National University of Life and Environmental Sciences of Ukraine

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GENERAL TECHNOLOGIES OF FOOD PRODUCTION

Textbook

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The textbook presents the general fundamentals of food production technology, concepts and definitions, tasks, and technologies of individual food products, focusing on aspects of resource conservation at enterprises. Particular attention is paid to the mechanisms of influence of certain technological parameters of production processes on the formation of the quality of the final food product on the example of dairy products with a high fat content.

The publication is intended for applicants, postgraduate students and teachers of higher education institutions, as well as food industry professionals.

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Introduction

There are several definitions of the term “technology”.

Technology – a set of knowledge about modern methods of processing raw materials to produce a high quality finished product at the lowest cost

Technology – a set of processing methods, manufacturing, changing the state, properties, shape and composition of supplies, materials and semi-finished products. These methods are used in the process of manufacturing products for food and industrial use.

Technology can also be viewed as the science of influencing supplies, materials and semi-finished products by appropriate methods and means.

Technology – a branch of applied knowledge that studies ways to manufacture products that are safe and necessary for humans and presents the most efficient methods from an economic and technological point of view to ensure the appropriate quality of the final product.

In general, food technology is a set of modern methods of processing raw materials into finished products, and on the other hand, it is a scientific discipline that develops and improves these methods. Accordingly, the main tasks of food technology should be ensured*:*

- the specified or optimal properties of the finished food product provided that it is completely safe for humans;
- harmlessness to the environment and people involved in the production process;
- the corresponding optimal process efficiency;
- the ability to control technological processes using the simplest means;

- defined or optimal reliability of technological processes.

Thus, the main goal of food technology is to expand the range of products and develop the most effective ways to produce the high-quality food products people need at the lowest cost.

Raw materials for food production are classified according to various criteria:

- the content of certain food components (carbohydrate, fat, protein, mineral, essential oils);
- of primary and secondary origin;
- information on how to recycle and store it;
- moisture content and the presence of substances hazardous to human health;
- storage and transportation in normal and special conditions, etc.

Primary raw materials for food production can be of plant (grain, fruits, vegetables, berries) and animal origin (meat, milk). Some finished food products (flour, sugar, butter, oil, wine, yeast, etc.) are used as secondary raw materials.

The range of industrially produced food products is very wide and almost impossible to count. The bakery industry alone has hundreds of products, and the confectionery industry has over a thousand. Industrial technologies have been developed for special-purpose food products, such as children's food, preventive (therapeutic) food and food for those working in harsh climatic conditions.

The emergence of new types of food products has necessitated the use of fundamentally new technological operations, modes of their implementation and the development of appropriate designs of machines and apparatus. Of course, with the emergence of small private enterprises for the manufacturing of food products, their technology is also being refined.

The textbook helps students to develop the skills and abilities of professional activity. Along with classical technologies, attention is paid to aspects of modern production – the main directions and methods of process intensification, the development of food compositions taking into account modern approaches to diet formulation and nutritional theories. The text describes in detail the technologies of beer, grain and its products, ethyl alcohol, oil, starch and starch molasses, as well as the issues of regulating the quality of spreads and various types of butter, and presents approaches to expanding the product range based on the use of modern functional and technological ingredients.

The information in the sections allows you to broaden the horizons of specialists applying classical food technologies; to consolidate in practice the knowledge and skills of performing complex technological processes.

The presented material of the manuscript can be used in the research works by applicants, undergraduate and graduate students, teachers of higher educational institutions, specialists in the food industry, including the dairy industry. The information in this textbook will enable future food industry professionals to acquire skills in controlling technological processes and ensuring product quality and safety.

The manual is set out in accordance with the programs and curricula for bachelors in the specialty 181 “Food Technologies” for the purpose of methodological support of the discipline “General Technologies of Food Production: Technology of Milk and Dairy Products”, ‘Food Quality Control’, ‘Student Research Work’.

SECTION 1.
THEORETICAL ORIGINS OF THE GENERAL TECHNOLOGY OF FOOD PRODUCTION

1.1. Trends in food technology development

Trends in society primarily affect which products are most competitive on the market. This is reflected in the conceptual approach to the development of food technologies. Consumers choose products with a high content of fat, protein, and carbohydrates because of their taste and composition, which is based on modern nutritional theories. Innovations in the food market, for example, enrichment of food products with healthy components of plant origin or, conversely, animal origin, are largely based on the analysis of the Western European market, where this trend has been formed long ago and is constantly evolving. In the Ukrainian market, food products with multifunctional ingredients are increasing in demand and are the basis for expanding the product range.

In the coming years, the size of the so-called “young middle-aged” group is expected to increase. According to some prognoses, the percentage of the population over 45 will reach 50% in 2020. People in this age group increasingly expect to live a full and active life. At the same time, with age, conservatism in the consumption of essential food components occurs, and the diet itself may be small or not very well selected. As a result, a certain nutritional deficit may occur, which can also be filled with foods with multifunctional ingredients.

Along with this trend, there is a steady increase in the number of young people who travel a lot. Their life rhythm is unstable. This category consumes a lot of so-called “fast food” and, as a result, a decrease of the intake of vitamins, macro- and microelements and other nutrients occurs. Potential consumers of the above-mentioned products represent this category as well.

In recent years, the population of all age groups has become aware of the need and opportunities for "self-medication". Sales of vitamins, mineral and dietary supplements are in second place after cough and cold remedies.

Compared to traditional food, which is consumed to maintain the body's vital functions, functional food gives the body more than traditional food. Its consumption means the desire to obtain special physiological effects, improve health and possibly prevent diseases. The food market is increasingly experiencing a need for new ingredients, such as polyphenols, carotenoids, omega-3 fatty acids, dietary fiber, taurine, carnitine, melatonin with different physiological functions, etc.

Combinations of vitamins A, C, and E are especially popular. Many manufacturers of beverages, juices and nectars, dairy and meat products include products enriched with such complexes in their product range. Products with multifunctional ingredients can be classified according to various criteria, as shown in Figure 1.1.

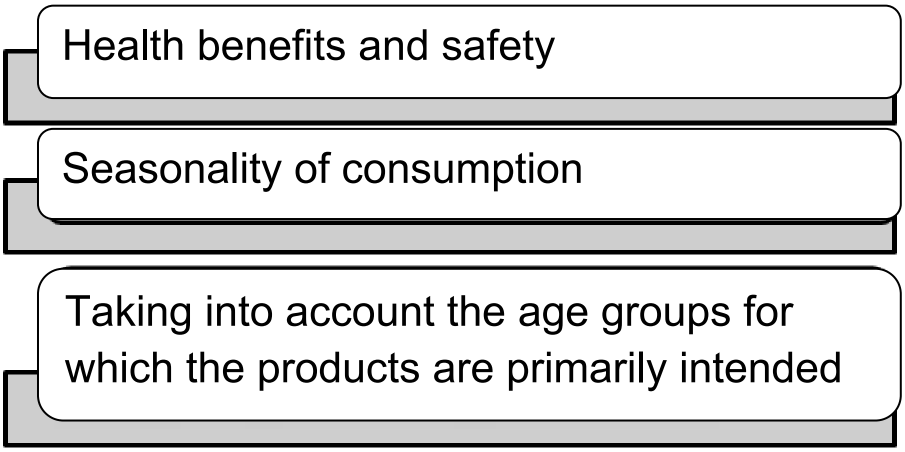


Fig. 1.1 – Criteria for the classification of food products with multifunctional ingredients

For example, drinks adapted to certain times of the day can provide an energy boost, have a refreshing effect, act as a calming agent or replace food to some extent. For example, beverages with dietary fiber are well suited to the concept of specialty beverages - "meal replacements" or for consumption during short breaks, for example at work. For mornings and evenings, "shock" drinks with caffeine can be offered to provide a boost of energy.

For the target group of consumers of different food products, the concept of controlling body weight or preventing osteoporosis can be used – (for women), for the prevention of diabetes, heart disease or lowering cholesterol (for the elderly); for stimulation or recovery (for athletes).

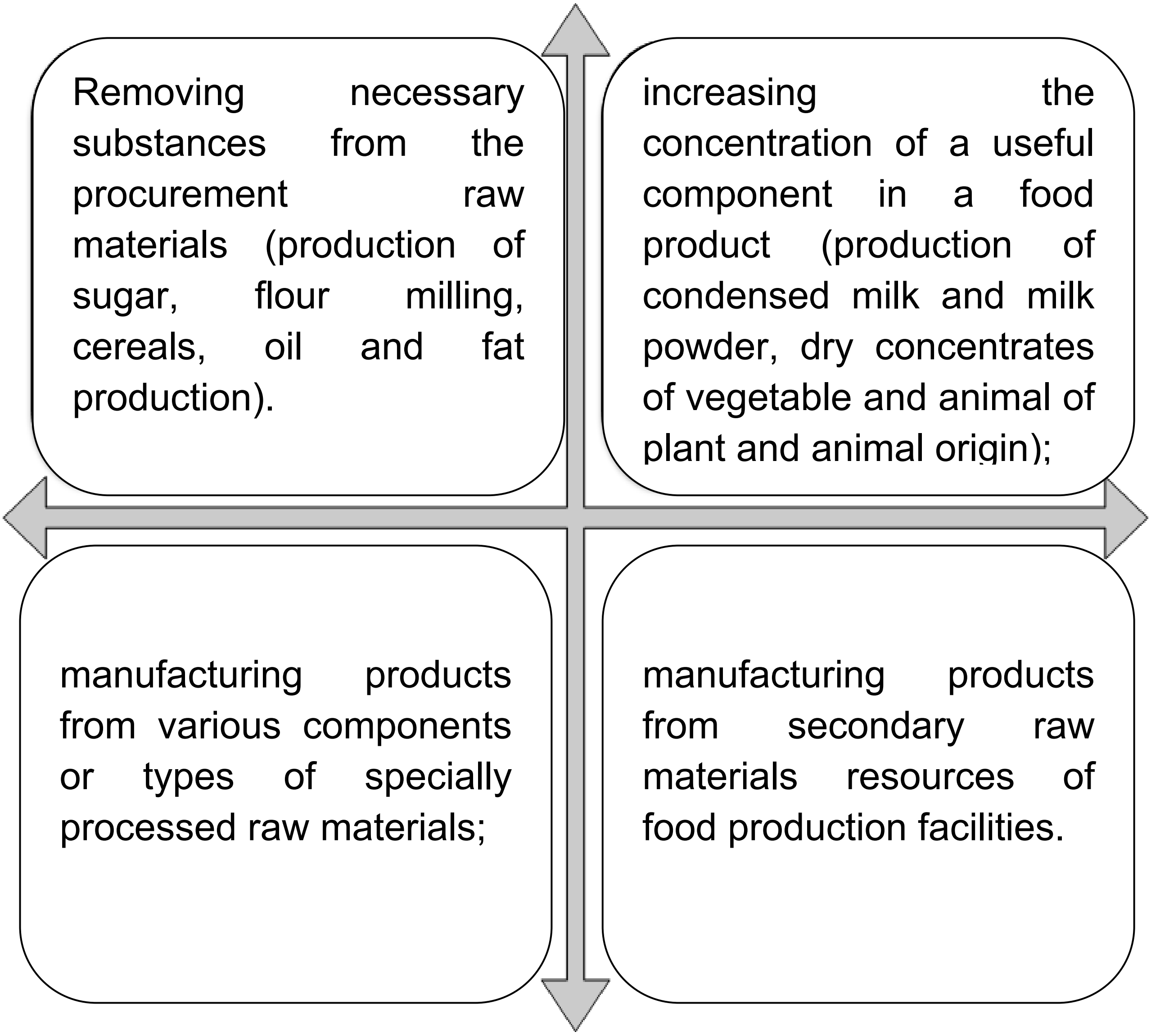
The use of herbal oils as multifunctional ingredients in our country began with the production of high quality infant formula. Women's milk substitutes contained natural vegetable oils in accordance with the nutritional needs of infants.

Today, the use of herbal oils in various industries, including the dairy industry, has expanded significantly. This is due not so much to the search for cheap sources of raw materials as to changes in the perception of healthy eating and the emergence of new generation high-quality milk fat substitutes on the market. Many fermented milk products with therapeutic and prophylactic properties based on milk, vegetable fats and proteins using kefir fungi, lactobacilli and bifidobacteria have appeared.

The addition of soy protein isolate to cow's milk or meat raw materials improves the nutritional and preventive properties of these products.

The use of soy components in the production of various food groups due to such functional features of the protein as easy digestibility and low cost make them attractive for use in the food industry, and allow them to significantly increase their biological value and expand and reduce the cost of the product range.

The distribution of food production by the method of obtaining the final product is shown in Figure 1.2.



Removing necessary substances from the procurement raw materials (production of sugar, flour milling, cereals, oil and fat production).

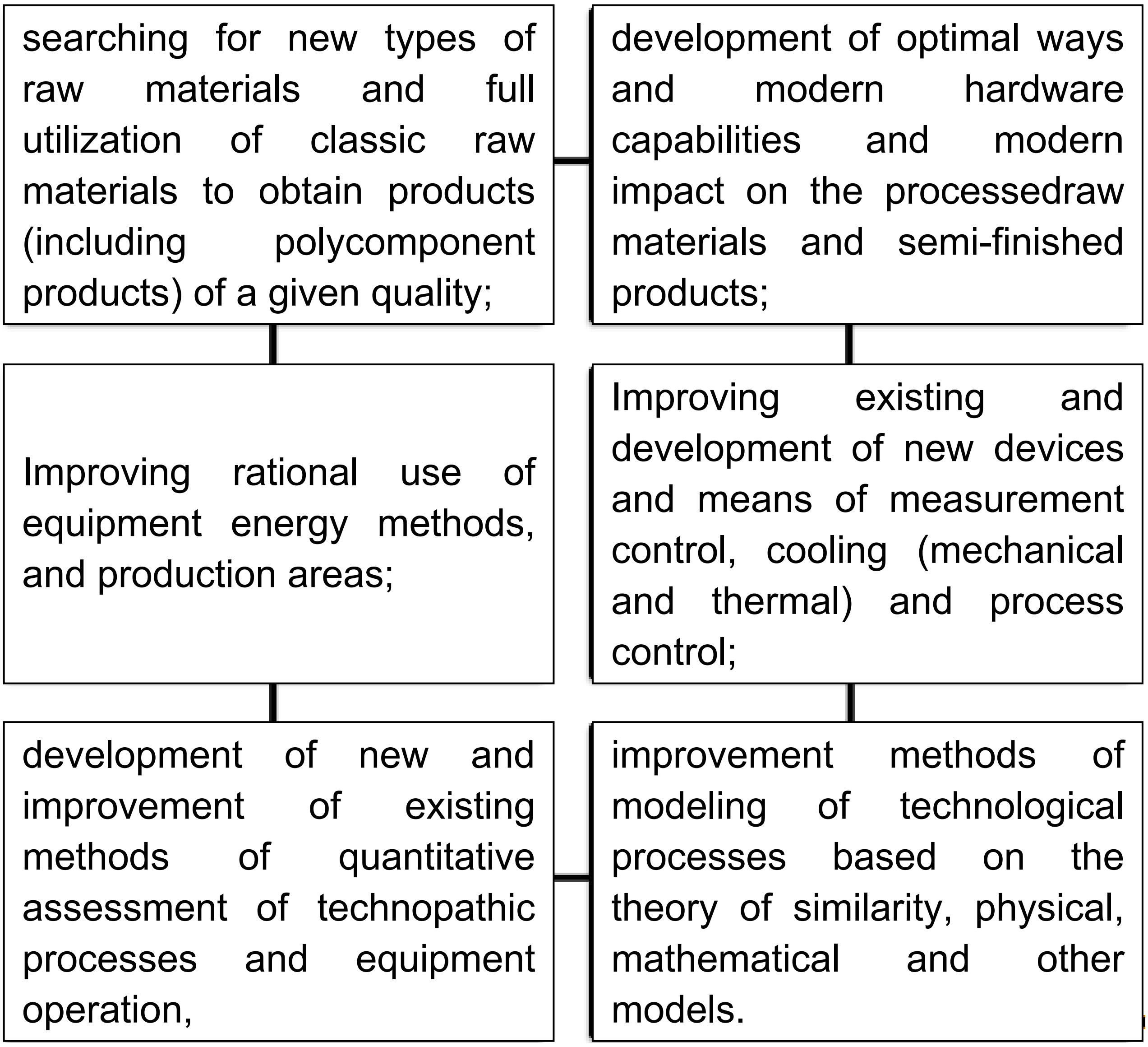
increasing the concentration of a useful component in a food product (production of condensed milk and milk powder, dry concentrates of vegetable and animal of plant and animal origin);

manufacturing products from various components or types of specially processed raw materials;

manufacturing products from secondary raw materials resources of food production facilities.

Fig. 1.2 - Methods of obtaining the final product

The main tasks of the technology should be supplemented with the information presented in Fig. 1.3.



searching for new types of raw materials and full utilization of classic raw materials to obtain products (including polycomponent products) of a given quality;

development of optimal ways and modern hardware capabilities and modern impact on the processedraw materials and semi-finished products;

Improving rational use of equipment energy methods, and production areas;

Improving existing and development of new devices and means of measurement control, cooling (mechanical and thermal) and process control;

development of new and improvement of existing methods of quantitative assessment of technopathic processes and equipment operation,

improvement methods of modeling of technological processes based on the theory of similarity, physical, mathematical and other models.

Fig. 1.3 – Extended tasks of the technology

There are also classifications that emphasize the processing of mono- and polycomponent raw materials, the completeness of their utilization, the main technological processes and methods of obtaining raw materials, etc.

1.2. Basic principles of implementation of food technologies in production conditions

Implementation of the technology in production environments requires taking into account the following principles: maximum use of raw materials, minimum energy, equipment efficiency, reduction of process duration, and optimization of the option.

Raw materials account for a significant portion of the total cost of food production, so maximizing their use is one of the main methods of reducing the costs of manufacturing products.

To control the degree of raw material utilization, a material balance sheet is drawn up, which in production conditions is a product calculation. This calculation, unlike the material balance sheet, is closer to the actual conditions of the process, as it takes into account losses at all stages of the technological process. Thus, this calculation takes into account the raw materials (basic and auxiliary materials), the products generated (target, by-product, wastes), and losses at all stages of the technological process. This makes it possible to assess the degree of utilization of food raw materials and identify the stages at which this degree is the highest.

> *The material balance sheet is based on a unit of product weight or the amount of product produced per unit of time (hour, day, year).*

Balancing is the very first step in the analysis and synthesis of any production process flowchart.

Product calculations take into account all possible deviations from the theoretical yield of the main product arising from thermodynamic (the equilibrium state of the reverse reaction course does not allow the main transformations to be completed), kinetic (the theoretical possibility of transformation is not achieved due to low reaction rates), and other reasons due to the process mechanism itself (for example, side reactions reduce the yield of the main product).

The main criteria for the quality of raw materials are a high content of useful components and a minimum amount of impurities, damage and flaws. If the raw materials are of poor quality, their losses while processing increase, the productivity of production lines decreases, and the cost of the finished product increases.

Ukraine has sufficient quantities of the main types of raw materials for food production, but due to natural and climatic conditions, some types cannot be grown (tea, coffee, cocoa beans, some types of spices). The most promising method of conserving resources is to replace food raw materials used for technical purposes (production of soap, drying oil, varnishes, enamels, etc.).

In addition, it is important to expand the raw material base by increasing the duration of storage by canning (slowing down or stopping the vital activity of microorganisms and enzymes), storage at low temperatures, in an inert gas atmosphere, and separation of microbial waste products.

> *Important conditions for the storage of raw materials include a high level of organization, mechanization and automation of cargo operations, the use of special-purpose containers, and bulk transportation of dry (flour, sugar) and liquid (beer, oil, liquid sugar) products.*

The main signs of food value are the nutritional properties of its components and their optimal ratio. Along with this, flavor, aroma, color, structure, appearance, and the ability to preserve native properties during storage play a significant role. Marketable properties that help consumers determine the quality of the product, as well as those that ensure the ease of circulation of goods in trade and sales, such as appearance, shape, packaging, size, pattern, etc., are important. Food products and their production are subject to appropriate hygienic requirements for complete harmlessness to the human body.

Food quality is characterized by a high dependence on the composition and quality of raw materials, their complete harmlessness to human health and high nutritional value. The quality of raw materials is also determined by a system of indicators that reflect the chemical composition, physical properties, humidity, contamination, uniformity, and caloric content.

> *An important characteristic is the content of nutrients in the raw material that are necessary for the manufacture of the finished product (sugar in beets, starch in potatoes, etc.), as well as the possibility of extracting them from the raw material.*

This leads to certain requirements for the design of food processing plants and the operation of production lines.

Energy can be saved by using modern equipment, applying less energy-intensive technological operations, reusing heat, reducing its loss to the environment, bringing technological operations only to the required degree of completion, and separating any target components at intermediate stages.

A common way to reduce energy losses is to use the waste heat for other technological operations that can be carried out at lower temperatures, as well as the method of reusing the heat of the main stream (cooling deflagration units with the product flow, multi-hull evaporators, etc.). Heat losses can also be reduced by better matching flow directions, replacing evaporation with moisture freezing, insulating hot surfaces, etc.

The main ways to implement the principle of the best use of equipment are as follows:

- recirculation of flows for the purpose of stabilizing regimes, heat recovery or reusing;
- consistency of operations and process flows.

The principle of the best use of machines and apparatus defines the basic requirements for equipment, as shown in Fig. 1.4. The main principles of reducing the process duration are to increase:

- the driving force of the process, i.e. differences in temperature, pressure, voltage, electric current, etc;
- the phase contact surface in order to expand the possibilities of contact (collision) of different flows;
- values of kinetic coefficients.

Intensification methods can be of a different nature and carried out with different technical means.

high productivity and intensity of work;

the highest product yield and maximum process separation capacity (extraction of valuable or removal of safe component);

minimal energy consumption for grinding, mixing, transportation of materials and the best use of energy generated in and supplied to the machine;

mode stability, easy operation and safety during maintenance;

low cost of the device and repair, reliability in operation, possibility of sanitizing

Fig. 1.4 – Basic requirements for equipment determined by the principle of best use

The driving force can be increased if one:

- increases the differences in concentration, partial pressure, and temperature;
- increases the contact surface due to the formation of a suspended fluidized bed, mixing of the solid phase, changes in the concentration of the solid phase, and an increase in the ratio of phase velocities;
- increases the kinetic coefficients due to surface activation, changes in the structure of the solid phase, an increase in the relative velocity of the phases, and an increase in flow turbulence.

The purpose of the optimal variant principle is to improve the quality of the food product and reduce the cost of its production.

This principle provides for a combination of:

- the sequence of technological operations,
- physical and biochemical laws,
- the technological modes of processes,
- the design parameters of machines and apparatus,
- the basic laws of process control,
- the management of economic indicators of production,
- the market conditions aimed at reducing production costs and maximizing profits.

The principle of the optimal variant involves:

- a determination of the productivity of technological lines,
- a compliance of equipment performance of certain types with the productivity of the technological line,
- a continuity or frequency of operation of individual sections (equipment).

1.3. The importance of food for public health

The nutrition is the main condition for human existence, as food provides the human body with everything it needs to build cells and tissues, and replenishes energy consumption for all types of life activities. In addition, food supplies the human body with vital regulators and reserve materials. In this context, normal nutrition should provide the necessary amount of energy and material to restore the body's structure.

> *Food products should be nutritious and contain proteins, fats, carbohydrates, vitamins, minerals and water in sufficient caloric content to cover the energy expenditure in the human body.*

According to modern concepts of rational nutrition, food should contain regulators of human physiological activity, including ballast substances. According to scientific recommendations, the main components of food products – proteins, fats and carbohydrates should be in a 1:1:4 ratio, and the average daily requirement for these components should be 100, 100 and 400 g, respectively. The oxidation of 1 g of protein releases 16.7, fat – 37.7, and carbohydrates – 15.7 joules of energy. All the substances that make up food are divided into organic (proteins, fats, carbohydrates, food acids, vitamins, enzymes) and mineral (water, micro- and macroelements).

The proteins are divided into simple and complex. The nutritional value of proteins is determined by their biological value, i.e. the correspondence of the amino acid composition of a nutritious protein to the composition of human body proteins and digestion, depending on the physical and chemical properties of the protein and the way the product is processed.

The biological value of food products is determined mainly by the amount of so-called “essential” amino acids that are not synthesized in the human body and must be ingested with food. Such proteins are found in meat, dairy products, fish, and eggs. The first eight amino acids are “essential”, the rest are synthesized in the human body.

There are four levels of organization in the structure of a protein. The primary structure is caused by amino acids connected by peptide bonds in a certain sequence. In addition to peptide bonds, disulfide bonds are important. The secondary structure is a helical or woven polypeptide chain, anchored mainly by hydrogen bonds of the polar groups of neighboring amino acids. The tertiary structure of a protein means the spatial arrangement of a helix, and the quaternary structure – a large protein molecules with several peptide chains connected by non-covalent bonds. Hydrogen, ionic, and hydrophobic bonds play an important role in the construction of secondary, tertiary, and quaternary structures.

