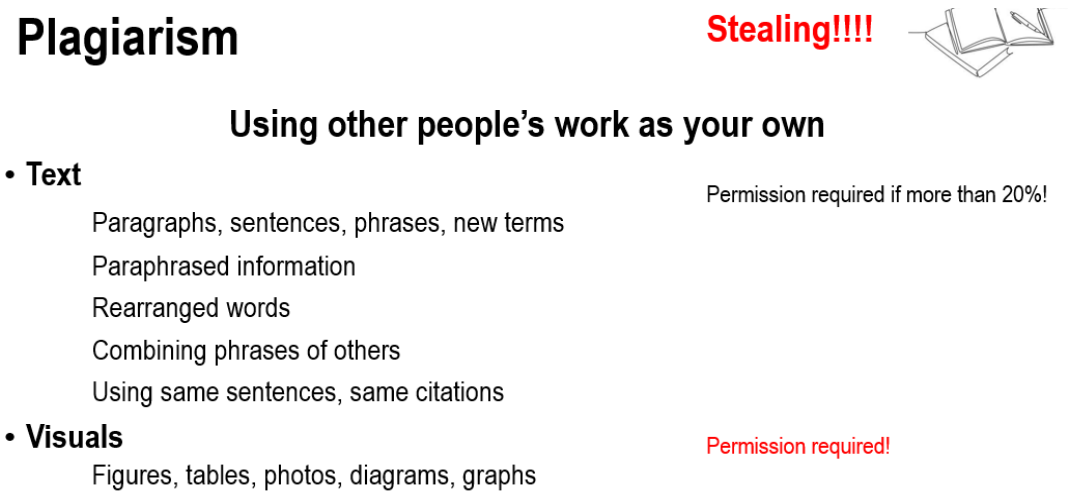


Fig. 2.4 Advise on using other people's work.

[9] Academic English Reading and Writing. Paraphrasing. Accessed on June 16, 2024. Available at: https://englishreadingwriting.blogspot.com/p/paraphrasing.html

To obtain permission to use figures, tables, or long texts, follow these steps.
Identify the copyright holder: Determine who owns the rights to the material. This could be the original author, publisher, or a third party.
Locate contact information: Find the contact details for the copyright holder. This information is often available in the publication itself or on the publisher's website.
Draft a permission request: Write a formal request for permission.
Send the request: Email or mail your permission request to the copyright holder. Some publishers may have an online form for permissions.
Follow up: If you don't receive a response within a reasonable time frame (e.g. two to four weeks), follow up with a polite reminder.
Keep records: Maintain a copy of your request and any correspondence, including the permission granted, for future reference.
Acknowledge the source: Once permission is granted, ensure you correctly cite the original source and include any specific wording required by the copyright holder.

Example of permission request.

[Your Name]
[Your Address]
[City, State, ZIP Code]
[Email Address]
[Date]

[Copyright Holder's Name]
[Title/Position]
[Company/Organisation Name]
[Address]
[City, State, ZIP Code]

Dear [Copyright Holder's Name],
I am writing to request permission to use the following material from your publication:

- *Title of the Work: [Title]*
- *Author: [Author]*
- *Material to be Used: [Specify figures, tables, long text passages, etc., with page numbers if applicable]*

The material will be used in [describe your work, such as a thesis, article, book, or presentation] which will be [describe how it will be published/distributed, e.g., printed, distributed online, etc.].
I will ensure that full credit is given to the original source as per your requirements. Please let me know if there are any specific conditions or acknowledgments you require.
Thank you for considering my request. I look forward to your response.
Sincerely,
[Your Name]

Reasons for plagiarism according to Šprajc et al. (2017).

- Not aware of plagiarism.
- Desire to get good grade or recognition.

- Forget why we use evidence.
- Do not believe in own writing.
- Insufficient time.
- Belief they will not get caught.

Ways to avoid plagiarism according to Pun (2021).

- Paraphrase and cite the source.
- Summarise and cite the source.
- Quote and cite the source.
- Cite own materials.
- Always follow the rules.

Academic publishing's ethical policies demand that anything we take from any other paper, even our own, must be correctly sourced and cited. Everything! What counts as self-plagiarism? It is repeating own writing or data; presenting old data as new (duplication); adding new data to already published material; and publisher copyright - your own words may not belong to you.

Tips to avoid self-plagiarism[10]

- Always correctly cite your previously published material in any new work.
- Ensure that any of previously published text or data is used to support new material and arguments in the new work, with the sufficient original content to warrant a new publication.
- Whenever possible, publish your findings as a unified whole to avoid fragmentation data, unless there are valid reasons for doing so.
- Always inform journal editors if the work you are submitting includes previously published material.

There are various systems in place to check for plagiarism

- Cross Check, iThenticate, Turnitin
- Grammarly
- Manual search (phrases of more than 5 words)

Writing tool examples

- Managing citations (Mendeley, Zotero, RefWorks, End Note and other)
- Language editing (MS Word, Grammarly, real person, artificial intelligence)
- Writing tools for collaboration (Google docs, MS Word online)
- Backup!!

Practical work

Analyse the scientific articles.
Set up of automatic reference management tool.
Do active reading, highlighting the useful terms and phrases for future use.

[10] Avoiding Self-plagiarism in academic writing. Charlesworth Author Services. Accessed on June 16, 2024. Available at: https://www.cwauthors.com/article/WhatIsSelf-Plagiarism.

Materials

Laptop.
Access to scientific databases.

Methods

Practical application of reference manager tools.
Creating and editing library.
Inserting citations and reference lists in the document.

Results

Five relevant articles added to the reference manager library and cited here.

Conclusion

Write conclusions about your experience working with databases and reference manager tool.

Approved by _____

Name, Surname, signature

Date _____

Theme 3

Selection and critical analysis of articles

Theoretical materials

The major considerations when selecting articles:

- relevance, new knowledge;
- study design, sample size, methods;
- statistical analysis;
- clarity from the hypothesis through results and discussion till conclusions.

Important points to consider when critically evaluating published research papers are described at https://www.open.edu/openlearn/mod/oucontent/view.php?id=64126&section=1. Simple review articles (also known as 'narrative' or 'selective' reviews), systematic reviews, and meta-analyses offer quick overviews of progress in a field, summarising specific topics or research areas. They serve as guides, comprehensive information sources, and reference points for primary research studies. These reviews are often the first step toward a detailed investigation, specific inquiry, or understanding a rapidly evolving field. At the postgraduate level, demonstrating this understanding is essential for assignments, essays, or dissertations.[11]

Key questions to ask when appraising a research paper:[11]

- "Is the study's research question relevant?
- Does the study add anything new to current knowledge and understanding?
- Does the study test a stated hypothesis?
- Is the design of the study appropriate to the research question?
- Do the study methods address key potential sources of bias?
- Were suitable 'controls' included in the study?
- Were the statistical analyses appropriate and applied correctly?
- Is there a clear statement of findings?
- Does the data support the authors' conclusions?
- Are there any conflicts of interest or ethical concerns?"

Practical work / seminar

Working with databases.
Preparation of background information for scientific article, making library with possible references.
Presentation of the selected journals.

Materials

Laptop.

[11] OpenLearn. The Open University is incorporated by Royal Charter (RC 000391), an exempt charity in England & Wales and a charity registered in Scotland (SC 038302). . Accessed on June 16, 2024. Available at: https://www.open.edu/openlearn/mod/oucontent/view.php?id=64126&section=1.

Access to scientific databases.

Methods

Use of searchable databases.
Presentation and discussion.
Application of Scopus Artificial Intelligence (AI) or other AI tools for the first overview of the topic.

Results

Background information for the scientific article on your selected topic.
List the research gaps, why your study is important.

Conclusion

Write conclusions about the available scientific literature on your topic.

Approved by _____

Name, Surname, signature

Date _____

Theme 4

Elements of academic language

Theoretical materials

Writing academic texts involves three key elements: audience, purpose, and material. Keeping all research material organised in one place allows for quick reading and identification of relevant content using various highlighting techniques. Using different coloured highlighters helps distinguish main ideas from evidence and align appropriate arguments with the topic. The key elements of writing are presented in Fig. 4.1.

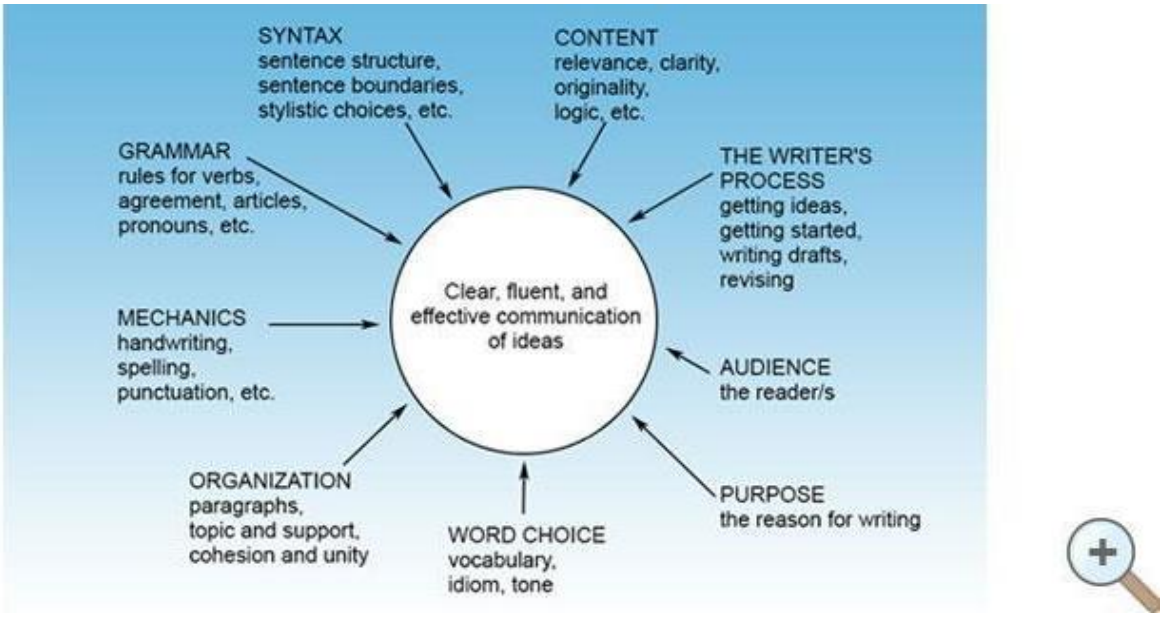


Fig. 4.1 The key elements of writing.[12]

Academic language - key features:

- Objectivity,
- Formality,
- Precision,
- Hedging (to express caution and avoid strong, unqualified statements)[13].

[12] The key elements of writing. Accessed on June 16, 2024. Available at: https://pdfweb.truni.sk/e-ucebnice/eap/dat. 6e-a68b-37b05785b0d8.html?ownapi=1#.

[13] Explore the key features that make up academic style. The University of Melbourne. Accessed on June 16, 2024. Available at: https://students.unimelb.edu.au/academic-skills/resources/reading,-writing-and-referencing/writing-effectively/academic-style.

In academic writing, it is essential to be clear, evidence-based, and grammatically correct. The writing should be impersonal, objective, and specific. In academic language, it is important to avoid conjunctions, idiomatic expressions, incomplete sentences, and slang. Conjunctions can create overly complex sentences, while idiomatic expressions may not be understood universally. Incomplete sentences fail to convey complete thoughts and ideas, and slang lacks the formality and precision required in scholarly writing. Clear and precise language ensures effective communication of ideas.[14]

Types of paragraphs

A paragraph consists of a series of sentences that revolve around a central idea known as the topic. It's essential to ensure thematic unity in paragraphs, meaning each paragraph supports one coherent idea that contributes to your overall argument. Achieving paragraph unity is best done through a clear topic sentence, which encapsulates the main point of the paragraph, similar to a mini thesis statement. While a thesis statement guides the entire essay, the topic sentence guides the paragraph. However, unity isn't guaranteed solely by a topic sentence or thesis statement; for an essay to be unified, all paragraphs must relate to the thesis, whereas a paragraph achieves unity when all sentences align with the topic sentence. It's important to note that not all paragraphs require topic sentences; opening and closing paragraphs often serve different functions. In academic writing, placing the topic sentence at the beginning of a paragraph is typically most effective because it prepares the reader for what follows. Maintaining focus on the topic sentence helps ensure a paragraph remains unified by avoiding irrelevant information. To develop ideas within a paragraph, one can employ various techniques to logically expand upon and illustrate the topic sentence.[15]
There are different types of paragraphs:

- illustration;
- definition;
- analysis or classification;
- comparison or a contrast;
- qualification;
- process;
- combination of methods.

Paragraph unity and coherence
"Paragraphs should have both coherence and unity. A paragraph with unity develops a single idea thoroughly and links it to the rest of the paper. Paragraph coherence is achieved when sentences are ordered in a logical manner and when clear transitions link sentences."[16]
Paragraph unity[16]

- Develop a paragraph around a major idea. Express this idea in the topic sentence.
- Make the relationship between the main idea of the paragraph and the thesis of the paper clear. Don't assume that the reader will "get it." Spell it out for him/her.
- Support the main idea of the paragraph with details.

---

[14] Language Used in Academic Writing. Study Smarter. Accessed on June 16, 2024. Available at: https://www.studysmarter.co.uk/explanations/english/5-paragraph-essay/language-used-in-academic-writing/.

[15] Paragraphs. University College, University of Toronto. Accessed on June 16, 2024. Available at: https://www.uc.utoronto.ca/paragraphs.

[16] Paragraph unity and coherence. American University, Academic Support Center, Writing Lab, updated 2009. Accessed on June 16, 2024. Available at: https://www.american.edu/provost/academic-access/upload/paragraph-unity-and-coherence.pdf

- Create separate paragraphs for those details that explore your topic from different perspectives.
- Eliminate sentences that do not support the main idea. Alternately, you may revise the main idea to include those sentences.

Paragraph coherence[16]

Decide on an order for your sentences that will best develop the paragraph's main idea. Your supporting sentences are raw materials. They will not make sense to a reader unless they are put in order. This order could be based on several factors:

- Chronological sequence. This is useful for describing a sequence of events.
- Modified chronology. Sometimes a major idea presented early in a paragraph can be supplemented with necessary background information.
- Spatial position of different objects. This method is useful for description.
- 'Conversation' between different experts. By moving between a series of key positions, a writer can establish a sense of dialogue and develop a complex argument. Logical form of argument. Some form of logical proof, like a syllogism, can serve as the basis for order.

Once you have put your sentences in order, express the connections between them with transitional words or phrases. Think of these as signposts to guide the reader through your paragraph. They should be clear.

Active versus passive voice, subject and verb agreement, verb tense

The choice between active and passive voice depends on the emphasis you want to place on either the doer of the action (active voice) or the action itself (passive voice). For most clear and direct communication, active voice is preferred, while passive voice can be used strategically depending on the context and intention of the writing.

Most books on good writing advocate preferring the active form to the passive form. Also, software applications that automatically check a text for grammar and style, will usually highlight any usages of the passive and recommend using the active as an alternative. However, in research manuscripts, the passive is often a much better option (Wallwork, 2013).

The passive is generally used in preference to the active in all the cases below. The active equivalent might be preferential when giving oral presentations or in other more informal contexts:

1. To describe processes. In such cases the main interest is not in who or what carried out the actions; the most important item is the subject of the sentence. Typically this is found in the methods section. Only use 'we' in the methods if it is not clear who carried out the action.
2. When making general references to the literature or to what is happening in the world in general.
3. When it is unnecessary, difficult, or impossible to identify the originator of the action.
4. To report what is commonly believed to be true.
5. To report formal decisions or to make announcements (Wallwork, 2013).

Use of articles

Articles: «A» «An»

- Use with unspecified, singular, countable noun
  Examples
  A sample density .... (not specified, any sample)
  Use lemon juice in water to remove rust (not a countable)

- «An» precedes a vowel sound
  Examples: an uncommon, but a unique or a European

Articles: «The»

- When item has already been specified
- When item is about to be specified
- When item is otherwise known to the reader
- When a countable is unique

Articles: «no article»

- No articles for both, noon, midnight, winter, childhood, biology. History, oxygen, Ireland, Monday, June, fifteen, Table 1, Figure 2
- None in above sea level, below zero, by accident, at once, at present, in case, by chance, in addition, in brief, in contract, in detail, in effect, in full, in fact, on time, on purpose, within reach, without doubt, without warning

Space

- Always between number and unit of measurement (sometimes except number and per cent, check with the journal)
- Sometimes between number and various signs (−; ±; =; >; ≤; ≤) the space is added (check with the journal)

Word choice

Examples of preposition problems are listed in Fig. 4.2.

- absent **from**
- added **to**, not into
- apply **for** (money), but apply ointment, **apply to** the university **for** money
- approve / disapprove **of**
- agree / disagree **with**
- associate **with** (and correlate / consistent **with**, but relate **to**, characteristic **of**
- **at** this level
- **on** average
- compare **with** (in USA often compare **to**)
- in connection **with**
- different **from**
- dissolved **in**, but extracted **from**
- the effect / influence **of** xx **on** xx
- essential **to**
- exclusive **of**
- foreign **to**
- grateful **to** xx **for** the xx
- an increase **in** (not of) x; a reduction **in** cost
- independent **of**, dependent **on**
- isolate **from**
- participate **in**
- prefer x **to** y
- prior **to**
- in the range **of**
- similar **to**
- varies **with**

Fig. 4.2 Prepositions in English language.

Hedging (signposting) words and phrases

Consider different approaches to effectively guide your reader through your writing. Here are tips for using signposting language.

- **Choose judiciously**: Signposting words vary in their nuances and can confuse readers if misused. Ensure you select the appropriate word to accurately convey the relationship you aim to express.
- **Use intentionally**: It's unnecessary to include a signposting word in every sentence. Before adding one, assess whether it enhances clarity or unnecessarily complicates your writing.
- **Edit thoughtfully**: When reducing word count, the temptation may be to remove signposting words to retain more information. However, omitting signposts can obscure your message, making it challenging for readers to grasp your intended meaning. Effective signposting aids in maintaining coherence and understanding.

Academic writing often employs introductory verbs such as "seem," "tend," "look like," "appear to be," "think," "believe," "doubt," "be sure," "indicate," and "suggest." Certain lexical verbs, including "believe," "assume," and "suggest," are also commonly used. Modal adverbs like "possibly," "perhaps," and "conceivably" help convey uncertainty or possibility. Additionally, "that" clauses, such as "It could be the case that…," "it might be suggested that…," and "there is every hope that…," are frequently used to introduce tentative statements or hypotheses.

Signposting words serve a valuable role in introductions by indicating your structure, and they are reiterated in the opening lines of paragraphs to show their connections. At the sentence level, they clarify the links between ideas. Given the variety of links and relationships, it's important to select the appropriate signposting word for each context. For examples see the material provided by Newcastle University at https://www.ncl.ac.uk/academic-skills-kit/writing/academic-writing/signposting/.

Punctuation

- No comma ever goes before «that», but a comma does go before «which»
- A comma always accompanies «whereas»
- The comment requires surrounding punctuation: commas, parentheses, or dashes. The label for commas that surround comments is «fetal parentheses». They can «grow up» to become parentheses or even dashes.
- Punctuate after, never before, parentheses, unless they contain a complete sentence.
- Semicolons link closely related, but independent clauses.

Chief Uses of the Comma

- List-commas, Final commas before «and», often comma before «or»
  A, b, c, and d
  A, b, c, or d
- Introductory word or phrase (Does an oral pause follow?)
  First, ...
  Finally, ...
  In May, ...
- Dependent clause (always use if initial). Is the clause dependent?
  If you wish, you can go.
- Adjective series A comma goes where and could appear.

Clean, sterile, expensive instruments.

- Apposition (paired) Identical, not defining.
  Paula, our director, arrived.
  But: our director Paula arrived.

Dash vs. Hyphen[17]

Hyphen (-)		Used for compound words	*Freeze-dried*
En-dash (–)	Width of the letter *n*	Used as the symbol for ranges	*10–12%*
Em-dash (—)	Width of the letter *m*	A punctuation mark to set apart parenthetic statements	*The gene expression—after normalisation, of course—showed enrichment in the…*

British vs. American English spelling

Majority of journals accept both British and American spelling, but not in the same article!

Table 4.1

Examples describing differences in British and American spelling

British	American
colour, flavour, odour	color, flavor, odor
fibre, centre	fiber, center
sulphur	sulfur
analyse	analyze
aesthetic, anaemia	esthetic, anemia
distil, fulfil	distill, fulfill
defence, licence(noun)	defense, license
programme, tonne	program, ton
diarrhoea	diarrhea
grey	gray

[17] Duke Graduate School Scientific Writing Resource. Accessed on June 16, 2024. Available at: https://sites.duke.edu/scientificwriting/dash-v-hyphen/.

Measurement units

- Metric system
- Two ways of writing (m/s or m s^{-1}). Both are correct, consult the author guidelines and examples of published articles. Be consistent!
- To compare results convert values in the same measurement units

Common mistakes non-native authors make when writing in English

Mohebi et al. (2018) in their study found 4,322 errors across 50 articles, with grammatical errors being the most frequent. Punctuation errors were the most common, totalling 989 instances, while errors involving auxiliary verbs were the least frequent, with only 19 instances. The errors ranked in descending order as follows: grammatical, mechanical, lexical, and discoursal.

Table 4.1

The frequency and percentage of errors in descending order (Mohebi et al., 2018).

Rank	Type of error	Frequency (%)
1	Punctuation	989 (22.88)
2	Spacing	453 (10.48)
3	Articles	410 (9.49)
4	Wrong word	376 (8.5)
5	Pluralization	363 (8.40)
6	Capitalization	187 (4.32)
7	Subject-verb agreement	191 (4.42)
8	Ambiguous sentences	159 (3.68)
9	Transitional words/phrases	154 (3.57)
10	Prepositions	142 (3.29)
11	Verb tenses	120 (2.78)
12	Conjunctions	117 (2.71)
13	Active/passive voice	115 (2.66)
14	Persian structure	107 (2.48)
15	Possessives	102 (2.36)
16	Sentence fragments	65 (1.50)

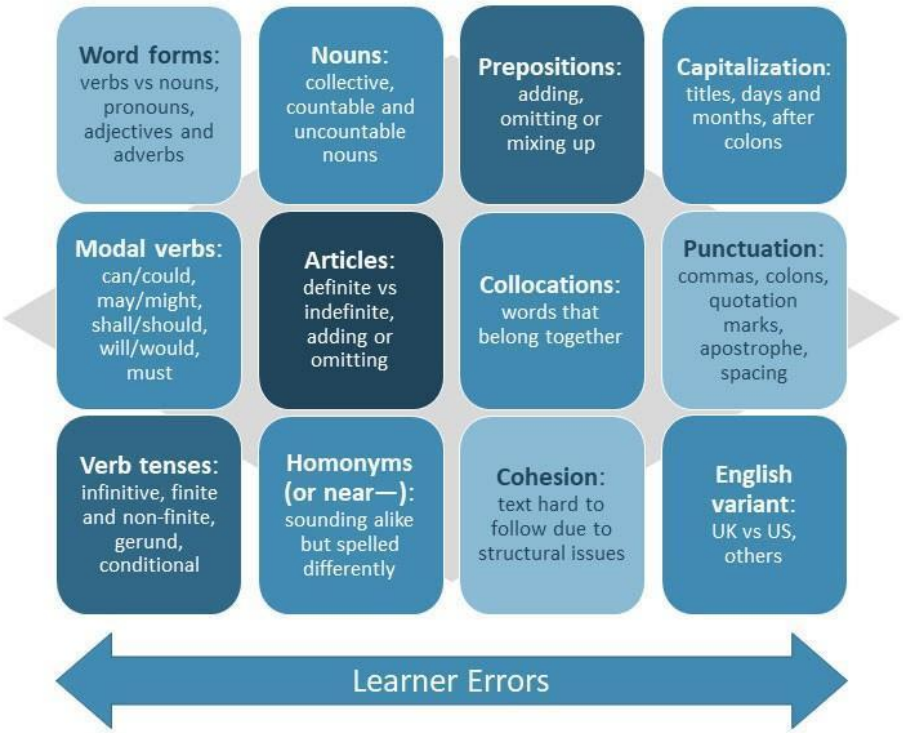


Fig. 4.3 Mistakes non-native speakers often make when writing in English (Berquin, 2021).

For examples of typical grammar errors in English writing visit also https://blog.wordvice.com/common-grammar-mistakes-writing/.

- 21% of all writing errors.
- Determiners: words that come before a noun or noun phrase and tell us if the noun is general or specific and often specify a quantity.
- Articles (a, an, the).
- Determiner words (this, that, every, each, which, that).
- Prepositions: words that precede a noun or pronoun and show that word's relationship to another word in the same sentence or clause.
- Subject-verb agreement: a concept that requires a subject and verb to agree in number (singular/plural).
- Verb form (6 in total): the base (dictionary form), the infinitive (to + base), the 3rd person singular (verb + s), the present participle (verb + ing), the past simple, and the past participle (different verb tenses).
- Verb tense shifts: always use one tense or start a new clause or sentence to avoid verb tense shifting.

For commonly confused words and misused phrases in English see the Wordvice blog at https://blog.wordvice.com/commonly-confused-words-phrases/.

Check your wording with:

- Google Scholar (https://scholar.google.com/);
- the Merriam-Webster online dictionary (https://www.merriam-webster.com/);
- list of common expressions in research papers (https://blog.wordvice.com/useful-phrases-for-writing-academic-papers/);
- the most useful verbs for the different parts of a paper (https://blog.wordvice.com/recommended-verbs-for-research-writing/);

- check your use of prepositions (https://blog.wordvice.com/common-research-paper-writing-mistakes-prepositions/).

Practical work / seminar

The use of different terms in English. Error recognition.
Presentation of the manuscript outline.
Complete the task on English term use in the Moodle platform.

Practical work on paragraph unity

- Read the provided paragraph (in the Moodle platform). Find and cross out sentences that are off the topic.
- The given sentences are a scrambled paragraph (task in the Moodle platform). Put the sentences in order according to the diagram. This is how to proceed. Step 1: Find the topic sentence. Step 2: Find the concluding sentence. Step 3: Then decide which sentences are supporting points and put them in order. Look for the words "First," "In addition" etc. Step 4: Decide which examples support which points. Step 5: Copy the sentences into the correct order.

Independent work

- Collect the data, which will be used in the manuscript (be ready to use it in the practical work next week).
- Draft an outline for the results and discussion part (content, subsections).
- You are welcome to do more of pre-writing for results and discussion part.
- Do not be afraid of language or content mistakes. You will fix those later in the revision and editing steps.

Materials

Laptop.
Access to scientific databases.
Access to Moodle platform.

Methods

Use of language elements in academic writing,

Results

The first draft of scientific manuscript, keeping in mind paragraph unity, using proper verb tenses and hedging words.

Fill in the table with synonyms to make verb meaning more specific

to look at	to compare	to show	to find out

Conclusion

Write conclusions about the most important language elements used in academic writing.

Approved by _____

Name, Surname, signature

Date _____

Theme 5

Visual elements for statistically based data presentation in manuscript

Theoretical materials

Visuals are becoming an essential component of science communication. Different visual elements could be used in scientific writing for better presentation of results (Fig. 5.1).

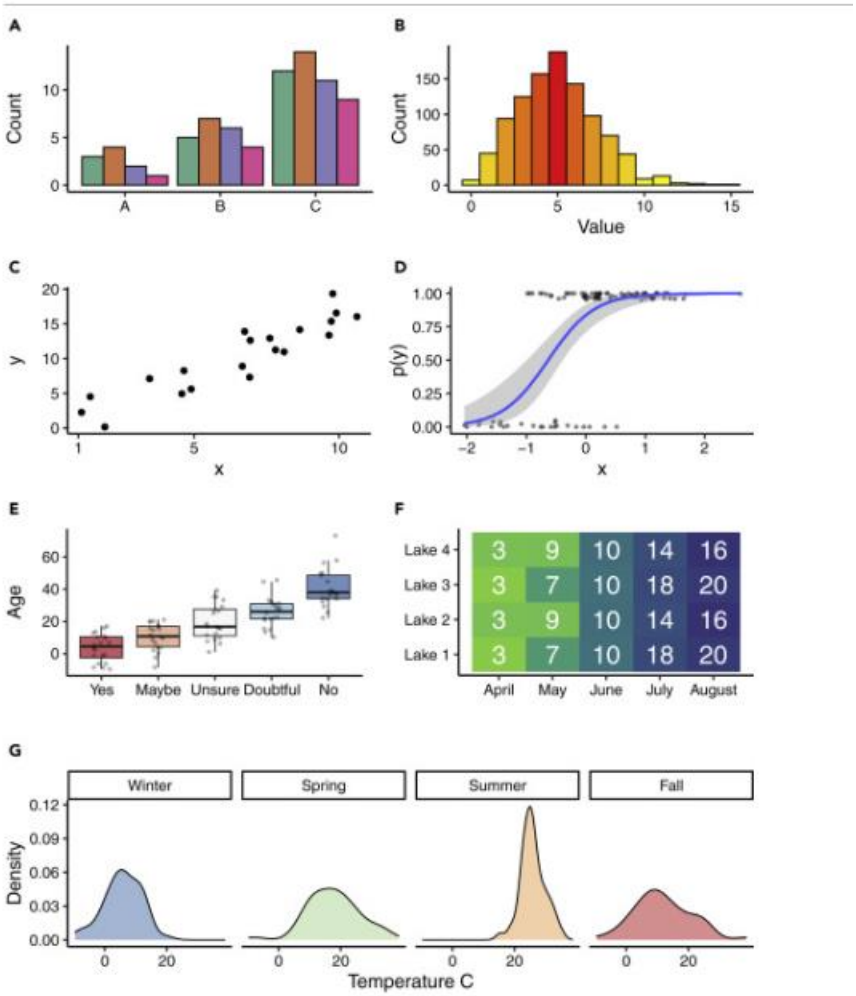


Fig. 5.1 Examples of visual design (Midway, 2020).

Descriptive statistics is the most commonly used tool for evaluation dataset. Microsoft Excel Data Analyses Toolpack could be used to perform it. The standard deviation should be presented for tables and figures. A low, or small, standard deviation means that the data points are closely clustered around the mean, while a high, or large, standard deviation indicates that the data points are more dispersed. Examples of standard deviation presentation and results of ANOVA analyses followed by Tukey test are presented in Fig. 5.2 and Fig. 5.3.

Samples	Before storage	After storage	Changes after storage
TPC (mg GAE/100 g DM)			
C	$14.82\pm0.71^{d,A}$	$15.60\pm0.61^{b,A}$	n.s.
B_HRP	$17.96\pm0.36^{c,A}$	$18.99\pm0.93^{a,A}$	n.s.
B_HLP	$23.15\pm0.93^{a,A}$	$16.94\pm0.45^{b,B}$	27% (↓)
B_HRM	$21.74\pm0.43^{b,A}$	$20.04\pm1.08^{a,B}$	n.s.
B_HLM	$23.75\pm0.43^{a,A}$	$16.98\pm0.28^{b,B}$	29% (↓)
DPPH• scavenging activity (mmol TE/100 g DM)			
C	$1.58\pm0.08^{c,B}$	$2.11\pm0.03^{a,A}$	33% (↑)
B_HRP	$1.70\pm0.08^{b,c,B}$	$2.28\pm0.05^{a,A}$	34% (↑)
B_HLP	$1.86\pm0.06^{a,b,B}$	$2.18\pm0.01^{a,A}$	17% (↑)
B_HRM	$1.99\pm0.10^{a,A}$	$2.14\pm0.12^{a,A}$	n.s.
B_HLM	$1.93\pm0.03^{a,B}$	$2.23\pm0.08^{a,A}$	16% (↑)
ABTS•+ scavenging activity (mmol TE/100 g DM)			
C	$1.06\pm0.05^{d,A}$	$0.56\pm0.06^{c,B}$	47% (↓)
B_HRP	$1.25\pm0.06^{c,A}$	$0.68\pm0.01^{d,B}$	46% (↓)
B_HLP	$1.80\pm0.08^{a,b,A}$	$1.32\pm0.04^{a,B}$	27% (↓)
B_HRM	$1.71\pm0.09^{b,A}$	$1.15\pm0.05^{b,B}$	33% (↓)
B_HLM	$1.92\pm0.06^{a,A}$	$1.10\pm0.03^{b,c,B}$	43% (↓)

All data are means ± standard deviation ($n=18$). ^{a,b,c}... – values with different superscripts in the same column for the same parameter are significantly different ($p\leq 0.05$). ^{A,B}– values with different superscripts in the same row are significantly different ($p\leq 0.05$). Abbreviations: C: control; B_HRP: biscuits with horseradish root pomace powder; B_HLP: biscuits with horseradish leaf pomace powder; B_HRM: biscuits with horseradish root juice microcapsules; B_HLM: biscuits with horseradish leaf juice microcapsules; DM: dry matter; n.s.: change is statistically insignificant ($p>0.05$). ↑: Percentage increase after 180-day storage. ↓: Percentage decrease after 180-day storage.

Fig. 5.2 Presentation of standard deviation in tables (Tomsone et al., 2020).

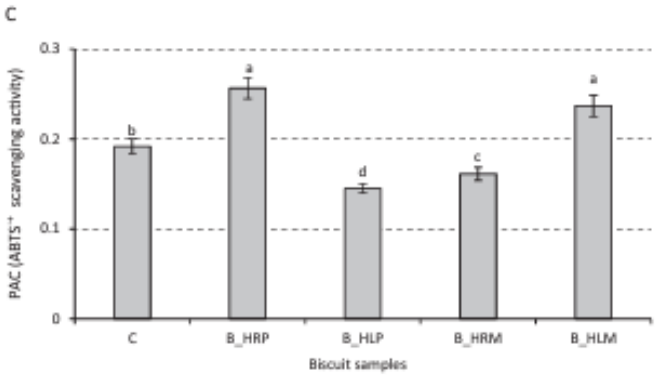


Fig. 5.3 Presentation of standard deviation in figures (Tomsone et al., 2020).

Creating tables and figures for a scientific article involves several key steps to ensure they are clear, accurate, and effectively convey your data.

Practical work

1. Descriptive statistics as tool for data presentation in article. Calculation of parameters based on own data or dataset provided by teacher.
2. Analyses of visual elements found in scientific articles based on concluding statistics methods.
3. Selection and preparation of appropriate visual elements for article using formatting guidelines (own data or dataset provided by teacher).

Materials

1. Scientific databases such as sciencedirect.com, scopus.com and webofscience.com
2. Dataset obtained in scientific research or dataset provided by teacher.

Methods

Microsoft Excel software, free online software such as Canvas, Heatmapper etc.
For Microsoft excel – Functions and Data Analyses Toolpack.

Results

5.1. Calculate the following parameters for provided dataset: Mean, Median, Mode, Range, Standard Deviation, Minimum, Maximum, Quartiles (Q1, Q2, and Q3), and Percentiles. Present data in a self-made table.
5.2. Analyses of the visual elements of article. Please fill the table by adding brief descriptions.

Questions	Visual element 1	Visual element 2	Visual element 3
Clarity			
Are the titles clear?			
Are the values properly labelled with units of measurement?			
Is the font size of the text and labels correct?			
Are the data represented accurately?			
Are error bars or confidence intervals included?			
Design			
Is the design of the visual elements clear?			
Are legends provided?			

Questions	Visual element 1	Visual element 2	Visual element 3
Are different data series clearly distinguishable through the use of colours, patterns, or markers?			
Are the chosen visualisation types appropriate for the data being presented?			
Are the visualisations of high resolution and quality, suitable for publication?			
Do the visual elements provide additional insights that complement the textual content?			
Is there enough information provided about how the visualisations were created for others to reproduce them?			

5.3. Prepare a table or figure showing significant differences between the analysed samples. Give conclusion about the dataset.

Conclusion

Please write conclusions about the importance of visual elements in the scientific articles.

Approved by _____

Name, Surname, signature

Date _____

Theme 6

Preparing, editing, and submitting manuscripts

Theoretical materials

6.1 Preparation of the manuscript

6.1.1 Selecting a topic and conducting research

Selecting an appropriate topic is the first crucial step in preparing an academic manuscript. This decision shapes the entire research and writing process. To begin, identify broad areas of interest by reflecting on subjects that genuinely intrigue you within your academic field. These should be areas you are passionate about and eager to explore further. Consider current trends and debates in your discipline, which might spark ideas for your research.

Fig. 6.1 Steps in the creation of manuscripts (Sheehy et al., 2019).

Conduct preliminary research to refine your broad interests into a specific topic. Review recent publications, such as journal articles, conference papers, and books, to identify emerging issues and gaps in the existing literature. Academic databases like JSTOR, PubMed, and Google Scholar are excellent resources for this purpose. By exploring these sources, you can get a comprehensive overview of the current state of research and identify areas that require further investigation.

Once you have a broad area of interest, narrow it down to a specific aspect or question. A focused topic is easier to manage and allows for more in-depth exploration and analysis. Ensure that your chosen topic is not too broad, which can make the research overwhelming, nor too narrow, which might limit the availability of resources and data. To further refine your topic, discuss your ideas with mentors, advisors, or colleagues. Their feedback can help you assess the feasibility of your research, considering factors such as access to data, resources, and ethical considerations.

After selecting a topic, conducting thorough research is essential to build a strong foundation for your manuscript. A comprehensive literature review is critical to understanding the existing body of work on your chosen topic. Summarise key theories, findings, and methodologies from previous studies to situate your research within the broader academic conversation. Identify gaps, inconsistencies, or areas that require further exploration, as this will help you position your research to contribute new insights to the field.

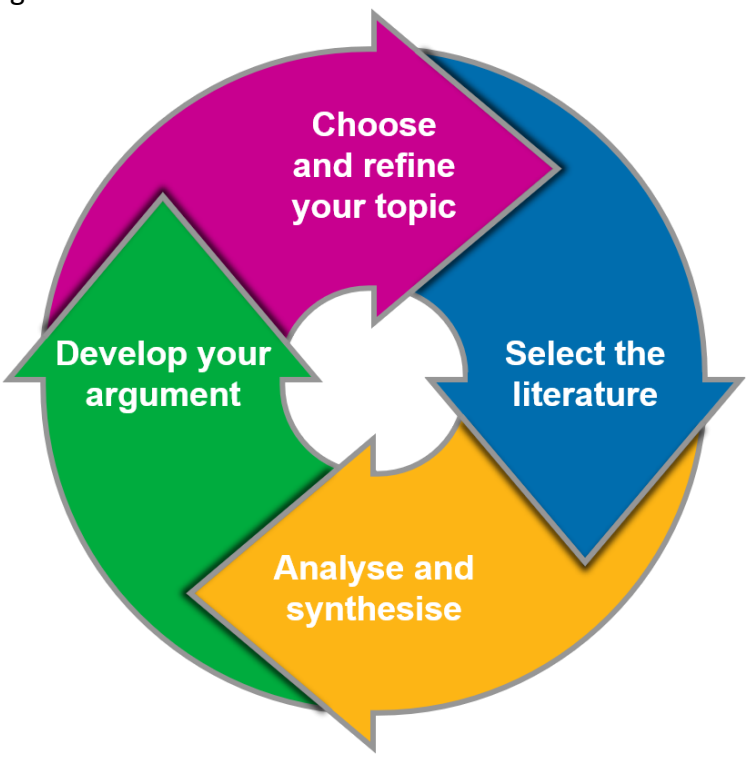


Fig. 6.2 Selecting a topic and conducting research.[18]

Gather original materials such as research articles, historical documents, and statistical data. Depending on your field, primary sources might include experimental results, survey data, or archival records. Evaluate the authenticity and reliability of primary sources to ensure they are credible and relevant to your research question. Utilise secondary sources such as reviews, analyses, and interpretations of primary data to gain broader perspective and contextualise your research. Critically evaluate the credibility, relevance, and quality of secondary sources to ensure that they come from reputable publishers and authors.