> *The most important properties of proteins for technology are their ability to denature, swell, and foam.*

A denaturation is a change in the native spatial orientation of molecules without breaking covalent bonds, which occurs under the influence of elevated temperatures, mechanical, chemical, and other influences. As a result of denaturation, the ability of proteins to dissolve in water, salt, alkali, and alcohol solutions decreases. Their ability to swell, absorb water, and form gelatin is also reduced. The protein in wheat flour swells in water to form gluten. Proteins can also form emulsions and foams. These properties of proteins are widely used in food manufacturing technology. Specific proteins – enzymes – act as biological catalysts. Proteins in the human body are broken down into amino acids, and these are used to synthesize the body's own proteins. Each enzyme catalyzes only certain reactions. For example, the enzyme protease breaks down proteins, amylase breaks down starch (from the Latin amylum), lipase breaks down fats (lipids), etc.

> *The use of enzymes in food technology significantly speeds up technological processes, improves product quality, and increases the yield of the finished product.*

The substances that accelerate enzymatic reactions are called activators, and those that slow them down are called paralyzers (ions of silver, mercury, copper, lead, arsenic, etc.).

> *The lipids are fats and fat-like substances that are involved in all important metabolic processes in the body.*

In the absence of fat in the tissues, the synthesis of proteins, carbohydrates, provitamin D, and a number of hormones decreases. The body's resistance to disease is also reduced.

By chemical nature, fats are triglycerides – a combination of glycerol with three fatty acids. The properties of fats are determined mainly by the composition of the original fatty acids and are divided into saturated and unsaturated. The latter have the ability to attach hydrogen and other elements to their molecules. At normal temperature, they are in a liquid state (oleic, linolenic, linoleic, arachidonicSaturated fatty acids (palmitic, stearic, etc.) are normally solid. Fats are highly soluble in gasoline, ether and other organic solvents. Fat-like substances, or lipids, are similar in composition and properties to fats, but have some additional groups of atoms in their molecules. Plant and animal tissues contain phospholipids and stearins, which play an important role in metabolism. Cholesterol, a fat-like substance that is easily synthesized in the body, is a component of most cells in a healthy body. When cholesterol levels are exceeded, a healthy body can easily eliminate it. Along with fat, the human body receives fat-soluble vitamins A, D, E, K.

> *The fat-like substances and fats are used in the food industry as emulsifiers. The saturation of double bonds*

> *with hydrogen in unsaturated fatty acids (hydrogenation) is used in industry to convert liquid oils into solid compounds (hydrated fat), which are used as a component of margarine. The largest proportion of fat is found in meat and dairy products and in butter.*

Carbohydrates are the most common organic compounds in nature. They are divided into:

- ❖ monosaccharides, or simple sugars, which are the main structural units – monomers (glucose, fructose, galactose, mannose);
- ❖ oligosaccharides (diaccharides, trisaccharides and tetrasaccharides); sucrose (beet and cane sugar), maltose (starch sugar), lactose (milk sugar);
- ❖ polysaccharides, consisting of hundreds and thousands of monosaccharides (starch, fiber, glycogen, pectin, etc.).

The source of carbohydrates is plant-based foods such as bread, cereals, potatoes, vegetables, fruits, and berries. Monosaccharides are very easily absorbed by the body. They taste sweet and are water-soluble. If the sweetness of sucrose (regular sugar) is taken as 1, then the sweetness of fructose is 1.73, inverted sugar - 1.3, glucose - 0.74, galactose - 0.32, refined sugar - 0.23, lactose - 0.16. Glucose, fructose, and sucrose are found in free form in fruits and vegetables, and inverted sugars are found in honey and caramel. Glycogen is found in the liver and is a reserve food substance. The most important carbohydrate for humans is starch. In the daily human diet, it makes up 30...85% of the total amount of carbohydrates.

The native starch is insoluble in cold water, but can adsorb up to 30% moisture. The swollen starch grains and polysaccharides dissolved in water are called starch glaze. Glazing occurs at a temperature range of 53...80 °C, which is specific to each type of starch. Starch glaze is the basis for some culinary products (jellies, sauces, soups, purees, etc.).

> *Fiber, or cellulose, and pectin (dietary fiber) are high molecular weight compounds of carbohydrate nature.*

They are almost not directly absorbed by the body, but play an important role in nutritional physiology, form complex compounds with heavy metals and remove them from the body. It is an important means of preventing and treating occupational diseases.

Food acids (malic, citric, lactic, tartaric, etc.) are present in all foods and give them a certain flavor. In some cases, food acids are formed during technological processing (fermentation, etc.).

1.4. Aspects of resource saving in the food industry

Resource saving is a progressive way to improve the efficiency of food production in Ukraine. Resource-saving measures at enterprises are a very relevant and cost-effective implementation that not only saves raw materials, but also affects the growth of production with the same amount of raw materials, fuel, auxiliary materials, etc.

The task of resource-saving measures at food enterprises is to fulfill the following functions and principles that ensure the balance of social, environmental and economic components of production:

- stimulating the rational use of food raw materials and the introduction of resource and energy-saving technologies;
- meeting the needs of consumers at the required level based on modern nutritional theories;
- search for new alternative types of raw materials of plant or animal origin that would reduce costs in general;
- development of innovative technologies that involve the use of secondary resources in product formulations or mixtures;
- reducing the negative impact on the environment through the use of new eco-friendly technologies for waste-free production;
- participation in the development of resource saving strategies and environmental protection programs;
- environmental monitoring, which includes accounting for the consumption of raw materials by enterprises and organizations in the industry;

- raising the professional level of specialists in various fields, environmental education and training, and providing specialists in various fields with the necessary information.

The implementation of these measures is hampered by problems that are common to almost all Ukrainian food production enterprises. The main ones are:

- outdated production technology and equipment, low level of automation;
- insufficient qualification level of employees or inability to improve their skills in specialized institutions, including abroad
- lack of sources of funding for resource-saving measures;
- lack of information;
- lack of legal basis for liability for irrational use of food resources;
- lack of proper control over resource saving by public administration bodies;
- lack of centralized accounting of used resources of animal and plant origin;
- small volumes of implementation of resource-saving projects at the enterprises of the industry.

After analyzing the above-mentioned tasks, principles and problems, we can identify certain factors (technical, organizational, socio-economic) that contribute to the implementation of resource-saving activities in food production. The relevant information is presented in Fig.1.5.

Technical factors

- Application of technologies that ensure minimal consumption of raw materials of animal origin through combining with ingredients of plant origin and vice versa.
- The use of modern equipment that ensures minimal material consumption throughout the entire technological chain
- Improving the quality of material resources and using modern multifunctional raw materials.
- Improving transportation and storage conditions for raw materials and finished products
- Creating a material base for modeling resource consumption and developing innovative technologies.
- Improvement of technological modes of processing raw materials for food products.

1.5.

Organizational factors

- Improvement of accounting for the receipt and use of raw materials.
- Reducing the cycle from receiving various raw materials to their processing
- Maximum utilization of secondary raw materials.
- Development and implementation of organizational and technical measures to save raw materials.

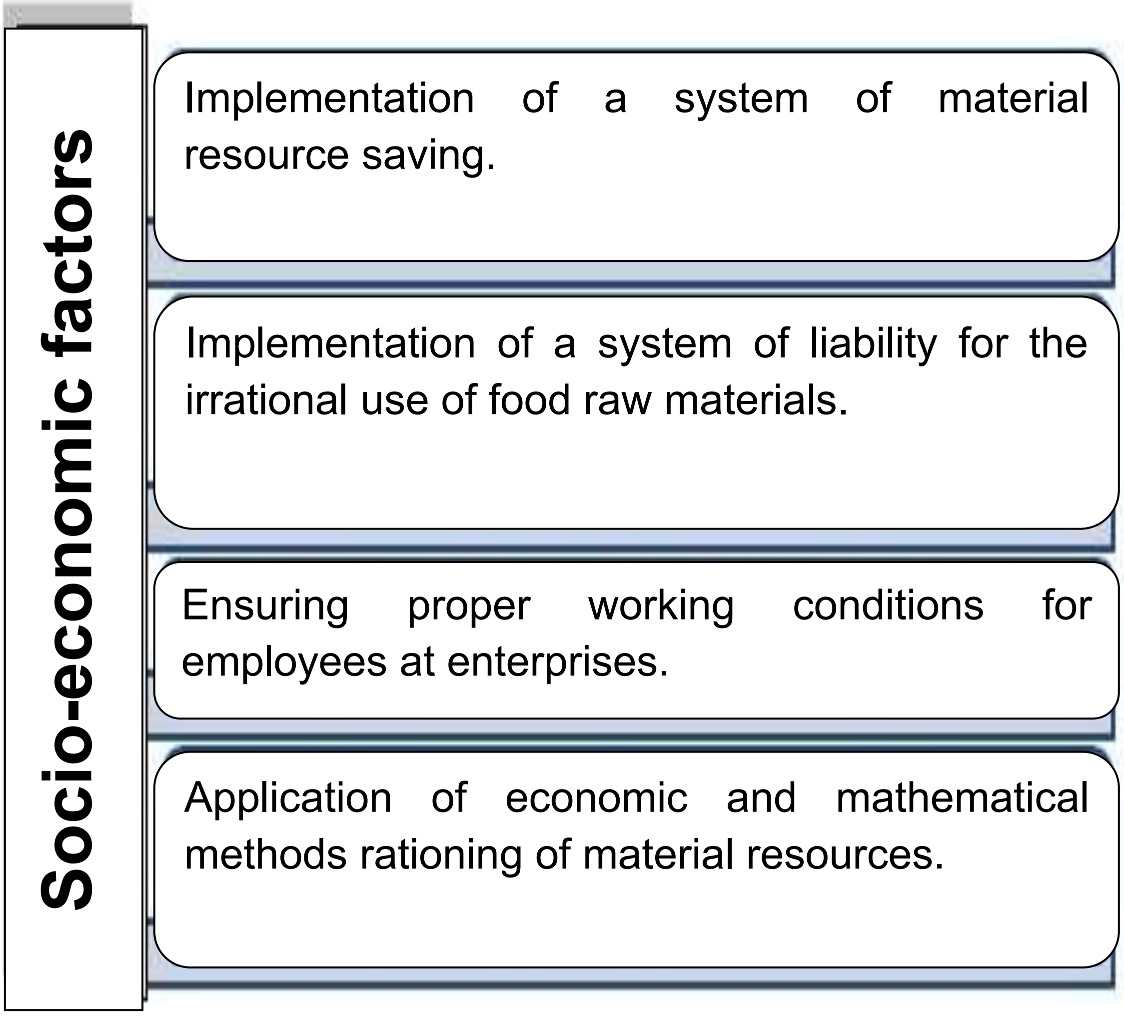


Fig. 1.5 – Factors contributing to the implementation of resource-saving activities in food production

The solution of these problems will contribute to the rational and efficient use of all types of resources involved in the enterprise.

SECTION 2.
FEATURES OF FOOD PRODUCTION FROM RAW MATERIALS OF PLANT ORIGIN

2.1. General characteristics of technological stages of storage and preparation of raw materials for production

Storage of raw materials is a component of any technological process, the purpose of which is: storage of raw materials without losses or with minimal losses; storage or improvement of raw material quality.

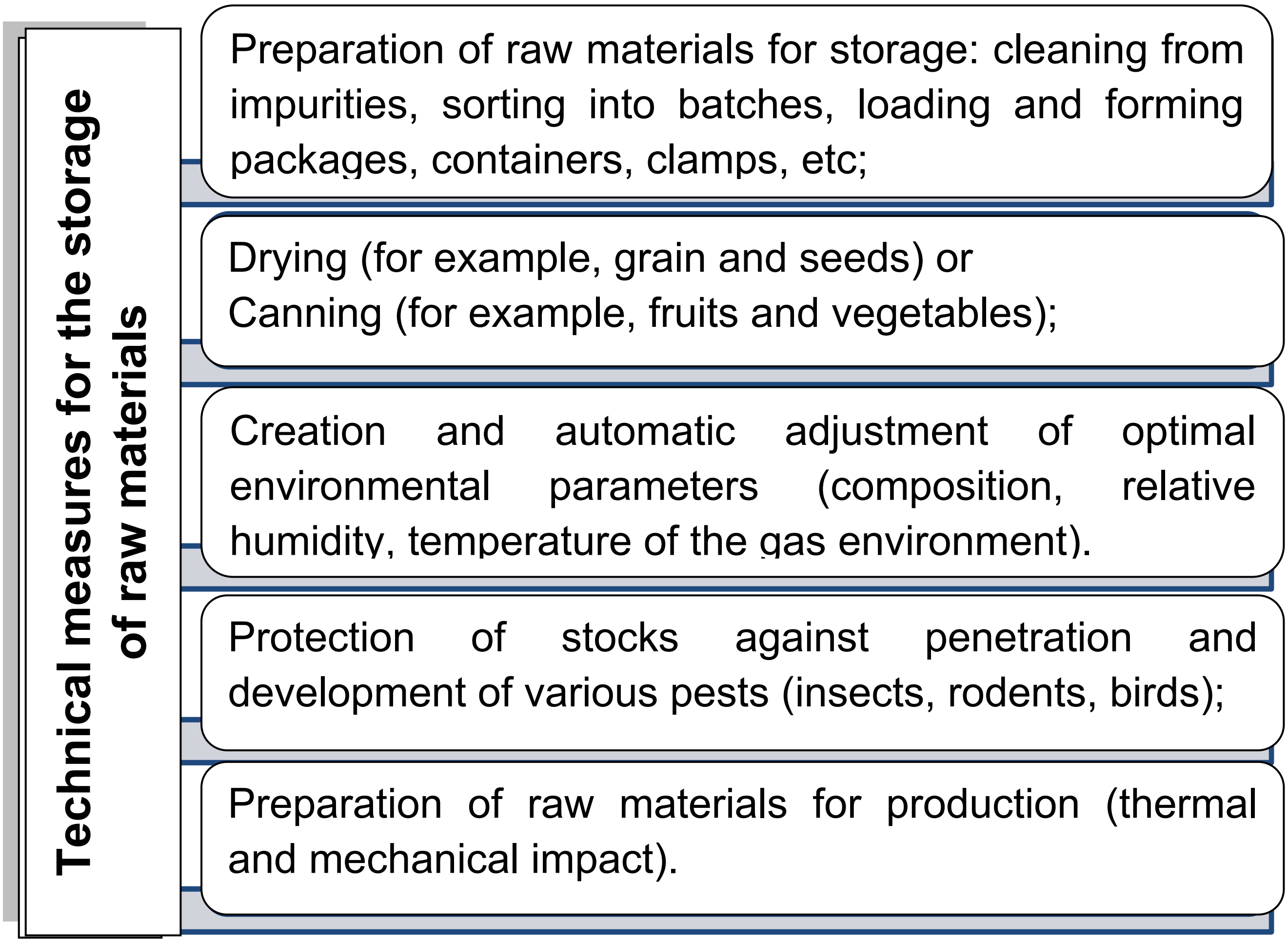
The practical implementation of these tasks is provided by a set of technological measures that make up the essence of technological storage. The most important of these measures are presented in Fig. 2.1.

The implementation of these measures will not only save weight, but improve the technological properties of raw materials, on which the quality of finished food products primarily depends.

Losses of raw materials during storage are due to its physiological properties and storage conditions.

> *There are two types of losses: weight loss and quality loss. The first type is associated with a decrease in weight, and the second – with a decrease in the raw material of useful substances (for example, sugar in sugar beets, starch in potatoes, oil in seeds).*

Both types of losses are interrelated, but mass loss does not always cause a loss of quality, for example, with mechanical losses (spillage). In most cases, the loss of mass of products is accompanied by a decrease in their quality, or vice versa, a decrease in quality is simultaneously the cause of the loss of mass of products.



Technical measures for the storage of raw materials

Preparation of raw materials for storage: cleaning from impurities, sorting into batches, loading and forming packages, containers, clamps, etc;

Drying (for example, grain and seeds) or
Canning (for example, fruits and vegetables);

Creation and automatic adjustment of optimal environmental parameters (composition, relative humidity, temperature of the gas environment).

Protection of stocks against penetration and development of various pests (insects, rodents, birds);

Preparation of raw materials for production (thermal and mechanical impact).

Fig. 2.1 – Technical measures for raw material storage

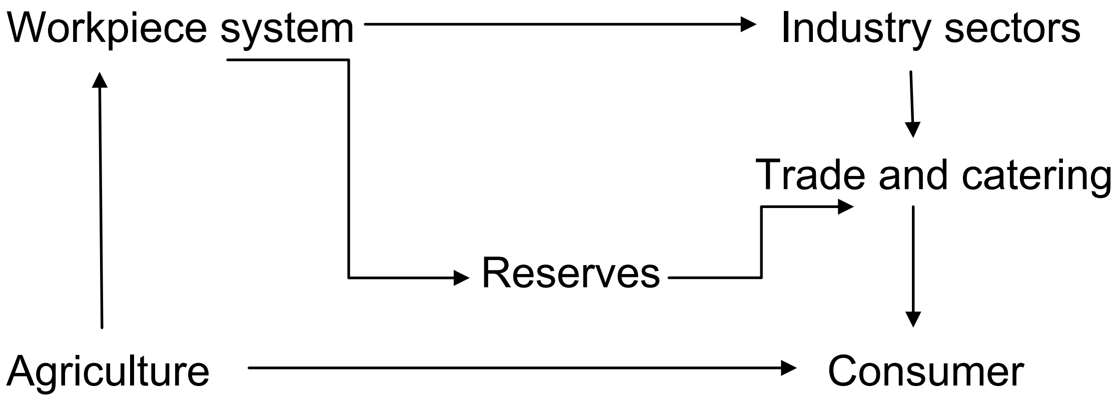
Losses during storage and transportation of raw materials can be divided into five main groups: mechanical, or physical, physicochemical, biological, biochemical and chemical. Each of these groups, depending on the causes that brought them about, is divided into the corresponding subgroups.

Physical and chemical losses include mass losses by evaporation. This type of loss is typical for liquid products, fruits and vegetables.

Biological losses, depending on the causes that bring them about, can be divided into two subgroups: losses due to microbiological processes and losses resulting from the development of pests.

Biochemical losses are mainly associated with the processes of respiration and are characteristic of all living organisms of both animal and plant origin.

Chemical losses can be caused by various reasons: the action of radiation, including light, air oxygen, the presence of inorganic catalysts. All these processes correlate with the action of temperature and the presence of moisture in the environment. Nationwide, the movement of raw materials is carried out according to the following scheme:



In all links of the given scheme, stocks of raw materials are organized. On a functional basis, they are divided into basic, industrial, trade-industrial, universal and specialized. Basic stocks are devided into sectoral and regional; industrial ones are part of industrial enterprises; trade-industrial are organized in the trading system, where often the storage functions are supplemented by the primary processing of raw materials.

Universal warehouses store a variety of raw materials compatible for storage, and in specialized warehouses – raw materials of only one type.

Bulk materials are stored in containers and in dry conditions of bunkers, silos.

Grain at food enterprises, depending on their capacity, is stored in granaries of the barn or elevator type. Modern enterprises for grain processing build grain silos of the elevator type.

Corn grain at the mills is initially stored in the cobs in bulk in special storages called corn cribs. Modern crib is made of reinforced concrete with a capacity of 5 thousand tons or more.

Flour is stored in flour storages. The warehouse for bulk storage of flour should provide at least its seven-day stock for production.

It is not allowed to store in the flour warehouse products and materials with a pungent smell (fish, gasoline, kerosene), as well as production waste.

Salt, sugar, starch are stored in separate storehouses from flour and grain.

Juicy raw materials have the ability to deteriorate quickly. Short-term storage is carried out at the raw material sites of the plant. The site should have a roof, asphalt or concrete pavement, a slope for draining water and a sewer for their drainage.

Liquid products (molasses, vegetable oil, sugar syrup) are stored in containers. This raw material is transported through pipes, which in winter should be heated with a steam jacket. Periodically, the pipes are washed with hot water.

Methods of preparing raw materials for production are varied and depend on its type, physical condition and methods of subsequent processing. The methods of preparing dry raw materials, as well as methods of preparing juicy (fruit and vegetable) raw materials are similar.

Preparation of dry raw materials consists of sorting and purification from foreign impurities, mixing in optimal proportions, weighing and sorting. The listed operations can be supplemented by others depending on the type of raw materials and conditions of further processing.

Preparation of fruit and vegetable raw materials at canneries is very diverse and depends on the type of raw materials. The stages of preparation of fruits and vegetables are shown in Fig. 2.2.

> *Calibration is called the separation of fruits in size.*

Washing, depending on the raw material, is carried out before and after cleaning. To remove dirt and earth, vegetables are thoroughly washed in special machines.

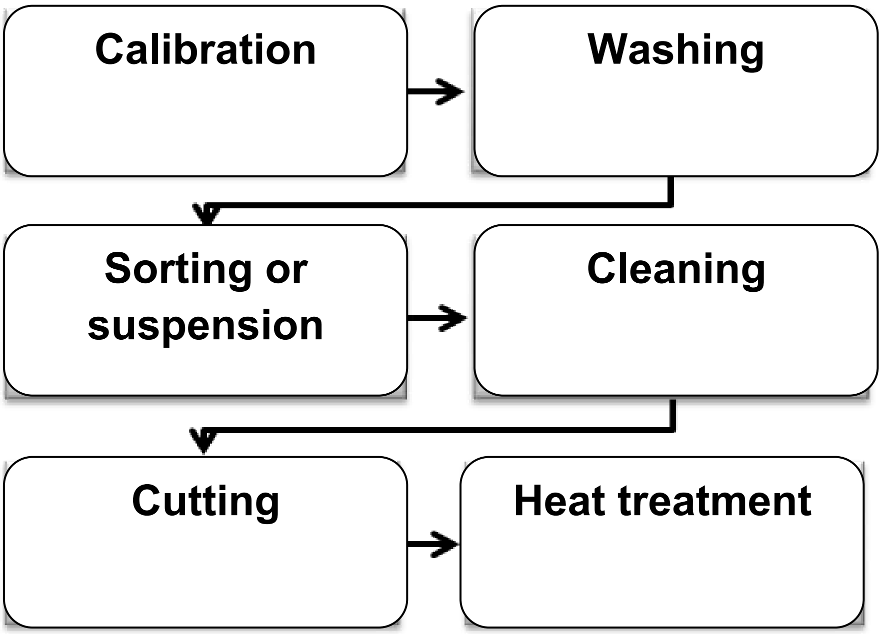


Fig. 2.2 – Stages of preparation of fruits and vegetables

Purification includes the removal of the stalk, seeds, remnants of greenery, peel.

> *Sorting (inspection) is organized as an independent process in the conveyor or combined with cleaning. Sorting is carried out by color, shape and other signs.*

Cutting vegetables is made on special cutting machines.

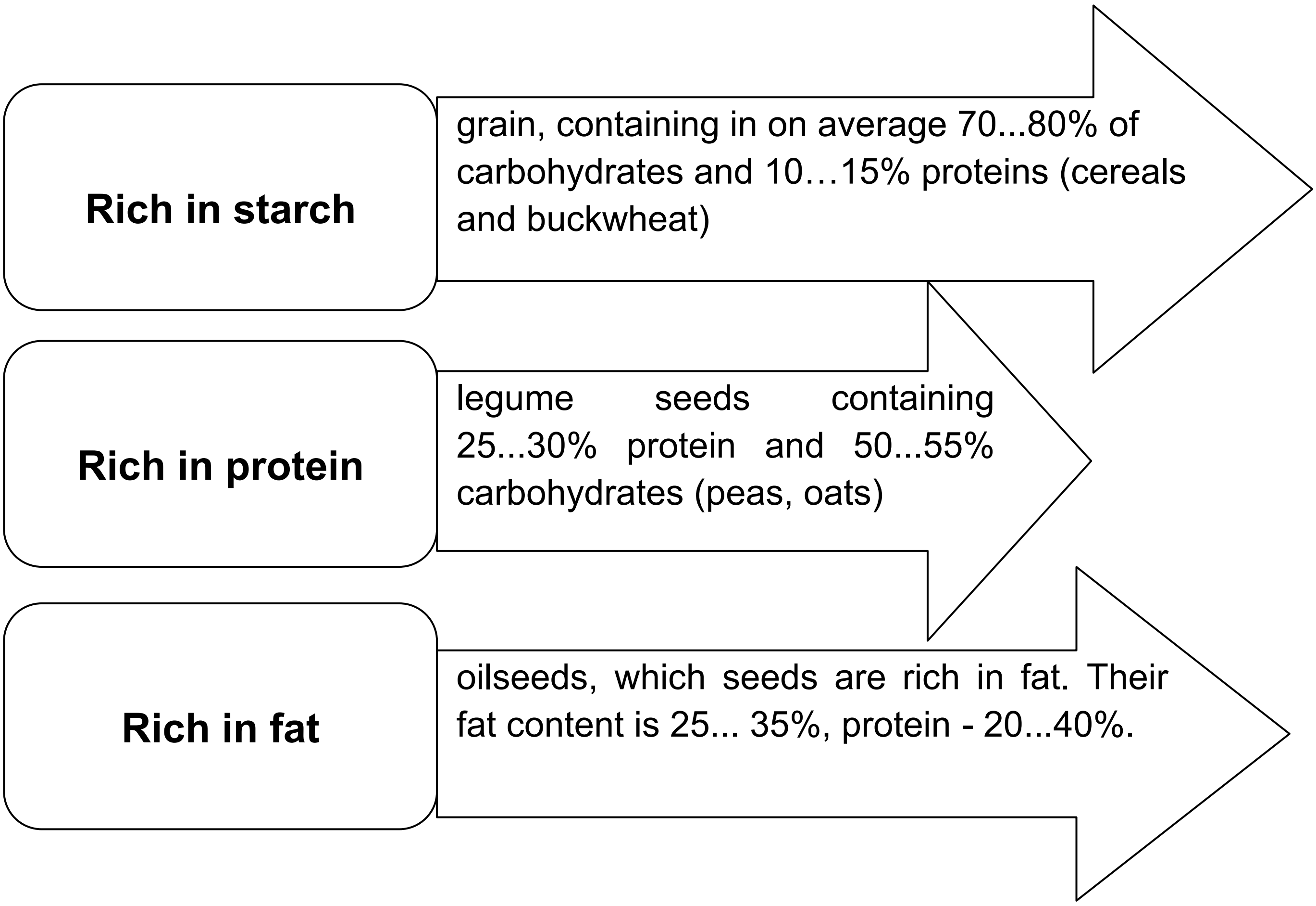
Heat treatment consists of blanching and roasting.

2.2. Characteristics of grain and grain crops

Grain production is the leading branch of agriculture. This is due to the fact that grain products are not only food (in the form of bread, pasta, cereals, etc.), but also the main feed base for animal husbandry.

Directly with food, a person annually consumes about 140 kg of various products from grain.

In general, the group of grain products includes about 100 different types of grain and seeds, but the most important are 9... 10 types of crops. Grain classification by chemical composition is shown in Fig.2.3.



Rich in starch

grain, containing in on average 70...80% of carbohydrates and 10…15% proteins (cereals and buckwheat)

Rich in protein

legume seeds containing 25...30% protein and 50...55% carbohydrates (peas, oats)

Rich in fat

oilseeds, which seeds are rich in fat. Their fat content is 25... 35%, protein - 20...40%.

Fig. 2.3 – Grain classification by chemical composition

In practice, grain is often classified depending on the intended purpose, its use.

So, it is customary to divide the grain into flour, cereal, feed, technical and sowing types.

To produce flour, wheat grain, rye, as well as a small amount of corn, barley, rice are mainly used.

Cereals include: millet, buckwheat, rice, barley, oats, peas, wheat.

Feed type includes: oats, barley, corn.

Technical: barley, oilseeds, rye, etc.

Grain of one crop can be used for different purposes, so this classification for the intended purpose is conditional.

Brief description of individual crops. Wheat has 22 species. The most important food value have two types. This is soft and durum wheat. According to its biological properties, wheat is of winter and spring types. The average yield of winter wheat is higher than spring. But spring wheat grains have the highest baking properties.

The basis of the commodity classification of wheat is a number of certain, free characteristics. These are primarily generic (soft and hard) and biological (winter and spring) features, as well as grain color (red and white). According to these features, wheat is divided into six types: I – soft spring red, II I – spring hard, III I – spring white, IV I – winter red, V I – winter white, VI I – winter hard.

A certain type of grain has its own technological properties.

In the world balance of grain crops, the share of soft wheat used for the production of bakery flour accounts for 95% and only 5% is the share of durum wheat used in the production of pasta.

There are 12 types of rye. Only one species is cultivated – sowing rye. This is winter culture. Along with the production of flour, a significant amount of rye is used in the production of malt.

In terms of barley production, it occupies the second place in our country, after wheat. There is one type of barley, which in turn is divided depending on the structure of the colossus into two-row and multi-row barley. Barley has both winter and spring forms

> *The barley grain contains little protein, which makes it possible to use it as a valuable raw material (in the form of malt) for production.*

For technical purposes (malt production) and for the production of cereals spring two-row barley is used. Winter barley is used exclusively for feed purposes.

Oats are a spring crop. In our country we grow sowing oats and Byzantine oats. The high content of protein, fat, fiber, vitamins in the grain of oats determines the nutritional and feed usage.

> *From oats a number of products for dietary and baby food: cereals, oat flour, coffee substitutes, cookies, etc. are received.*

But due to the increased fat content, products made from oats are the least shelf-stable compared to other grain products.

Rice is the main food product for more than two billion people. Rice grain is rich in carbohydrates, mainly starch, and relatively poor in protein, the content of which in shelled grain is 8%. Rice is mainly used for the manufacture of cereals, as well as for the production of flour and starch.

Rice groats have high taste properties and are easily digested, which makes it possible to use it for dietary and baby food.

Cultural features are divided into two subspecies: common rice and short-grain rice. In our country only a common rice is grown. An important biological feature of rice is the high need for water and the ability to withstand prolonged flooding. Therefore, rice is grown in irrigation.

Corn is the third most important cereal crop in the world (after wheat and rice). Its peculiarity is that it has high performance and the possibility of diverse use.

About 25% of corn grains received in the world are used directly for food, all other grains are used for various industries of the processing industry or for feed of farm animals.

In ripe cobs, grain accounts for 80% of its mass. The budding of corn grain is very rich in lipids, the content of which is close to 40% of the total mass of the budding.

Corn is divided into eight types: dent corn, starch-sugar corn, popcorn, wax and others. In our country, the most common are dent corn (for forage purposes) and flint corn (for processing into food products).

Millet – groats culture Obtained from millet cereal is called husked millet. Millet is also used to produce malt in the production of alcohol.

Buckwheat is grown to produce grain, as well as honey. The fruit of buckwheat, freed from the fruit shell, is called the core and is used as a cereal.

> *Buckwheat has high taste, contains an increased amount of fiber and minerals, which makes it suitable for dietary nutrition.*

Legumes are a group of crops that includes: peas, fodder beans, soybeans, beans, peanuts, etc. A characteristic feature of legume seeds is a high protein content, which is two to three times more compared to cereals of bread. In addition, soybean seeds, peanuts contain a significant amount of lipids.

Peas are the main legumes.

> *In our country, two types of peas are grown: sown, having a food purpose, and target, which is used for feed purposes.*

Soy is one of the ancient cultures. Among legumes, soybeans occupy the first place in the world in terms of nutritional value, and in terms of gross seed harvest among cereals – the fifth place, behind wheat, rice, corn and barley.

The soybean genus includes 40 species, and one species is grown as a crop – cultivated soybean. The main world soybean growing areas: China, Japan, India, South America, USA.

Soy is used to produce oil and protein substances: soy milk, soy cheese (tofu in Japan), soy sauce. But soy flour is not subject to storage because of the fat content. The second drawback is the presence of a specific smell. In addition, soy contains oligosaccharides that are not absorbed by the human body. This applies to other legumes. At present, a significant number of bean isolates are made in the world, which are used to produce meat substitutes and to enrich flour products with proteins.

Assessment of grain quality allows us to determine its benign quality, degree of usability, storage stability, technological properties, correctly organize transportation, storage and processing.

The standards for any grain products include indicators that allow you to determine the quality of grain:

- *Organoleptic assessment - the appearance of the grain (normal or heating), color, smell.*
- *Humidity. The level of grain moisture depends on many factors and the chemical composition of the grain, weather conditions during harvesting, harvesting methods, post-harvest processing, transportation and storage conditions.*

Grain moisture condition is shown in Fig. 2.4.

Dry	Medium dryness	Raw
up to 14 % of the total	from 14% to 15,5%	from 17%

Fig. 2.4 - Grain moisture condition

Humidity should be considered when choosing technological schemes for processing grain products. Therefore, humidity is determined at all technological stages.

Clogging – the undesirable presence of impurities in grain, which reduces the nutritional value of the grain, worsens the taste.

Impurities found in grain products are divided into cereals and garbage.

Grain impurities – broken and eaten grains of the main crop (if there is a half-grain):

- grains of the main crop, deformed and damaged, crushed, underdeveloped, sprouted, moldy;
- grains of cultivated plants that belong to grain impurities according to the standard (for harvested wheat, these are grains of rye and barley).

The classification of garbage impurities is shown in Fig. 2.

Mineral impurities	lumps of earth, pebbles, etc.
Organic impurities	parts of the stem, leaves seed shells of wild-growing plants
Seeds of cultivated plants	not classified as grain impurities

Fig. 2.5 – Classification of garbage impurities

Harmful impurities that can cause poisoning of people and animals include: fungal diseases of plants (mycosis); grains affected by fusarium, as well as poisonous weed seeds (mustard, sophora, etc.).

The content of harmful impurities is strictly regulated by the total amount and should not exceed 1% of the weight of the grain.

When receiving grain must be checked for infection by pests of grain stocks, with the exception of the tick (unacceptable). Infestation of barn pests is determined by the number of specimens of living insects in 1 kg of grain.

The absolute mass is the mass of 1000 grains in grams. This indicator characterizes the grain size and fullness. The higher the absolute mass, the better the grain.

The absolute mass of grain (in g): soft wheat – 25... 35, hard wheat – 28... 40, rye – 17... 25, oats – 22... 42, barley – 30... 45, millet – 4... 7.

Alignment: the degree of uniformity of individual grains in a given batch of grain in size. It is determined by sieving the grain (usually 100 g) through a set of sieves.

The glassy appearance characterizes the consistency of the grain endosperm, the degree of protein binding to the endosperm starch. The stronger the bond, the better the technological properties of the grain. The glassy grain should not have a powdery particle larger than the ¼ of its size. The glassy grain has a transparent consistency, and the powdery grain is opaque, brittle, white on the cut.

According to this feature, the grain is divided into glassy, partially glassy and powdery.

> *The higher the glassy appearance, the greater the yield of flour of higher grades. The glassy appearance of durum wheat is not lower than 90%. The glass level is taken into account when preparing the grain for grinding.*

The amount of raw gluten is directly dependent on the protein content. Wheat protein is insoluble in water (gliadin and glutein), but has the ability to absorb moisture. After removing the starch from the kneaded dough (from flour and water), gluten remains. The content of raw gluten in the grain ranges from 12 to 50%.

Grain hoodness is determined by separating films, the mass of which is attributed to the mass of grain and is expressed in percent. It varies within such limits in% for oats – 5... 17%, barley – 6... 16%, millet – 20... 40%, rice – 17…25%.

> *In grain harvested for malt production, as well as used in the alcohol and brewing industries, germination and germination energy are regulated by standards. In grain, content of small cereals and small grains is normalised.*

Fresh collected grain, which has high humidity, should immediately be subject to purification from impurities of self-heating development, that is, unauthorized temperature increase in the mass of grain. At the same time, the grain shell darkens, the amount of gluten decreases and its quality deteriorates, automatic processes increase and acidity increases. Grain can have a musty smell, bitter taste because of the development of molds. This grain is not used.

2.3. Beer Technology

Beer is a low-alcohol drink obtained from malt and unbroken cereals (barley, wheat, corn, rice, treticale, etc.) by alcohol fermentation of hopped wort with beer yeast. It not only quenches thirst, but also increases the tone of the body, improves metabolism and digestibility of food.

> *Beer is a rather complex system of organic and inorganic crystalloids and colloids in a weak aqueous-alcoholic solution.*

It consists of more than 400 compounds that determine the high quality and necessity for a person of this product.

Beer contains more than 30 minerals and microelements, which are mainly of malt origin. The alcohol content in beer does not exceed 10% vol., extractive substances - from C to 10%, of which 80% are carbohydrates, and 70% of them are dextrins. Along with dextrins, beer contains a small amount of maltose and very little glucose. A significant number of extractive substances are protein compounds and their hydrolysis products: albumoses, peptides, amides and amino acids. Beer contains bitter, tannins and dyes, as well as organic acids - lactic, amber, oxalic, malic. It is very important that beer contains biologically active substances, including vitamins (thiamine, riboflavin, nicotinic acid), and brewer's yeast contains vitamin B_1 in significant quantities.

One of the important components of beer is hops. It not only gives a drink bitter pleasant taste and special aroma, but also is used as a preservative, inhibiting harmful for beer lactic fermentation.

> *The bitterness and antiseptic properties of hops are due to hop acids*

There are a lot of beers. Each variety is characterized by a certain aroma, taste, color, the presence of an appropriate amount of extractive substances, alcohol content, degree of fermentation and other physical and chemical indicators. The brewing industry in Ukraine specializes in the production of light and dark beers.

> *The main raw material for the production of beer is malt, made from sprouted and dried barley in special conditions.*

In addition to malt, one should use water, hops, various crops (barley, wheat, corn, rice, treticale), yeast, sprouted grain concentrates, enzyme preparations, sugar.

Brewing barley, compared to other cereals used in brewing, has significant advantages: it grows almost everywhere, unpretentious to soil and climatic conditions; easily processed to produce malt; the shell of crushed barley malt loosens the layer of crushings, which ensures good filtration of the wort when separating the plug. The composition of barley malt and its enzymes make it possible to obtain beer with the best quality indicators.

Hops along with water and malt is also the main type of raw material for the production of beer. Due to the content of bitter substances, essential oil, polyphenols, it is an indispensable raw material for the production of beer.

> *It is hops that determines the characteristic specific properties of beer the most: along with unique taste and aromatic qualities, it acquires the ability to withstand turbidity during storage. Foam formation and foam resistance of the drink improve.*

Valuable substances that contain hops give beer a special biological significance. The presence of more than 400 different compounds in hops contributes to the fact that it is used in folk and scientific medicine. The most important components of hops for brewing are essential oils and hop acids. And the main property of hops is an elegant aroma, which during technological processing is transmitted to beer without an extraneous unpleasant smell. Hop components are effective agents for the precipitation of high molecular weight nitrogenic substances from wort, have a positive effect on the foam resistance of beer, and also have a bactericidal and preservative effect on the final product.

Nowadays, without natural biologically active organic catalysts of protein origin, that is, enzymes, it is impossible to produce high-quality beer. Unlike inorganic catalysts such as acids, alkalis, metals and their oxides, enzymes are not harmful to the human body. In the technological processes of brewing, the specific action of enzymes makes it possible to obtain the maximum amount of wort and beer with a minimum content of side substances.

Beer production includes the following technological processes: preparing of beer wort, fermentation of wort, fertilization and maturation of beer, lighting and bottling of beer in bottles and kegs.

Brewer's wort preparation consists of five stages, as shown in Fig. 2.6.

The most important technological process of wort preparation is conversion of fermentative components of malt and its substitutes (barley, wheat, rice, corn, sorghum, treticale and other cereals) into soluble extract.

Before grinding, malt and its substitutes are cleaned from dust, organic and inorganic impurities.

> *Air-sieve separators with magnetic devices, movable sieves and dust separators are used for cleaning grain products.*

Malt is moistened before grinding, due to which the shell becomes softer and better separates from the core, forming an optimal filter layer during the separation of the mash into wort and shot.

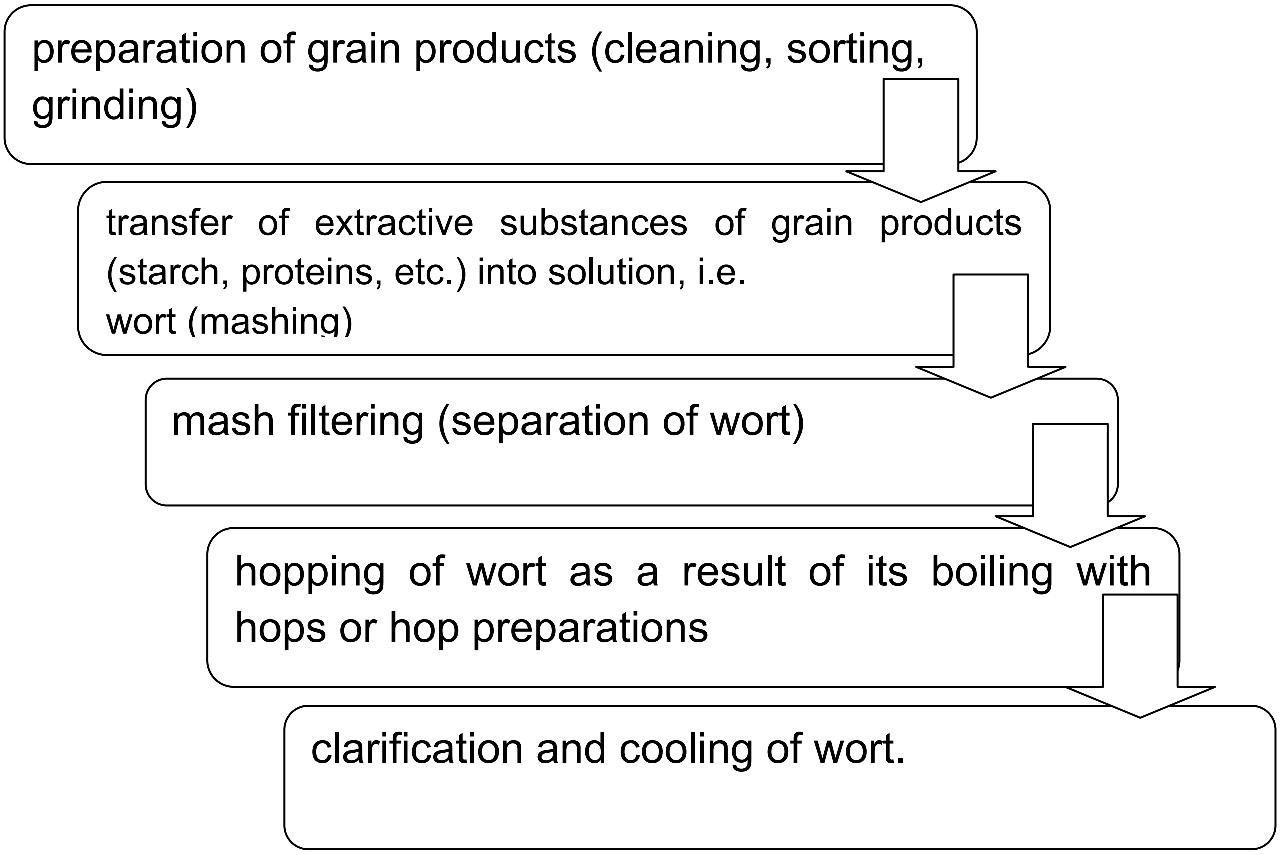


Fig. 2.6 – Stages of beer wort preparation

The purpose of grinding malt and grain products is to create the most favorable conditions for the action of water and enzymes on grinding fractions, as well as to accelerate physical and chemical processes, which ensures rapid dissolution of substances and enzymatic conversion of insoluble compounds (starch, proteins, etc.) into soluble ones. It is necessary to achieve a complete conversion of the extract of grain products into wort.

During grinding of grain products, as well as malt, the shell should remain in the form of the largest particles, which will not only bake the formation of an optimal loose filter layer, but also significantly reduce the transition of undesirable substances into wort.

Conversion of extractive substances of grain products and malt into solution (mashing) is carried out in a stopper, where crushed malt and grain products are mixed with water, heated and boiled. The apparatus is a cylindrical container with a double spherical bottom, forming a steam chamber, with which the mash is heated and boiled. The apparatus is equipped with a distribution valve for directing the pumped mash mass into the filtration apparatus.

In cereals and malt, the potential nutrients for yeast are not in the form that they could use. Therefore, the high molecular weight compounds present in the grain must be broken down into molecules suitable for consumption by yeast.

> *At the mashing stage, enzymes present in malt break down starch and proteins present in it and other cereal additives. The cleavage products – simple sugars, amino acids and lower peptides – can be used by yeast during beer production.*

In classical beer technologies, malt is used not only as the main raw material, but also as a source of enzymes for splitting insoluble substances. However, malting is an expensive process of obtaining enzymes. Significant savings can be achieved by partial replacement of malt with untreated grain and industrial enzyme preparations.

In the process of mashing in the stopper, it is necessary to create optimal temperature conditions for the action of enzymes. Starch undergoes enzymatic changes that occur in three stages: gelatinization, liquefaction and acidification.

The optimal temperature pauses during mashing of malt are: the beginning of mashing at a temperature of 40... 45 °C to thin the mash under the influence of cytolytic and other enzymes, then the temperature of the mash rises to 50...52 ° C – protein pause, optimal for the action of peptidases; for the icing of starch, the limit temperature is 73 ° C, optimal for the action of α-amylases.

In brewing, two methods of mashing are used: infusional and boiled.

> *According to the infusion method of mash preparation, water is to be heated to such a temperature that its initial value during mixing with malt is 40 °C.*

Half of the amount of water is poured in the mash apparatus, and then simultaneously crushed malt and the rest of the water with stirring. The mash is kept for 30 minutes at 40 °C. In the process of mixing, it is heated to 52 °C at a rate of 1 °C per minute and for the effectiveness of peptidases at this temperature, a pause of 30 minutes is made. Then the mass is heated to 63 °C (maltose pause), held for 30 minutes, then to 72 ° C and kept until the final icing, which is determined by iodine sample. The sugar mash is heated to 76... 78 ° C and pumped into a filtration apparatus for filtration.

The single-brewing method consists in the fact that half of all the water that is spent on one mash is poured into the mash apparatus, it is heated to such a temperature that after adding the crushed malt the mash temperature reaches 50... 52 ° C. Then the stirrer is turned on and crushed malt is lowered into the apparatus from the hopper, simultaneously supplying the remaining water.

The temperature of the mash mass after stirring is set within 50-52 ° C, which corresponds to the optimum for the action of proteolytic enzymes. At this temperature, the mash is kept for 30 minutes (protein pause), then with the stirrer turned off, 1/3 of the thick mass is lowered into the boiling apparatus. This part of the mash is called broth. In the boiling apparatus, the mash is heated to 62... 63 ° C with stirring and kept for 20 minutes (maltose pause), then the temperature is increased to 70... 72 ° C and kept for 15 minutes for starch icing. After icing, the mass is heated to boiling and boiled for 20 minutes with the stirrer running. To preserve the activity of enzymes in the main mash, the broth is pumped into the mash apparatus slowly, directing it to the center of the apparatus for better mixing. The single-brew process is used only for processing well-dissolved malt with high acetic acid capacity.

The double-brewed method of mashing makes it possible to process malt of different quality, while the temperature regime of mashing can change.

Triple-brewed method is applied mainly for manufacturing of dark beers and processing of poorly dissolved malt in order to increase extract yield.

Filtration of the mash, that is, its separation into wort and shot, is carried out in the filtration apparatus according to the following successive operations: preparation of the filtration apparatus, pouring of sieves with water (15 minutes), pumping of the mash into the filtration apparatus (20 minutes), settling of the mash (25... 30 minutes), passing of taps and return of turbid wort (10 minutes), filtration of the first wort (90 minutes)), shot washing (120 min), shot unloading (25 min).

Filtration presses are also used to filter beer mash, on which all labor-intensive processes are mechanized and automated.

Filtered wort coming from filtration apparatus or filter press is boiled with hop in wort copper.

> *The purpose of boiling wort with hops is to stabilize its composition, evaporate to a specified concentration, extract aromatic and bitter substances from hops, inactivate enzymes, coagulate proteins and sterilize wort to ensure pure fermentation and obtain a stable product.*

After wort introduction into wort copper temperature in it is set within 63-75 ° C. Under these conditions, α -amylase saccharifies the starch, which passes into the wort after washing the shot. Upon completion of introduction into the wort copper of washing water from the filtration apparatus and upon reaching a complete set of wort, it is heated to boiling and boiled for about 2 hours.

The wort in the wort copper must be boiled at such an intensity that the amount of water that evaporates estimated at least 5... 6% in 1 hour.

> *End of boiling is determined by mass fraction of dry substance in wort, presence of large flakes of coagulated proteins in it and transparency in hot state.*

Mass fraction of dry substance is determined in cooled wort sample by sugar meter.

Hopped wort is a complex polydisperse system (dispersed colloids, suspensions, emulsions and molecularly soluble substances).

After boiling, the wort is passed through a hop separator, and then directed to cooling and clarification, the purpose of which is to reduce the temperature from 100 ° C to 6 or 15 ° C (depending on the fermentation methods), saturate the wort with air oxygen, so that yeast actively multiplies under aerobic fermentation conditions, and precipitates suspended particles. Complete clarification of the wort during cooling eliminates the difficulties encountered during the main fermentation process, and also prevents turbidity and infection of beer.

Preliminary cooling of the wort and its clarification take place in a settling apparatus, which has the form of a cylindrical reservoir with a jacket or coil, a flat, slightly inclined bottom and a spherical lid.

Wort clarification can also be carried out in a hydrocyclone apparatus, which is a cylinder with a conical lid and a flat bottom. Hot wort enters the apparatus tangentially in the form of a jet through the inlet branch pipe at a speed of 20 m/s, due to which it rotates inside the apparatus. Suspended wort particles under the action of hydrodynamic forces gather in the center of the bottom, where a cone of sediment is formed, which is periodically blown away. Wort is also clarified on separators.

The most effective and hygienic way to prepare wort for fermentation is to cool it on plate heat exchangers, which are also used to pasteurize beer and sterilize wort.

For preliminary cooling of wort in plate heat exchanger artesian water with temperature up to 20 ° C is used, and for final cooling – icy water with temperature 1 ° C or brine.

Control of wort preparation for fermentation (cooling and clarification) consists in establishing of normative degree of fermentation, loss of extract between wort copper and fermentation apparatus, degree of clarification and biological control. Losses of extract from cooking to fermentation compartments are determined based on the difference between the extract yields in these compartments. Based on the obtained data, the amount of wort in the fermentation apparatus is determined. Losses of extract from cooking to fermentation compartments should not exceed 1%. To reduce them, you should carefully remove the wort from the sludge and hop shot. Fermentation of beer wort takes place in fermentation machines of various types. The causative agents of fermentation are yeast.