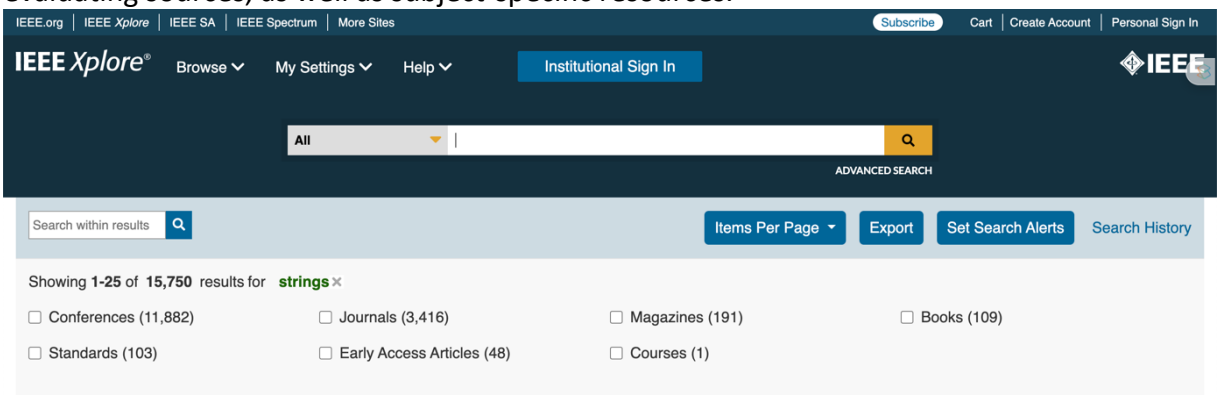
If your research involves collecting new data, develop a clear and robust methodology. This might include designing experiments, conducting surveys, or performing fieldwork. Ensure that your methods are rigorous, ethical, and appropriate for your research question. Obtain the necessary approvals from institutional review boards (IRBs) or ethics committees if human or animal subjects

[18] A basic guide to writing a literature review. Avidnote. Accessed on June 16, 2024. Available at: https://avidnote.com/basic-guide-writing-literature-review/

are involved. Document your process meticulously to ensure reproducibility, keeping detailed records of your methods, data collection procedures, and any changes made during the research.
To organise your research effectively, use digital tools such as reference management software like Zotero or EndNote. These tools help you manage citations and create bibliographies efficiently. Keep detailed notes on each source, including bibliographic information, summaries of key points, and relevance to your research. Consider using digital note cards or spreadsheets to organise this information systematically.

Fig. 6.3 Zotero: reference programme.[19]

Use academic databases like JSTOR, PubMed, Google Scholar, and IEEE Xplore to access a wide range of scholarly articles and publications. These databases offer advanced search features to help you find relevant literature quickly. Use university and public library systems to find books, theses, and other valuable resources. Many libraries offer interlibrary loan services to access materials not available in your institution's collection. Tools like Zotero, Mendeley, and EndNote can help you manage and cite your sources efficiently. These tools allow you to store, organise, and format your references in various citation styles. Many universities and libraries also provide online guides to assist with research methods and resource selection. These guides often include tips for finding and evaluating sources, as well as subject-specific resources.



[19] Zotero: Managing Research Materials in a Better Way. The University of Hong Kong. Libraries. Accessed on June 16, 2024. Available at: https://blog-sc.hku.hk/zotero-managing-research-materials-in-a-better-way-2/

Fig. 6.4 Academic databases.[20]

Throughout the research process, stay organised by keeping your research materials and notes well-organised. Create folders and subfolders for different aspects of your research, and maintain a consistent naming system for your files. Critically evaluate the credibility, relevance, and quality of each source, distinguishing between high-quality, peer-reviewed articles and less reliable materials. Stay current with the latest research developments in your field by regularly checking academic journals, attending conferences, and participating in relevant online forums. Follow ethical guidelines for conducting research, especially when dealing with human or animal subjects. Ensure that you have the necessary approvals and that your research adheres to ethical standards, respecting confidentiality and obtaining informed consent when required.

By carefully selecting a topic and conducting thorough research, you lay a solid foundation for your manuscript. This preparation phase is crucial to ensuring that your subsequent writing is well-informed, focused, and relevant to your academic field. Taking the time to properly prepare will make the writing process smoother and increase the likelihood of producing a high-quality manuscript.

[20] National Library of Medicine. Accessed on June 13, 2024. Available at: https://pubmed.ncbi.nlm.nih.gov/

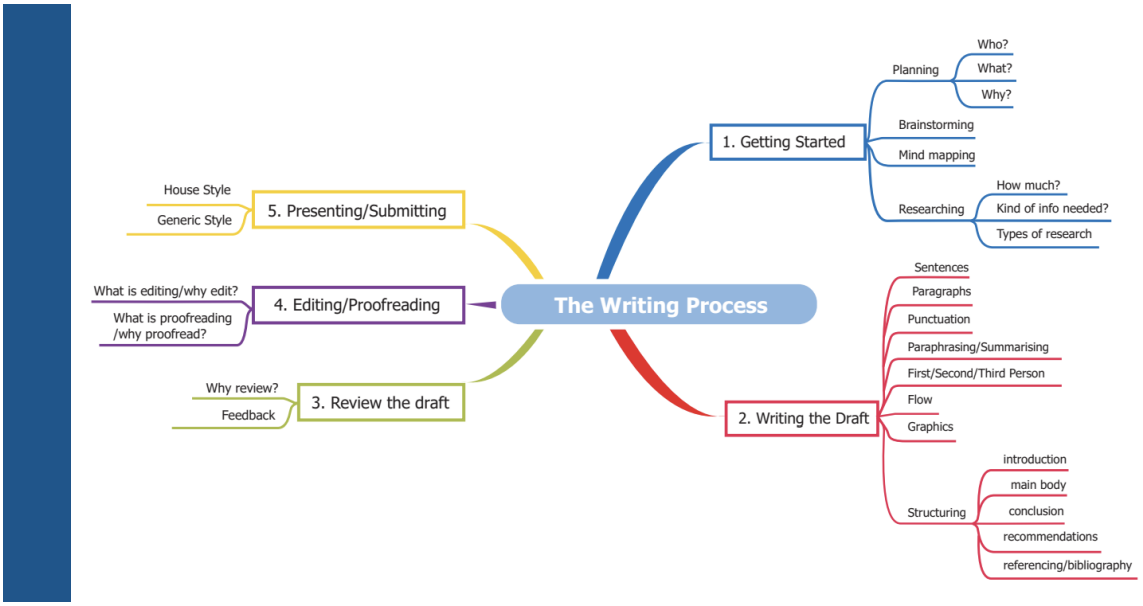


Fig. 6.5 Map of the academic process (Sheehy et al., 2019).

6.1.2 Developing a thesis statement

Developing a strong thesis statement is essential for guiding the direction and focus of your manuscript. Your thesis statement should clearly articulate the main argument or central idea of your research, providing a roadmap for both you and your readers.

To develop an effective thesis statement, start by reflecting on the primary question or problem your research addresses. Consider what you aim to discover, prove, or argue through your study. A well-crafted thesis statement should be specific, concise, and arguable, presenting a clear stance that can be supported with evidence.

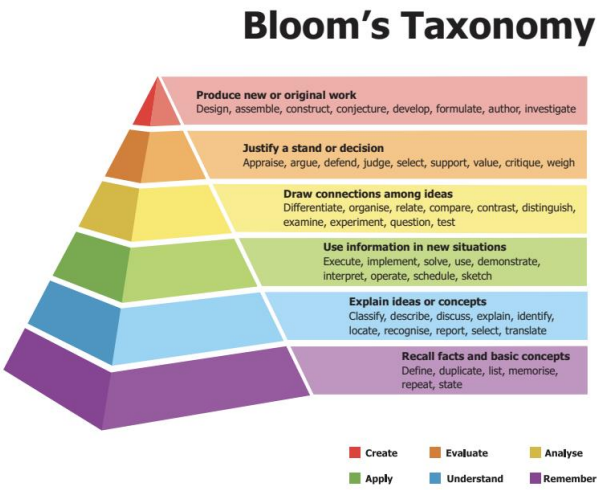


Fig. 6.6 Bloom's taxonomy (Sheehy et al., 2019).

Begin by drafting a preliminary thesis statement that summarises your main argument. As you conduct further research and refine your ideas, revisit and revise your thesis statement to ensure it

accurately reflects the scope and focus of your work. Your thesis statement should evolve as your understanding of the topic deepens and new insights emerge.

Ensure that your thesis statement is clearly stated in the introduction of your manuscript. This helps readers understand the purpose and direction of your research from the outset. Additionally, revisit your thesis statement throughout the writing process to ensure that your argument remains consistent and aligned with your initial goals.

A strong thesis statement not only guides your research but also helps you stay focused and organised. It serves as a reference point for evaluating the relevance and significance of the information you include in your manuscript. By developing a clear and compelling thesis statement, you create a solid foundation for constructing a coherent and persuasive argument.

6.1.3 Creating an outline

Creating an outline is a crucial step in organising your manuscript and ensuring a logical flow of ideas. An effective outline helps you structure your research and writing, making the process more efficient and manageable.

Start by identifying the main sections of your manuscript, typically including the introduction, literature review, methodology, results, discussion, and conclusion. Each section should have a clear purpose and contribute to the overall argument of your manuscript.

Within each section, break down the content into key points and subpoints. For example, in the literature review, identify the major themes and studies you will discuss, and organise them in a logical order. In the methodology section, outline the steps you will take to conduct your research, including data collection and analysis methods.

Use your outline as a roadmap to guide your writing. Begin with a broad overview of each section and gradually add more detail as you develop your manuscript. This helps ensure that your argument progresses logically and that each point builds on the previous one.

An outline also helps you identify any gaps or weaknesses in your argument, allowing you to address them before you begin writing in earnest. It provides a clear framework for organising your thoughts and ensures that you stay focused on your main argument.

As you write, refer back to your outline regularly to stay on track. Be flexible and willing to revise your outline as needed, based on new insights or changes in the direction of your research. A well-structured outline is an invaluable tool for producing a coherent, well-organised manuscript.

In summary, the preparation of an academic manuscript involves selecting a topic and conducting thorough research, developing a clear thesis statement, and creating a detailed outline. These steps provide a strong foundation for your writing, ensuring that your manuscript is focused, organised, and well-supported by evidence. By taking the time to carefully prepare, you increase the likelihood of producing a high-quality manuscript that makes a meaningful contribution to your academic field.

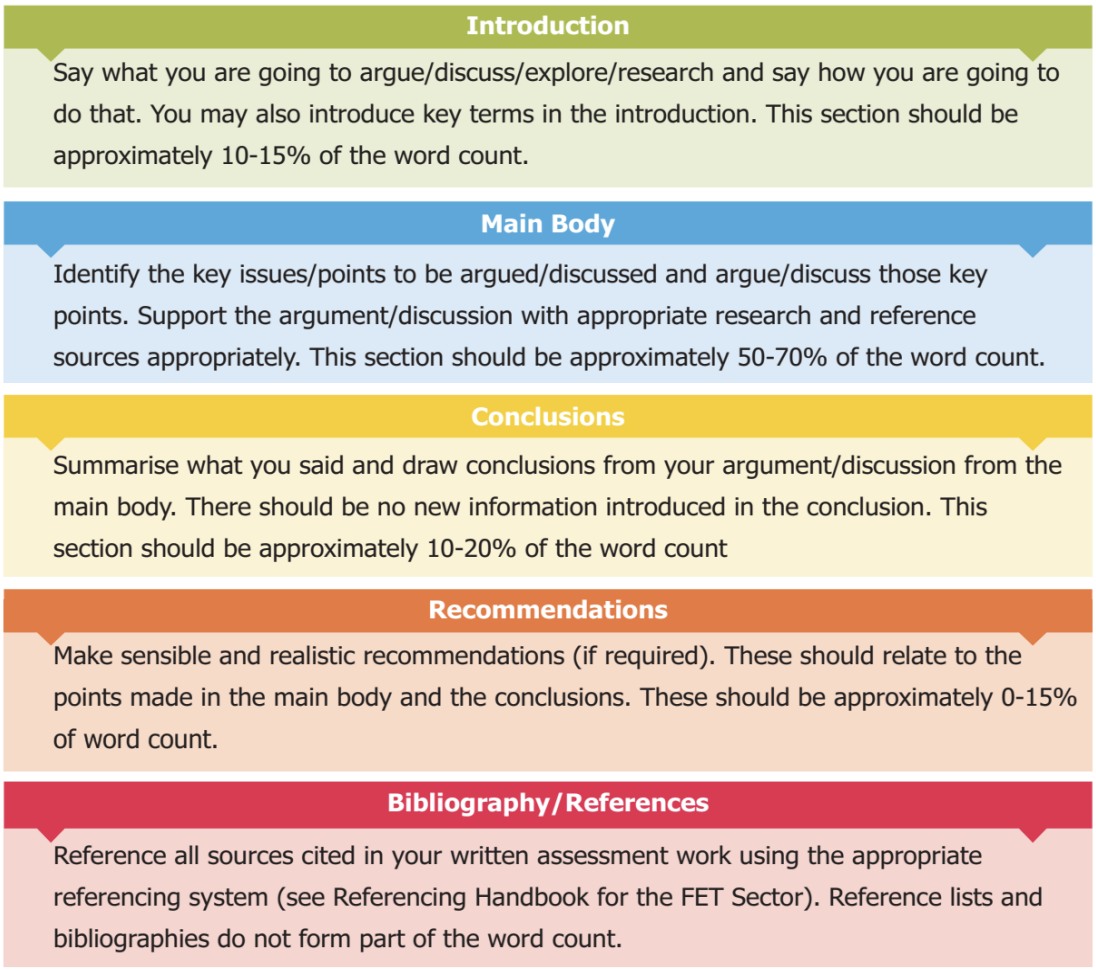


Fig. 6.7 Structure of the manuscript (Sheehy et al., 2019).

6.2 Writing the manuscript

6.2.1 Structuring the manuscript

Structuring your manuscript meticulously is crucial to effectively communicate your research findings in food technology. Each section plays a distinct role in presenting your study's objectives, methodologies, results, interpretations, and implications with precision and clarity.

Author information

Begin your manuscript with a section dedicated to author information, which should include the full names of all contributing authors, their respective affiliations (including department, institution, city, and country), and contact details such as email addresses. Clearly identify the corresponding author, who will serve as the primary point of contact for correspondence regarding the manuscript. This section establishes transparency and accountability in academic publishing, ensuring proper attribution of contributions and facilitating communication between authors and readers.

Title

Crafting an effective title is paramount, as it serves as the first point of engagement for readers and determines the discoverability and relevance of your manuscript in academic databases. Your title should succinctly encapsulate the essence of your research while enticing readers to delve deeper into your study. It should be informative, concise, and accurately reflect the scope and focus of your investigation. Employ keywords strategically to optimise search engine visibility and enhance the accessibility of your work to the scholarly community.

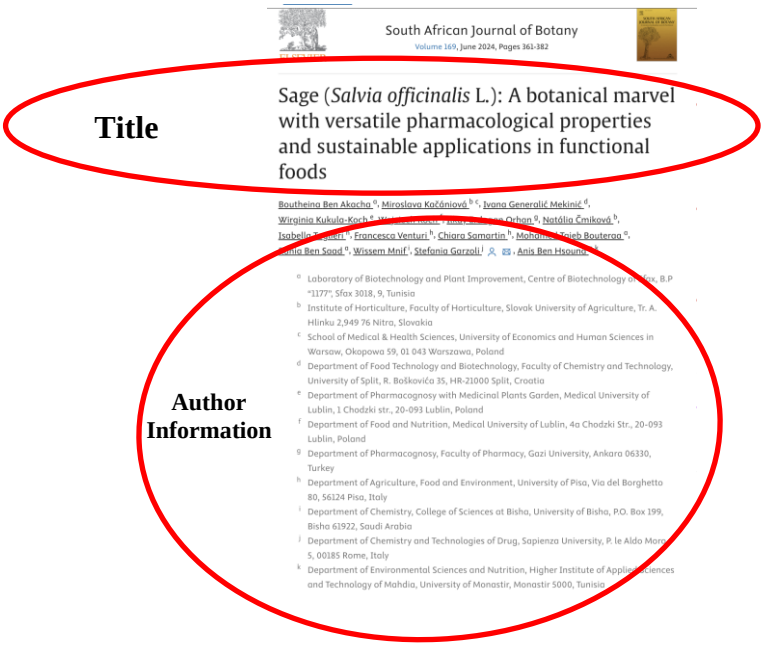
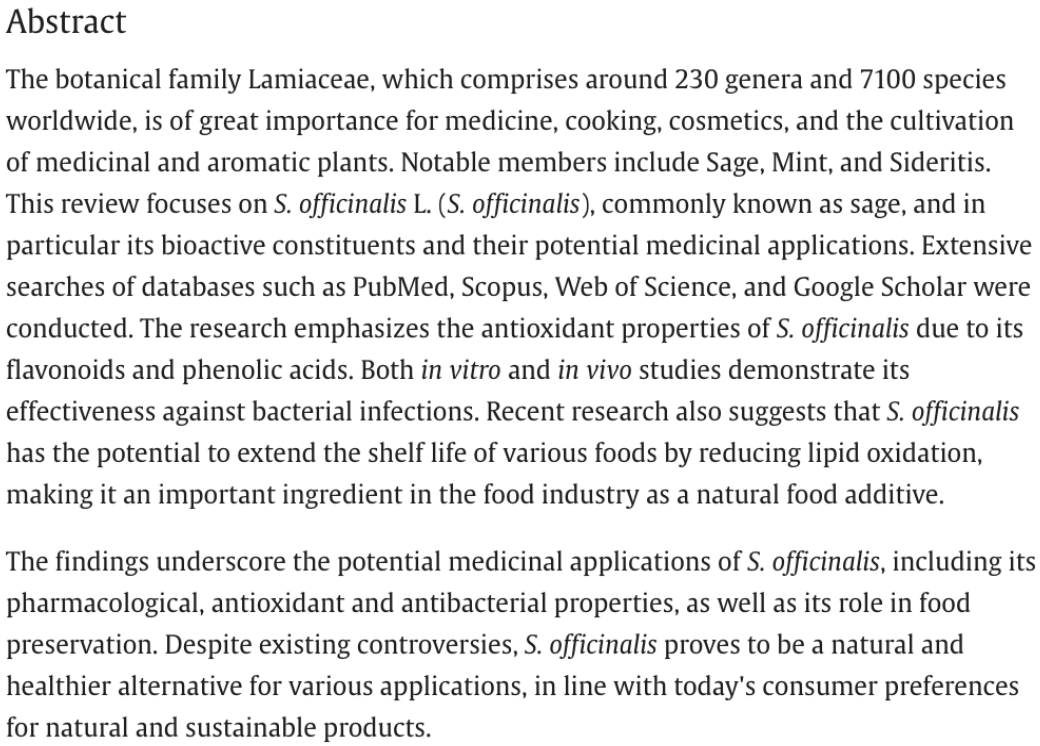


Fig. 6.8 Structure of the manuscript – title and author information (Ben Akacha et al., 2024).

Abstract

The abstract is a concise summary of your entire manuscript, providing a snapshot of the study's background, objectives, methods, results, and conclusions. It serves as a critical entry point for readers, enabling them to quickly grasp the significance and implications of your research. Structure your abstract into distinct sections, including a brief introduction to the research topic, a statement of the research objectives or hypotheses, a summary of the methods employed, a synopsis of key findings, and a succinct conclusion highlighting the study's implications and contributions to the field. Keep your abstract within 250-300 words to maintain consciousness while conveying essential information effectively.



Abstract

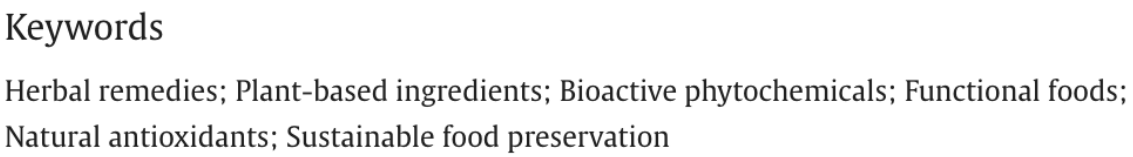
The botanical family Lamiaceae, which comprises around 230 genera and 7100 species worldwide, is of great importance for medicine, cooking, cosmetics, and the cultivation of medicinal and aromatic plants. Notable members include Sage, Mint, and Sideritis. This review focuses on *S. officinalis* L. (*S. officinalis*), commonly known as sage, and in particular its bioactive constituents and their potential medicinal applications. Extensive searches of databases such as PubMed, Scopus, Web of Science, and Google Scholar were conducted. The research emphasizes the antioxidant properties of *S. officinalis* due to its flavonoids and phenolic acids. Both *in vitro* and *in vivo* studies demonstrate its effectiveness against bacterial infections. Recent research also suggests that *S. officinalis* has the potential to extend the shelf life of various foods by reducing lipid oxidation, making it an important ingredient in the food industry as a natural food additive.