Important for clarification of beer after fermentation is agglutination (flocculation or gluing and settling) of yeast cells, that is, the ability of yeast to enlarge into conglomerates and quickly settle to the bottom. This is due to the electric charge of yeast and their autolysis. Under the influence of its own enzymes during the aging of the cell, the biochemical decay of proteins, carbohydrates and fats occurs and they dissolve, that is, undergo autolysis.

Modern beer technology is characterized by the combination of fermentation and beneficiation in a cylinder-conical apparatus.

> *Its essence lies in the fact that in one apparatus of large capacity (from 100 to 2000 m3) two stages are combined: the main fermentation and beneficiation.*

The entire biotechnological process lasts 14... 15 days instead of 28 (for Zhihulivske beer).

With the first clarified wort, strongly fermented yeast (0.5... 1.0 l per 1 hl of wort) is introduced into the conical part of the apparatus and aeration is carried out with sterile air. The fermentation temperature is maintained in the range of 9 to 14 °C and controlled by the supply of refrigerant. The end of fermentation is determined by reducing the mass fraction of dry matter in beer for 24 hours established for each variety. On the fifth day, the visible final mass fraction of 2.2... 2.5% of dry matter is reached. Then the beer is cooled untill the formation of a dense precipitate of yeast at a temperature of 0.5... 1.5 ° C. In the cylindrical part the temperature 3... 4 °C is maintained for 6... 7 days, and then reduced to 0.5... 1.5 °C and the beer finishing process is carried out.

Yeast is removed from the conical part in 10 days from the beginning of fermentation.

> *In brewing, a number of ways are used to ferment beer wort and to produce beer. This is a periodic, semi-continuous, accelerated in cylindrical-conical fermentation apparatus, etc.*

According to traditional technology distinguish cold (5... 8 ° C) and warm (7... 12 ° C) fermentation in batch apparatuses. The main indicator of fermentation is the final degree of fermentation. With grassroots fermentation in young beer, part of the carbohydrates (1... 1.5%) is left for fermentation and natural saturation of beer with carbon dioxide.

In classical technology, two-stage fermentation is followed, according to which immediately after the main fermentation in separate apparatuses (first stage), young beer is freed from the bulk of yeast, cooled, fermented (second stage) and ripened in special apparatuses.

> *The purpose of the digestion is to complete the biochemical transformation of the leftover yeast into the final products – carbon dioxide, alcohol, esters, aldehydes, higher alcohols, organic acids, amino acids, etc. after the main fermentation. At the same time, diacetyl turns into acetoin, the final formation of aroma, taste, foam resistance and stability of beer occurs.*

During the fermentation of beer in horizontal or vertical apparatuses, the same biochemical processes occur as during the main fermentation, but due to the low temperature and a small number of yeast cells, they are significantly slowed down. Soluble carbon dioxide content increases from 0.2 to 0.4% at the optimum pressure in the 0,04...0,07MPa apparatus.

After ripening, beer is aged, filtered, cooled and treated with proteolytic enzyme preparations to increase its stability. Sedimentation and timely release of yeast cells help to exclude complex chemical transformations, which significantly affects the formation of the taste and aroma of beer, mainly due to the formation of aromatic alcohols and esters.

> *After aging, the beer is filtered through diatomaceous,*

membrane or other filters to remove macromolecules of proteins, yeast cells, protein-tannin compounds and hop resins.

Bottling of beer into glass bottles is carried out on automatic lines, which consist of an automatic machine for removing bottles from a box, a bottle-washing machine, a dispensing machine, a plugging, bracing, labeling machines and an automatic machine for placing bottles in boxes. Beer is also poured into plastic environmentally friendly bottles, beer cans from a special sheet tin intended for food and drinks, and kegs with a capacity of 10... 60 liters.

2.4. Oil technology

The main oil crop in Ukraine is sunflower. Its share is more than 75% of the total production of vegetable oil. Sunflower belongs to the botanical family of asters, its bloom is picked up in inflorescences such as baskets. The fruit is achene with a fragile, shell. The best sunflower varieties are characterized by high yield (35... 40 c/ha) and oil content (52... 60%). The content of the fruit shell and husk is about 20%.

Cotton plant is the second most important oil culture in the world, belonging to the Malva family. The oil content of seeds is 22... 24, husks – 40... 44%.

Other oil crops are processed in much smaller volumes – flax, soy, ricin, rape, sesame, peanuts, mustard.

Flax belongs to the flax family. Its blossoms are of the tassel type, the fruit is a box that can range from one to ten seeds. Yield – 7... 10 c/ha, oiliness - 46... 48%. Flax seeds go for processing without separating the seed shell.

Soybeans belong to the family of legumes, flowers harvested in blossoms such as tassels, fruit-beans, ranging from two to five seeds. The oiliness of soy seeds is 19... 22, husks – 5...10 %.

Oil is also produced from seeds of pumpkins, fir,

> *tomatoes, olives, apricots, peaches, apples, cherries, grapes, plums, from all kinds of nuts, corn germs, wheat and other crops.*

Herbal oils must meet the requirements of standards. Thus, sunflower oil must comply with the requirements of GOST, according to which oil, depending on the method of cultivation, is divided into the types presented in Fig. 2.7.

Refined oils, deodorized and non-deodorized, as well as hydrated of the highest and first grades, should be transparent and without sediment. For hydrated oil of the second grade and unrefined, weak haze or "mesh" caused by the presence of wax and waxy substances in the oil is allowed. Refined deodorized oil should have a taste devoid of individuality and have no smell.

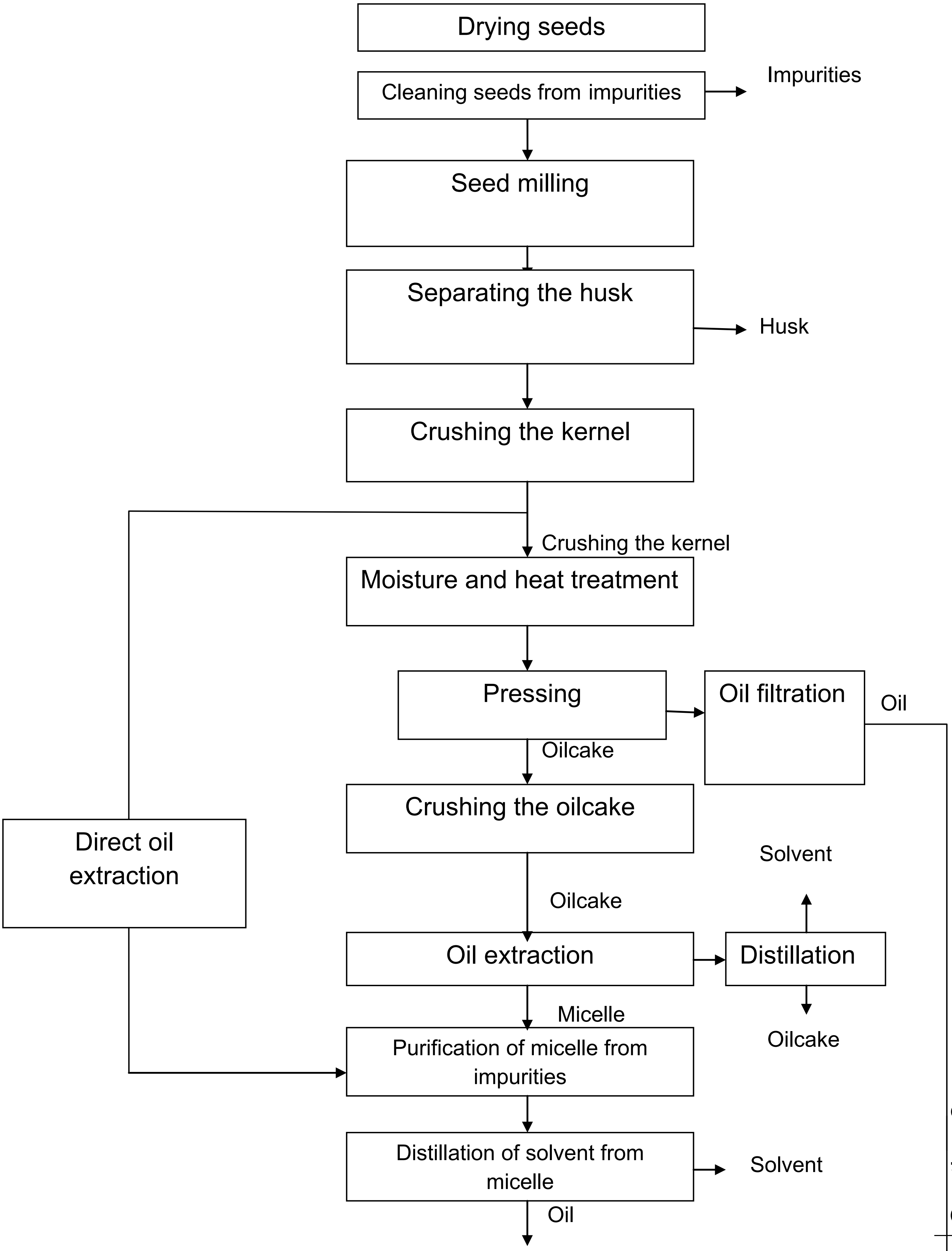
- refined
- deodorized
- undeodorized
- hydrated – premium, first and second grades
- unrefined - premium, first and second grades

Fig. 2.7 - Types of oil

Undesodorized oil and hydrated one of the highest and first grades should have the taste and smell characteristic of sunflower oil, without foreign smells, tastes and bitterness. The same are the requirements for the smell and taste of unrefined oil of the highest and first grades. Second-grade oil, hydrated and unrefined, may have a slightly musty smell and taste of light bitterness. In refined vegetable oil there should be no sediment, phosphorus-containing substances and soap. Oils are dominated by unsaturated fatty acids (oleic, linolinic, linoleic - 70... 80% and in less quantity - saturated (palminic, stearic - about 15... 20%).

Oil production consists of many operations, during which complex physical and chemical processes take place in the oil raw materials. The basic scheme of processing of oil raw materials is shown in Fig. 2.8.

Seeds of the vast majority of oil plants after harvesting comes from moisture, which for the most part exceeds the permissible values for harvesting and technological processing. The most common way to reduce the moisture content of the seeds is heat drying, during which the seeds are heated using a drying agent.


Drying seeds
Cleaning seeds from impurities
Impurities
Seed milling
Separating the husk
Husk
Crushing the kernel
Crushing the kernel
Moisture and heat treatment
Pressing
Oil filtration
Oil
Oilcake
Crushing the oilcake
Direct oil extraction
Solvent
Oilcake
Oil extraction
Distillation
Micelle
Oilcake
Purification of micelle from impurities
Distillation of solvent from micelle
Solvent
Oil

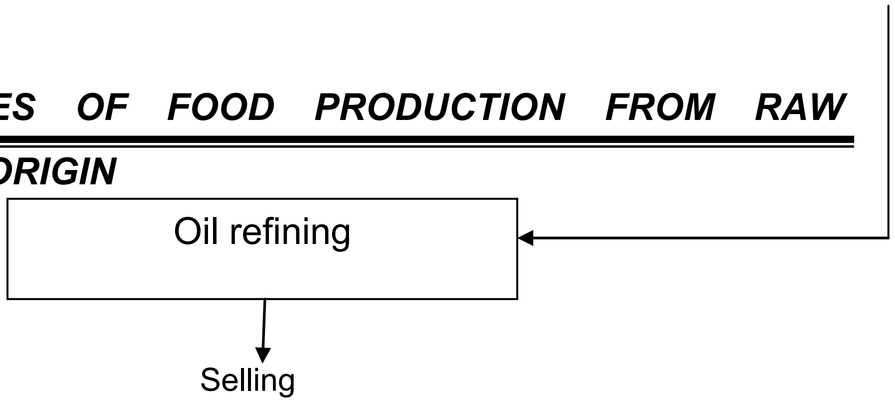


Fig. 2.8 – Principle scheme of oil raw material processing.

Fat reserves in oil seed tissues and fruits are not evenly distributed: the main part is concentrated in the nucleus of the seed - the embryo and endosperm, the fruit and seed membranes contain a small amount of oil, which has a different (stronger) lipid composition. In this regard, during the processing of many oil crops and fruits from the main fat-bearing tissue – the kernel separate small-leaved external (fruit and seed) shells of seeds.

At the same time, the oiliness of the processed raw materials increases, the productivity of technological equipment increases, the number of extracted oil and bleach increases.

> *Separation of the shell from the kernel consists of the operation of destruction of the covering shells of seeds and the subsequent distribution of the resulting mixture to the core and husk.*

Fruit shell of sunflower seed is destroyed by centrifugal mills.

The quality of milling is characterized by the presence of undesirable fractions in it - whole seeds and partially destroyed seeds, destroyed nucleus and oil dust. The presence in the milling of unruly seeds is undesirable: it increases the size of the husk in the kernel. Also undesirable is the presence in the milling of sulfur and oil dust. The sap easily gives fat to the husk even during short contact. Oil dust in general is not separated from husks, which comes from production, and losses of oil with husks increase.

The separation of the milling into husks and cores is based on the difference in their size and aerodynamic properties. The husk is much larger in size from the core and has less resistance to the airflow. First, fractions of rushes are obtained, which contain particles of husks and kernels of the same size, and then in the airflow, each fraction obtained is divided into husks and kernel, using aspiration fans for this.

> *The aspiration fan consists of two main parts: the dissector and the aspiration chamber.*

After aspiration fan receives kernels, unruly seeds and husks. The core goes for further processing. The unruly seed is fed into a airsive-separator similar to the one used to clean the seed. Here, a large husk gathers in the precipitating cones after blowing the unruly seed with the atmospheric air. An unruly seed with less husk content (enriched) goes to re-milling to the milling machine. The waste for re-distribution is fed to the control fan, which differs from the main working set of sieves and the air regime in the aspirating chamber. Husks are removed from the workshop by conveyors.

The work of the milling-fan shop is evaluated by the size of the husk and finished kernels, that is, by the percentage content of husk in the kernels and by the loss of oil in the husk leaving the production in the form of oil dust, grain of kernels and oiling of the husk during contact with the destroyed kernels. The huskiness of the kernels intended for obtaining oil at press plants should not exceed 3, at extractive – 8%. The shells of cotton seeds are destroyed and separated from the cores on machines of a different design, but the technological sequence of operations remains the same.

To extract oil from seeds or from kernel, it is necessary to destroy their cell structure. The final result of the grinding is the transfer of oil contained in the seed to the state necessary for the next technological operations. The necessary step of cutting raw materials is achieved by mechanisms that cut and crush seeds or kernels. The cutting is done on rolling machines.

The material obtained after fragmentation is called a "crumb," which is characterized by a very large specific surface. During the destruction of the cell membranes, during the trimming, the structure of the fat part of the cell is also disturbed, a significant proportion of the fat is released and adsorbed on the surface of the "flesh" particles.

> *Well-grinded crumb should consist of one-sided by size*

> *of particles, contain no whole kernels, at the same time the content of very small (powdery) particles in it should be small.*

For reception of a crumb apply rolling machines.

Extraction of the oil from the pulp is accomplished by pressing or extracting, or most often by combining these two methods.

Oil adsorbed in the form of films on the surface of the particles of the grinded kernels is retained by significant surface forces. For effective separation, it is necessary to weaken this connection. To do this, use hydrothermal (moisture-heat) cutting of crumb, preparation of pulp or roasting.

> *During moisturizing and the subsequent heat treatment of the crumb, the connection of lipids with the non-lipid particle of seeds, proteins and carbohydrates is weakened and the fat goes into a relative free state, its viscosity decreases remarkably.*

Then the crumb is heated to a higher temperature, and moisture thus decreases and at the same time there is a partial denaturation of proteins, which changes the plastic properties of the crumb. Thus, under the action of moisture and warmth, the crumb changes its physical and chemical properties and turns into a pulp.

In the production conditions shown in Fig. 2.8, the process of preparing the pulp consists of the following operations. The final moisture content of the finished pulp for sunflowers is 5... 6%. A pulp with these characteristics provides effective oil pre-extrusion.

For final squeezing, the pulp parameters should be different (final humidity 3... 4%, temperature 110...120°C).

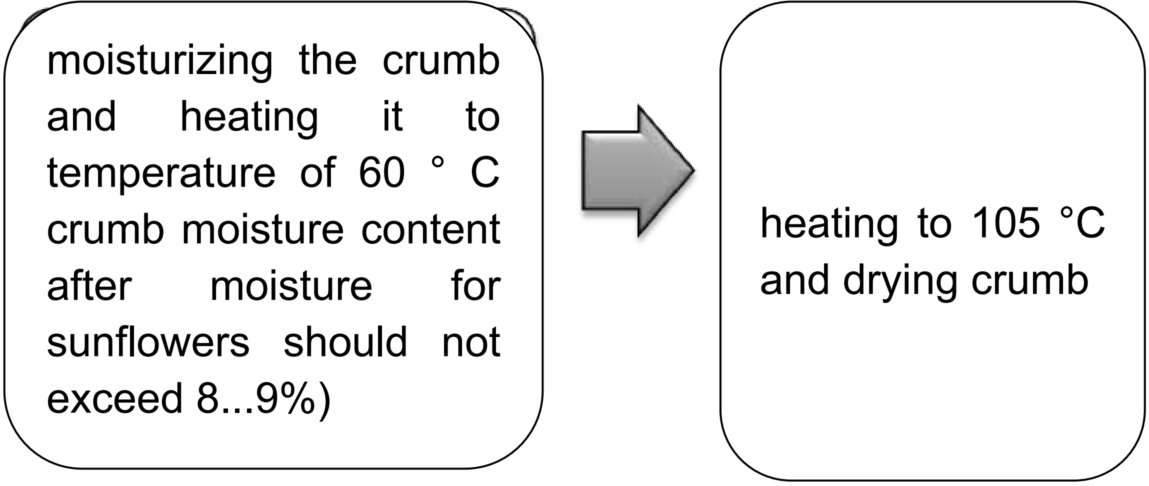


Fig. 2.8 – Pulp preparation process

Drum, screw steam and roasting vats are used for preparation of pulp. The most common vats are roasts of six or five vats. Pressing as a method of extracting oil from seeds and fruits precedes the final degreasing of the material by the action of an organic solvent - extractant.

Squeeze the oil on screw or other presses. Depending on the working pressure of pressing and oil content of the resulting cake, screw presses are divided into presses of preliminary (shallow) oil extraction - fore presses and presses of final (deep) oil extraction.

In practice, screw presses of one-time final extrusion are used, which repeatedly perform preliminary and final extrusion in one apparatus.

By pressing it is impossible to achieve complete degreasing of the pulp.

> *The only way that makes it possible to ensure the complete extraction of the oil is extractive.*

Forpress oil cake before entering for extraction is subjected to treatment in order to give its structure grits, granules or petals, which provide maximum extraction of oil with solvents.

> *Cutting of forpress oil cake is carried out in such a condition: rough cutting of oil cake, the second, more thin, cutting on roll and other crushers, which provide oil cake grit.*

Before obtaining of petals the grit is moistened and warmed up to increase the plasticity, then grit comes to flattening roll on which an oil cake petal in the thickness 0.25... 0,5 mm is received. It is also possible to obtain petals during direct extraction from high-quality seeds, for example soybeans, which are extracted in the form of so-called raw petals.

Grade A and B gasoline and hexane are used as solvent for oil extraction. Gasoline and hexane are chemically inert and do not corrode the equipment, but they are explosive and toxic. Therefore, the work of extractive shops is strictly regulated by the relevant rules and regulations.

> *Herbal oil is most often extracted by immersing the material or by stepwise irrigating the mixed material with a solvent. Other extraction methods are less common.*

In the process of extraction by immersion, oil from the oil material is removed by passing it through the solvent flow under countercurrent conditions, during which the extracted solvent and the material are continuously transferred to each other.

The advantage of extraction by immersion lies in the high rate of extraction and the short duration of the degreasing process, the simplicity of the design of the extraction apparatus, the high efficiency of using its geometric volume (up to 98%). With this extraction method, the possibility of formation of explosive mixtures of wind and solvent in apparatuses is excluded.

> *Disadvantages of extraction by immersion are low concentration of final micelles, high content of impurities in them, significant height of extractors.*

In production, the stripping operation is called micelle distillation. The extracted cake coming out of the extractor goes from 20 to 30% of the solvent, which is removed by heating in digesters using sharp steam. Optimal denaturation of proteins and inactivation of toxic, undesirable substances are achieved. Extracted cake, which is supplied for cleaning, should have a humidity within 3.5... 9%, and its temperature should not exceed 40 °C. The solvent content in the extracted cake should not be more than 0.1, iron admixtures – more than 0.01%.

The solvent removed from the micelle and extracted cake is regenerated by condensation from steam-gas compounds in heat exchangers-condensers.

In crude oils there are always various impurities which complicate their processing and reduce quality of the received products. Part of these admixtures is removed from cells of a seed under action of heat, pressure and an organic solution together with oil.

Therefore, in commercial oil there are always phospholipids, viscous, dyes and products of hydrolysis of these substances (free fatty acids, mucus, diglycerol and other substances).

In the oil obtained from seed there are also products of oxidation of various compounds of lipid nature. The content of products of hydrolysis and oxidation of lipids in the oil depends on the quality of the seed coming for processing and the intensity of the technological effect on the seed. In addition to soluble substances, commercial oil also contains mechanically trapped solid impurities – particles of pulp and cake.

> *Cleaning oil from related substances is called refining. During the refinement, it is necessary not only to remove undesirable, but also to preserve all valuable substances contained in fat, to prevent their loss and decay.*

Modern methods of refining fats and oils are presented in Fig. 2.9.

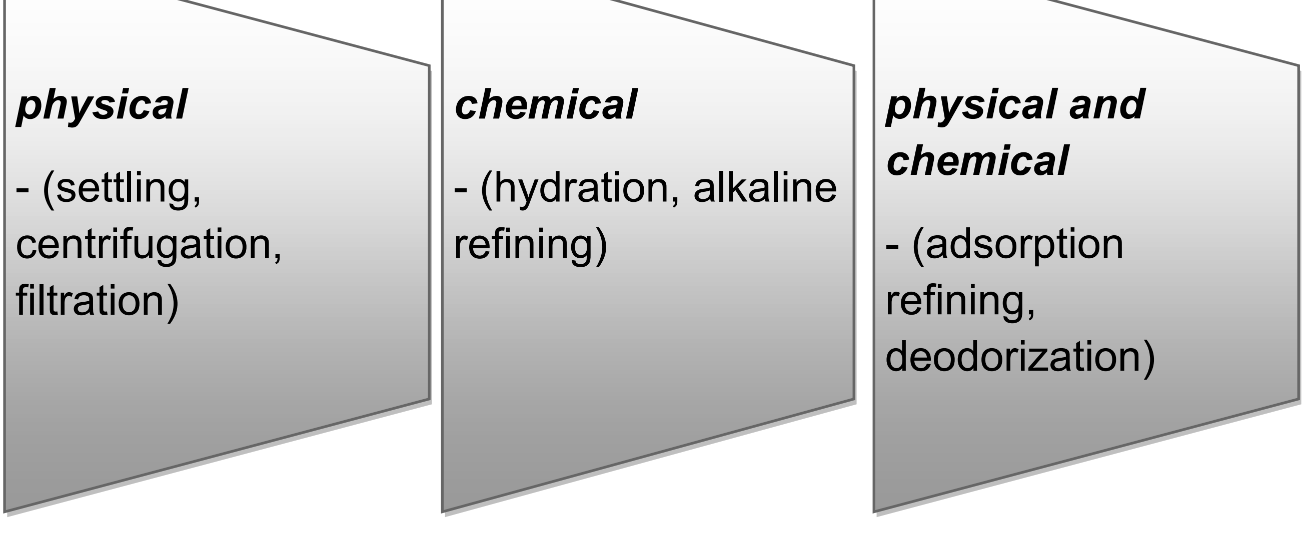


Fig. 2.9 – Modern ways of refining fats and oils

The choice of the method of refining depends on the composition and quantity of the impurities, their properties and purpose of the oil. For the most part, several methods are combined to completely clean the oil.

2.5. Ethyl alcohol technology

About 150 industries use ethyl alcohol as a raw material or auxiliary material. Of great importance is alcohol in the manufacture of medicines, perfumes, films. The main part of ethyl alcohol is used for the preparation of alcoholic beverages – vodka, liqueurs, and alcoholization of grape wines.

Alcohol is obtained from raw materials containing starch (potatoes, cereal grains), sucrose (molasses). Non-food alcohol is also produced from cellulose (wood), the so-called hydrolysis alcohol, as well as from sulfite alkalis is obtained in the production of cellulose. The chemical industry produces synthetic ethyl alcohol from ethylene.

In the general technology of food production, the technology of alcohol from food starch-containing and sugar-containing raw materials is considered.

Potatoes during hydrotransport are freed from sand, stones, light impurities (straw, tops, etc.) and washed.

The grain is cleaned on air-sieve separators. In this case, the grain is freed from light impurities by the air flow, from large, small and ferromagnetic impurities.

Purified raw materials are crushed, as a rule, on crushers of various types. When grinding potatoes, mash is formed with particles of 2... 4 mm, when grinding cereals – milling (coarse flour, passage through a sieve with holes d = 1 mm should be at least 90%).

The crushed raw material is mixed with hot water to obtain a mass of mash containing 18... 20% of dry substances. To potato high-starchy mash is added 0.1... 0.5 kg of water per 1 kg of mash; grinding is mixed with water in a ratio of 1: (2.5... 3). Potato mash is heated by steam, grain, usually by hot water. The mash temperature is 50... 70 ° C.

Mash is prepared in a mixer, where liquefying enzymes are added. Mash stays in mixer for 15... 30 min.

Part of the enterprises introduced low-temperature boiling (enzymatic liquefaction). Under the action of enzymes at a temperature of 85... 95 ° C for 1.5... 2 hours, the starch of the raw material is liquefied. Starch from a water-insoluble form passes into a water-soluble form and becomes easily accessible to the action of acetic enzymes. Dilution of starch is carried out in high-temperature boiling (t = 140... 170 ° C and at the corresponding pressure) for 0.5... 1.5 hours.

Into the liquefied mass cooled to a temperature of 60 °C saccharifying materials (malt or enzyme preparation) are added, under the influence of which starch is saccharified to form maltose and glucose.

$$(C_6H_{10}O_5)_n + nH_2O \xrightarrow{\textit{enzyme}} nC_6H_{12}O_6$$

A significant part of starch is saccharified at a temperature of 57...58 °C for 10...30 min.

> *The residual starch is further saccharified at the next stage – during fermentation.The saccharinizer is a collector with a stirrer and a cooling surface.*

After saccharification, the wort is cooled to a temperature of 30...34 °C and is divided into two streams: the larger part of about 92...94% is sent to the fermentation apparatus, and less than 6...8% – to the yeast generator, where the wort is acidified with sulfuric or lactic acid to pH 3.5...4 and mixed with the inoculated yeast. In the yeast generator the yeast accumulates rapidly and thus mature yeast is obtained, which in the amount of 6...8% of the total amount of wort are fed into the fermentation apparatus, where the rest of the wort mass is fed.

Under the influence of the enzymatic complex of yeast fermentation of sugar into alcohol takes place:

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2 + Q$$

Fermentation is heat-generated. To maintain the optimum fermentation temperature (t = 28...30 °C), heat must be removed, which is done by water through the cooling surface.

Types of fermentation are shown in Fig. 2.10.

Fermentation can be batch, semi-continuous (cyclic) or continuous. In the cyclic and continuous fermentation methods, fermentation apparatus (7...9 pcs.) are connected into a battery through which the entire fermenting mass passes sequentially. The last fermentation apparatus discharges the mature wort. The fermentation duration is 48...56 hours.

In case of batch fermentation the whole process is carried out in one apparatus, where the production yeast is pre-set, and then the apparatus is filled with cooled saccharified wort. The fermentation duration is 56...72 hours.

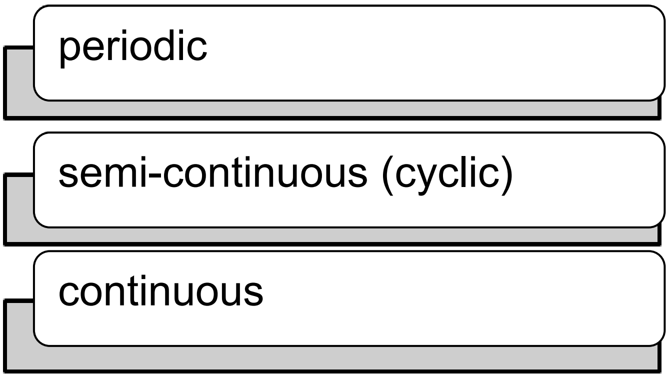


Fig. 2.9 – Types of fermentation

The carbon dioxide released during fermentation, passing through the alcohol trap, is emitted into the atmosphere or used for the production of liquid or solid carbon dioxide.

> *Ripe brew contains 7...10% by volume of ethyl alcohol and 5...7% of dry matter. The content of unfermented sugar should not exceed 0.45 g/100 ml*

In addition to alcohol, mature brew contains a number of volatile impurities. They are usually formed during the fermentation process. The amount of volatile impurities usually does not exceed 1% of the amount of ethyl alcohol.

During distillation in an incomplete distillation column 1, ethyl alcohol with all volatile impurities is removed from the brew. The result is a brew condensate (distillate) containing 30...40% alcohol and a cubic residue (waste) (alcohol-free brew). The waste is discharged from the bottom (cube) part of the column. The distillation process is carried out in a still with 20...25 plates, due to the supply of heating steam to the column cube.

> *Distillation is the purification of alcohol from impurities that have volatile properties greater than those of ethyl alcohol. The distillate contains head (more volatile impurities), tail (less volatile impurities) and intermediate impurities that accumulate in the middle part of the full distillation column.*

The main impurities, consisting mainly of esters and aldehydes, are removed from the brew condensate in the distillation column, which is a complete distillation column. The head fraction, containing esters and aldehydes in concentrated form, is discharged from the top of the column, and the epurate (brew distillate, free from major impurities) is discharged from the bottom of the column. The epurate is fed to the middle part of column 3, where the alcohol is freed from intermediate impurities (fusel oil) and luther water and concentrated to 96.2...96.5% v/v. The rectified (purified) alcohol is discharged from the top of the distillation column, while the residue water containing all tail impurities less volatile than alcohol is discharged from the cube (lower part) of the column. Intermediate impurities are removed from the lower third of the column. All columns are supplied with heating steam from below.

Grain contains about 50% starch, and potatoes about 15%. From 1 ton of raw starch, about 65.5 dl of anhydrous (100%) alcohol is obtained, including 94.6...98.2% of rectified alcohol, 0.2...4% of the head fraction, 0.4% of fusel oil (higher alcohols C3, C4, C5) and about 1% of alcohol is lost during its separation from the brew and purification. This produces about 7.5 m of wastes.

> *Wastes contain 92...95% water, 5...8% dry matter, including 2...3% nitrogenous (protein) substances, carbohydrates, fats, vitamins B and D. Wastes are a valuable animal feed.*

Features of ethyl alcohol technology from molasses. The sugar-containing raw material for ethanol production is molasses, a by-product of sugar production. It contains 75...80% of solids, including 45...50% of sucrose. Producing alcohol from molasses is easier than producing ethanol from starch-containing raw materials.

The schematic diagram of molasses processing into alcohol is shown in Fig. 2.10.

Molasses contain insufficient phosphorus and nitrogen particles for yeast life. Therefore, phosphorus and nitrogen salts are added to the molasses beforehand, as well as acidity is increased to pH 3.5...4 and antiseptics are added, since molasses contain undesirable microflora that reduces alcohol yield and contributes to increased accumulation of by-products during fermentation.

High acidity and antiseptics inactivate (inhibit) the vital activity of foreign microflora. The molasses are thoroughly mixed with nutrient salts, acid and antiseptic and aged for 8...24 hours.

Active life of yeast (saccharomycetes) is possible at a dry matter concentration of no more than 22...23%. The molasses are mixed with water to the above solids concentration. The resulting molasses is continuously fed to the yeast generator, where the yeast concentration is accumulated and maintained at a certain level.

The yeast generation process is carried out at a temperature of 30...34 °C and under aeration, the process duration is 4...6 hours. In mature yeast the concentration of dry matter decreases from 22...23 % to 7...8 %. Mature yeast continuously flows into the main (first) apparatus of the fermentation battery, which contains 7...10 fermentation apparatus. The last of them produces mature brew, which is then fed for distillation.

The process of alcohol separation from the brew and its purification is the same as for the distillation of mash obtained from starch-containing raw materials.

> *Wastes from molasses brew, unlike grain brew, is not consumed by animals, as it contains a lot of mineral salts. It is used as a fertilizer for fields and as a raw material for the production of dry feed yeast.*

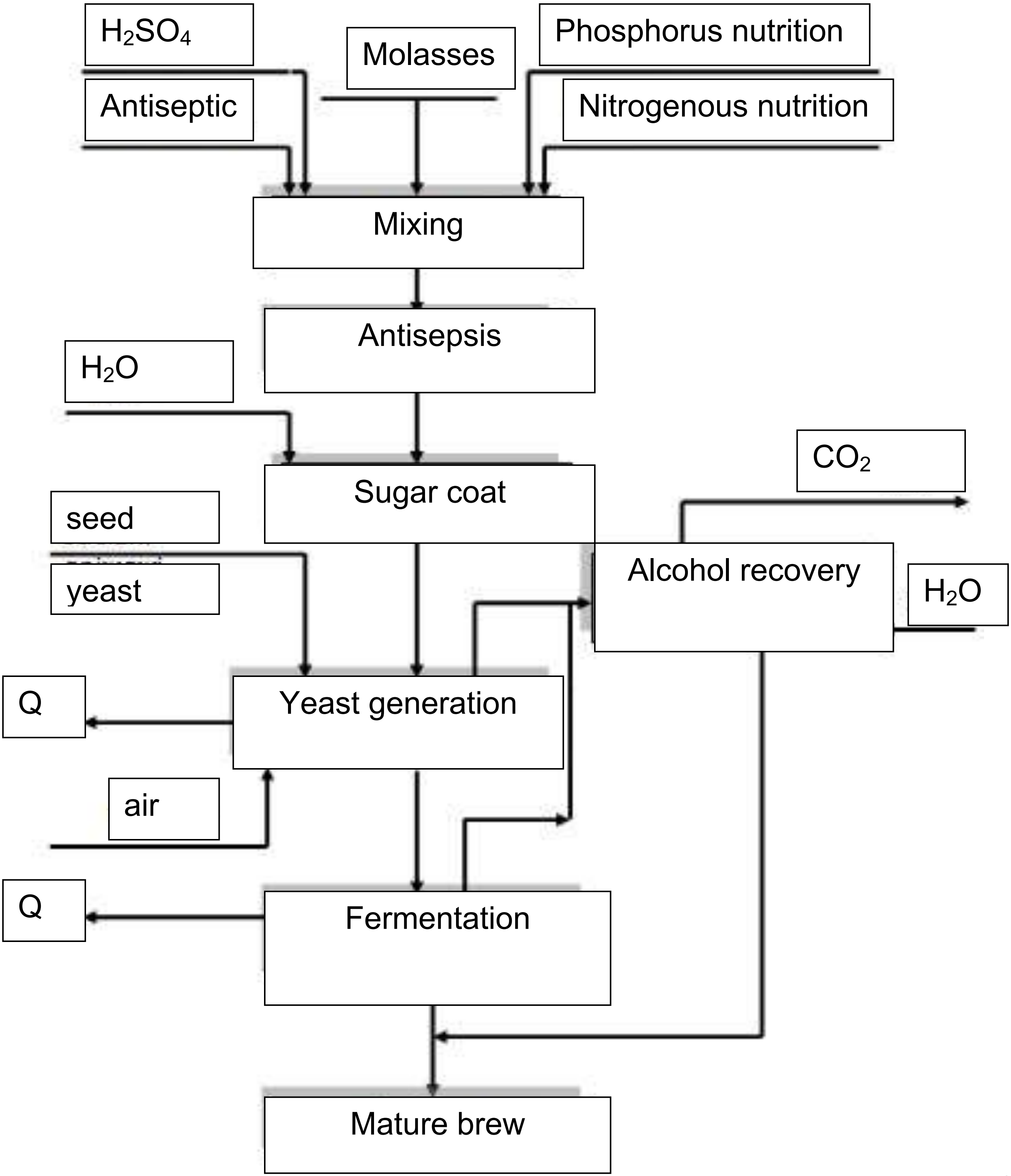


Fig. 2.10 - Schematic diagram of molasses conversion into alcohol

In most distilleries that process molasses, yeast is removed from the mature brew before distillation. The mature brew is separated to produce yeast concentrate and yeast-free mash. The brew is fed to distillation, and the yeast concentrate is washed with water and pressed to produce pressed baker's yeast. For every decaliter of alcohol produced, one needs 1.5 kg of baker's yeast. The yield of alcohol per ton of sucrose is 65.5-0.95 dal.

Production of ethyl alcohol from whey. Modern methods of producing alcohol from whey based on lactose fermentation are divided into the following main groups:

- Alcohol production using native (non-concentrated) whey with low lactose content;
- Alcohol production using concentrated whey with lactose content of 15...20%;
- Production of alcohol using whey in which lactose is hydrolyzed by an enzyme;
- Alcohol production using immobilized cells of microorganisms-producers.

The most developed batch method of alcohol production from whey includes the stages shown in Fig. 2.11.

The process is carried out in special yeast cultivation apparatus (fermenter), which maintain constant pH, temperature and aeration. The nutrient medium is deproteinized whey, which contains mineral salts (ammonium sulfate, diammonium phosphate, potassium and magnesium salts) and a pure culture of the producer, necessary for the active growth of yeast.

The yeast strains used as a producer are Kluyveromyces fragilis, Kluyveromyces lactis or Candida Pseudotropicalis. Biomass growth occurs at a temperature of 28...30 °C and a pH of 4.5.

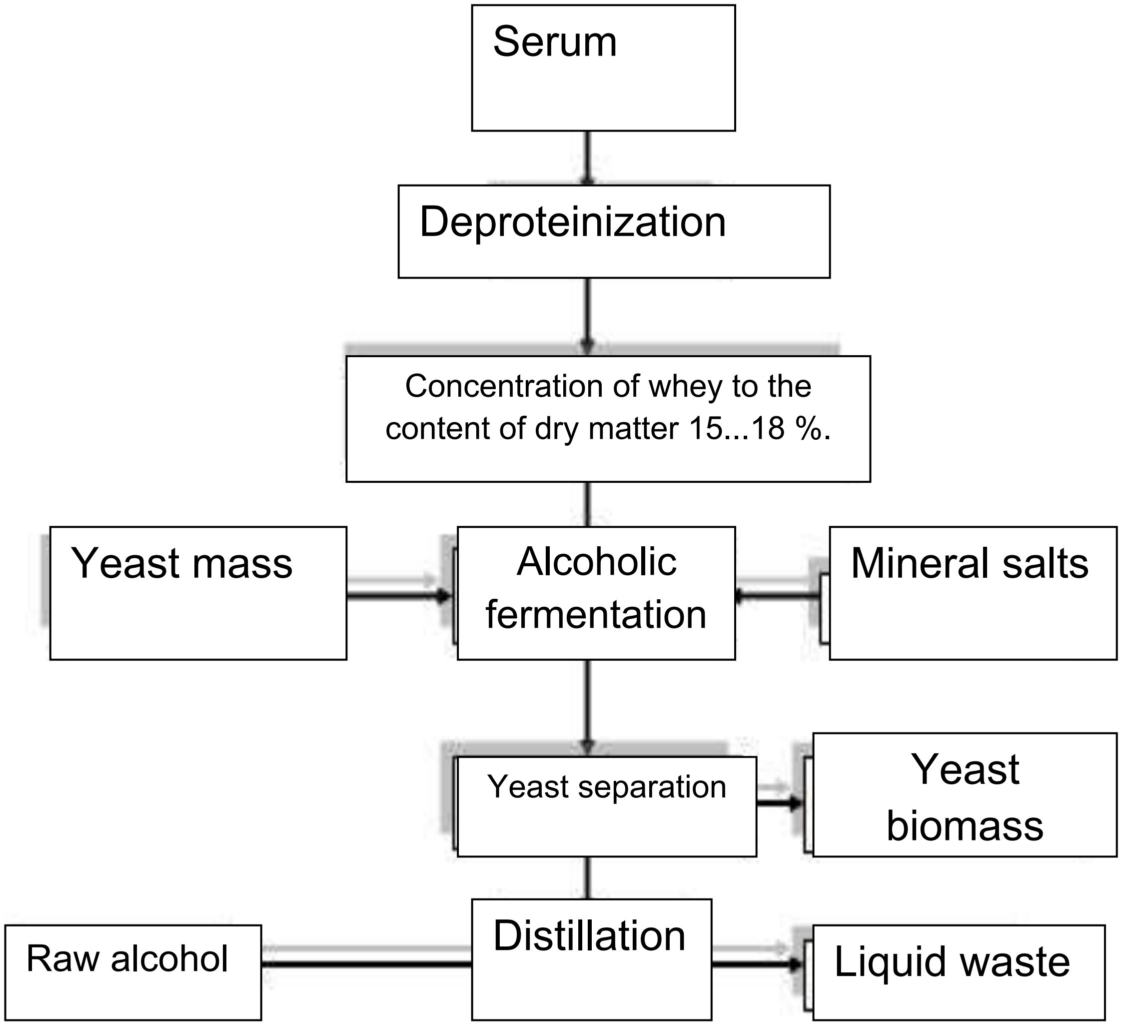


Fig. 2.11 – Batch production of alcohol from whey

The whey is deproteinized, pasteurized, condensed in vacuum evaporators to a lactose content of 17...18 %, mineral salts are added, and the required pH and temperature are set. The medium prepared in this way is inoculated with yeast.

Fermentation is carried out in fermentation apparatus at a temperature of 28...30 oC, pH 4.5. Fermentation duration 48...72 hours.

Yeast is removed by separation or on a filter press and further distillation of the brew to produce alcohol from whey is similar to operations performed to produce ethanol from traditional feedstocks.

2.6 Technology of starch and starch molasses

Starch is a polymer of glucose (C6H10O5), which is formed in plants and is their main reserve carbohydrate. The most suitable sources for its industrial production are potatoes, corn, wheat, rye and other starch-containing crops.

Corn as a raw material for starch production has advantages over potatoes because it is highly transportable and better stored. This makes it possible for corn processing plants to operate year-round, while potato processing plants operate for only 3 to 5 months. Obtaining starch from corn is somewhat more difficult than from potatoes due to the more complex structure of corn kernels and higher protein and fat content than in potatoes. However, the raw materials are used more fully in production than in potato processing, and the factories are technically better equipped. Losses of raw material dry matter during corn processing are much lower than during potato processing. Starch yields from 1 hectare of potatoes and corn are about the same. In some cases, dry potato starch has better nutritional properties than corn starch, as it produces more viscous pasteurized solutions.

Starch is contained in the cells of plant tissues and is released from them in the form of starch grains.

> *Starch and products derived from it are widely used in the confectionery industry, in the production of molasses and glucose, in the textile industry, in the paper industry and in many other sectors of the national economy.*

To produce raw starch, after starch grains are separated and cleaned from contaminants, cell walls must first be destroyed by mechanical grain processing and extractants (in corn starch production). Corn supplied for processing in grain or cobs must have a moisture content of 13...16% and meet other requirements (contamination, impurities, etc.).

> *Corn kernels have an embryo, which weighs from 8 to 12% of the grain weight. Fatty substances are contained in the germ.*

There are five elements in a corn kernel: the hull, which consists of two layers – pericarp and aleurone, endosperm, germ, and hull.

The valuable components of the corn kernel – starch, protein and fat – are separated during processing and used to produce marketable products, feedstuffs and oil. The extract obtained during the soaking process is also processed and used in the yeast, enzyme and other industries.

Flow chart of starch production. Fig. 2.12 shows a closed-loop scheme of starch production from corn, consisting of the following elements: grain cleaning from impurities, soaking, grinding and separation of the germ, grinding of the gruel, separation of starch from the gruel, washing and drying of starch.

The grain is fed to the soaking section to soften the grain, which facilitates the separation of starch, hulls and germ.

> *The soaking process removes a significant portion of the soluble substances in corn that make it difficult to separate starch - sugars, dextrins, amino acids, proteins, ash, etc. During the soaking process, the mechanical strength of the grain is reduced, and soluble elements of the grain are extracted.*

The soaking is carried out with sulfuric water in soaking tanks with a capacity of 50...120 m3. The sulfuric water solution is obtained by saturating water with sulfuric ahydride obtained by burning sulfur in special furnaces.

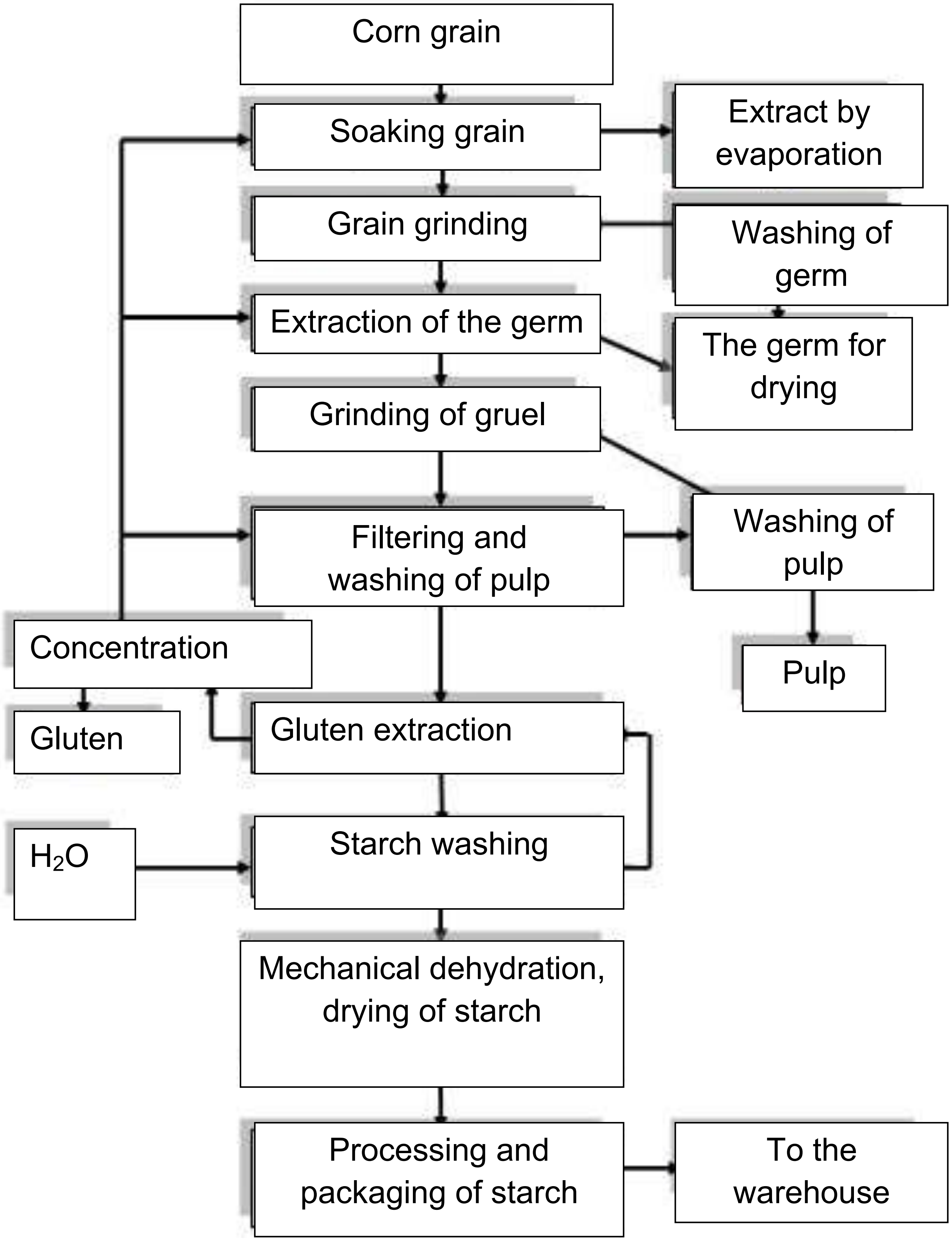


Fig. 2.12. – Scheme of corn starch production

Vats are grouped into batteries with a volume of 10... 16 days of operation and connected by pipeline and chute.

> *To soak the grain, an anti-current extraction method is used.*

Fresh solution of sulfur-pure acid is supplied to the last unit of the battery, from which unloading is provided. Within a few minutes, the filled water is pumped through a vat, taking it from below and feeding it up. This method is called "self-circulation." After circulation, the solution is fed to the next apparatus. After that, the grain from the tail unit is unloaded. The solution is thus pumped from the apparatus into the apparatus towards incoming corn. Gradually, the concentration of soluble substances in the extract increases and, finally, the extract enters the vat, into which fresh corn is loaded (head apparatus). Condensed extract is selected with concentration of dry substances 7... 9%. To maintain the extraction temperature in vats 48... 50, extract is periodically heated in heat-exchange units. Extraction time is 48... 50 hours. During soaking corn grain undergoes complex physical and chemical processes.

About 70% of mineral salts, 40% of soluble carbohydrates and 13% of soluble protein pass from grain to soaking water. Total in soaking water takes 7.. 10% of grain solids. Under the action of sulfur acid, the grain softens and swells, and the protein is denatured. The grain prepared in such a way is fed by a hydraulic conveyor for substituting and separating the embryo.

> *Before grinding, the grain enters the hopper and is sent to the crushers. Arc screens are used to separate surface moisture. The main purpose of grinding is to separate the germ from the grain. This also removes up to 25% of starch.*

In the soaking process, the connection of the embryo with the endosperm is weakened. Thanks to soaking, the embryo becomes elastic and is almost not grinded, which contributes to its further extraction on separators or hydrocyclones.

After two-fold cutting of corn grain and extraction of sprouts from it, the obtained mass consists of starch, large particles of endosperm, gluten. To remove the starch bound to the non-starchy part of the grain, it is necessary to subject the gruel to further trimming on millstones or mills.