The findings underscore the potential medicinal applications of *S. officinalis*, including its pharmacological, antioxidant and antibacterial properties, as well as its role in food preservation. Despite existing controversies, *S. officinalis* proves to be a natural and healthier alternative for various applications, in line with today's consumer preferences for natural and sustainable products.

Fig. 6.9 Example of abstract (Ben Akacha et al., 2024).

Keywords

Keywords are pivotal for enhancing the discoverability and indexing of your manuscript in academic databases and search engines. They should encompass the core concepts, variables, or themes addressed in your study, enabling researchers to locate your work efficiently. Select keywords that are specific, relevant, and representative of the main content of your manuscript. Aim for a balance between breadth and specificity, incorporating terms that capture the breadth of your research while remaining focused on its primary objectives and outcomes. Limit your keyword list to 3-6 terms to ensure clarity and relevance.



Keywords

Herbal remedies; Plant-based ingredients; Bioactive phytochemicals; Functional foods; Natural antioxidants; Sustainable food preservation

Fig. 6.10 Example of keywords (Ben Akacha et al., 2024).

Highlights

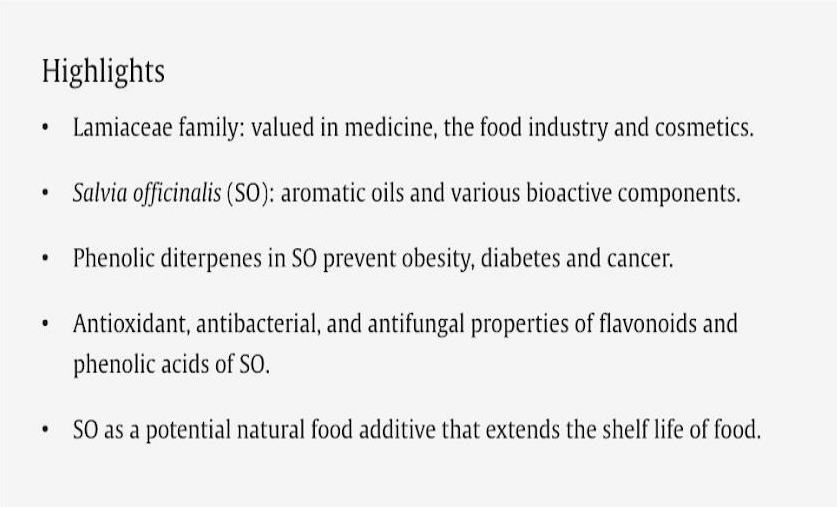
Some journals require a “Highlights” section that summarises the most exciting, interesting points from your manuscript. This is a great opportunity to emphasise the impact and importance of your work! However, it requires a different writing strategy than the one you use.

Highlights are typically written as 3–5 bullet points, each a complete sentence that describes a main result or conclusion of the study. The most common length seems to be approximately 85 characters maximum; although, some journals routinely publish highlights that are slightly longer or may

request a short paragraph instead of bullet points. Here are the questions to answer before you start writing your highlights.

After you have written highlights based on your completed manuscript, you might realise that your manuscript doesn't focus enough on the most exciting findings. This is a great opportunity to substantially edit your manuscript to shift its focus toward the most important or innovative findings. In the end, the highlights and the most emphasised points in the manuscript should match or overlap considerably.

When facing strict word or character limits, it is essential to write concisely. Even if you are well within the journal's limits, keeping the highlights brief will encourage potential readers to look at your work. Ways to reduce word or character count include replacing longer phrases with shorter ones, removing unnecessary words (especially at the beginning of a sentence), and using active voice. Even if you are writing the highlights for experts in your field, use the simplest, clearest words possible to describe your findings. It can be tempting to choose more interesting terms, but complex language may discourage readers from reading the rest of your article. If you choose to use any uncommon abbreviations in your highlights, be sure to define them at first use. Write with your reader in mind, and make it easy for them to learn what you have discovered.



Highlights

- Lamiaceae family: valued in medicine, the food industry and cosmetics.
- *Salvia officinalis* (SO): aromatic oils and various bioactive components.
- Phenolic diterpenes in SO prevent obesity, diabetes and cancer.
- Antioxidant, antibacterial, and antifungal properties of flavonoids and phenolic acids of SO.
- SO as a potential natural food additive that extends the shelf life of food.

Fig. 6.11 Example of highlights (Ben Akacha et al., 2024).

Introduction

The introduction serves as the foundation upon which your research is built, providing readers with a comprehensive understanding of the context, rationale, and significance of your study in food technology. Begin by delineating the broader research area and elucidating the key issues or gaps in knowledge that your study seeks to address within the realm of food technology. Conduct a thorough review of relevant literature, highlighting seminal works, theoretical frameworks, empirical findings, and debates pertinent to your research topic in the field of food technology. Clearly articulate the research question or hypothesis driving your investigation, emphasising its novelty, relevance, and potential contributions to the food technology field. Provide a roadmap for the manuscript, outlining the structure and organisation of subsequent sections to guide readers through the logical progression of your argument.

Fig. 6.12 How to write an Introduction (Portwood-Stacer, 2019).

Example:

"In recent years, there has been a growing interest in the utilization of edible coatings as a sustainable solution for enhancing the shelf life and quality of fresh produce. While edible coatings offer promising benefits in reducing postharvest losses and preserving food freshness, there remains a need for comprehensive research to evaluate their efficacy and application in various food products. This study seeks to address this gap by investigating the impact of edible coatings enriched with natural antimicrobial agents on the shelf life and quality of strawberries during storage. Drawing on existing literature on edible coatings and postharvest preservation, we hypothesize that incorporating natural antimicrobial agents into edible coatings will effectively inhibit microbial growth and extend the shelf life of strawberries. The following sections will detail the research methodology, present the findings of the study, and discuss their implications for food preservation practices and future research."

Materials and Methods

The methods section offers a detailed exposition of the procedural framework, methodologies, and techniques employed to conduct your study in food technology. Provide a comprehensive description of the research design, including its conceptual underpinnings and operationalisation within the context of food technology. Specify the characteristics and selection criteria of materials, samples, or food products used in the study, along with the rationale for their inclusion or exclusion. Detail the procedures, protocols, or interventions implemented during food processing, coating application, storage, and quality evaluation, ensuring clarity, accuracy, and replicability. Discuss any ethical considerations, institutional approvals, or safety measures implemented to ensure the integrity and safety of food products and research participants. Provide justification for the chosen methodologies, addressing their suitability, validity, reliability, and potential limitations in assessing the effectiveness of edible coatings in food preservation.

Example:

"This study employed a randomized controlled trial design to investigate the efficacy of edible coatings enriched with natural antimicrobial agents in preserving the quality and extending the shelf life of strawberries during storage. Freshly harvested strawberries were obtained from local farms and randomly assigned to three treatment groups: (1) strawberries coated with an edible coating enriched with cinnamon essential oil, (2) strawberries coated with an edible coating enriched with oregano extract, and (3) untreated control strawberries. The coating formulations were prepared using food-grade ingredients and applied to the surface of strawberries using a dipping method.

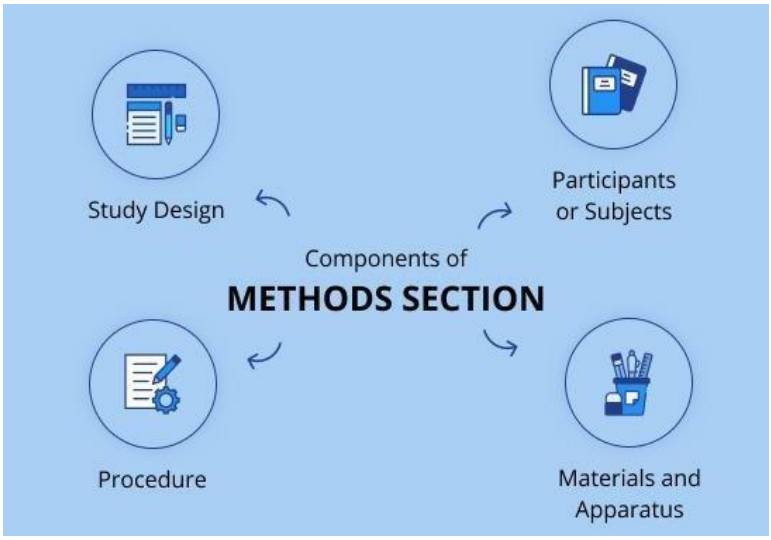


Fig. 6.13 How to write a methods section (Nova, 2024).

The treated and control strawberries were then stored under controlled environmental conditions (temperature, humidity) simulating commercial storage conditions for fresh produce. Sampling was conducted at regular intervals (e.g., every three days) during the storage period, and various quality parameters, including microbial counts, colour attributes, texture, and sensory characteristics, were evaluated using standardised methods. Statistical analyses, including analysis of variance (ANOVA) and Tukey's post-hoc test, were performed to compare the efficacy of different coating treatments in preserving strawberry quality and extending shelf life."

Results

The results section presents the empirical findings and outcomes of your study in a clear, concise, and systematic manner, focusing on the impact of edible coatings on the shelf life and quality of strawberries. Organise the presentation of results logically, adhering to the sequence of research objectives or hypotheses outlined in the introduction. Utilise tables, figures, graphs, or charts to visually represent quantitative data, trends, patterns, or relationships identified in your analysis. Provide textual descriptions and interpretations of key findings, highlighting their significance, magnitude, and implications for food preservation practices and future research in food technology.

Example:

"The quantitative analysis revealed significant differences in microbial growth inhibition among strawberries treated with different edible coatings enriched with natural antimicrobial agents. Both cinnamon essential oil and oregano extract coatings demonstrated superior antimicrobial efficacy compared to the untreated control group ($p < 0.05$). Specifically, strawberries coated with cinnamon essential oil exhibited a 50% reduction in total microbial counts, including aerobic bacteria and fungal pathogens, compared to the control group. Similarly, strawberries coated with oregano extract showed a 40% reduction in microbial counts, indicating a significant antimicrobial effect.

Furthermore, colour, texture, and sensory evaluations demonstrated that strawberries coated with edible coatings maintained their visual appearance, firmness, and flavour attributes significantly longer than the untreated control strawberries. Coatings enriched with cinnamon essential oil and oregano extract exhibited greater retention of colour brightness and firmness, as well as reduced development of off-flavours and odours during storage. These findings underscore the potential of edible coatings enriched with natural antimicrobial agents in preserving the quality and extending the shelf life of strawberries, offering a sustainable solution for reducing postharvest losses and enhancing food safety in the food industry."

Fig. 6.14 How to write a results (Betty, 2024).

Discussion

The discussion section offers a critical analysis and interpretation of the results, contextualising them within the broader theoretical, empirical, and practical landscape of food technology. Begin by synthesising the key findings and insights derived from your analysis, emphasising their alignment or deviation from existing literature and theoretical frameworks in food technology. Interpret the observed patterns, trends, or associations in light of your research objectives, hypotheses, or theoretical perspectives, addressing their theoretical, methodological, or practical implications for food preservation practices. Compare and contrast your findings with previous studies, identifying areas of convergence, divergence, or unresolved questions that warrant further investigation in food technology. Acknowledge any limitations or constraints inherent in your study design, data collection, or analysis, offering reflections on their potential impact and avenues for future research refinement or extension. Conclude the discussion by summarising the key takeaways and

contributions of your study, emphasising their significance for advancing knowledge, informing practice, or shaping policy in the field of food technology.

Example:

"The findings of this study provide compelling evidence of the efficacy of edible coatings enriched with natural antimicrobial agents in preserving the quality and extending the shelf life of strawberries during storage. The significant reductions in microbial growth, maintenance of colour, texture, and sensory attributes observed in coated strawberries underscore the potential of this technology to revolutionise post harvest preservation practices in the food industry. These findings are consistent with previous research on the antimicrobial properties of essential oils and plant extracts, highlighting their broad applicability in food preservation applications."

Figures and tables with captions

Figures and tables are essential visual aids that complement the textual presentation of your research findings, enhancing clarity, accessibility, and interpretability for readers. Select figures and tables judiciously to illustrate key concepts, trends, or relationships identified in your data analysis. Ensure that each figure and table is accompanied by a clear and informative caption that succinctly describes its content and significance. Use descriptive titles and labels to facilitate understanding and interpretation, avoiding excessive jargon or technical terminology. Arrange figures and tables sequentially and reference them appropriately in the text to maintain coherence and continuity in the presentation of your findings.

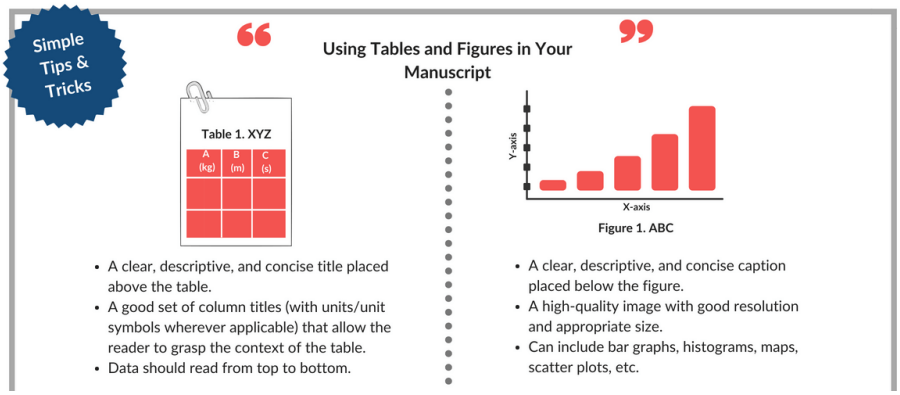


Fig. 6.15 Using tables and figures (Enago Academy, 2018).

Funding Information:

Disclose any sources of funding, financial support, or sponsorship that contributed to the conduct of your research. Provide details about funding agencies, grant numbers, and the role of funders in the study design, data collection, analysis, interpretation, and dissemination. Acknowledge the financial contributions that enabled the execution of the study while ensuring transparency and accountability in reporting potential conflicts of interest or biases.

Author Contributions:

Transparently delineate the contributions of each author to the conception, design, execution, and interpretation of the study. Specify the roles and responsibilities undertaken by each author in drafting and revising the manuscript, analysing data, conducting experiments, and interpreting findings. Acknowledge individual contributions to literature review.

6.2.2 Writing the first draft

Crafting the initial draft of your manuscript is an essential step in transforming your research into a coherent narrative. This phase involves translating your research notes, data analyses, and interpretations into written form, providing the groundwork for subsequent revisions and refinement.

Begin by reviewing your research notes, data transcripts, and analysis outputs to become familiar with the key findings and insights derived from your study. Create a rough outline or sketch of the manuscript structure, organising your content into logical sections based on the standard IMRAD (Introduction, Methods, Results, and Discussion) format or any other relevant structure prescribed by your target journal or publication venue.

Introduction

Start the introduction section by providing a succinct overview of your research topic's significance and relevance within the field. Clearly articulate the research question or objective driving your study, emphasising its novelty, importance, and potential implications. Summarise relevant literature, highlighting key findings, theoretical frameworks, and debates to contextualise your research. Conclude the introduction by outlining the subsequent sections' organisation to guide readers through the manuscript.

Methods

Describe the research design, materials, procedures, and analytical techniques used in your study with clarity and precision. Provide a detailed account of the sampling strategy, sample size calculation, and participant or sample selection criteria. Outline the specific steps and protocols followed during data collection, processing, and analysis to ensure transparency and reproducibility. Discuss any potential sources of bias, confounding, or limitations associated with your chosen methodologies and propose strategies to mitigate these challenges.

Results

Present your study's findings systematically, focusing on key outcomes, trends, or patterns observed in your data analysis. Utilise tables, figures, graphs, or charts to visually represent quantitative results, ensuring clarity and readability. Provide textual descriptions and interpretations of significant findings, highlighting their implications for addressing the research question or hypothesis. Avoid extensive interpretation in this section, as the discussion will provide a more in-depth analysis and interpretation of the findings.

Discussion

Critically analyse and interpret your study's findings within the broader context of existing literature and theoretical frameworks. Synthesise key findings and insights, emphasising their significance and implications for theory, practice, or policy. Compare and contrast your results with previous studies,

identifying areas of agreement, divergence, or ambiguity requiring further investigation. Discuss the theoretical, methodological, and practical implications of your findings, addressing any limitations or constraints inherent in your study design or data analysis. Propose directions for future research, highlighting avenues for extending or refining your study's findings.

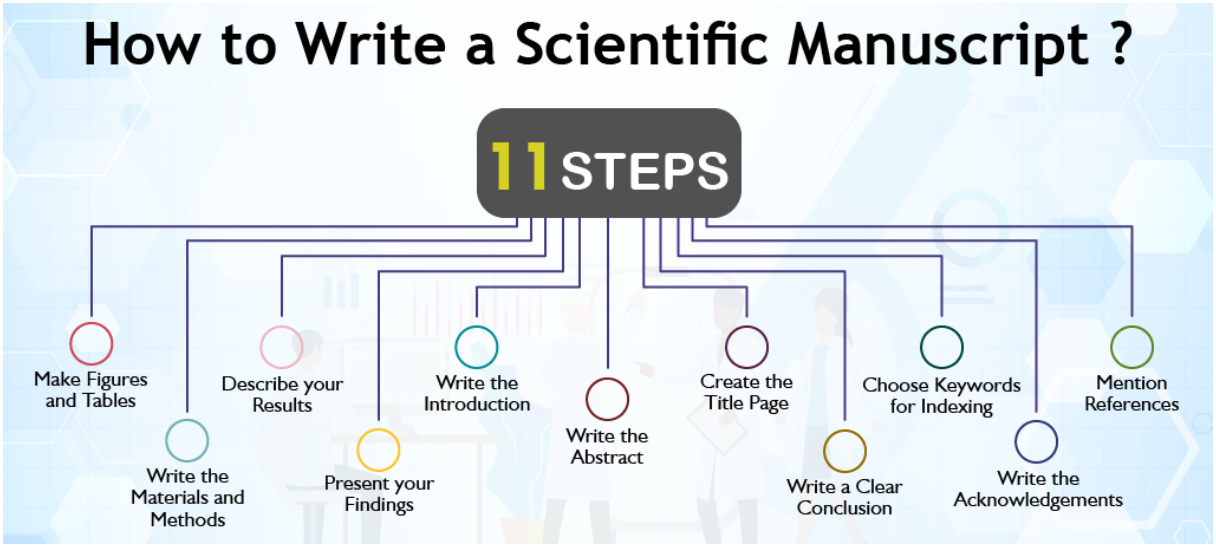


Fig. 6.16 Writing the first draft.[21]

6.3 Editing the manuscript before submission

6.3.1 Revising for content and structure

Revising for content and structure is the first step in refining your manuscript. It involves critically evaluating the organisation, coherence, and logical flow of your writing. Start by reviewing the overall structure to ensure a logical progression from introduction to conclusion. Consider whether each section effectively contributes to the overall argument or narrative of your manuscript. Pay attention to the clarity of content within each section, ensuring that the research objectives, methodology, findings, and conclusions are clearly articulated. Seek feedback from colleagues or mentors to identify any gaps or weaknesses in your manuscript's content and structure. Incorporate constructive feedback to refine and strengthen your manuscript further.

6.3.2 Language editing

Language editing focuses on refining the clarity, conciseness, and effectiveness of your writing. Clarify sentences and phrases to improve readability and comprehension. Avoid technical jargon and convoluted language that may hinder understanding. Enhance grammar and syntax by ensuring correctness in sentence structure, verb agreement, and punctuation. Choose precise and appropriate

[21] 11 Steps on How to write a Scientific Manuscript. Accessed on June 16, 2024. Available at: https://www.wordsdoctorate.com/blog-details/11-steps-on-how-to-write-a-scientific-manuscript/

words to convey your ideas effectively. Maintain consistency in writing style, tone, and voice throughout the manuscript. Address language bias by using inclusive and gender-neutral language where applicable. Engage with language specialists or professional editors to further refine the language and style of your manuscript.

6.3.3 Proofreading

Proofreading is the final step in the editing process, focusing on identifying and correcting errors in spelling, grammar, punctuation, and formatting. Review spelling and grammar using spell-checking tools and proofread the manuscript carefully to catch grammatical mistakes, typos, and syntax errors. Check punctuation and formatting for consistency and accuracy, including headings, font styles, and indentation. Verify the accuracy of references against the original sources, ensuring that all in-text citations correspond to entries in the reference list and follow the prescribed citation style. Confirm compliance with guidelines by referring back to the publisher's requirements and ensuring adherence to formatting and submission instructions.