The product obtained after cutting the gruel, contains free starch grains, whites, parts of gluten, fiber. Separate components are separated from the complex suspension by filtration, that is, by passing the suspension through sieves that distribute the suspensions by particle size in separate fractions. Sieving makes it possible to separate the starch from the large and shallow pulp. Centrifugation is used to remove more light particles of gluten and other impurities.

To increase the degree of distribution, the suspension is successively treated in several separators. Obtained starch milk is additionally purified on vacuum-filters or hydrocyclones. The yield of starch is from 60 to 66.7% of the weight of dry corn.

Processing of starch production waste. Except starch, from corn grain we receive other valuable food products: oil, corn forage, extract.

Technological scheme of starch molasses production. Molasses, which are a product of incomplete acid hydrolysis of starch, is used in confectionery, bread-baking, canning, liqueur-burning industries.

Molasses is a slightly yellowish, viscous liquid. Depending on the depth of hydrolysis molasses have different carbohydrate composition, it contains sugars and dextrins.

The process of starch hydrolysis is catalytic, chemical.

The catalyst – hydrogen ions.

And in enzymatic hydrolysis – amylolytic enzymes.

Hydrolysis can be expressed by the following reaction characteristic of polysaccharides:

$$(C_6H_{10}O_5)\ n \rightarrow nH_2O = nC_6H_{12}O_6$$

Fig. 2.13 shows a scheme for the production of starch molasses with a catalyst - hydrochloric acid adding active carbon for cleaning syrups.

The main stages of production of starch molasses are hydrolysis of starch, neutralization of hydrolyzate, extraction, purification and discoloration of syrup, concentration, purification of thick syrup, boiling and cooling.

Starch milk after purification and mixing with hydrochloric acid enters the converter. The first stage is the catalytic process of hydrolysis of starch, the result of which is the curing of starch.

Saccharification is performed periodically in autoclaves or in continuous apparatuses. The periodic autoclave has a cylindrical body with a spherical cover and a bottom.

Starch curing in the autoclave is carried out at a pressure of 0.28... 0.32 MPa.

The complete cycle of the autoclave operation includes filling the bubbler with acidic water, bringing it to a boil, brewing starch, increasing pressure, icing and blowing the finished syrup and takes about 20 minutes.

To ensure continuity of the process flow, at least two autoclaves are installed.

The next stage of production is the neutralization of acid hydrolysate. Neutralization is carried out with soda or chalk. During neutralization with soda, the following reaction occurs:

$$2HCl + Na_2CO_3 = 2NaCl + H_2O + CO_2$$

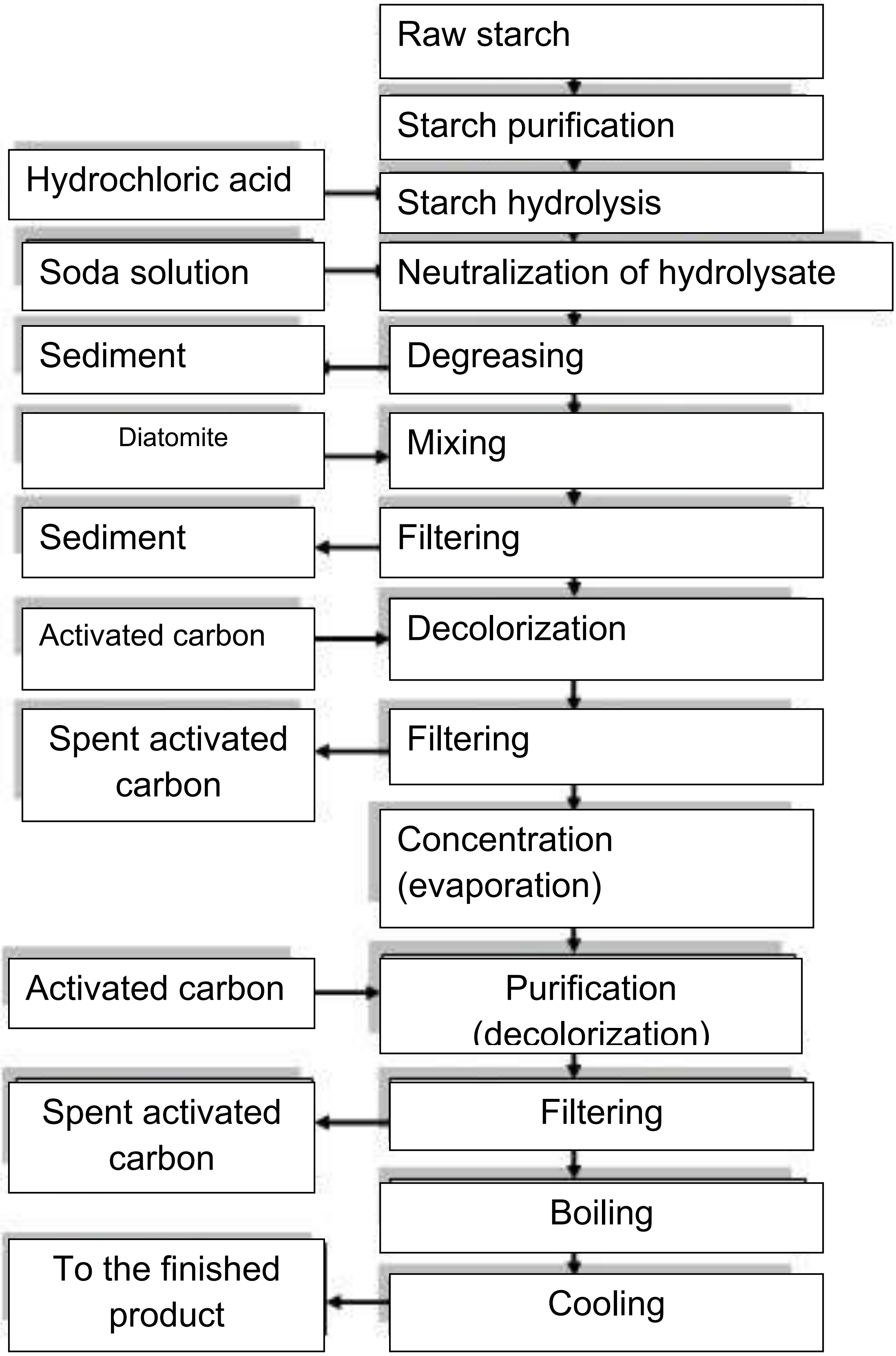


Fig. 2.13 – Scheme of starch molasses production

If sulphuric acid is used for acidification, then neutralization of the hydrolyzate can be carried out with chalk SaSO3.

In this case, there is such a recurrence:

$$H_2SO_4 + CaCO_3 = CaSO_4 + H_2O + CO_2$$

Gypsum (SaSO4 precipitates and is easily filtered. Neutralization takes place at 96... 98 ° C in vats with mixers.

As a result of the neutralization process, residual mineral acids (HSI, H2SO4), which are unacceptable in food products, are converted into harmless salts (NaCI) or into an insoluble sediment (CaSO4), which is removed from the hydrolysate to the sediment.

If molasses are made from corn starch, then there is fat in the hydrolysate that must be removed. If it is not removed, then filtration will not be effective. Therefore, neutralized hydrolyzate is primarily subjected to degreasing. Fat floats to the surface of the syrup and can be removed by creaming.

The apparatus used for degreasing is a steel rectangular tank with partitions, due to which the movement of the neutralized syrup is complicated, which helps to extract fat. Fat floats to the surface and is separated. The most progressive is the centrifugal method of separating fat on separators.

Defatted syrup is sent for filtration. To facilitate and enhance the quality of the process, diatomite is added to the syrup in special mixers. The resulting suspension is fed to periodical filtrpresses or drum vacuum filters. Filtered clear syrup has a yellow color. Adsorption is used for its discoloration, elimination of odor and separation of mineral salts.

Bone or activated carbon is used as adsorbent.

After the syrup is treated with the adsorbent in the mixer, it is filtered again. The syrup thus prepared goes to evaporation in evaporators.

The main purpose of evaporation is to bring the concentration of dry substances in the syrup to 56... 57% by weight.

Evaporation is carried out in multihull evaporation unit. Typically, tricorpus evaporators are used with lower heat consumption and obtaining a syrup with low coloring.

Syrup obtained after evaporation is treated once more with adsorbent, fluttered and then subjected to final boiling to concentration of dry substances not less than 78%.

> *To prevent decomposition of valuable substances, boiling of thick syrup is carried out in vacuum apparatuses of periodic action with significant liquefaction of 85... 89 kPa.*

To boil the syrup, devices are used with a heated chamber composed of horizontal copper tubes, which provides a low level of boiling liquid, and hence a low temperature depression. Boiling is carried out at a temperature of 50 ° C.

The final operation of the technological process is to cool the molasses to a temperature of 40... 45 ° C. This process is difficult due to the high viscosity of molasses. To prevent decomposition of molasses, cooling should be carried out quickly – no more than 1.5 hours.

SECTION 3
GENERAL PROVISIONS OF MILK PROCESSING TECHNOLOGY

3.1. Prospects for resource saving in the milk processing industry

The dairy industry is one of the leading sectors of the food industry, which is a promising base for the introduction of resource-saving measures. It is generally known that complete processing of all components of raw materials, rational use of by-products, reduction of regulatory losses are the most important factors for increasing the production of dairy products and increasing the efficiency of the enterprise. Processing of all components of raw materials is advisable, because raw materials are characterized by high a nutritional value.

All factors contributing to resource saving at dairy enterprises can be divided into several areas and presented in the following form (Fig. 3.1).

The implementation of these areas should be combined with changes in structural policy, information, financial and organizational support, regulatory – legal sphere.

Real examples of resource saving in the dairy industry are the result of the introduction of new technologies, primarily dependent on the rational use of secondary raw materials and the production of milk-containing products, which include raw materials of plant origin. This direction is relevant not only in terms of efficiency, but also in terms of plant-based dairy production. Despite the prepared regulatory framework for products based on dairy resources, the process of their implementation and, accordingly, implementation is difficult.

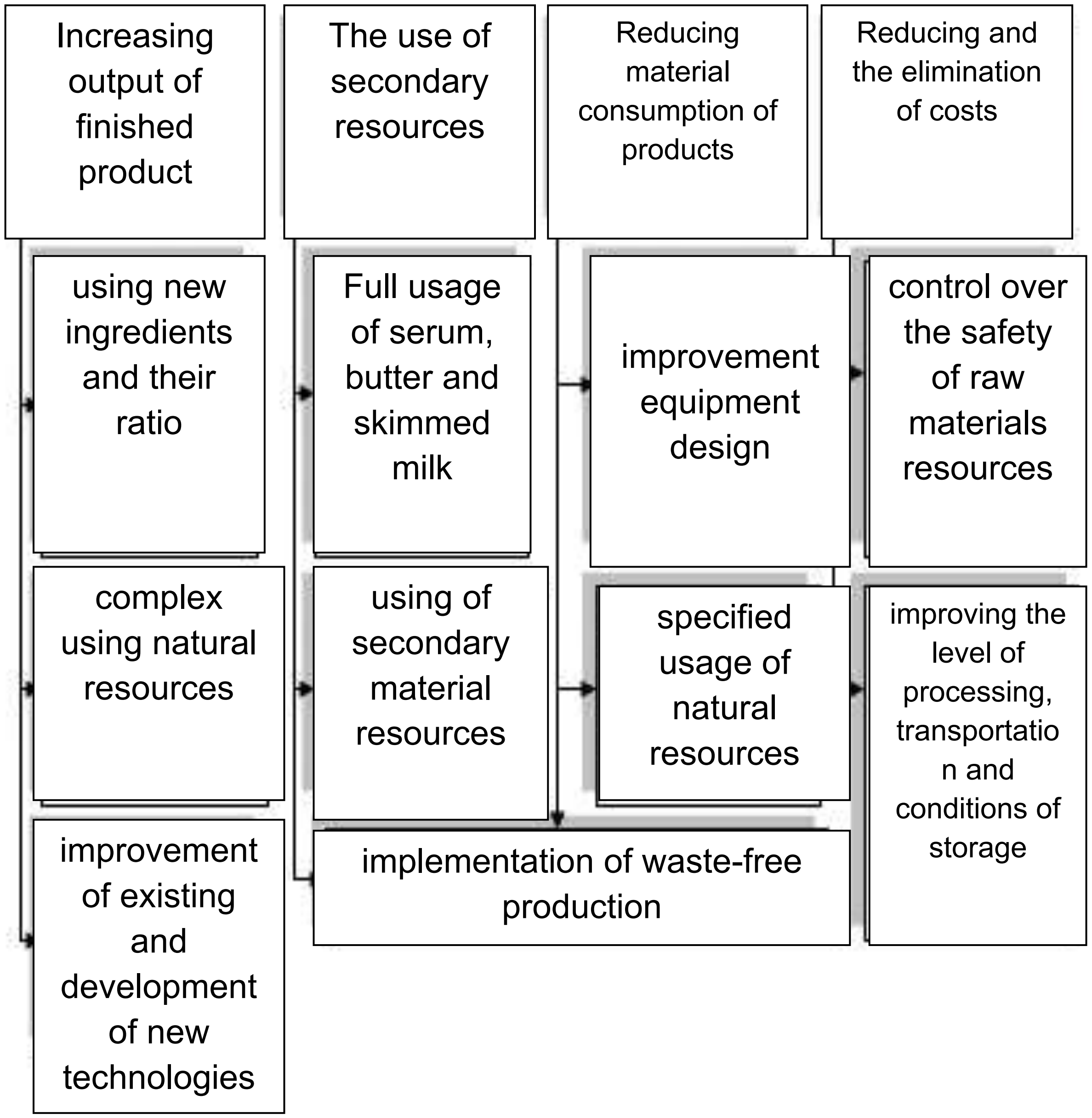


Fig. 3.1 – Factors contributing to resource saving at dairy enterprises

The main feature of the technology of fermented milk products with vegetable fats is the production of a stable milk-plant emulsion. Cold skim milk is heated in the regeneration section to a temperature of 60... 65 ° C and supplied to the emulsifier, where heated vegetable fat is simultaneously supplied. Then the vegetable cream passes sequentially through the pasteurization, regeneration and cooling sections. The rest of the technological processes of production of fermented milk products with the above composition are similar to the parameters of production of traditional dairy products.

Also relevant is the processing of skimmed milk and buttermilk. Non-fermented and fermented, fatless and low-fat drinks, fermented milk cheese, milk-protein concentrates, whole milk substitutes, low-fat canned milk, casein are widely made from skimmed milk. These products not only contribute to production efficiency, but also significantly expand the range of products. Some of them have increased biological value, dietary properties. The range of products containing buttermilk is also quite wide – these are fresh and fermented drinks, ice cream, concentrates (condensed and dry), fermented milk cheese and curd products, rennet cheeses, sour cream products. Also rational is the use of buttermilk in dry powder form in the baking and confectionery industry, in the preparation of medicines and feed concentrates.

In recent years, competition onmarket for the sale of dairy products is becoming more stringent, because the production of classic products exclusively from dairy raw materials is less profitable. Most domestic consumers are guided by a product that is in the low price category. One of the main tasks facing manufacturers in these conditions is to reduce the cost of production while maintaining and increasing the growth of quality indicators.

The solution to this problem is the use in the production of not only dairy raw materials, but also its substitutes, which have a relatively lower cost. The introduction of such substitutes requires strict control, because they should not impair the quality and safety of the milk-containing product. It is this rule that is guided by domestic butter and fat factories, which introduce the production of fats at a qualitatively new level.

The relevant is a partial replacement of dairy raw materials with plant materials and full use of all milk components in cheese production. For example, quite widespread production of cheeses with plant components is in Southeast Asia, Northern Europe and the American continent. In Japan, China, Korea and other countries, cheese is made from soy (soy isolates, concentrates and tofu). In Germany, they produce potato cheese, in France, where there are many types of cheeses, the addition of vegetable and fruit raw materials is common. Greece. Italy, Spain, Portugal also produce cheeses with the addition of spicy plants and wild plants. The production of milk-containing and with a combined composition of raw materials is rational for all branches of milk processing, because it allows to increase the volume of production with the most efficient use of raw materials, expand the range of products and increase its competitiveness, create additional resources of dairy raw materials, prevent seasonal dependence. In Ukraine, they sell a sufficient number of products with plant components – it is primarily spreads, cheese and sour cream products, fermented milk drinks, canned milk defatted with sugar and vegetable fats, ice cream and more

Various companies offer equipment that allows you to fully mechanize production, guarantees high hygienic performance, allows the manufacture of fermented milk cheese and rennet cheese on one line, idle time of equipment is equal to zero, increases the yield of the product – 6.5 liters of milk per 1 kg of traditional fermented milk cheese, reduce production losses by 0.5%.

An example is the organization of the production of decorative cheeses "Filata Paste," which makes it possible to use “not-for-cheese” milk with an acidity of up to 25ºT and bacterial contamination of up to 2 million CFU/ml. In this technology, there is no maturation period and salt pools, which speeds up the technological process, significantly saves energy resources and the area of the production premises. At the same time, the yield of the finished product increases – about 1 kg of cheese is made from 10 liters of milk mixture.

Energy-saving technologies are offered in the production of dry dairy products, which allows producing from 15 to 1000 liters of product per day. A feature of the equipment is that one ton of steam in a multi-vessel evaporator removes up to 12 tons of moisture from the product, which significantly saves time and electricity.

The expansion of the main classic assortment of the dairy industry is a constant task of enterprises, which ensures their competitiveness in the modern market. This type of product includes products with a high fat content – spread and butter, which are long-term storage products. Spread and butter technologies are quite complex, diverse and require an appropriate approach to their study.

3.2. Mechanical and thermal processing of milk

High quality dairy products can be produced only from benign whole milk, characterized by an appropriate chemical composition, optimal physical, chemical and microbiological indicators that determine its suitability for processing. Changes in the properties and, in particular, microbiological indicators of whole milk are largely due to the vital activity of microorganisms that enter the milk in case of non-compliance with the sanitary and hygienic rules of milking, keeping animals, washing equipment for milking, preservation and transportation of milk. To prevent bacterial contamination of raw materials, it is necessary not only to observe the sanitary and veterinary rules for obtaining milk, and to subject it to primary processing.

> The purpose of primary processing is to ensure the stability of milk in the process of its transportation and preservation.

Primary processing covers the following processes:

- cleaning,
- cooling,
- saving before sending for processing or sale.

Cleaning is carried out to remove mechanical contaminants and microorganisms. One of the cleaning methods is filtration under the influence of gravity. During filtration, the milk must overcome the resistance created by the metal or fabric partition of the filter. As a result of milk passing through the filter partition, contaminants are retained on it in an amount proportional to the volume of liquid passing through the filter. For filtration use, flannel, fabrics from lavsan and polypropylene fibers. The effectiveness of cleaning depends on the structure of the tissue.

Currently, filters of various designs are used to filter milk. When filtering, use flasks with a flat or cone-shaped grill, on which the filter cloth is attached. The disadvantage is that a precipitate accumulates on the fabric, which, when further filtered, is eroded by subsequent portions of milk and penetrates with it into the container.

There is a method of filtering milk by pumping it through metal filter screens. This method is less effective than manual filtration. Mechanical impurities under the pressure that creates the pump are broken, turned into dust and pass through the filter. By checking the mechanical purity of milk after this method of purification, individual particles of mechanical impurities on the cotton circle are not fixed. But it becomes gray, this indicates the spraying of impurities into milk.

In the case of milking with collecting milk into a milk line, closed milk filters installed in the milk line are used. They represent an expanded part of the milk line with an inserted milk pipe fixed in the expanded part with a rubber plug. At the end of the pipe there is a nozzle of six metal tubes connected by rings. A bag of filter cloth is put on the nozzle. Milk going through the milk pipeline, passing through the filter, is sent to the vacuum cooler, and then to the tank. The designs of milking machines make it possible to use a certain density for filtering fabrics that would not violate the vacuum milking regime.

In milking factories with collecting milk into a milk line, the use of tissues for cleaning milk has limitations. Synthetic fabrics (lavsan, capron) provide a normal milking mode on such installations, but due to the fact that the size of the holes in them corresponds to the size of particles of mechanical impurities, they do not guarantee the purification of milk of groups II and III to the quality of group I. The degree of purification of milk by various tissues is given in Table. 3.1.

Table 3.1 – Degree of purification of milk by various tissues

Filters	Filter sediment concentration (ratio to nonwoven filter)	Milk purity group	
		before filter	after filter
Nonwoven	100	II–III	I
Coarse calico	75	II–III	I–II
Lavsan	7,5	II–III	II
Capron	1,7	II–III	II–III

For effective purification of milk in milking plants with the collection of milk in the milk line, it is better to install two milk filters connected to each other in a common system due to three-way taps. The latter makes it possible to switch filters during milking to replace filter fabrics.

Periodically, every 15... 20 minutes, pollution must be removed from the filter. The cleaning efficiency is largely dependent on the pressure at which the filtration takes place. Of course, milk enters cylindrical filtration devices under a pressure of 0.2 MPa.

Filtration devices with fabric partitions have a number of disadvantages, which are presented in Fig. 3.2.

The most effective cleaning of milk occurs with the help of separating milk cleaners. Centrifugal purification is carried out in them due to the difference between the values of the densities of plasma particles of milk and related substances. Foreign impurities, the density of which is greater than the plasma particles of milk, are thrown to the drum wall and settle on it in the form of mucus.

short duration of continuous work	the need for frequent disassembly for washing
probability of rupture tissues	Reduction of filter performance depending on the duration of work

Fig. 3.2 – Disadvantages of filtration devices with fabric partitions

The milk for cleaning is fed through a central tube to a tray holder, from which it is directed into the slurry space between the edges of the tray stack and the lid. Then the milk enters the intercarrier space, the gap between the tray holder and the upper edges of the plates rises and exits through the holes in the drum cover. The cleaning process begins in the slurry space, and ends in trays.

Traditionally, in technological lines, centrifugal purification of milk is carried out at a temperature of 35... 45 ° C, because under these conditions the deposition of mechanical contaminants is more effective due to an increase in the speed of particle movement.

Centrifugal purification of milk, along with mechanical contamination, removes a significant part of microorganisms. This phenomenon is explained by the difference in their physical properties. Bacterial cells have dimensions of 0.8... 6.0 microns, and the sizes of protein particles of milk are much smaller (the largest of them – casein particles – reach only 0.1... 0.3 microns).

The essence of the process of milk bactofuging is to remove microorganisms from milk in order to sterilize it without heat treatment.

After the operation of bactofuging or microfiltration machine, the number of vegetative and spore forms of microorganisms decreases, respectively, due to centrifugal forces or passage through a semi-permeable membrane under pressure. Thus, the use of bactofuga to purify milk at a temperature of 55... 56 °C makes it possible to remove more than 96... 98% of non-aerobic and more than 94... 96% of aerobic bacteria and spores, especially oil-acid bacteria Clostridium tyrobutyricum, Clostridium butyrobutyricum. The maximum loss of the product is about 0.05... 0.10%.

> *The design features of the separators for bactofuging compared to conventional ones are to increase the acceleration by about 1.5 times.*

Complete removal of all microorganisms from milk has not yet been achieved, so bactofuging is used together with pasteurization. Since the cells of the destroyed bacteria remain in milk during heat treatment, complete inactivation of bacterial toxins, especially those left after the death of staphylococci and E. coli, is not guaranteed. Some thermophiles – inactivated in the process of pasteurization can restore their vital functions. Removal of bacterial cells from pasteurized milk by bactofugation eliminates the mentioned disadvantages of heat treatment. Whole milk is first heated in regeneration section of plate pasteurizer, and then in pasteurization section temperature is brought up to 75 °C. Then milk is bactofuged successively on two separators. During this treatment, up to 99.9% of bacteria are removed.

Separation is performed under action of centrifugal force in separator drum. Milk, distributed in the drum between the plates in the form of thin layers, moves at a low speed, which creates favorable conditions for the most complete separation of the high-fat fraction in a short time.

Increasing the viscosity of milk leads to a decrease in the rate of release of the fat fraction. Acidity and temperature of milk significantly affect the separation. Increased acidity of milk complicates the separation process, and an increase in milk temperature, on the contrary, improves separation.

> *Optimum separation temperature*
> *35.. 45 ° C. Heating milk to this temperature provides optimal degreasing.*

Much attention is paid to the separation of cold milk. However, this low temperature process on conventional separators results in a nearly halving of their productivity due to increased viscosity and partial crystallization of fat.

The separation process in the separator is carried out in this sequence. The whole milk enters the tray holder through the central pipe, from which it rises to the upper part of the set of plates and spreads between them through the channels formed by holes in the plates. In tray space fat balls as a lighter fraction of milk move to the centre of a drum, further on gaps between an edge of a plate and a plate holder rise up and enter into a chamber for cream. Then, under the head, the cream enters the branch pipe, on which a cream quantity meter and an adjusting valve are installed. Defatted milk as a heavier fraction is directed to the periphery of the drum, rises up and enters the nozzle, on which a pressure gauge and an adjusting valve are installed.

> *With mass fraction of fat in the incoming milk, a decrease in the number of initial cream leads to an increase in the mass fraction of fat in them and, conversely, an increase in the amount of cream reduces the mass fraction of fat in them.*

Based on the weight ratio of cream and skimmed milk, you can find the required fat content of cream. Having determined by calculation the ratio between the masses of cream and skimmed milk, this ratio is established using an adjusting device.

> *The release of fat from milk depends on the size of the fat balls, the temperature, the size of the separator drum and the speed of its revolutions.*

It is possible to increase the degree of skimming of milk by increasing the separation temperature or the drum speed or reducing the productivity of the separator. Without changing the completeness of the degreasing, the separation capacity and temperature can be changed. Thus, if you reduce the separation temperature from 35 to 17 ° C and, accordingly, halve the capacity of the separator, the completeness of degreasing will not decrease at a constant drum speed.

Separation of pasteurized milk leads to an increase in fat content of skimmed milk.

To reduce the capacity of the separator, a safety washer should be inserted into the tube of the regulatory chamber. To increase its productivity, it is necessary to increase the height of the regulatory chamber, that is, the pressure of the liquid at the inlet to the separator drum.

The completeness of degreasing is influenced by the uniformity of the gaps between the trays and the quality of the drum balancing. If the trays are crumpled or their number is insufficient and if they are located unreliably in the drum, as a result of which the gaps between them are not the same, then milk passes mainly where the gaps are larger. This breaks the stability of the process and reduces the effect of degreasing.

It positively affects the release of cream by increasing the frequency of rotation of the separator drum and the average radius of the working part of the plate. The larger the inner diameter of the drum, the better the degreasing.

Along with the optimal temperature regime, higher separation temperatures are used - 60... 85 ° C. At a separation temperature above 40 ° C, the breakdown of fat balls increases, coagulation of serum proteins can occur, which negatively affects the separation results. At the same time, increasing the separation temperature makes it possible to increase the productivity of the separator. In practice, high-temperature separation (85... 90 ° C) is used to produce cream with a fat content of up to 83% in the process of making oil by converting high-fat cream, but in this case the cream is separated (30... 40% fat).

Modern separators, make it possible to separate both cold (temperature 3... 4 ° C) and heated milk. The productivity of separators during cold separation is reduced by 3... 4 times.

> *Milk before separation is not desirable to withstand for a long time at low temperatures (1... 8 ° C), because under these conditions the plasma protein adsorbed on the surface of fat balls increases their density, worsens the separation process.*

Milk intended for separation should not be subject to active mixing, pumping, shaking, prolonged cooling, high-temperature heating, etc.

In addition to these factors, the quality of degreasing is influenced by the fat content in milk or milk mixture, as well as in the resulting cream, season, etc.

The purity of the separated milk significantly affects the degreasing process and the operation of the separator. In case of separation of contaminated milk, the sludge hole of the separator is quickly filled, and contaminants begin to be deposited on the plates of the separators of periodic action. This impairs the movement of milk between the plates, changes the speed and duration of the particles in the centrifugal field and, as a result, degreasing worsens. In this case, the movement to the periphery of the defatted milk is delayed, and it, rising between the plates, partially exits through the outlet for cream, which reduces their fat content. Therefore, purified milk with an acidity not exceeding 20 ° T should be used for separation.

During operation of separators it is necessary to observe some rules, which are given in Fig.3.3.

before starting the separator check the correctness of its assembly, the oil content in the crankcase, release the drum from the brakes and locking screws;

- the separator is put into operation so that from the beginning of the start-up to the reaching of the full frequency of revolutions passed approximately 5 minutes;

if vibration occurs during startup and knocking is heard, immediately stop the operation of the drum and troubleshoot the problem, perform repair and only then restart the separator again.

Fig. 3.3 – Separator operation rules

Homogenization is the treatment of milk (cream), which consists in dispersing fat balls by exposing milk to significant external forces.

When preserving whole milk and cream due to the difference in the density of milk fat and plasma, the fat fraction thaws. The speed of the process depends on the size of the fat balls, viscosity, the ability to connect the fat balls to each other. As it is known, the diameters of fat balls vary widely – from 0.5 to 18 microns. In the process of homogenization, the diameters of fat balls decrease by about 10 times, and the speed of their surfacing becomes less by about 100 times. In the process of crushing the fat ball, its shell substance is redistributed. Plasma proteins are mobilized to build the shells of the formed small balls, and part of the phosphatides passes from the surface of the fat balls to the milk plasma. This process helps stabilize the highly dispersed fat emulsion of homogenized milk. Therefore, with a high dispersion of fat balls, homogenized milk practically does not settle.

> *The purpose of homogenization is to grind fat balls of milk to sizes that provide the necessary stability of the fat phase of milk. To achieve this goal, the average diameter of fat balls should not exceed 2 microns.*

Homogenization efficiency depends on pressure and temperature.With increasing pressure, the mechanical effect on the product increases, the dispersion of fat increases, and the average diameter of fat balls decreases. At a pressure of 15 MPa, the average diameter of fat balls is 1.43 microns, and the homogenization efficiency is 74%; at a pressure of 20 MPa, the average diameter of the balls decreases to 0.97 microns, and the efficiency increases to 80%. Pressure increase can be achieved by equipping the homogenizer with two or three valves. Such homogenizers are called two- or three-stage. However, increasing the pressure leads to an increase in electricity consumption, so the optimal pressure should be 10... 20 MPa. the recommended homogenization pressure depends on the type and composition of the product being manufactured. With an increase in the content of fat and dry substances in the product, it is worth applying a lower homogenization pressure, which is due to the need to reduce energy costs.

With increasing temperature, the intensity of homogenization increases, and the thawing of fat also decreases. At temperatures below 50 ° C, the thawing of fat increases, which leads to a deterioration in the quality of the product. The optimal homogenization temperature is 60-65 ° C. At excessively high temperatures, whey proteins in the homogenizer can precipitate.

> *Homogenization efficiency also depends on the properties and composition of the product (viscosity, density, acidity, fat and dry matter content).*

With an increase in the acidity of milk, the homogenization efficiency decreases, since the stability of proteins decreases in acidic milk and protein agglomerates are formed, making it difficult to crush fat balls. At increase of viscosity and density of milk efficiency of homogenization also decreases.

Homogenization efficiency is considered satisfactory if the proportion of fat balls with a diameter of less than 2 µm exceeds 80... 85%.

Homogenization efficiency can be determined by settling the fat phase in milk after holding the sample in a measuring cylinder with a capacity of 250 cm3 for 48 hours at a temperature of 4 to 8 ° C. Degree of fat thawing, % is determined by the following formula:

$$DFS = \frac{Fm - Fl}{Fm - 0{,}6Fl}100, \qquad 3.1$$

where Fm – fat content of the initial milk,%; Fl - fat content of the lower layer of the milk sample subjected to thawing,%; 0.6 - indicates the percentage of the lower layer (60%) to the upper one (40%).

In addition to the specified method, it is possible to determine the effectiveness of dispersing fat: a) by centrifuging the sample in special tubes on a centrifuge TsLMP-24 at a rotation frequency of 1420 rpm for 5 minutes; b) by the ratio of optical densities measured on a spectrophotometer SF-4A etc.

In the dairy industry, developments are underway to use electromechanical and hydrodynamic devices for homogenization, which create elastic vibrations of the sound and ultrasonic ranges.

Homogenization methods using ultrasound have not yet been widely commercially adopted due to an insufficiently studied process and a low degree of dispersion compared to valve homogenizers. Comparing centrifugal and ultrasonic homogenizers with valve homogenizers, it should be borne in mind that the scope of their design and improvement is quite wide, while for valve homogenizers the possibilities of significant changes are practically exhausted.

Membrane methods of milk processing include baromembrane and electromembrane (for example, electrodialysis).

> *Baromembrane is the method of processing when the product passes through a semi-permeable partition (membrane) under the influence of excess pressure.*

Depending on the size of the separated particles, there are:

- reverse osmosis,
- ultrafiltration,
- nanofiltration,
- microfiltration, etc.

However, a clear boundary between baromembrane methods cannot be drawn, because they often overlap one another.

Membrane methods for separating and concentrating milk include ultrafiltration, reverse osmosis and electrodialysis.

> *Ultrafiltration is filtration under pressure using semi-permeable membranes made on the basis of synthetic polymer (cellulose acetate, polyamide, polysulfone) and ceramic materials.*

For ultrafiltration, membranes with pores of 50... 100 nm are used. Such membranes trap molecules larger than the pore size and allow small molecules to pass through. In ultrafiltration, it is necessary to overpower the osmotic pressure of the solution to be divided, because the solvent is transferred in the direction opposite to the increase in the concentration of solution retained by the filter. Therefore, ultrafiltration is carried out under a pressure of 0.1... 0.5 MPa.

In the dairy industry, ultrafiltration is used to extract proteins from milk or whey. During ultrafiltration, serum under pressure moves between semipermeable membranes. One part of the serum (filtrate) passes through the membranes, while leaving whey proteins on the filter. The resulting filtrate consists mainly of water, lactose, mineral salts. The rest of the whey is a concentrate consisting of all whey proteins and water, lactose and mineral salts that have not passed through the membranes. The ratio of the volumes of concentrate and whey received after ultrafiltration is usually 1:5.

Ultrafiltration is successfully used to concentrate whey proteins of cheese whey. Whey-protein concentrates and filtrates are used to produce traditional and new types of food products, characterized by increased biological value, in particular in the production of dietary, medicinal and baby food products.

> *Reverse osmosis is the separation of solutions through semi-permeable membranes with pores less than 50 nm in size at a pressure of 1... 10 MPa.*

Under the condition of reverse osmosis, only water passes through the membranes, and all other parts of the milk raw material are retained by the membrane. There is a concentration of dairy raw materials.

> *Electrodialysis is the transfer of ions from one solution to another, carried out through the membrane under the influence of an electric field created by electrodes located on both sides of the membrane.*

Electrodialysis is subjected only to those substances that, when dissolved, dissociate into ions or form charged complexes. Electroneutral substances, for example lactose, sucrose, whose molecules do not carry any charge during dissolution, do not participate in electrodialysis.

In the dairy industry, milk whey is subjected to electrodialysis treatment in order to demineralize it. In addition to proteins and lactose, milk whey contains an increased amount of mineral salts, which makes it difficult to process it into food products, especially for children. The release of serum from mineral salts using electrodialysis is 8... 10 times cheaper than when using ion-exchange resins for this purpose.

Advances in the technology of fractionation and modification of milk components based on ultrafiltration, electrodialysis, reverse osmosis have led to the wider use of dairy ingredients in various sectors of the food industry (baking, confectionery, meat).

> *The use of membrane processes in the dairy industry contributed to the creation of waste-free production, which made it possible to increase the efficiency of using raw materials for food purposes.*

As a result of the use of membrane processes, all milk solids are completely processed into full-fledged food. This makes it possible to increase the production of marketable products from a unit of raw materials and reduce its cost. Ultrafiltration products have found application in the production of dairy drinks, fermented milk cheeses and hard ones. The introduction of ultrafiltration in cheese factories contributes to an increase in cheese yield by 15... 20% due to the use of whey proteins, a reduction in rennet costs by 75... 80%, as well as a partial solution to the problem of wastewater processing.

Heat treatment is one of the main technological operations of milk processing, which is carried out in order to obtain safe microbiological indicators of dairy products. It is a combination of modes of exposure to temperature (heating or cooling) and the duration of exposure at this temperature. During heat treatment in milk and dairy products undergo complex biochemical and physicochemical changes, as well as changes in the components of milk. Therefore, the efficiency of processing depends on the properties and composition of milk. The most important technological properties of milk are shown in Fig. 3.4.

- Suitability for in-line processing with the use of mechanization and automation;
- Ability to concentrate dry substances by evaporation of free moisture under vacuum conditions, spraying and contact;
- Possibility of separation of milk components by means of centrifugal force (fat), ultrafiltration (protein), crystallization (lactose);
- Resistance to high-temperature treatment at equilibrium between cations (calcium, magnesium, etc.) and anions (citrates, phosphates, etc.);
- The ability to coagulate casein in the production of dairy products using acids (acid coagulation), rennet (rennet coagulation) and calcium chloride (calcium coagulation);
- High organoleptic properties;
- Antibacterial (bactericidal) properties.

Fig. 3.4 – The most important technological properties of milk

The objectives of the heat treatment of milk and dairy products are as follows:

- 3 neutralization of raw materials, i.e. reduction or complete removal of the total number of microorganisms and extermination (suppression) of pathogenic microflora;

- inactivation (destruction) of enzymes in order to increase the stability of products during storage;
- to give the products the optimal consistency (liquid, sour cream-like, pasty);
- giving specific taste, smell and color to pasteurized, spiced, fermented milk, sweet-shot, Vologda type butter, etc.;
- providing optimum temperature conditions for technological operations that take place after heat treatment-fermentation, thickening, storage, etc., as well as homogenization and separation that take place simultaneously.

The processes of cooling, heating, pasteurization and sterilization are applied to milk, when the heat from a more heated source (liquid, steam) passes to a less heated one. Hot water and water saturated steam are used as heat carrier for pasteurization, and water saturated steam is used for sterilization.

The amount of heat passing to the milk depends on:

- ✓ dimensions of heat transfer surface;
- ✓ duration of the process;
- ✓ temperature differences between product and working medium (temperature head);
- ✓ transmission coefficient.

The mode of heat treatment of milk for obtaining each type of product is determined by technological instructions.

Heating does not play a major role in the processing of milk and most often performs an auxiliary function. It is used before separation (35... 45 ° C), homogenization (60... 65 ° C), as well as in the production of various dairy products. In the case of separation and homogenization, milk viscosity is reduced, which improves the efficiency of these processes.

Heat treatment of milk at temperatures below its boiling point is called pasteurization.

The main requirements of effective pasteurization are to make milk safe and suitable for storage, without changing its properties. During pasteurization, regenerators should be used, which allows using up to 85... 90% of the heat spent on pasteurization to heat raw milk. The heat saving obtained through the use of a regenerator is characterized by a regeneration coefficient – that is, the ratio of the amount of heat returned to the total amount of heat consumed for heating to the pasteurization temperature. In the process of pasteurization, all pathogenic microflora is destroyed: tuberculosis and E. coli, salmonella, pathogenic staphylococci, etc. But pasteurized milk contains a certain number of cells of thermophilic spore-forming types capable of development.

> ***Pasteurization efficiency*** *is the percentage ratio of the number of bacteria killed by pasteurization to the number of bacteria in the original milk. Pasteurization modes generally accepted in the dairy industry in the production of drinking pasteurized milk guarantee pasteurization efficiency of up to 99.98%.*

During heating, irreversible changes in the heat-sensitive components of milk occur. Whey proteins, when heated to a temperature above 85 ° C, are substantially denatured. **Casein** is more heat-resistant and can withstand high-temperature treatment, which is due to the high content of proline and low content of sulfur-containing amino acids – cystine and cysteine. Milk proteins and fat ball shells form reducing sulfhydryl compounds during heat treatment, which cause the taste of pasteurization or boiling.

Milk fat, during heating – melts, and cooling – hardens again. Prolonged heat treatment at temperatures close to 100 ° C is accompanied by deep changes in the shells of fat balls, as a result of which fat is melted in the form of droplets freely floating on the surface of milk.

Short-term heating of milk slightly affects its organoleptic properties and milk sugar. Heating to temperatures above 100 ° C with prolonged exposure and even prolonged boiling cause milk browning. In this case, some amino acids of milk interact with milk sugar, resulting in the formation of dark-colored substances - **melanoidins.**

In the process of heating milk, acidic soluble calcium phosphates and citric acid calcium salts partially turn into insoluble salts. The resulting phosphoric acid partially cleaves calcium from caseinates. When milk is heated, phosphorus-calcium salts are deposited on the walls of heat exchange devices in the form of scale.

> *The accepted modes of heat treatment of milk cause a very significant destruction of vitamin C. Losses of vitamins A, B1 and B2 are insignificant.*

The unstable enzyme of milk is phosphatase, which is destroyed at a temperature of 80 ° C, the most heat-resistant are peroxidase and lipase of bacterial origin, which are destroyed at a temperature of 85... 95 ° C.

Titratable acidity of milk varies depending on temperature and treatment method. So, during the heating of milk in a heat exchanger at a temperature of 85... 145 ° C, the acidity decreases by 1.0... 1.5 ° T, (due to the release of carbon dioxide from it), and during the processing of milk in a steam contact apparatus at a temperature of 125... 145 ° C by 3 ° T.

For pasteurization, milk with an acidity of not more than 22 ° T can be used, to prevent the deposition of milk proteins on heat carriers, forming a layer of ignition. In milk with a high initial content of bacteria, even after pasteurization, a large number of microorganisms remain. The content of milk before pasteurization should be 106 cells in 1 cm3.

In the production of dietary dairy products, tougher pasteurization regimes are used, since:

- residual microflora should be minimal to ensure favorable conditions for the development of beneficial microflora – pure cultures of lactic acid bacteria;
- high pasteurization temperatures, together with prolonged exposure, significantly change the physicochemical

properties of milk due to denaturation of protein substances that affect the consistency of drinks.

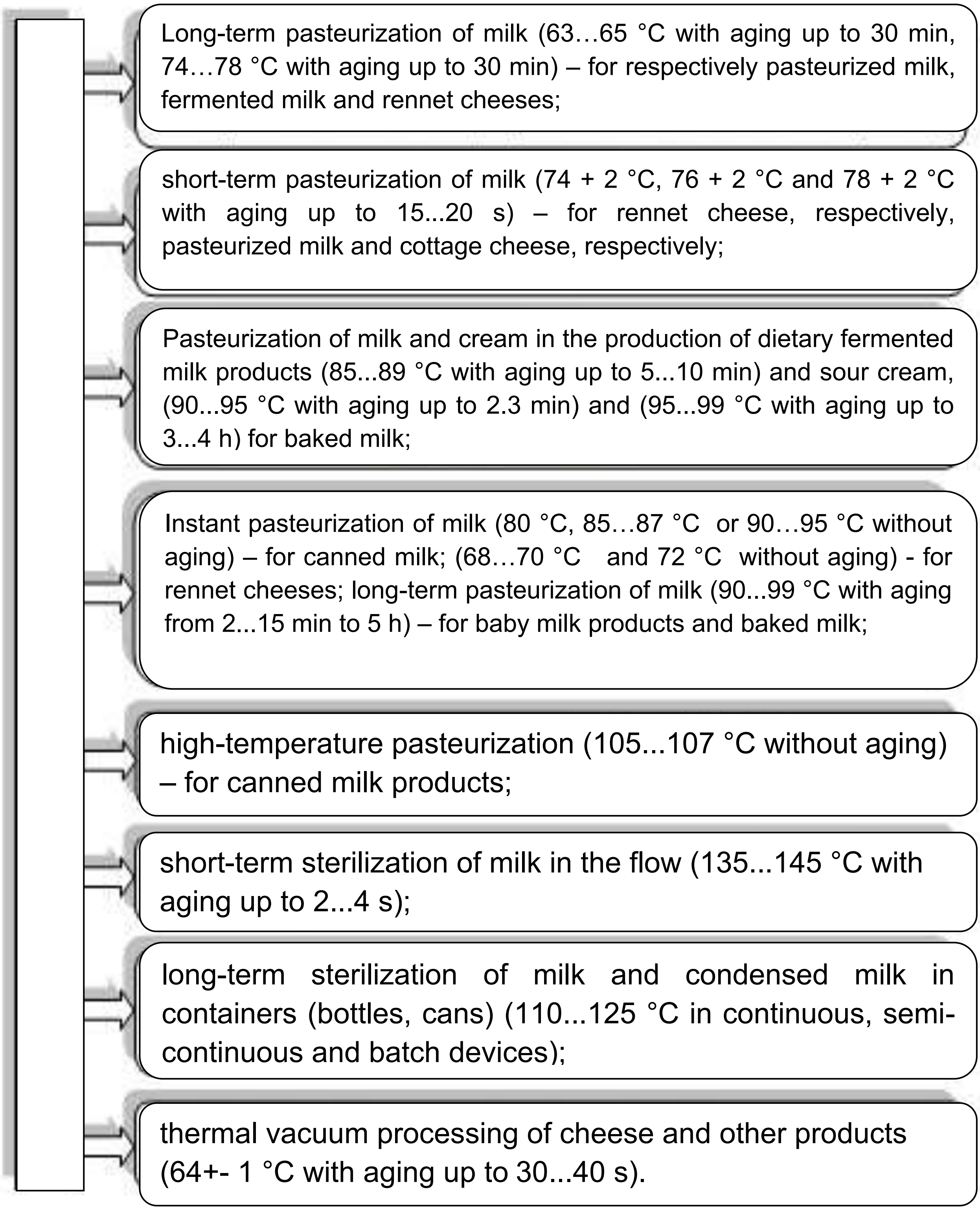
> *For the same reasons, quite strict heat treatment regimes are used in the production of canned milk. The exception is mild pasteurization modes in the production of rennet cheeses, the technology of which involves minimal changes in protein substances during heat treatment.*

Depending on the degree and duration of heating of raw materials, heat treatment in the dairy industry is divided into types, which are shown in Fig. 3.5.

All modes of heat treatment of raw materials for obtaining different types of dairy products are defined in the relevant technological instructions.

After heat treatment, milk is curdled for a longer time by rennet than whole milk. The reason for this is a decrease in the concentration of calcium ions due to a partial transition of calcium salts from a soluble to an insoluble state, as well as complex formation processes between all casein fractions.

Thermally treated milk has a slightly higher viscosity than whole milk, which is explained by the interaction of protein molecules, a strong deviation of the shape from the spherical, as well as the molecular interaction between peptide chains inside the molecules.



Long-term pasteurization of milk (63…65 °C with aging up to 30 min, 74…78 °C with aging up to 30 min) – for respectively pasteurized milk, fermented milk and rennet cheeses;

short-term pasteurization of milk (74 + 2 °C, 76 + 2 °C and 78 + 2 °C with aging up to 15...20 s) – for rennet cheese, respectively, pasteurized milk and cottage cheese, respectively;

Pasteurization of milk and cream in the production of dietary fermented milk products (85...89 °C with aging up to 5...10 min) and sour cream, (90...95 °C with aging up to 2.3 min) and (95...99 °C with aging up to 3...4 h) for baked milk;

Instant pasteurization of milk (80 °C, 85…87 °C or 90…95 °C without aging) – for canned milk; (68…70 °C and 72 °C without aging) - for rennet cheeses; long-term pasteurization of milk (90...99 °C with aging from 2...15 min to 5 h) – for baby milk products and baked milk;

high-temperature pasteurization (105...107 °C without aging) – for canned milk products;

short-term sterilization of milk in the flow (135...145 °C with aging up to 2...4 s);

long-term sterilization of milk and condensed milk in containers (bottles, cans) (110...125 °C in continuous, semi-continuous and batch devices);

thermal vacuum processing of cheese and other products (64+- 1 °C with aging up to 30...40 s).

Fig. 3.5 – Types of heat treatment of raw materials in the dairy industry

Heat exchangers used for milk heat treatment are divided by:

- *purpose – coolers, heaters, regenerators, universal installations;*
- *type of action – periodic and continuous;*
- *type of coolant – water heating, steam heating, cooling with water, icy water or brine;*
- *movement of liquids – direct-flow, counter-current;*
- *design – plate, tubular, irrigation, open and closed types, capacious with a jacket and a stirrer;*
- *number of sections – one-, two- and multi-section or combined, one- and two-cylinder.*

Simultaneously with pasteurisation, milk and cream are deodorised and degassed to improve organoleptic indices.

Organoleptic indicators of milk change the volatile substances and gases present in it, especially oxygen, which cause undesirable taste and smell. The oxygen present in milk in the process of milk preservation causes oxidation of the fat fraction and destruction of vitamins. Vacuum deodorizers are used to remove these undesirable substances.

> ***Deodorization** is usually carried out at a temperature of 65... 70 ° C and a dilution at 0.04...*
> *0.06 MPa for 4... 5 s. Under these conditions, milk boils and unwanted gases and volatiles are removed together with vapors.*

Sterilized milk is a processed milk at a temperature of more than 100 ° C with appropriate aging.

Sterilization treatment at high temperatures and packaging of products under aseptic conditions contribute to the production of high-quality long-term storage products. The disadvantage of sterilized milk is its lower nutritional and biological value compared to pasteurized milk due to the negative effect of high temperature, especially long-term action.

Sterilization is used in the production of drinking milk, cream and condensed sterilized milk preserves.

As a raw material for the production of sterilized milk, cow's whole milk is used not lower than the first grade, heat resistance by alcohol breakdown not lower than the third group (milk does not shrink under the action of 72% and higher ethyl alcohol). Milk should be of acidity 16... 18 ° T, its degree of purity according to the standard – not lower than group I, bacterial contamination according to the reductase sample – not lower than class I, the content of bacteria spores – not more than 100 in 1 cm3.

Milk not lower than the I grade with heat resistance corresponding to the IV group by alcoholic breakdown (withstanding the action of 70% ethyl alcohol) is allowed to be used for the production of sterilized milk, provided that stabilizer salts are added in accordance with the Instructions for the use of stabilizer salts in the production of sterilized milk. As the latter can be used: potassium citric acid trisubstituted one-water (K3S6N5 • H2O), sodium citric acid trisubstituted (Na3S6N5O7 • 5, 5H2O), potassium phosphate two-substituted three-hydrogen (K2NRO4 • 3H2O), sodium phosphate two-substituted twelve-hydrogen (Na2NRO4 • 12N2O).