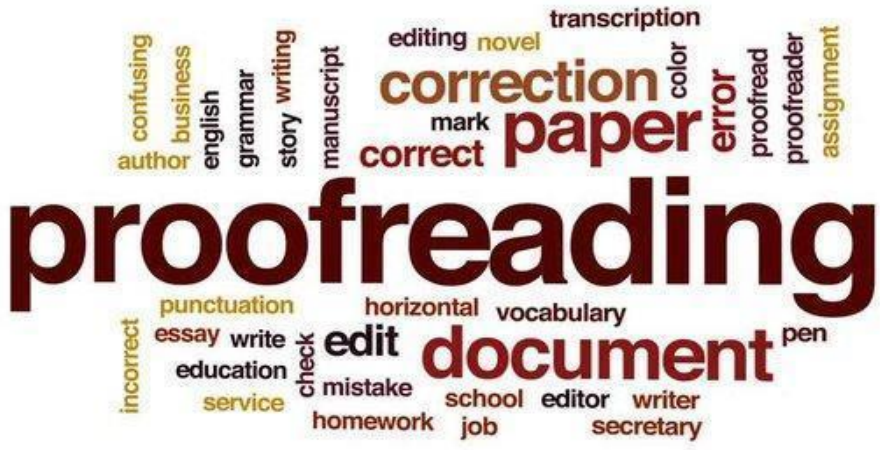


Fig. 6.17 What is proofreading?[22]

6.4 Formatting manuscript according to publisher's requirements

Ensuring your manuscript adheres to the publisher's guidelines is crucial for presenting your research professionally and facilitating the review process. Below are detailed steps on formatting your manuscript according to publisher requirements, including examples for various citation styles and variations in referencing styles within the text.

[22] Revising, Editing, and Proofreading. Writingservice ae. Accessed on June 16, 2024. Available at: https://writingservice.ae/blog/revising-editing-proofreading/

Review publisher guidelines

Carefully examine the publisher's submission guidelines for specific instructions on formatting, manuscript length, file format, font size, and citation style. Each publisher may have distinct requirements that authors must follow.

Example:

- Publisher A requires manuscripts to be submitted in Microsoft Word format, using 12-point Times New Roman font, with 1.5 line spacing, and APA citation style.
- Publisher B prefers manuscripts to be submitted in LaTeX format, with single line spacing, and IEEE citation style.

Use standard formatting guidelines

Employ standard formatting guidelines for academic manuscripts to ensure consistency and readability. Guidelines typically include font type, size, line spacing, and margin specifications.

Example:

- *Font: Times New Roman*
- *Font Size: 12 points*
- *Margins: 1 inch on all sides*
- *Line Spacing: Double-spaced*

Title page

Craft a title page containing the manuscript title, author names, affiliations, corresponding author details, and any acknowledgments or funding disclosures. Maintain consistency in author names and affiliations across all documents.

Example:

- *Title: "The Impact of Renewable Energy on Climate Change Mitigation"*
- *Authors: John Smith, Jane Doe*
- *Affiliations: Department of Environmental Science, University of XYZ*
- *Corresponding Author: John Smith (email: john.smith@example.com)*

Abstract and keywords

Compose an abstract summarising the key findings and implications of your research. Include a list of keywords that capture the essence of the manuscript to facilitate discoverability.

Example:

- *Abstract: "This study explores the effectiveness of renewable energy initiatives in mitigating climate change..."*
- *Keywords: Renewable Energy, Climate Change, Mitigation Strategies, Sustainability*

Fig. 6.18 Guideline (Frenté, 2023).

Main text

Organise the main text into sections such as Introduction, Methods, Results, Discussion, and Conclusion. Utilise subheadings to delineate subsections within each main section.

Example:

- *Introduction: Provides background information and research objectives.*
- *Methods: Describes the research design and methodology.*
- *Results: Presents the research findings.*
- *Discussion: Analyses the results and their implications.*
- *Conclusion: Summarises the main findings and suggests future research directions.*

Figures and tables

Ensure all figures and tables are clear, legible, and appropriately labelled. Include descriptive captions for each figure and table to elucidate their content and significance.

Example:

- *Figure 1: Global Distribution of Renewable Energy Sources*
- *Table 1: Summary of Survey Responses*

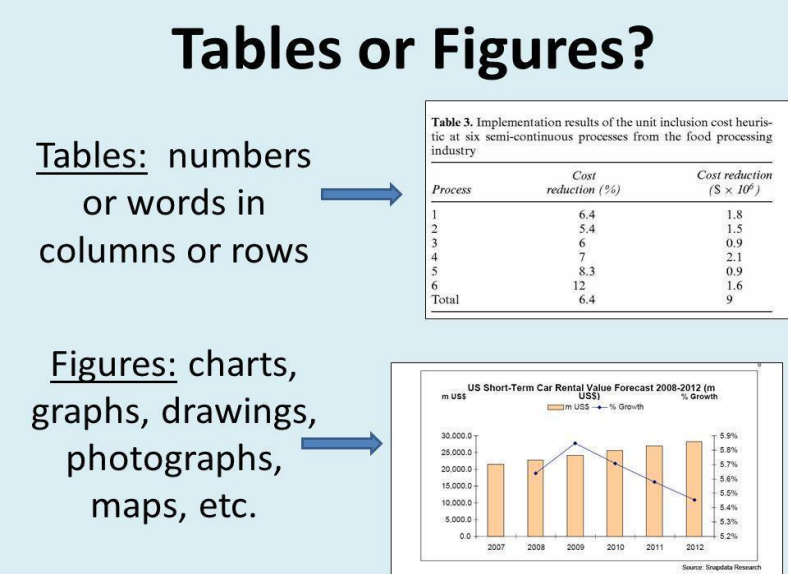


Fig. 6.19 Tables or figures? (Franz, n.d.).

References

Format citations and references according to the designated citation style specified by the publisher. Use citation management tools to ensure consistency and accuracy. In some journals, references may be listed in the text using the author's surname and year of publication in brackets (e.g. Smith, 2020) and then in the list of references used, authors will be listed alphabetically. In others, numerical citations may be required in the text, for example [1], and in the list of references they will be ordered in the order in which they were used in the text.

Example References:

APA Style:

- Book: Smith, J. (2020). *The Art of Writing*. Publisher.
- Journal Article: Johnson, A., & Doe, B. (2019). The Impact of Technology. *Journal of Science, 10*(2), 123-135.
- Website: National Institute of Health. (2020). Understanding Health. Retrieved from https://www.nih.gov/understanding-health

MLA Style:

- Book: Smith, John. *The Art of Writing*. Publisher, 2020.

- Journal Article: Johnson, Alice, and Brian Doe. "The Impact of Technology." *Journal of Science*, vol. 10, no. 2, 2019, pp. 123-135.
- Website: National Institute of Health. "Understanding Health." National Institute of Health, 2020, https://www.nih.gov/understanding-health.

Chicago Style:

- Book: Smith, John. *The Art of Writing*. Publisher, 2020.
- Journal Article: Johnson, Alice, and Brian Doe. "The Impact of Technology." *Journal of Science* 10, no. 2 (2019): 123-135.
- Website: National Institute of Health. "Understanding Health." https://www.nih.gov/understanding-health. Accessed Date.

Fig. 6.20 Citation styles (Jain, n.d.).

Supplementary materials

Include supplementary materials such as additional data, figures, tables, or appendices, if necessary, following the publisher's guidelines.

Example:

- *Supplementary Figure S1: Additional Results*
- *Supplementary Table S1: Detailed Data Analysis*

Proofreading

Thoroughly proofread the manuscript for grammar, spelling, punctuation, and formatting errors. Consider seeking feedback from colleagues or mentors to enhance clarity and coherence.

Example:

- *Proofreading Tip: Utilise spelling and grammar check tools to identify and correct errors.*

Compliance with ethical standards

Ensure compliance with ethical standards, including obtaining permissions for copyrighted materials.

Fig. 6.21 Ethical standards.[23]

6.4.1 Using Zotero for citation management

Zotero is a powerful citation management tool that can streamline the process of managing references in your manuscript. By utilising Zotero, you can efficiently collect, organise, and cite sources while writing your manuscript. Here's how to use Zotero effectively for citation management:

1. **Installation and setup:** Start by downloading and installing Zotero on your computer. Create an account to sync your library across multiple devices for seamless access.
2. **Adding references:** Use Zotero's browser extension or desktop application to add references from academic databases, websites, or PDFs. Organise your references into folders or collections based on the topic or theme of your manuscript.
3. **Citing sources:** When writing your manuscript, use Zotero's citation plugin for word processors (e.g. Microsoft Word or Google Docs) to insert in-text citations and generate a

[23] The Office of Ethics and Compliance. Stanford University. Accessed on June 16, 2024. Available at: https://oec.stanford.edu/seven-elements-ethics-and-compliance-excellence

bibliography automatically. Choose the citation style specified by the publisher to ensure consistency and accuracy.

4. **Formatting bibliography:** Customise the bibliography formatting style within Zotero to match the requirements of the publisher. Adjust citation styles, fonts, and spacing as needed to comply with the publisher's guidelines.
5. **Updating references:** Regularly update your Zotero library to ensure that all references are accurate and up-to-date. Check for any changes in author names, publication dates, or URLs to maintain the integrity of your citations.

Getting started

- Download and install Zotero from the official website (https://www.zotero.org/).
- Install the Zotero Connector browser extension for easy saving of web pages and online resources.
- Create a Zotero account to sync your library across multiple devices.

Adding sources to your library

- Use the Zotero Connector to save references from web pages, journal articles, books, and other online sources directly to your Zotero library.
- Manually add sources by entering the bibliographic information into Zotero.

Organizing your library

- Create collections to organise your sources by topic, project, or any other relevant category.
- Use tags to further classify and categorise your sources within collections.
- Arrange sources within collections manually or automatically by date, author, or title.

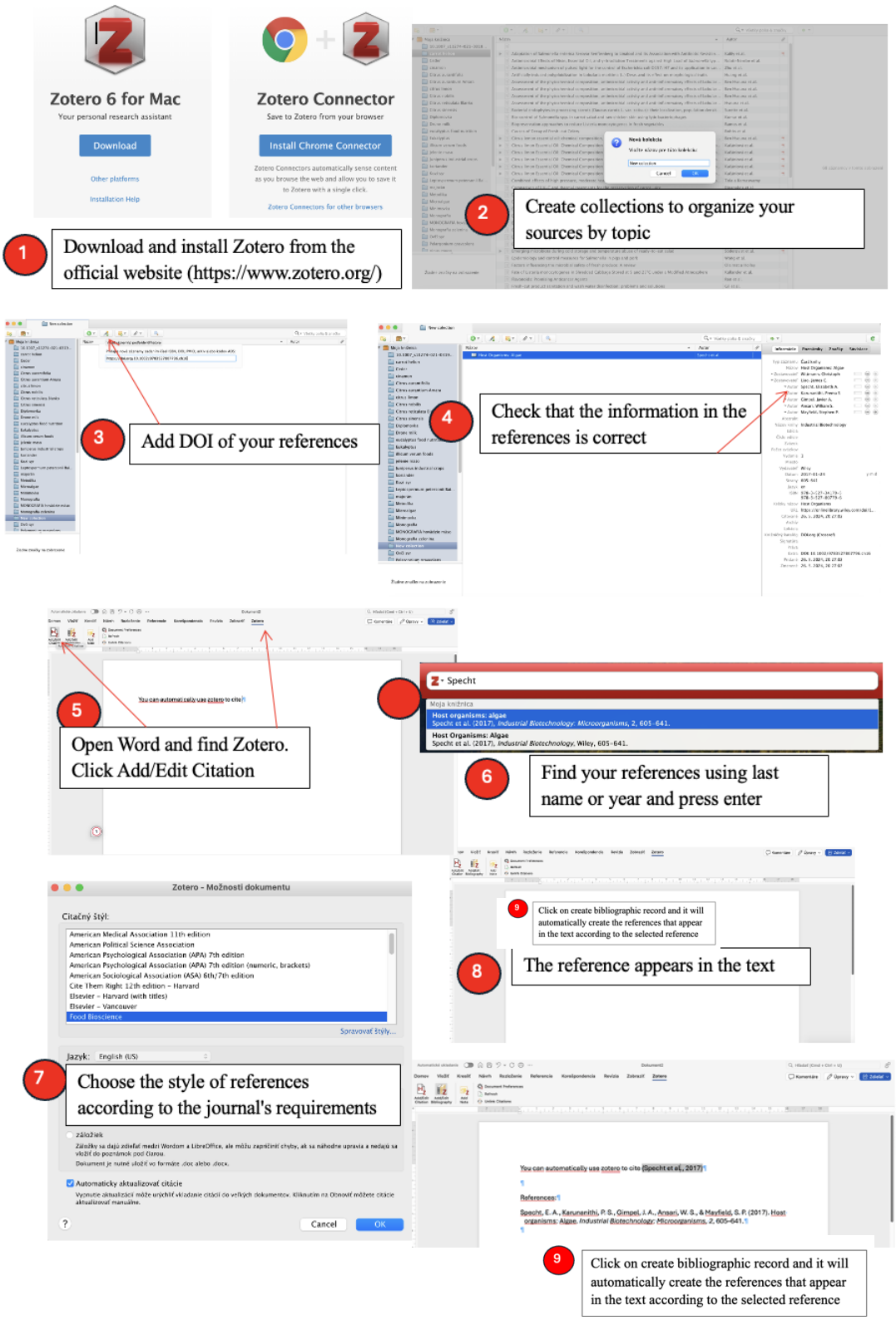


Fig. 6.22 How to use Zotero?

Managing citations and bibliographies

- Use Zotero to generate citations and bibliographies in a variety of citation styles, including APA, MLA, Chicago, and more.

- Install the appropriate word processor plugin (e.g. Zotero for Word) to easily insert citations and bibliographies into your documents.
- Customise citation styles and manage citation formatting options according to your preferences.

Collaborating and sharing

- Share your Zotero library with collaborators to facilitate collaborative research projects.
- Set permissions to control who can view and edit your shared library.
- Use group libraries to collaborate with specific teams or research groups.

6.4.2 Adhering to specific formatting guidelines

Each publisher may have specific formatting guidelines for manuscripts, including requirements for margins, fonts, spacing, headings, and reference styles. It's essential to carefully review and adhere to these guidelines to ensure that your manuscript meets the publisher's expectations. Here's how to adhere to specific formatting guidelines effectively:

1. **Review publisher's instructions:** Start by carefully reviewing the publisher's instructions for authors, which typically outline formatting requirements for manuscript submission. Pay close attention to details such as page layout, font size, line spacing, and citation style.
2. **Formatting text:** Format the text of your manuscript according to the specified font, size, and style. Use standard fonts such as Times New Roman or Arial, and adjust the font size as instructed by the publisher.
3. **Setting margins and spacing:** Set the margins and spacing of your document to meet the publisher's requirements. Ensure that there is adequate space between paragraphs, headings, and sections for readability.
4. **Including headings and subheadings:** Use consistent formatting for headings and subheadings throughout the manuscript. Follow the publisher's guidelines for the hierarchy of headings and the formatting of each level.
5. **Formatting tables and figures:** Format tables and figures according to the publisher's specifications regarding size, alignment, and labelling. Provide clear captions and ensure that tables and figures are referenced appropriately within the text.
6. **Finalising references:** Double-check the formatting of your references to ensure compliance with the publisher's preferred citation style. Make any necessary adjustments to citation formatting, bibliography layout, and reference list entries.

By meticulously adhering to the publisher's specific formatting guidelines, you can ensure that your manuscript meets the required standards for submission and publication.

6.5 Submitting the manuscript

Submitting your manuscript to a journal is the final step in the publication process. This section covers preparing the submission package and navigating the submission process effectively.

Fig. 6.23 Manuscript submission mistakes (Young, 2023).

6.5.1 Preparing the submission package

Preparing a comprehensive submission package ensures that your manuscript is ready for a review by the journal's editorial team. Here's how to assemble a complete submission package:

1. **Manuscript:** Your manuscript should be the central component of the submission package. Ensure that it is the final version, polished and free of errors. Format your manuscript according to the journal's guidelines, including margins, font size, line spacing, and citation style. Pay attention to details such as the title page, abstract, main text, figures, tables, and references.
2. **Cover letter:** Craft a well-written cover letter addressed to the editor-in-chief or handling editor of the journal. The cover letter serves as your introduction to the editor and provides an opportunity to highlight the significance of your research. Clearly state the purpose of your submission, summarise the key findings of your manuscript, and explain why it is a good fit for the journal. Include any additional information requested by the journal, such as conflicts of interest, funding sources, or ethical considerations.
3. **Author information:** Provide complete author information for all contributors to the manuscript. Include full names, affiliations, email addresses, and ORCID identifiers for each author. Ensure that the order of authors reflects their contributions to the research and that all authors have approved the final version of the manuscript for submission.
4. **Supplementary materials:** If your manuscript includes supplementary materials such as data sets, figures, tables, or multimedia files, ensure that they are properly organised and clearly

labelled. Include a separate file or folder for supplementary materials and provide instructions for reviewers on how to access and interpret these materials.

5. **Ethical statements:** Include any required ethical statements as specified by the journal. Declarations of conflicts of interest, funding sources, or adherence to ethical guidelines for research involving human or animal subjects should be clearly stated. Ensure that all ethical considerations are addressed transparently and accurately.
6. **Permissions:** If your manuscript includes copyrighted materials such as figures, tables, or excerpts from other publications, obtain permission from the copyright holder to reproduce these materials in your manuscript. Include documentation of permissions obtained or indicate that materials are used with permission.
7. **Checklist:** Use a submission checklist to ensure that all required components of the submission package are included and that all formatting and ethical guidelines have been followed. Double-check each item before finalising your submission to avoid delays or rejection due to missing information.

6.5.2 Navigating the submission process

Navigating the submission process can vary depending on the journal's submission system and editorial workflow. Here are detailed steps to follow when submitting your manuscript:

1. **Selecting a journal:** Choose a journal that is a good fit for your research based on factors such as scope, audience, impact factor, and editorial policies. Review the journal's author guidelines and submission instructions carefully to ensure that your manuscript meets their requirements.
2. **Creating an account:** If you haven't already done so, create an account on the journal's submission system. Provide accurate information and follow the prompts to set up your author profile. This account will allow you to track the progress of your submission and communicate with the editorial team.
3. **Uploading manuscript:** Use the submission system to upload your manuscript and any accompanying files. Follow the instructions provided to enter metadata such as title, abstract, keywords, and author information. Verify that all information is accurate and up-to-date before proceeding.
4. **Reviewing submission details:** Before finalising your submission, review all submission details carefully. Ensure that all components of the submission package are included and that formatting requirements have been met. Make any necessary corrections or additions to the submission package.
5. **Submitting manuscript:** Once you are satisfied with the submission details, submit your manuscript through the journal's submission system. Take note of any confirmation or tracking numbers provided by the system for future reference. Some journals may require payment of an article processing charge (APC) at this stage.
6. **Tracking submission status:** Monitor the status of your submission through the journal's submission system. Check for updates on the editorial review process, such as manuscript assignment, peer review, and editorial decision. Be prepared to respond promptly to any requests for revisions or additional information from the editorial team.

7. **Communicating with Editors:** Maintain open communication with the journal's editorial team throughout the submission process. Respond promptly to any enquiries or requests for clarification, and meet any deadlines set by the editors. Be professional and courteous in all communications, and provide any requested revisions or additional information in a timely manner.

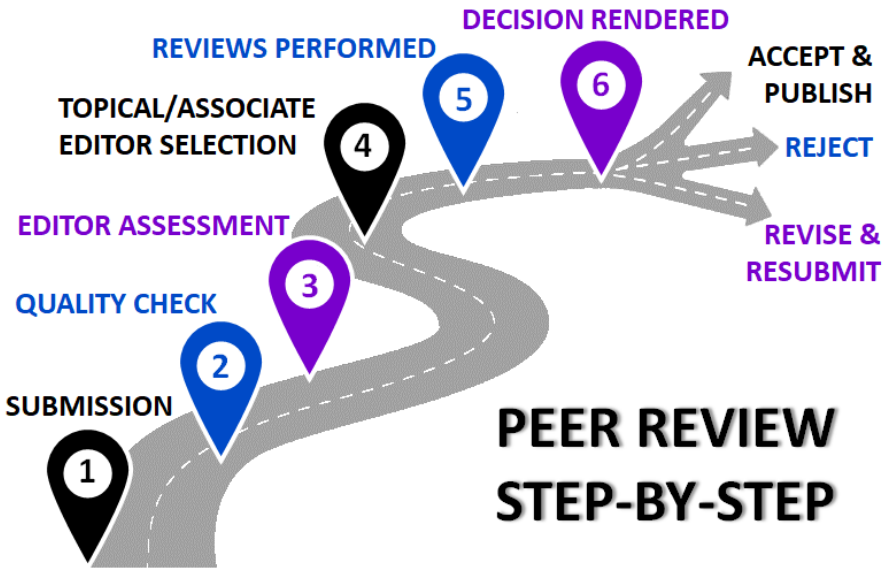


Fig. 6.24 Peer review step-by-step.[24]

6.6 Communication with editors and reviewers

6.6.1 Initial communication

When reaching out to editors and reviewers, ensure your email is professional, informative, and personalised. Here's a more detailed breakdown with examples:

Email Subject Line: "Submission of Manuscript for Consideration: [Title of Manuscript]"

Salutation: Dear Dr Smith,

Introduction: Dear Dr Smith,

I hope this email finds you well. My name is Emily Johnson, and I am a postdoctoral researcher at the Department of Neuroscience, University of XYZ. I am writing to submit our manuscript entitled

[24]How to navigate the peer-review process? Academic Writing and Authentic Publication for Medical Professionals. Accessed on June 16, 2024. Available at: https://www.linkedin.com/pulse/how-navigate-peer-review-process-academic-writing-and-authentic-pub

"Neuroplasticity Mechanisms in Alzheimer's Disease" for consideration for publication in Brain Research.

Manuscript details: The manuscript is a research article comprising 6000 words. It includes an abstract and covers topics such as the role of neuroplasticity in Alzheimer's disease progression and potential therapeutic interventions.

Rationale for submission: Our manuscript presents novel findings on the neuroplasticity mechanisms underlying Alzheimer's disease pathology. We believe it will make a significant contribution to the field by advancing our understanding of disease mechanisms and identifying potential targets for intervention.

Relevance to journal scope: Given Brain Research's focus on neuroscience research and its impact on clinical practice, we believe our manuscript aligns well with the journal's aims and objectives. It builds upon previous work published in Brain Research by integrating neuroimaging data with clinical outcomes to provide a comprehensive analysis of neuroplasticity in Alzheimer's disease.

Closing: Thank you for considering our manuscript for publication. Please find attached the manuscript for your review. Should you require any further information or have any questions, please do not hesitate to contact me at emily.johnson@email.com or +1234567890.

Best regards,

Emily Johnson

6.6.2 Writing a cover letter for submission

Crafting a comprehensive cover letter provides context and highlights the significance of your manuscript. Here's a more detailed example:

Header: Emily Johnson Postdoctoral Researcher Department of Neuroscience University of XYZ emily.johnson@email.com Date: [Insert Date]

Dr Jane Smith Editor-in-Chief Brain Research Journal Address

Salutation: Dear Dr Smith,

Introduction: I am pleased to submit our manuscript entitled "Neuroplasticity Mechanisms in Alzheimer's Disease" for consideration for publication in Brain Research. As the corresponding author, I attest that all co-authors have approved the manuscript for submission.

Rationale for submission: Our manuscript presents original research findings on the neuroplasticity mechanisms underlying Alzheimer's disease pathology. Through a combination of neuroimaging analyses and clinical assessments, we demonstrate significant alterations in brain plasticity associated with disease progression.

Relevance to journal scope: Given Brain Research's focus on neuroscience research and its translation into clinical practice, we believe our manuscript will be of interest to your readership. It builds upon previous work published in Brain Research by providing novel insights into the neurobiology of Alzheimer's disease and its implications for therapeutic interventions.

Suggested reviewers: (Optional) Based on their expertise in neuroplasticity and Alzheimer's disease research, we suggest the following potential reviewers for our manuscript:

1. Dr Michael Brown, Professor of Neuroscience, University of ABC Justification: Dr Brown's research focuses on neuroplasticity mechanisms in neurodegenerative diseases, making him well-suited to evaluate our manuscript.
2. Dr Sarah Johnson, Associate Professor of Neurology, XYZ Hospital Justification: Dr Johnson has expertise in clinical neuroimaging techniques and has published extensively on Alzheimer's disease, making her an ideal reviewer for our study.

Closing: Thank you for considering our manuscript for publication in Brain Research. We look forward to your feedback and the opportunity to contribute to the journal.

Sincerely,

Emily Johnson

Fig. 6.25 Cover letter (Herrity, 2023).

6.6.3 Suggesting possible reviewers

While optional, suggesting potential reviewers can facilitate the peer review process. Here's a more detailed example:

Example: *Based on their expertise and impartiality, we recommend the following potential reviewers for our manuscript:*

1. *Dr Michael Brown Professor of Neuroscience University of ABC Email: michael.brown@email.com Justification: Dr Brown's research focuses on neuroplasticity mechanisms in neurodegenerative diseases, including Alzheimer's disease. He has published extensively in this area and has served as a reviewer for similar manuscripts in Brain Research.*
2. *Dr Sarah Johnson Associate Professor of Neurology XYZ Hospital Email: sarah.johnson@email.com Justification: Dr Johnson has expertise in clinical neuroimaging techniques and has conducted research on neuroplasticity alterations in Alzheimer's disease patients. Her impartiality and experience make her a suitable candidate for reviewing our manuscript.*
3. *Dr David Lee Senior Scientist National Institute of Neurological Disorders and Stroke (NINDS) Email: david.lee@email.com Justification: Dr Lee's research interests include synaptic plasticity and neurodegenerative diseases. His expertise in the field and previous experience as a reviewer make him a valuable addition to the peer review process.*

6.6.4 Preparing responses to reviewer comments

Responding to reviewer comments requires careful consideration and thorough responses to address each point raised. Here's a detailed approach to preparing responses:

Review the comments: Carefully read through each reviewer's comments and suggestions, noting any areas of agreement or disagreement.

Organise responses: Group similar comments together and prioritise them based on their significance to the manuscript's revision.

Address each point: Provide clear, detailed responses to each comment, indicating whether you agree with the suggestion and explaining the changes made or the rationale for maintaining certain aspects of the manuscript.

Provide supporting evidence: When appropriate, provide additional data, references, or explanations to support your responses to reviewer comments.

Be concise: Keep your responses concise and focused, avoiding unnecessary repetition or overly technical language.

Express appreciation: Express gratitude to the reviewers for their time and feedback, even if you may disagree with some of their comments.

Example response:

Reviewer Comment: "The methodology section needs clarification regarding the sample size calculation and statistical analysis methods."

Response: Thank you for your comment. We have revised the methodology section to provide more clarity on the sample size calculation, including the rationale for the chosen sample size and the statistical analysis methods employed. We have also added references to relevant literature supporting our approach.

Reviewer 2

In general, I did not find this study to make a valuable contribution to the literature or to science.

Author response: While we appreciate the reviewer's feedback, we respectfully disagree. We think this study makes a valuable contribution to the field because [describe the knowledge gained, insights provided, questions answered, etc. by your study and/or its results or findings].

1. Comment from Reviewer 2 asking for discussion or analyses that are not possible given constraints on the data available.

Author response: Thank you for pointing this out. Although we agree that this is an important consideration, it is [beyond the scope / not appropriate for inclusion / cannot be analyzed] in this manuscript because [provide a justification for why the content cannot be added to the manuscript].

Fig. 6.26 Responses to Reviewer (Bahnik, 2019).

6.6.5 Revising the manuscript based on feedback

Revising the manuscript based on reviewer feedback is a critical step in the publication process. Here's how to approach the revision process:
Review feedback: Carefully review the feedback provided by the reviewers, noting areas where revisions are needed and considering how to address each comment effectively.
Make revisions: Implement changes to the manuscript as suggested by the reviewers, ensuring that each revision improves the clarity, accuracy, and overall quality of the manuscript.
Maintain consistency: Ensure that revisions are consistent throughout the manuscript, maintaining a coherent narrative and logical flow of information.
Seek clarification: If you have any questions or uncertainties about specific reviewer comments, seek clarification from the reviewers or the journal's editorial team.
Example revision:
Reviewer Comment: "The results section would benefit from additional data visualisation to enhance understanding of the findings."
Revision: We have revised the results section to include additional data visualisation, including bar graphs and scatter plots, to enhance the presentation of our findings. These visualisations provide a clearer representation of the data and facilitate interpretation by the reader.

6.6.6 Writing a second cover letter for resubmission

When submitting a revised manuscript, it's important to provide a second cover letter to accompany the resubmission. Here's how to structure the cover letter:
Header: Include your contact information and the date of resubmission.
Salutation: Address the editor-in-chief or handling editor by name.

Introduction: Briefly reintroduce the manuscript and summarise the revisions made in response to reviewer feedback.
Highlight changes: Provide a detailed overview of the changes made to the manuscript, including specific sections that were revised and the rationale for the revisions.
Express gratitude: Express gratitude to the reviewers for their constructive feedback and to the editorial team for the opportunity to revise and resubmit the manuscript.
Example second cover letter:
[Your Name] [Your Affiliation] [Your Email Address] [Date of Resubmission]
Dr Jane Smith Editor-in-Chief Brain Research Journal Address
Dear Dr Smith,
I am writing to resubmit our manuscript entitled "Neuroplasticity Mechanisms in Alzheimer's Disease" following revisions based on the feedback provided by the reviewers. We appreciate the opportunity to revise and resubmit the manuscript for further consideration.
In response to the reviewers' comments, we have made several revisions to the manuscript to address their concerns and improve the clarity and quality of the presentation. Specifically, we have revised the methodology section to provide additional clarification on the sample size calculation and statistical analysis methods. We have also enhanced the results section with additional data visualisation to facilitate understanding of the findings.
We would like to express our gratitude to the reviewers for their constructive feedback and to the editorial team for their consideration of our manuscript. We believe that the revisions made have strengthened the manuscript and addressed the concerns raised by the reviewers.
Thank you for considering our revised manuscript for publication in Brain Research.
Sincerely,
[Your Name]

6.7 Further communication

6.7.1 Addressing additional reviewer feedback

After resubmitting the revised manuscript, reviewers may provide additional feedback or request further revisions. Here's how to address this feedback:

Review feedback: Carefully review any additional feedback provided by the reviewers, noting any new comments or suggestions for revision.

Prioritise revisions: Prioritise revisions based on the significance of the feedback and its potential impact on the manuscript's quality and clarity.

Communicate with editors: If you have questions or concerns about specific reviewer comments, communicate with the editors to seek clarification or guidance.

Revise manuscript: Implement revisions to the manuscript as needed, ensuring that each revision improves the clarity, accuracy, and overall quality of the manuscript.

Example response:

Reviewer Comment: "The discussion section lacks critical analysis of the study limitations and potential implications for future research."

Response: Thank you for your feedback. We have revised the discussion section to include a more comprehensive analysis of the study limitations and the potential implications for future research. We have highlighted areas where further investigation is warranted and discussed the potential impact of our findings on clinical practice.

Fig. 6.27 Reviewer feedback.[25]

6.7.2 Resubmitting the manuscript

When resubmitting the manuscript after addressing additional reviewer feedback, follow these steps:

Prepare resubmission: Ensure that all revisions have been completed and that the manuscript is ready for resubmission.

Write cover letter: Provide a brief cover letter accompanying the resubmission, summarising the revisions made in response to reviewer feedback.

Submit manuscript: Resubmit the revised manuscript through the journal's submission system, following the instructions provided by the editors.

[25]Guidelines for Addressing to Reviewers' Comments. Pubrica Knowledge Works. Accessed on June 16, 2024. Available at: https://pubrica.com/academy/manuscript-editing/guidelines-for-addressing-to-reviewers-comments/

Example cover letter:

[Your Name] [Your Affiliation] [Your Email Address] [Date of Resubmission]

Dr Jane Smith Editor-in-Chief Brain Research Journal Address

Dear Dr Smith,

I am writing to resubmit our manuscript entitled "Neuroplasticity Mechanisms in Alzheimer's Disease" following revisions based on additional feedback provided by the reviewers. We appreciate the opportunity to address their comments and further improve the manuscript for consideration for publication.

In response to the reviewers' additional feedback, we have made further revisions to the manuscript to address their concerns and enhance the clarity and quality of the presentation. Specifically, we have revised the discussion section to provide a more comprehensive analysis of the study limitations and the potential implications for future research.

We would like to express our gratitude to the reviewers for their continued engagement with our manuscript and to the editorial team for their consideration of our work. We believe that the revisions made have strengthened the manuscript and addressed the concerns raised by the reviewers.

Thank you for considering our revised manuscript for publication in Brain Research.

Sincerely,

[Your Name]

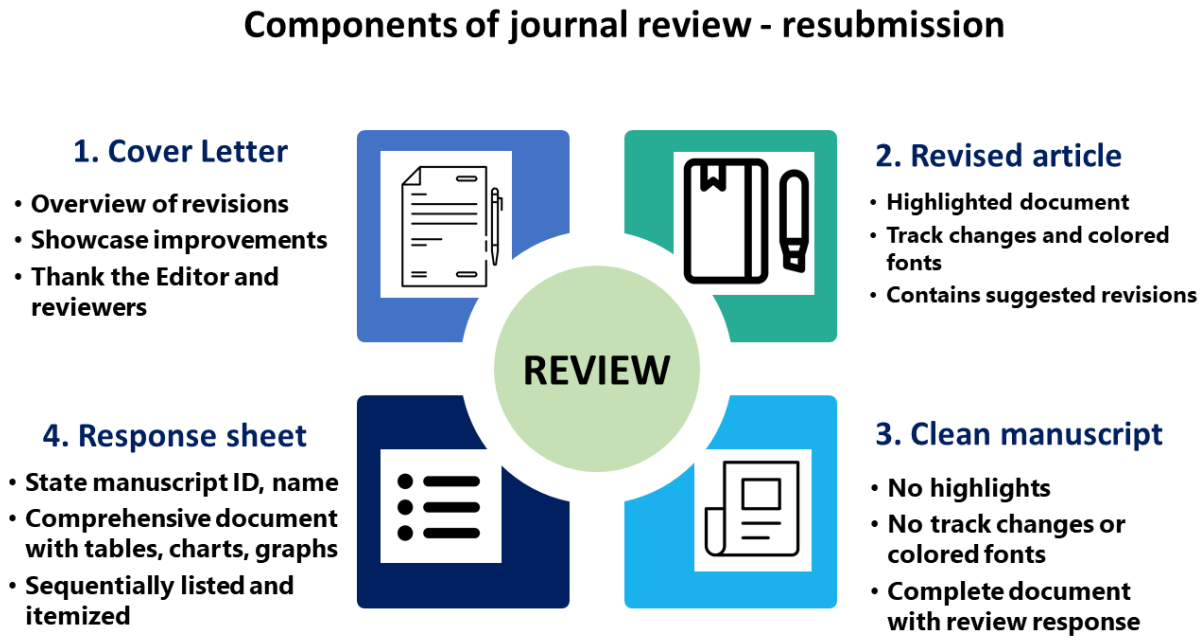


Fig. 6.28 Components of journal review (Bhowmik, 2021).

6.7.3 Final proofreading and approval

Before the manuscript is accepted for publication, it undergoes a final proofreading and approval process. Here's how to ensure the manuscript is ready for publication:

Proofread carefully: Thoroughly proofread the manuscript for any typos, grammatical errors, or formatting inconsistencies.

Check figures and tables: Ensure that all figures, tables, and captions are correctly labelled and formatted according to the journal's guidelines.

Review author information: Double-check author names, affiliations, and contact information for accuracy.

Verify references: Check all references for accuracy and consistency, ensuring they are formatted according to the journal's citation style.

Submit final manuscript: Once you are satisfied that the manuscript is error-free and meets all requirements, submit the final version through the journal's submission system.

Example acknowledgement:

"We acknowledge the support of our research team and funding agencies for their contributions to this work."

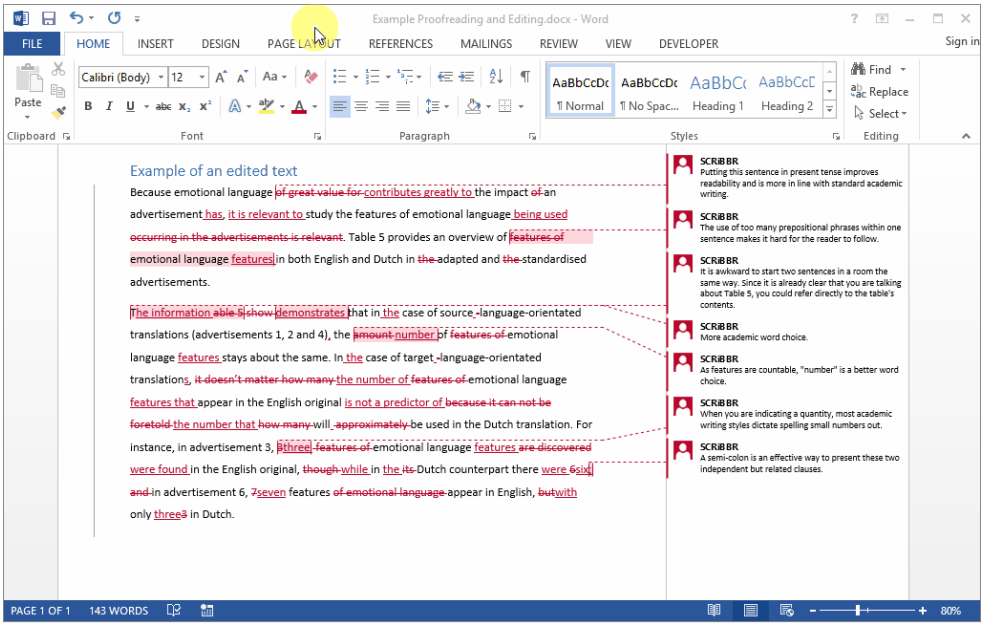


Fig. 6.29 Final proofreading and approval.

6.8 Language improvement services

6.8.1 Utilising professional language editing services

Language editing services can help improve the clarity, readability, and overall quality of your manuscript. Here's how to utilise professional language editing services effectively:

Research service providers: Conduct research to identify reputable language editing services that specialise in academic writing and have experience in your field of study.

Select the right service level: Choose the appropriate service level based on your needs and budget. Most editing services offer different levels of editing, ranging from basic proofreading to substantive editing.

Submit manuscript for editing: Once you've selected a service provider and service level, submit your manuscript for editing. Be sure to follow the provider's guidelines for submission and provide any specific instructions or preferences you may have.

Review edited manuscript: Carefully review the edited manuscript to ensure that all edits are acceptable and consistent with your intended meaning. Address any queries or suggestions provided by the editor.

Incorporate changes: Incorporate the suggested changes and revisions into your manuscript, making sure to maintain the integrity of your research and arguments while improving clarity and readability.

Example: *"After completing the initial draft of my manuscript, I decided to utilise the services of XYZ Editing, a reputable language editing service with expertise in the field of [Your Field]. I selected their premium editing package, which included comprehensive language editing and formatting services. The editing process was smooth and efficient, and the editor provided valuable feedback and suggestions for improving the clarity and coherence of my writing. After reviewing the edited manuscript, I incorporated the suggested changes and revisions into the final version of my manuscript, confident that it was now polished and ready for submission to a journal."*

6.8.2 Tools for language improvement

In addition to professional editing services, there are several tools and resources available to help improve the language and readability of your manuscript. Here are some useful tools:

Grammarly: Grammarly is an AI-powered writing assistant that can help identify and correct grammar, punctuation, and spelling errors. It also provides suggestions for improving sentence structure and clarity.

Fig. 6.30 Grammarly tool.[26]

Microsoft Word's Spelling and Grammar Check: Microsoft Word's built-in spelling and grammar check feature can help catch basic errors and inconsistencies in your writing. However, it's important to remember that this tool may not catch all errors or provide suggestions for improving clarity.

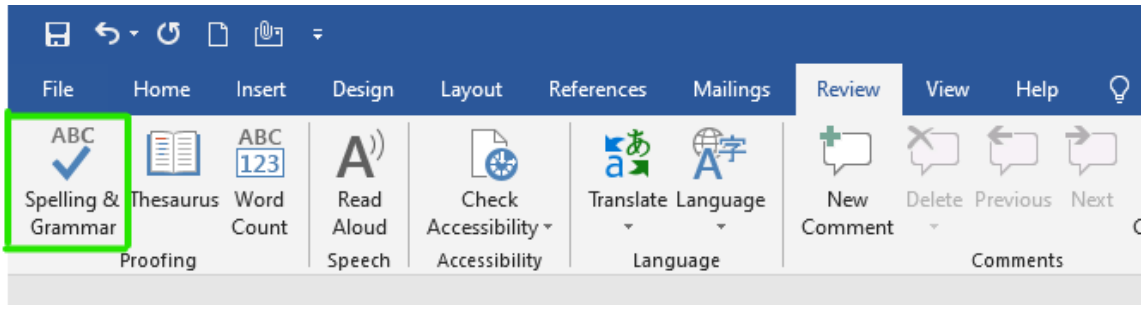


Fig. 6.31 Microsoft Word's Spelling and Grammar Check

Style guides: Consult reputable style guides such as the Publication Manual of the American Psychological Association (APA), the Chicago Manual of Style (CMS), or the Modern Language Association (MLA) Handbook for guidance on formatting, citation style, and language usage.

Peer review: Seek feedback from colleagues, mentors, or peers in your field to identify areas for improvement in your writing. Peer review can provide valuable insights and perspectives to help strengthen your manuscript.

Example: *"In addition to professional language editing services, I also utilised several tools and resources to improve the language and readability of my manuscript. I regularly used Grammarly, a writing assistant tool, to catch grammar and punctuation errors and improve sentence structure. I also consulted the Publication Manual of the American Psychological Association (APA) for guidance on formatting and citation style. Additionally, I sought feedback from colleagues and mentors in my field through peer review, which helped me identify areas for improvement and refine my writing further."*

By utilising professional language editing services and leveraging tools and resources for language improvement, you can enhance the clarity, readability, and overall quality of your manuscript, increasing its chances of acceptance for publication.

[26] Responsible AI that ensures your writing and reputation shine. Grammarly. Accessed on June 16, 2024. Available at: https://www.grammarly.com/

6.9 Reviewing manuscripts submitted by other students

6.9.1 Guidelines for providing constructive feedback

When reviewing manuscripts submitted by other students, it's essential to provide thorough and constructive feedback that helps the authors improve their work. Here are detailed guidelines to follow:

Be specific and detailed: Provide specific comments on different sections of the manuscript, including the introduction, methods, results, discussion, and conclusion. Offer detailed feedback on the clarity of writing, organisation of ideas, coherence of arguments, and accuracy of information.

Address strengths and weaknesses: Highlight both the strengths and weaknesses of the manuscript. Acknowledge what the author has done well, such as clear research objectives or thorough literature review, while also pointing out areas that need improvement, such as ambiguous methodology descriptions or incomplete data analysis.

Offer suggestions for improvement: Provide constructive criticism by offering suggestions for how the author can improve their manuscript. This could include recommending additional references to support their arguments, suggesting alternative research methodologies, or proposing ways to enhance the interpretation of results.

Provide examples and evidence: Support your feedback with specific examples and evidence from the manuscript. Quote relevant passages to illustrate your points or refer to specific figures, tables, or data points to clarify your comments.

Be respectful and professional: Maintain a respectful and professional tone in your feedback, even if you disagree with certain aspects of the manuscript. Avoid using harsh or derogatory language and focus on providing constructive criticism that helps the author improve their work.

Example feedback: *"In the methods section, you have provided a clear description of the study design and data collection procedures, which is commendable. However, I noticed that you did not specify the inclusion and exclusion criteria for participant selection, which could impact the validity of your findings. I recommend adding this information to ensure transparency and reproducibility in your study."*

6.9.2 Ethical considerations in peer review

Peer review is a cornerstone of academic publishing, and it's crucial to approach it with integrity and ethical considerations. Here are detailed ethical guidelines to follow:

Maintain confidentiality: Treat all manuscripts and peer review correspondence as confidential documents. Do not discuss or share any confidential information without explicit permission from the journal and the authors.

Declare conflicts of interest: Disclose any potential conflicts of interest that could bias your review, such as personal relationships with the authors, professional collaborations, or competing research interests. If you feel unable to provide an unbiased review due to a conflict of interest, recuse yourself from the review process.

Provide honest and fair feedback: Offer honest, fair, and constructive feedback based on the quality of the manuscript. Avoid bias or prejudice based on factors such as the authors' reputation, institutional affiliation, or personal beliefs.

Avoid plagiarism and unethical practices: Refrain from plagiarising ideas, content, or data from the manuscript under review. Ensure that your feedback is original and does not infringe on the authors' intellectual property rights. Report any suspected instances of plagiarism or unethical practices to the journal's editorial office.

Respect authorship rights: Respect the authorship rights of the manuscript's authors and acknowledge their contributions appropriately. Do not use or disclose any ideas, findings, or data from the manuscript without proper attribution.

Example ethical consideration: *"As a peer reviewer, it is imperative to uphold the highest ethical standards throughout the review process. This includes maintaining strict confidentiality regarding all manuscript materials and peer review correspondence, disclosing any potential conflicts of interest that could compromise the integrity of your review, providing honest and fair feedback based solely on the quality of the manuscript, avoiding plagiarism or unethical practices, and respecting the authorship rights of the manuscript's authors. By adhering to these ethical guidelines, you contribute to the integrity, credibility, and fairness of the peer review process."*

Practical work

1. Preparation, editing examples of manuscripts.
2. Learn how can be submitting manuscripts in different journals.
3. Editing the manuscript examples before submission.
4. Language editing, tried preparing sentence in different forms.
5. Preparing cover letter examples.
6. Formatting manuscripts according to the publisher’s requirements in different journals.
7. Reviewing manuscripts submitted by other students.

Materials

Text editing in a Word document. Prepare all parts of manuscript with some hypothesis of the study, which will be described in the example manuscript.

Methods

Available searchable journals in all databases. Some journals show examples of the process for correcting manuscripts. Find an example of a cover letter on the internet and write one yourself.

Results

Prepared example of the manuscript, editing in the same template from a journal.

Conclusion

After completing practical and independent work, find optimal journals for publishing and prepare all points in this module theme.

Approved by _____

Name, Surname, signature

Date _____

Theme 7

Presenting scientific results

Theoretical materials

7.1 Poster presentation

7.1.1 Preparing a poster based on the manuscript

Creating an effective academic poster involves summarising the key elements of your research in a visually appealing and concise format. Here's a detailed guide on what to do, what not to do, common mistakes, and recommended design programs.

Fig. 7.1 Poster presentation (Pamplona, 2021).

7.1.2 What to do

1. Identify key content: Select the most important aspects of your manuscript to feature on your poster. Focus on your research question, objectives, methods, results, and conclusions. Aim to present the essence of your research without overwhelming the audience with too much information.

Example: *For a manuscript on the effects of a new drug on hypertension, your poster should highlight the background of hypertension, the research hypothesis, the experimental design, key findings, and the implications of these findings.*

2. Create a structured outline: Organise your content into clear sections, typically including the title, authors and affiliations, introduction, objectives, methods, results, discussion, and conclusions. Ensure each section is succinct and directly related to your central research question.

3. Use clear and concise language: Avoid long paragraphs and use bullet points, short sentences, and simple language to convey your message. Aim for clarity and brevity to make your poster easily readable from a distance.

4. Visualise data: Incorporate charts, graphs, tables, and images to visually represent your data. Visuals should be high-quality, clearly labelled, and relevant to your findings. Ensure that the text accompanying the visuals explains them effectively.

5. Design and layout considerations: Choose an appropriate size and format. Check the specific size requirements and guidelines provided by the conference or event. Common poster sizes include A0 (84.1 cm x 118.9 cm) and A1 (59.4 cm x 84.1 cm). Ensure your poster fits within the allotted space.

Title and headings: The title should be large and easy to read from a distance. Use a clear, bold font and ensure the title captures the essence of your research. Headings for each section should be distinct and help guide the viewer through your poster.

Font and text size: Use a legible font such as Arial or Times New Roman. Titles should be at least 85 pt., section headings at least 50 pt., and body text at least 24 pt. This ensures readability from a distance.

Colour scheme: Choose a colour scheme that enhances readability and is visually appealing. Use contrasting colours for background and text to ensure the text stands out. Avoid using too many colours, which can be distracting.

Balance and spacing: Ensure your poster has a balanced layout with adequate spacing between sections. Avoid cluttering the poster with too much text or too many images. White space helps in maintaining a clean and organised look.

Consistency: Maintain consistency in fonts, colours, and styles throughout the poster. This helps in creating a professional and cohesive appearance.

Example layout: *For a research study on climate change impacts on coastal ecosystems:*

- ***Title:*** *"Assessing the Impacts of Climate Change on Coastal Ecosystems",*
- ***Authors and affiliations:*** *John Doe, Jane Smith - University of XYZ,*
- ***Introduction:*** *Brief background on climate change and coastal ecosystems,*
- ***Objectives:*** *To assess the impacts of rising sea levels on coastal biodiversity,*
- ***Methods:*** *Description of study area, data collection, and analysis methods,*
- ***Results:*** *Key findings with supporting graphs and images,*
- ***Discussion:*** *Interpretation of results and implications for conservation,*
- ***Conclusions:*** *Summary of key takeaways and recommendations for future research.*

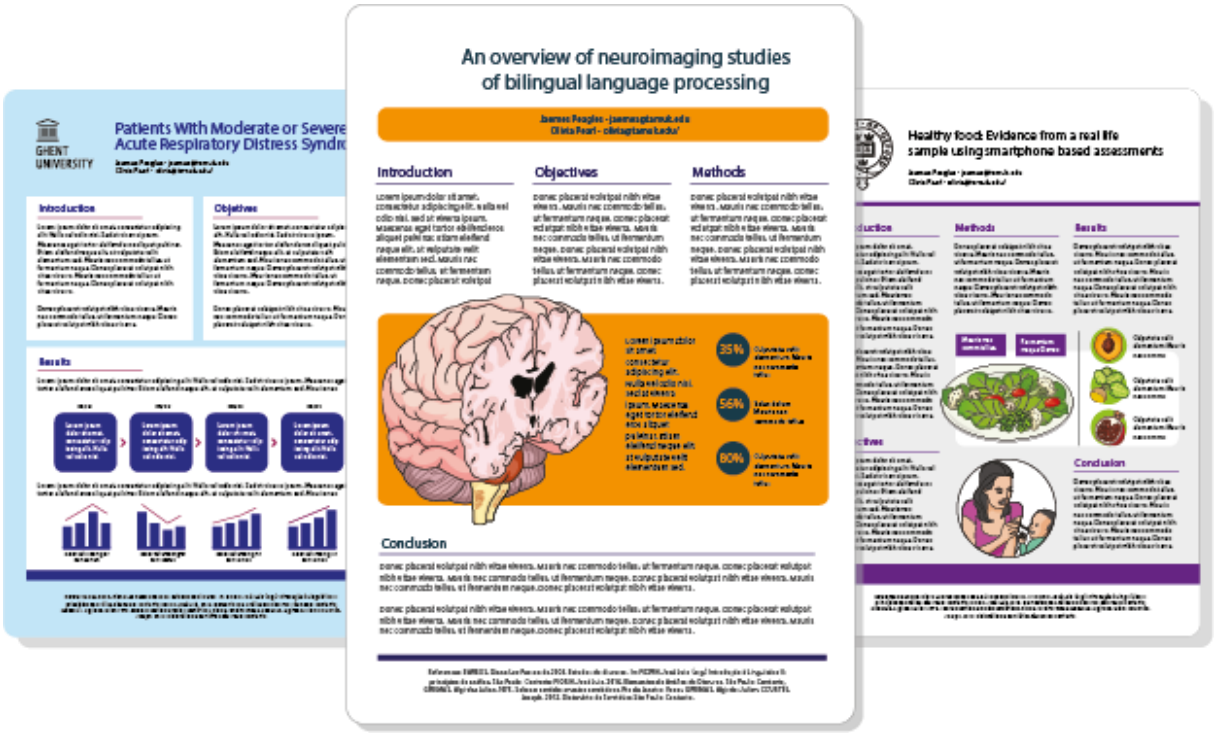


Fig. 7.2 Different types of posters (Pamplona, 2021).

7.1.3 Tips for effective poster presentation

- **Prepare your pitch:** Prepare a brief (3-5 minute) summary of your poster that you can present to interested viewers. Focus on the key points and be ready to answer questions.
- **Example pitch:** "Our study investigates the impact of rising sea levels on coastal ecosystems. We found significant changes in species composition and habitat loss, highlighting the urgent need for conservation measures. This research provides critical insights into how climate change is affecting our coastal environments."
- **Engage your audience:** Be approachable and ready to engage with viewers. Smile, make eye contact, and show enthusiasm for your research. Be open to questions and feedback.
- **Use visual aids:** Use a pointer or your hands to guide viewers through your poster. Highlight key sections and visuals to make your explanations clearer.
- **Practice:** Rehearse your pitch and explanations multiple times. Practice answering potential questions and explaining your methods and results concisely.
- **Be prepared for auestions:** Anticipate common questions about your research and prepare concise, clear answers. Be honest if you don't know the answer to a question and offer to follow up if needed.
- **Bring handouts:** Provide handouts or business cards with your contact information and a brief summary of your research. This allows interested viewers to follow up with you later.
- **Stay by your poster:** Remain near your poster during the designated presentation times. This shows your commitment and willingness to discuss your work with others.
- ***Example interaction:*** *When a viewer approaches, greet them with a smile and a brief introduction: "Hello, my name is [Your Name], and I'm excited to share my research on the impacts of climate change on coastal ecosystems with you. Please feel free to ask any questions as we go through the poster."*

Fig. 7.3 Poster.[27]

7.1.4 What not to do

Avoid clutter: Do not overload your poster with too much text or too many visuals. This can overwhelm viewers and make it difficult to grasp the main points of your research.
Do not use small fonts: Avoid using small fonts that are difficult to read from a distance. Ensure that all text is legible and easy to read.
Avoid jargon: Do not use excessive jargon or technical language that may be unfamiliar to your audience. Aim for clarity and simplicity in your language.
Do not ignore design principles: Avoid using clashing colours, inconsistent fonts, or a chaotic layout. Follow basic design principles to create a visually appealing and professional poster.
Example of what not to do: A poster with tiny text, cluttered visuals, and clashing colours will likely fail to communicate your research effectively. For instance, using multiple font types and colours indiscriminately can make your poster look unprofessional and hard to read.

7.1.5 Common mistakes

Too much text: Including too much text can make your poster overwhelming and difficult to read. Focus on the key points and use bullet points or short sentences to convey your message.
Poor quality images: Using low-resolution images can make your poster look unprofessional. Ensure all visuals are high-quality and clearly labelled.
Lack of focus: A poster that tries to cover too much ground can be confusing. Stick to the most important aspects of your research and present them clearly.

[27] Poster Presentations. International Pharmaceutical Federation Accessed on June 16, 2024. Available at: https://fip.eventsair.com/ppr-summer-meeting/poster-presentations

Ignoring audience: Failing to consider your audience can result in a poster that is either too technical or too simplistic. Tailor your content to the knowledge level of your expected audience.

Example of common mistakes: A poster that tries to present every detail of the research study with dense paragraphs and low-resolution images is likely to lose the audience's interest quickly.

7.1.6 Programs to use

Microsoft PowerPoint: PowerPoint is widely used for creating academic posters. It offers a range of design tools and templates to help you create a professional poster.

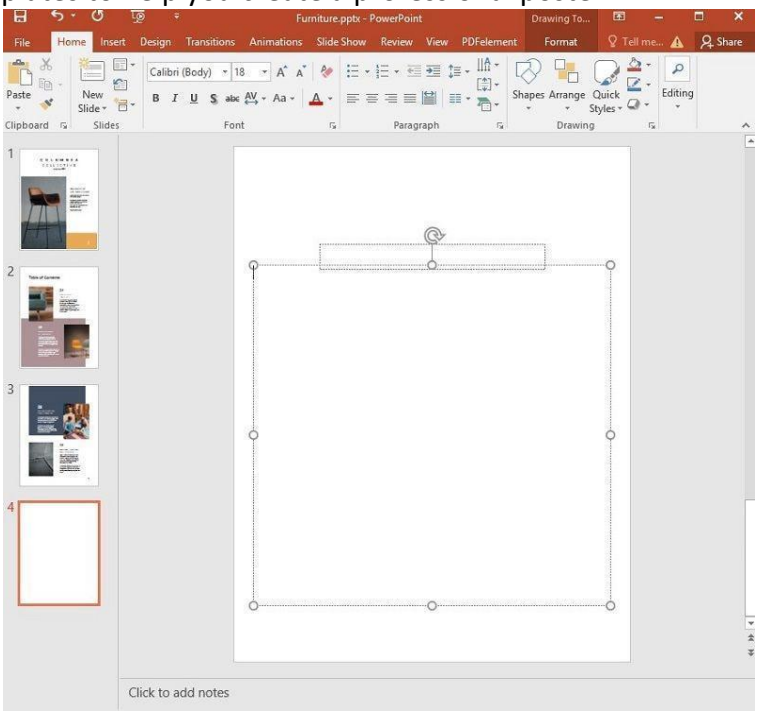


Fig. 7.4 Microsoft PowerPoint posters (Williams, 2024).

Adobe Illustrator: Illustrator is a powerful design tool that allows for precise control over the layout and design elements of your poster. It's ideal for creating high-quality visuals and complex designs.

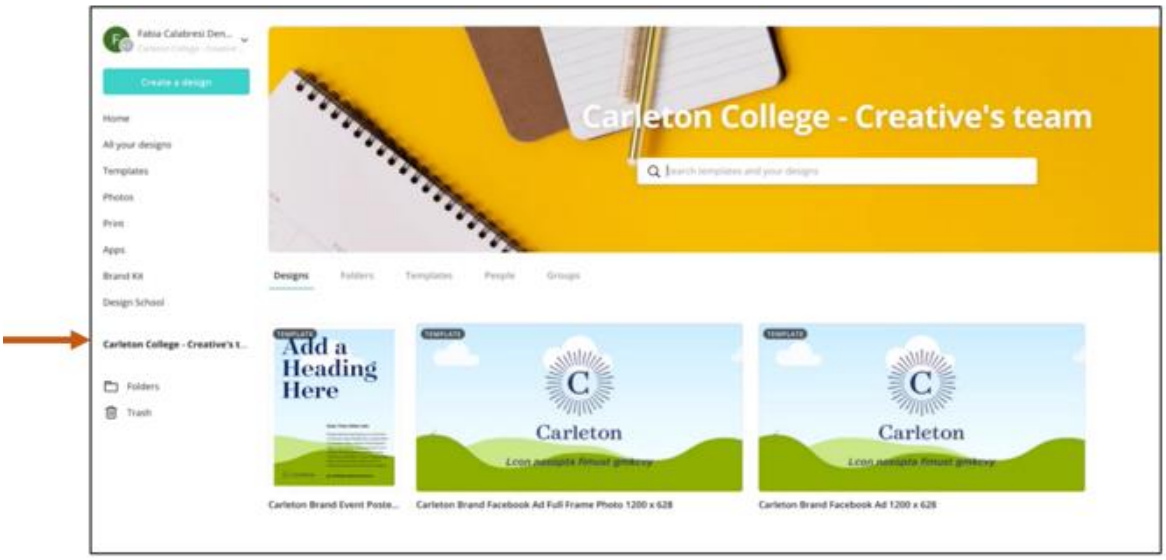
Fig. 7.5 Adobe Illustrator.[28]

Canva: Canva is an online design tool that provides user-friendly templates and design elements. It's a good option for those with limited design experience.

[28] Adobe Illustrator Software. Accessed on June 16, 2024. Available at: https://fileinfo.com/software/adobe/illustrator

Choosing a Carleton template

1. Go to Carleton College - Creative Team's folder.
2. Select your preferred template.



3. On the template screen, choose a template you want to use and click on it.
4. Select "use this template" and a copy of that template will be made on a new window.

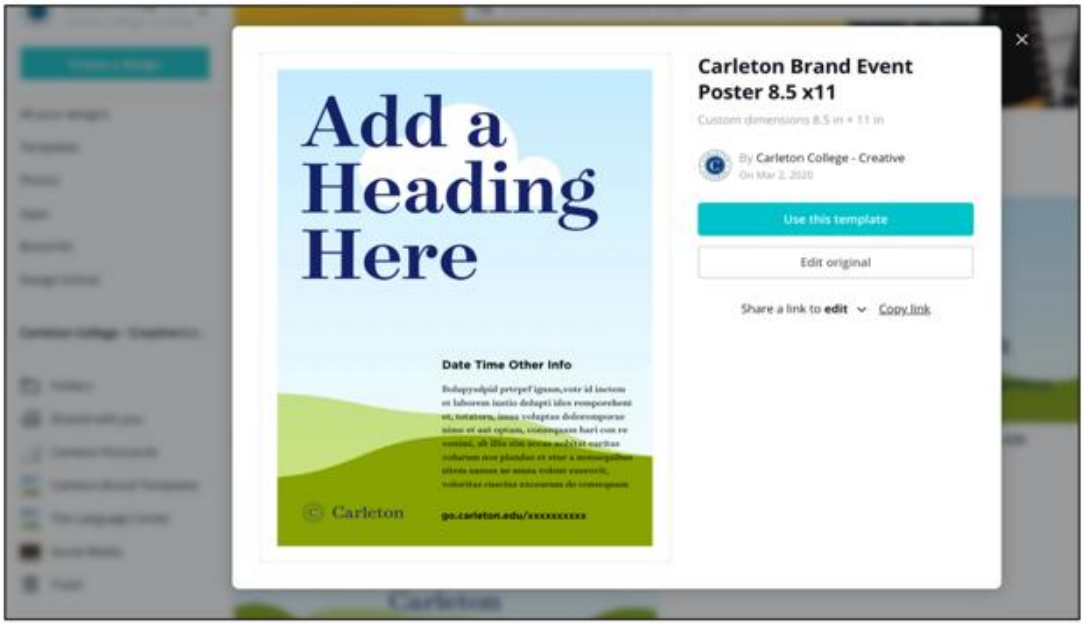
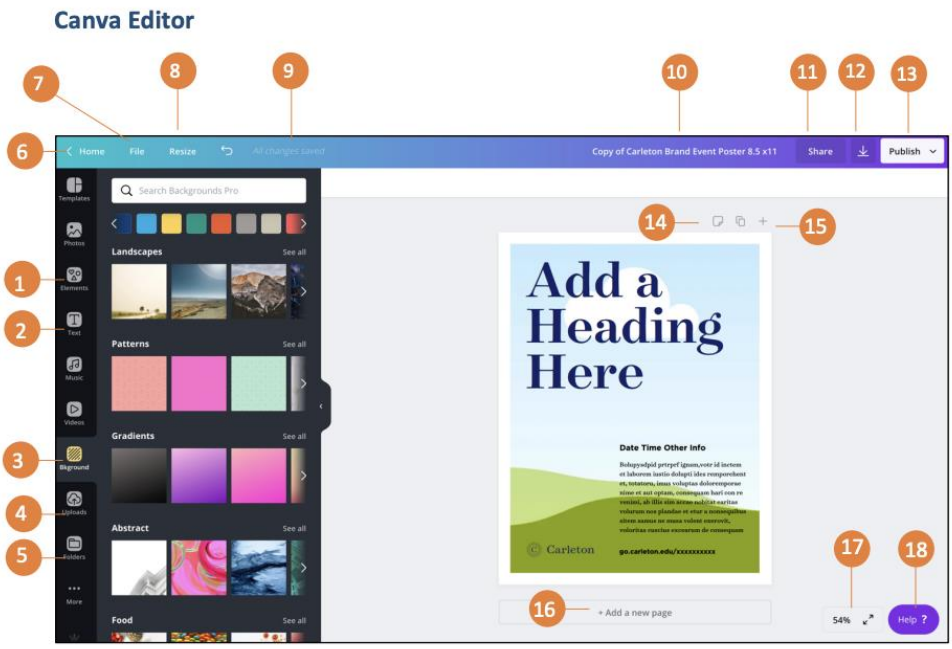


Fig. 7.6 Canva.[29]

[29] Canva User Guide. Accessed on June 16, 2024. Available at: https://d31kydh6n6r5j5.cloudfront.net/uploads/sites/158/2020/06/Canva-Userguide.pdf



1. **Elements**: Select photos, frames, shapes, lines, etc. to add to your design.
2. **Text tab**: Beyond the text placeholders already available to you, the text tab gives you options to add additional pre-formatted text heads, sub-headings, and body text. There are also font combinations available. **Of note: Use caution in how you use these, as they are not Carleton-branded.**
3. **Background tab**: Carleton-branded colors are available just below the search bar. While there are a variety of patterns, landscape, and other background options, it is not advised to use colors that fall outside of the Carleton brand.
4. **Uploads tab**: This area allows you to upload your own elements such as images and graphics.
5. **Folder**: All of your designs, favorites, purchases, items shared with you, and folders are available here.
6. **Home**: Takes you back to your home page.
7. **File**: Create a new design, show margins, show print bleed, save all your changes, move to folder, resolve comments, see version history, make a copy, download your design, or look for help.
8. **Resize**: Allows you to change the size of your design.
9. **All changes safe:** While Canva automatically saves your changes, much like Google Docs and Slides, this feature gives you an opportunity to ensure your changes were saved before closing out of the platform.
10. **Document name:** Allows you to change the naming convention of your design at any time.
11. **Share**: Allows you to share your design with others. This feature also gives you the flexibility to adjust restrictions, allowing individuals to view or edit.
12. **Download**: This feature gives you different options and formats to download your design in.
13. **Publish**: Download your design, share a link, make a presentation, email the design, or share it on social media.
14. **Add notes**: Add notes to your design.
15. **Page controls**: If you have more than one page, use this area to navigate between them. You also have the ability to copy them and delete them.
16. **Add a new page**: Directly add new pages with this button.
17. **Zoom Control**: Make your work area larger or smaller.
18. **Help**: Access and use Canva's support functionality, while still working on your design.

Postersmith: Postersmith offers a specialised platform for designing and printing academic posters. It provides templates and design tools tailored to scientific posters.

Example of Program Use: *Using PowerPoint, you can start with a blank slide and set custom dimensions for your poster. Use the drawing and text tools to create sections, add images, and insert text boxes. Save the final poster as a PDF for printing or digital submission.*

7.2 Oral presentation

7.2.1 Preparing an oral presentation based on the manuscript

Presenting your research orally involves transforming the detailed information from your manuscript into a concise, engaging, and clear presentation. Here's a detailed guide to help you prepare effectively:

1. Understand our audience: Identify who your audience will be and tailor your presentation to their level of expertise and interest. This will help you decide how much background information to provide and which aspects of your research to emphasize.

Example: If presenting to a general audience, simplify complex technical terms and provide more background information. For a specialized audience, focus on the novel aspects and implications of your research.

2. Highlight key points: Select the main points from your manuscript that you want to convey. Typically, these include the research question, hypothesis, methods, key results, and implications of your findings. Aim to tell a compelling story about your research.

Example: *For a study on the impact of dietary interventions on obesity, focus on the rationale behind the study, the methodology, the most significant findings, and their implications for public health.*

3. Create visual aids: Develop slides to visually support your oral presentation. Use PowerPoint, Keynote, or similar software to create slides that highlight your key points. Ensure your slides are not text-heavy and include visuals such as graphs, charts, and images to make your data more accessible.

Example: *A slide summarising your results might include a bar graph showing the differences in obesity rates before and after the dietary intervention.*

7.2.2 Structuring the presentation

An effective oral presentation should have a clear structure that guides the audience through your research. Here's a typical structure:

1. Introduction

- Greet your audience and introduce yourself.
- Provide a brief overview of the topic and its importance.
- State your research question or hypothesis.

Example Introduction: *"Good morning, everyone. My name is Dr Jane Smith, and today I will be presenting my research on the impact of dietary interventions on reducing obesity rates. Obesity is a*

major public health issue, and finding effective strategies to combat it is crucial. Our study aims to assess whether specific dietary changes can significantly reduce obesity."

2. Background and objectives

- Offer some background information to set the context.
- Clearly state the objectives of your research.

Example background: *"Obesity rates have been increasing globally, leading to a rise in related health conditions such as diabetes and cardiovascular diseases. Our objective was to evaluate the effectiveness of a low-carb, high-protein diet in reducing obesity in a sample population over six months."*

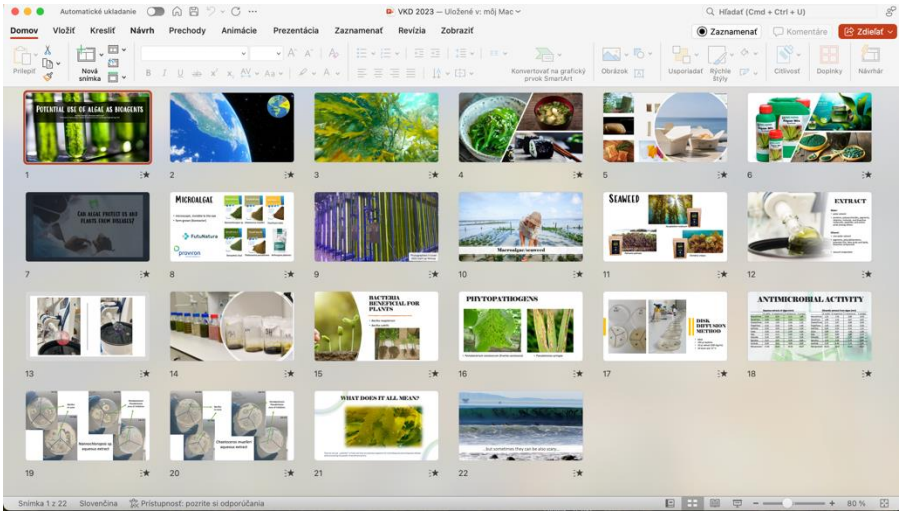


Fig. 7.7 How the presentation should look like.

3. Methods

- Describe the methods and experimental design.
- Explain how the data was collected and analysed.

Example Methods: *"We conducted a randomised controlled trial with 200 participants divided into two groups. One group followed the low-carb, high-protein diet, while the control group maintained their usual diet. We measured participants' weight, BMI, and other health indicators at the start and end of the study."*

4. Result

- Present the key findings of your research.
- Use visuals to make the data clear and engaging.

Example Results: *"Our results showed a significant reduction in weight and BMI in the intervention group compared to the control group. Specifically, the intervention group lost an average of 7 kg, while the control group lost only 2 kg."*

5. Discussion and conclusion:

- Interpret the results and discuss their implications.
- Summarise the main takeaways and suggest future research directions.

Example discussion: *"These findings suggest that a low-carb, high-protein diet can be an effective strategy for reducing obesity. However, further research is needed to explore the long-term sustainability and health impacts of this diet. We recommend future studies to include larger sample sizes and longer follow-up periods."*

6. Q&A session

- Invite questions from the audience and provide clear, concise answers.
- Be prepared for critical questions and provide thoughtful responses.

Example Q&A invite: *"Thank you for your attention. I would now be happy to take any questions you might have about our research."*

7.3.3 Tips for effective oral delivery

Delivering your presentation effectively is as important as the content itself. Here are some tips to ensure you engage your audience and communicate your research clearly:

1. Practice: Rehearse your presentation multiple times to become comfortable with the material and the flow. Time yourself to ensure you stay within the allotted time.

2. Engage with your audience: Maintain eye contact, use expressive body language, and speak with enthusiasm. Engage your audience by asking rhetorical questions and encouraging interaction.

Example engagement: *"Imagine being able to reduce obesity rates significantly with a simple dietary change. This is what our study aimed to explore."*

3. Speak clearly and pacing: Speak clearly and at a moderate pace. Avoid speaking too quickly, which can make it hard for your audience to follow, or too slowly, which can cause them to lose interest.

4. Use visual aids effectively: Ensure your slides are clear, not overcrowded with text, and that visuals complement your spoken words. Refer to your visuals as you present to help illustrate your points.

Example visual aid use: "As you can see in this graph, the intervention group showed a significant reduction in BMI over the six-month period."

5. Handle questions gracefully: Listen carefully to questions, take a moment to think if needed, and provide clear, concise answers. If you don't know the answer, it's okay to admit it and offer to follow up later.

Example handling questions: *"That's a great question. While our study did not explore long-term effects, it is something we are planning to investigate in future research."*

6. Stay professional: Dress appropriately, arrive early to set up, and ensure all technical equipment works. Maintain a professional demeanour throughout the presentation.

7. Use notes wisely: Use notes or cue cards if necessary, but avoid reading from them directly. They should serve as prompts rather than a script.

Example of notes use: *Have bullet points on your cue cards to remind you of key points rather than full sentences.*

Fig. 7.8 Tips for effective oral delivery (Donnelly, 2023).

7.3 Presentations

7.3.1 Engaging your audience

Engaging your audience is crucial for an effective presentation. It helps maintain their interest and ensures that your message is understood and remembered. Here are detailed strategies for engaging your audience:

1. Connect with your audience: Begin your presentation by establishing a connection with your audience. Introduce yourself and your topic in a way that highlights its relevance and importance. Use anecdotes or real-world examples to make your research relatable.

Example: *"Good afternoon, everyone. I'm Dr Alex Johnson, and today I'll be sharing my research on sustainable farming practices. Growing up on a farm, I saw firsthand the challenges farmers face, which inspired this study on how we can improve agricultural sustainability."*

2. Use stories and analogies: Stories and analogies can simplify complex concepts and make your presentation more engaging. They help the audience relate to your research on a personal level.

Example: *"Imagine trying to water your garden with a leaky hose. No matter how much water you use, most of it is wasted. This is similar to the inefficiencies we found in traditional irrigation systems, which led us to explore more sustainable alternatives."*

3. Encourage interaction: Encourage your audience to participate by asking questions, seeking their opinions, or inviting them to share their experiences. This makes your presentation more dynamic and keeps the audience engaged.

Example: *"How many of you have experienced issues with soil erosion on your farms? Please raise your hands. Great, I see quite a few hands. Our research addresses this common problem by introducing new soil conservation techniques."*

4. Maintain eye contact: Eye contact helps build a connection with your audience and makes your presentation more personal. It shows confidence and helps you gauge the audience's reactions.

5. Vary your tone and pace: Monotone speeches can be dull. Vary your tone, pitch, and pace to emphasise key points and maintain interest. Use pauses effectively to allow important information to sink in.

Example: *"After implementing our new irrigation method, we observed a dramatic 40% reduction in water usage. [Pause] This significant improvement underscores the potential of sustainable practices."*

6. Use humour appropriately: Appropriate humour can make your presentation more enjoyable and memorable. Be mindful of your audience and the context to avoid offending anyone.

Example: *"When I first started this research, I didn't realize I'd be spending so much time with worms. But as it turns out, they are excellent indicators of soil health!"*

Fig. 7.9 Engaging your audience.[30]

7.3.2 Handling questions and feedback

Handling questions and feedback effectively is a vital part of any presentation. It demonstrates your expertise and willingness to engage with your audience.

1. Anticipate questions: Before your presentation, think about potential questions your audience might ask and prepare concise, thoughtful answers. This helps you respond confidently and promptly.

Example: *"If you're asked about the scalability of your sustainable farming practices, you might respond: 'While our initial study was conducted on small plots, we are currently working on scaling these practices to larger agricultural areas.'"*

2. Listen carefully: When a question is asked, listen carefully without interrupting. This shows respect for the questioner and ensures you fully understand the question before responding.

[30] Business conference flat. Marketing training. Coach near projector screen. Freepick. Accessed on June 16, 2024. Available at: https://www.freepik.com/premium-vector/business-conference-flat-marketing-training-coach-near-projector-screen_15209708.htm

3. Clarify if necessary: If a question is unclear, politely ask the person asking the question to clarify. This helps you provide a more accurate and relevant answer.

Example: "Could you please clarify what you mean by 'long-term impacts'?"

4. Stay calm and professional: Maintain a calm and professional demeanour, even if the questions are challenging or critical. Take a moment to think before responding if needed.

Example: *"That's an excellent point. While we did not investigate that aspect in this study, it is certainly a valuable direction for future research."*

5. Acknowledge limitations: Be honest about the limitations of your study. Acknowledging limitations shows humility and an understanding of the scientific process.

Example: *"Our study focused on a specific region, and we acknowledge that results might vary in different climatic conditions. Future research should explore these practices in diverse environments."*

6. Engage the entire audience: When answering a question, address your response to the entire audience, not just the questioner. This keeps everyone involved and ensures that the information benefits all.

7. Follow up if necessary: If you don't know the answer to a question, it's okay to admit it. Offer to follow up after the presentation or suggest resources where the questioner might find the information.

Example: *"That's a great question, but I'm not sure of the exact answer at the moment. I'll look into it and get back to you."*

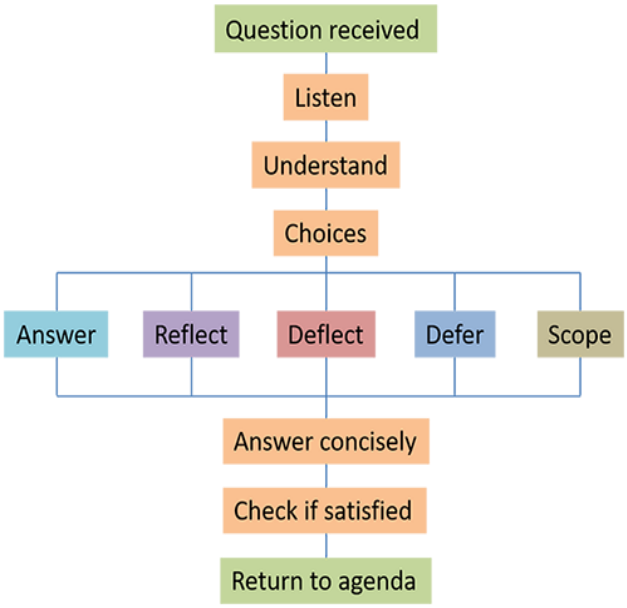


Fig. 7.10 Handling questions and feedback (Tapsai et al., 2021).

7.3.3 Using visual aids effectively

Visual aids can greatly enhance your presentation by illustrating your points and making complex data more understandable.

1. Choose the right visuals: Select visuals that clearly support and enhance your message. These can include graphs, charts, images, videos, and diagrams.

Example: *For a presentation on crop yield improvements, use bar graphs to compare yields before and after implementing new farming techniques.*

2. Keep slides simple: Avoid cluttering your slides with too much text or too many images. Each slide should convey one main idea. Use bullet points, short sentences, and relevant images to keep it clear.

Example: *A slide might include:*

- *A title: "Improved Crop Yields"*
- *A bar graph showing yield data*
- *A brief bullet point summary*

3. Use high-quality visuals: Ensure all visuals are high resolution and professionally presented. Blurry images or poorly designed graphs can detract from your presentation.

4. Consistent design: Maintain a consistent design throughout your slides. Use the same fonts, colours, and layout styles to create a cohesive look.

Example: *If you use blue and green for your graphs and text highlights, stick to those colours throughout your presentation.*

5. Label visuals clearly: All visuals should have clear labels and captions. This helps the audience understand what they are looking at without confusion.

Example: *A graph should include labelled axes, a legend, and a descriptive title.*

6. Practice with your visuals: Rehearse your presentation using your visual aids. Ensure that you can smoothly transition between slides and use the visuals to support your spoken words.

Example: *Practice pointing out specific data points on a graph as you discuss them.*

7. Use animations sparingly: Animations can help highlight important information, but overuse can be distracting. Use them sparingly and only when they enhance your message.

Example: *Use an animation to highlight the difference between two data sets, but avoid excessive transitions and effects.*

8. Backup plan: Always have a backup plan in case of technical difficulties. Bring printed handouts of your slides and have your presentation saved on multiple devices.

Fig. 7.11 Using visual aids effectively.[31]

Practical work

1. Poster preparation based on the manuscript.
2. Preparation of oral presentation based on the manuscript.
3. Presentations.

Materials

Study of different tools for preparing the presentation. Different available databases for preparing presentations and posters.

Methods

The best choice for first preparing a presentation and poster is PowerPoint, it is easy. Then you can prepare the poster and presentation using other tools.

Results

Example of the presentation. Example of the poster.

[31] Marketing Illustrations. Freepick. Accessed on June 16, 2024. Available at: https://www.freepik.com/premium-vector/marketing-illustrations_36464938.htm

Conclusion

Various tools are used to ensure an interesting presentation or poster on one side. The basis of every presentation and poster is to impress the audience, both with basic knowledge and results, as well as with a visual display of the results.

Approved by _____

Name, Surname, signature

Date _____

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