Sterilized milk is produced according to one or two-stage schemes. For the first milk is sterilized once – before bottling or after it. The second involves double sterilization of milk – in the stream before bottling and in containers. The two-stage method guarantees the sterility of the product more, but causes deeper changes in the natural properties of milk.

Among the sterilized types of drinking milk, sterilized milk of long-term storage, produced on the basis of ultra-high temperature (UHT) treatment at a temperature of more than 135 ° C and aseptically packaged in bags of combined material, prevails.

Sterilized milk is produced in two ways: sterilization in containers or UHT treatment followed by aseptic product pouring.

Technological operations of acceptance and preparation of raw materials are typical for all used methods of sterilized milk production. These include: purification, cooling, normalization, pasteurization, if necessary – the introduction of stabilizing salts. In the case of using dry dairy products, the process is supplemented by an additional operation for their preparation and restoration.

Purification and cooling of milk. The milk selected by weight and quality is purified in milk purifier separators. To maintain heat resistance, it is advisable to use cold cleaning of milk, and after cleaning the milk is immediately cooled to a temperature of (4 ± 2) ° C.

Normalization in production of all kinds of sterilized milk is carried out by weight fraction of fat in a stream or by mixing with defatted milk or cream.

If it is necessary to store milk for more than 4 hours until the moment of sterilization to maintain heat resistance, it is pasteurized at a temperature of (76 ± 2) ºC with aging of up to15... 20 s with subsequent cooling to a temperature of (4 ± 2) ºC.

Before sterilization, be sure to check the heat resistance of milk. Milk of group III and higher of heat resistance by alcoholic sample is directed to sterilization without addition of stabilizing salts.

> *The heat resistance of group IV milk is increased to group III or II by adding one of the listed salts in the optimal dose from 0.01 to 0.03% of the milk weight. The stabiliser salt solution is introduced into pasteurised milk immediately before sterilisation. It is not recommended to store milk with stabilizing salts.*

For sterilization in containers, a periodic method of batch processing in autoclaves or continuous processing in vertical hydrostatic towers or horizontal sterilizers is used.

The technological process of production of sterilized milk in bottles (single and two-stage methods) is carried out in the following sequence: acceptance and preparation of raw materials; normalization, introduction of stabilizing salts, preliminary heat treatment (pasteurization in the case of a one-stage sterilization regime or preliminary sterilization – two-stage) and homogenization, bottling, sealing and labeling, sterilization of milk in bottles by one of these methods and cooling.

At two-stage method milk prepared for sterilisation is heated up to temperature of homogenisation, homogenised, after that – preliminary sterilisation and cooling of milk. Further operations are similar to the sequence of operations of the one-step mode.

Batch processing in autoclaves is used in the production of small quantities of sterilized products in a single stage method.

At sterilisation of milk in an autoclave usually carry out preliminary heat treatment of milk at temperature (75 ± 5) ºC and homogenise it at this temperature and pressure (22,5 ± 2.5) MPa. Then milk is sent for bottling in clean heated bottles. Bottles are closed, contained in a steam chamber and sterilised at temperature 110... 120 ºC within 15... 40 minutes. Then all batches cool down to temperature 20 ºC, and an autoclave is filled with the new batch.

Continuous processing of milk in containers should be used in the production of more than 10 thousand bottles per day.

There are two types of continuous sterilization machines (Fig. 3.6.).

○ hydrostatic tower sterilizer for bottles;

○ horizontal rotary sterilizer with a valve closure the shutter

Fig. 3.6 – Types of continuous sterilization machines

The hydrostatic tower sterilizer consists of a central chamber in which the sterilization temperature is maintained with steam under pressure balanced from the side of loading and unloading with columns of water forming equivalent pressure. Water from the loading side is heated, and from the unloading side it is cooled.

In the hydrostatic tower, the milk container slowly moves along the conveyor through successive heating and cooling zones, the dimensions of which correspond to the required temperature and holding time at different stages of processing.

When using this equipment, the product is made according to a two-stage sterilization scheme. Prepared for sterilisation milk after centrifugal cleaning and normalisation by a weight part of fat is warmed up to temperature (65 ± 5) ºC, homogenised at the same temperature and pressure (22,5 ± 2,5) MPa. The milk is then heated in a stream in a pre-sterilization unit similar to a high temperature treatment unit. Milk is sterilised at temperature (137 ± 2) ºC with an exposure of 20 s and cool down to temperature 30... 70 ºC (depending on a bottle material – as a rule, for plastic bottles the lower temperature is required).

Before processing in the hydrostatic column pre-sterilized and cooled milk is poured into clean heated bottles with a capacity of 0.5 and 1.0 dm3. The temperature of glass bottles should be 60... 70 ºC to avoid thermal beating when spilling milk.

Sealed milk bottles are sent to a continuous sterilizer tower, where they sequentially pass four towers.

The cycle of the hydrostatic sterilizer is about 40... 60 minutes, including 12... 18 minutes to pass through the sterilization section.

Cooled to a temperature of (45 ± 5) ºC milk bottles are transfered to the labeling machine, and then stacked in polymer boxes or metal baskets and sent to the storage chamber, where the product is cooled to a temperature of 20 ºC by fans or natural air circulation.

Sterilized milk in bottles should be stored in the absence of direct sunlight at a temperature of 1... 20 ºC not more than two months from the date of manufacture, including at the manufacturer's enterprise not more than one month.

A horizontal rotary sterilizer with a valve shutter is a relatively low-frame unit with a mechanical drive of the rotor, through which the filled container passes into a zone of relatively high pressure (high temperature), where it is exposed to sterilization temperatures of 132... 140 ºC for 10...12 min. The total cycle is 30... 35 min.

A rotary sterilizer with a valve shutter like a tower can be used to sterilize both glass and plastic bottles.

> ***UHT –*** milk processing compared to traditional sterilization in hydrostatic towers helps to save time,

> labor costs, energy and production areas. UHT - cutting is a fast process and much less affects the taste of milk.

According to ultra-high-temperature technology, T-milk is the most common among sterilized dairy products.

The use of this heat treatment method involves the mandatory aseptic filling of the product into bags made of pre-sterilized packaging materials. Any intermediate reservation between processing and packing should be carried out in aseptic conditions to prevent secondary bacterial contamination.

There are two main types of high temperature processing systems, differing in the way milk is heated in the stream.

In systems with indirect heating, heat is transferred to the product from the heating medium through the heat transfer surface (plate, pipe wall). These systems are based on heat exchangers:

- lamellar (lines "Steriterm," "Sordi-Lodi");
- tubular (line "Elikster");
- screw type.

In direct exposure systems, the product comes into direct contact with a heating medium (steam) that is injected into the milk stream (steam is injected into the product) or, conversely, a stream of milk is injected into the steam-filled chamber. Then the product is cooled in a vacuum chamber, where the same amount of steam is removed from the milk as was introduced in the injector, and then by indirect cooling in a plate or tubular heat exchanger it is further cooled to the filling temperature.

Since in direct exposure systems the product is mixed with the heating medium, the quality of the latter requires strict control.

The quality of milk, especially its bacteriological indicators, largely depends on the duration and temperature of preservation. It is known that fresh milk contains special bactericidal substances that not only prevent the growth of bacteria, but destroy them. In uncooled milk quickly develop microorganisms that cause its souring. So, at a temperature of 32 ° C for 10 hours, the acidity of milk increases 2.8 times, and the number of bacteria increases 40 times. In milk cooled to 12 ° C, acidity does not increase for 10 hours, and the total number of bacteria does not change significantly.

> *So, **the cooling of milk** is one of the main factors that cause the suppression of the development of unwanted pathogenic microflora and contribute to the preservation of milk quality.*

The reproduction of most microorganisms found in milk slows sharply when it cools below 10 ° C and almost completely stops at a temperature of about 2... 4 ° C.

Milk after acceptance at the enterprise is cooled or aftercooled for the purpose of short-term storage of its original properties and limiting the development of microflora before processing. For longer storage (4... 16 h) raw materials are pasteurized, cooled and stored in tanks. The usual cooling of milk (up to 8... 10 ° C), deep cooling (up to 3... 5 ° C), freezing and storage in a frozen state (below minus 20 ° C) are distinguished.

To increase the shelf life, dairy products are cooled during the manufacturing process, and drinking milk – directly after temperature processing.

> *Optimal shelf life of milk cooled to 4... 6 ° C lasts no more than 12 hours. With longer storage of milk at low temperatures, defects in taste and consistency occur.*

Freezing is the release of ice crystals from the solution, as a result of which the physicochemical properties of milk and dairy products change. The property of defrosted milk to renew a product of previous quality depends on the moisture content in the frozen mass.

Milk is frozen in three stages (Fig. 3.7.)

hypothermia

dehydration

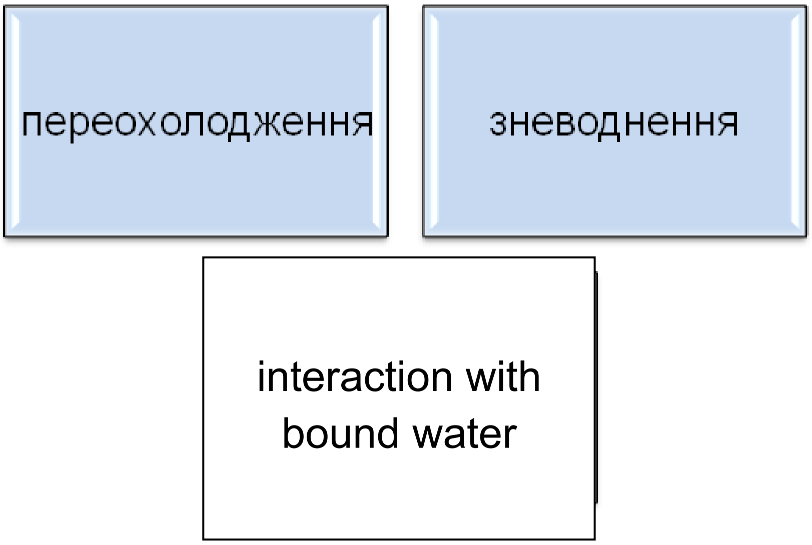


Fig. 3.7 – Milk freezing stages

Dehydration of milk depends on the cooling temperature and the rate of ice formation. If ice is formed quickly, the milk does not exfoliate. The amount of frozen water in milk at minus 1 ° C is 45%, at minus 21 ° C – 95% and at minus 25 ° C reaches 97.1%. Thus, milk frozen at a temperature of minus 21, minus 25 ° C, actually does not contain free water, 3.5% is bound water, so for a long time (up to 18 months) the milk does not change.

The method of fast (layered) freezing of milk at a temperature of minus 23 ° C - minus 25 ° C has found application in industry. Milk frozen at this temperature after melting does not differ from the original.

Freezing whey and skim milk can thicken them. To thicken skim milk 2.5... 4.0 times, freeze it to a temperature of minus 1.7 °C - minus 3.5 °C. At this temperature, 80% turns into crystals, and at a temperature of minus 8 °C – up to 90% of water, which corresponds to a degree of thickening of 5.7.

Cooling causes a change in the components and properties of milk, in particular, reduces the strength of the casein clot, promotes the hardening of fat in fat balls. Milk freezing takes place when it is cooled to a temperature below minus 0.55 °C. During the crystallization of water, the concentration of salts in the unfrozen part of the milk increases. The volume of frozen milk increases by 10%, which can cause the destruction of equipment.

3.3. Requirements of the current standard for raw milk

DSTU 3662:2018 "Cow milk. Specifications" (Raw Cow Milk. Specifications) applies to whole raw cow milk when purchased from dairy farms, collective agricultural enterprises, private and state farms, regardless of ownership and type of activity, milk processing enterprises, milk buying enterprises and is intended for processing into dairy products. The requirements of this standard are mandatory.

Milk that is purchased should be obtained from healthy cows in farms that are safe for infectious diseases, and in terms of quality, meet the requirements of this standard.

Milk after milking should be filtered and cooled.

Milk should be natural, whole, clean, without extraneous smells and tastes, inherent to raw milk flavors and smells.

In appearance and consistency, milk should be a homogeneous liquid from white to slightly yellow coloe, without sediment and clots.

Mixing milk from healthy cows and freezing milk is not allowed.

The content of inhibitory substances (detergents, preservatives, formalin, soda, ammonia, hydrogen peroxide, antibiotics) is not allowed as well.

According to physical-chemical, sanitary-hygienic and microbiological indicators, milk quality is divided into three categories: extra, higher and first, according to the requirements specified in Table 3.2.

Table 3.2. – Distribution of milk by grades

Characteristics	Milk grade		
	extra	higher	first
Taste and smell	Peculiar to milk without foreign flavors and odors		
Acidity	16…17°T	16…17°T	≤19°T
Cleanliness group	1	1	1

Total bacterial colonization	≤100	≤300	≤500
Temperature	≤6°C	≤8°C	≤10°C
Mass fraction of dry matter	≥12,2%	≥1,8%	≥11,5%
Number of somatic cells	≤400		

Milk of all kinds must have a density of at least
1027 kg/m3 at a temperature of 20 ° C.

The mass fraction of fat and protein in milk must meet the basic standards, which are approved by the Cabinet of Ministers of Ukraine.

In terms of safety, milk must meet the requirements specified in Table 3.4.

Table 3.4 – Safety parameters of milk

Name of the safety indicator, units of measurement	Maximum permissible level
Toxic elements, mg/kg not more than:	
Lead	0,1
Cadmium	0,3
Arsenic	0,05
Mercury	0,005
Copper	1,0
Zinc	5,0
Microtoxins, mg/kg not more than:	
Antibiotics of the nitrocycline group	0,01
Penicillin	0,01
Streptomycin	0,5
Pesticides, mg/kg not more than:	
Hexochlorane	0,05
Gamma isomer	0,05
Nitrates, mg/kg not more than:	10
Hormonal drugs, mg/kg not more than:	
Diethylbsetral	Not allowed

Estradial 17	0,002
Radionuclides, Bq/kg, not more than:	
Strontium 90	20
Cesium 137	100

The purchase price for milk and the payment system is established and regulated by the relevant regulatory documents, taking into account the established basic standards for fat and protein.

It is allowed, by agreement of the parties, to purchase milk with a density of > 1026 kg/m3 at a temperature of 20 ° C and an acidity of 15 ° T to 21 ° T, but fresh and whole, which is evaluated on the basis of an extra control sample, by the highest or first grade, if it complies with the standard by organoleptic indicators, purity, general bacterial contamination, number of somatic cells, mass fraction of dry substances.

Milk that does not meet the requirements of this standard refers to non-carbonaceous and can be used for processing in accordance with industry recommendations that are approved in the prescribed manner.

3.4. Sanitization of equipment and containers

At dairy enterprises, equipment, milk pipelines, containers must be thoroughly washed and disinfected daily after the end of the technological cycle in accordance with the requirements. Sanitization of tanks for the production and storage of dairy products should be carried out after each emptying.

Experiments have established that from insufficiently processed equipment 10... 20 times more microbes get into pasteurized milk than from qualitatively washed and disinfected.

> *Processing equipment consists of two independent processes: washing and disinfection.*

The main requirements that relate to the washing process are the complete removal of all milk residues and other contaminants from the surface of the equipment.

> *The purpose of disinfection is the complete destruction of pathogenic microbes and the reduction of non-pathogenic to an extent that cannot be harmful to the manufacture of dairy products.*

It should be noted that only thoroughly washed equipment and containers can be disinfected. Equipment processing time depends on its purpose:

- capacities for storing and transporting milk (baths, tanks, flasks, etc.) – immediately after emptying;
- milk heat treatment equipment – after the end of the operating cycle (at least after 6... 8 hours of continuous operation);
- equipment for washing and filling bottles - every 5-6 shifts after the end of work, as well as when switching to bottling pasteurized milk after bottling fermented milk products (bottling machines);
- equipment for the manufacture of sour-milk cheese and cheese products (coolers, self-pressing tables, pipelines) – at the end of each shift;
- equipment for packaging dairy products – after the end of work (at least after two shifts during continuous operation);
- milk transportation equipment (pipelines) – immediately after the end of the working cycle and at least once a day;
- filter materials (haze, flannel, etc.) and bags for bottling of callier – after each application.

Washing efficiency depends on the factors shown in Fig. 3.8.

-type, concentration, temperature and time of exposure to detergent

-type and quality of contamination;

-shape, material and quality of the surface to be cleaned;

-method of washing;

-water quality.

Fig. 3.8 – Washing efficiency factors

Equipment and containers are usually contaminated with fat, proteins and milk salts. For washing, you should use chemical (alkaline) detergents that would emulsify fat and dissolve protein. To remove the milky stone, more complex than other contaminants, acid detergents are additionally used.

> *The following chemicals are used for equipment washing: crystalline sodium carbonite (soda ash), sodium metasilicate (liquid glass), sodium phosphate (trisodium phosphate), sodium hydroxide (caustic soda), nitric acid and synthetic detergents authorized by the Ministry of Health.*

This is due to the lack of detergent, which would be equally suitable for washing all types of equipment.

The basic requirements for alkaline detergents and evaluation of the results of their use are given in Table 3.3.

Table 3.3 – Requirements for alkaline detergents and evaluation of their use results

Detergents	Emulsification	Flushing ability	Sterilizing ability	Ability to prevent the formation of milk stones	Wettability	Ability to dissolve milk solids
Soda ash	Satisfa	Satisfact	Relativel	Poorly	Satisfactor	Relativel

	ctory	ory	y good		y	y good
Caustic soda	Satisfactory	Poorly	Very good	Poorly	Poorly	Very good
Sodium metaselicate	Good	Relatively good	Good	Satisfactory	Relatively good	Good
Trisodium phosphate	Satisfactory	Good	Not enough	Good	Good	Relatively satisfactory

For washing process equipment and utensils, various factory-made means or mixtures of individual components made at the enterprise are used (Table 3.4.).

Table 3.4 – Detergent mixtures of individual components

Mixture number	Mixture content, % wt.			
	Sodium hydroxide	Soda ash	Trisodium phosphate	Liquid glass
1	–	50	40	10
2	–	18,5	18,5	63
3	10	50	35	5
4	65	–	30	5

Mixture No. 1 is intended for washing equipment that does not come into contact with hot milk and made of corrosion-resistant steel or other tin-coated metal; 2 – for equipment made of aluminum; 3 – equipment that comes into contact with hot milk (except for those made of aluminum); mixture No. 4 – for equipment made of containers made of glass and porcelain.

In the absence of one of the components of the mixture, as an exception, a solution of calcined or caustic soda is used.

Concentrations of washing solutions depend on the objects of washing. They are selected according to the Instructions for washing and disinfection of equipment.

Working solutions of acids and alkalis or detergent mixtures, from dry substances or concentrated solutions should be prepared in compliance with safety precautions in enameled or corrosion-resistant dishes.

For the preparation of detergent and disinfectant solutions, for rinsing equipment, tap water is used in accordance with the requirements of GOST 7525:2014 "Drinking water." Materials that are produced for the preparation of detergent and disinfectant solutions must be checked for compliance with the requirements of the NTD.

For disinfection of equipment, chlorine lime solutions with a concentration of 100... 400 mg/l of active chlorine are used, depending on the purpose of the equipment. Prepare them from a concentrated 10% solution.

In air, chlorine lime easily decomposes, losing chlorine, so in the surface layers the content of active chlorine is less than in deep ones.

When chlorine lime is dissolved in water, calcium chloride decomposes into calcium oxide hydrate, calcium chloride and hypochlorous acid HOCI, which decomposes into hydrochloric acid and oxygen. The released oxygen has a sterile effect, oxidizing organic compounds.

After washing and disinfecting, the equipment should be rinsed well with tap water until the detergents (control on phenolphthalein or litmus paper) and disinfectants (control – no chlorine smell) are completely removed. Control of the mode and quality of washing is carried out according to the current instruction on the sanitary treatment of equipment at the enterprises of the dairy industry.

Plate and tubular pasteurizers are washed until complete removal of traces of acid and alkali residues.

Periodically during the shift, the controllers on the filter check the bottles for residual alkali by phenolphthalein, everything else (washing, disinfection of dishes, equipment and inventory) – periodically, but at least once a week. Washing solutions should be prepared in common containers. In the process of their preparation shop should submit them to the laboratory to determine the concentration.

Regardless of the washing method (manual, mechanical) and the purpose of the process equipment, containers, etc., the entire processing process consists mainly of four successive stages, which are shown in Table 3.5.

Table 3.5 - Main stages of process equipment washing

Equipment washing sequence	Manual method	Circulation method
Rinse with water to remove product residues	Tap water or water with a temperature of 35...40 °C	Rinse with tap water
Washing with hot alkaline detergent	0.5% solution of soda ash or other detergent mixtures at a temperature of 50...55 °C	0.5...1% solution of soda ash or other detergents at a temperature of 65...70 °C, 5...10 min
Rinse with water until all traces of detergent disappear	35…40 °C	40…45 °C
Disinfection	a) steaming with sharp steam for 2...3 min; b) treatment with chlorine solutions (150...200 mg/l of active chlorine) for 3-5 minutes. At a temperature of 50 °C, rinse with tap water.	

Washing can not begin, using hot washing solutions, because under the influence of high temperatures, the proteins of milk residues denature, and can stick to the walls. Washing begins with water of a temperature sufficient to dissolve the fat, but does not denature the protein of the milk residues.

During washing and disinfection of any equipment, attention should be paid to the shape of the treated surface. Especially carefully it is necessary to wash uneven surfaces and sites where remains of milk and dairy products or detergents can remain.

SECTION 4

PECULIARITIES OF PRODUCTION OF DAIRY PRODUCTS WITH HIGH FAT CONTENT

4.1. Characterization of dairy raw materials for the production of spreads and butter

The ingredients for the production of spreads are cream and skimmed milk (acidity not exceeding 20 °T), which are obtained from cow's milk that meets the requirements of DSTU 3662: 2018; plastic and cheese cream; whole and (or) skimmed milk powder; vegetable fats; oils; fat compositions and milk fat substitutes; whole or skimmed condensed milk; ghee; milk fat; raw butter (acidity not exceeding 20 °T) obtained during the production of sweet cream butter and dry buttermilk.

It is allowed to include sunflower, corn, peanut, cottonseed, olive, mustard, rapeseed, palm, coconut, palm kernel oils; palm stearin and vegetable fats and fat compositions in spread formulations. Flavors (food-grade natural and identical to natural ones), colorants (anato and β-carotene), emulsifiers, stabilizers, preservatives, acidity regulators, antioxidants are also used to improve organoleptic characteristics.

> *The peroxide number of refined deodorized vegetable fat components, as well as raw milk components, should be no more than 3 mmol of active oxygen per kg.*

Besides, modern combining technologies involve the addition of dietary fiber, cereal products, extracts, vitamins, protein concentrates, agar, bifidobacteria, non-traditional vegetable oils (milk thistle, camelina, linseed, sea buckthorn), protein-carbohydrate supplements, symbiotics, biologically active substances, etc. to spread formulations.

When butter is produced by the methods of churning and transformation of high-fat cream, dairy raw materials are used, as shown in Fig. 4.1.

- whole cow's milk
- cream
- whole milk powder
- skimmed condensed milk
- raw butter

Fig. 4.1 – Raw milk

In the case of sour cream butter, bacterial starter cultures D (*Lactococcus lactis subsp cremoris, Lactococcus lactis subsp. lactis, Lactococcus lactis subsp., Lactis biovar diacetylactis) and LD (Lactococcus lactis subsp. cremoris, Lactococcus lactis subsp. lactis, Lactococcus lactis subsp., Lactis biovar diacetylactis, Leuconoctoc mesenteroides subsp. cremoris, Leuconoctoc lactis)* or fermentation preparations are added. For long-term storage butter L *bacterial starter cultures (Lactococcus lactissubsp. cremoris, Lactococcus lactis subsp. lactis, Leuconoctoc mesenteroides subsp. cremoris, Leuconostoc lactis, Leuconostoc mesenteroides subsp. dextranicum*), are more appropriate, as this ensures a mild flavor.

The following non-dairy ingredients are added to the main raw materials in the production of butter with fillers: refined sugar, cocoa powder, natural coffee and chicory, soluble coffee, juices, syrups and concentrated fruit and berry extracts, natural honey; Vitamins (retinol, microbiological β-carotene or «caroline» microbiological in oil); emulsifiers (distilled and soft monoglycerides, mono- and diglycerides of fatty acids emulsifier); stabilizers (corn and potato starch, carboxymethyl starch, sodium carboxymethyl cellulose, pectin, gelatin); preservatives (sorbic acid, sodium, potassium and calcium salts of sorbic acid, benzoic acid); acidity regulators and antioxidants (high-grade and first-grade lactic acid, citric acid).

DSTU 8131:2015 «Raw cream. Technical conditions» (*Raw Cream Specifications*) establishes requirements for raw milk cream obtained by separation of raw cow's milk intended for industrial processing into dairy products.

Cream is a fat emulsion obtained from milk by separation. During the separation of whole milk, large fat globules (larger than 1 micron) are concentrated in cream, while small ones are transferred to skimmed milk. Cream is a polydisperse multiphase system. They contain the same ingredients as whole milk, but with a different ratio of fat to plasma.

> *Raw cream is a homogeneous fat emulsion of milk fat in plasma obtained from raw milk by separation, chilled, and intended for further processing.*

Raw cream is a cream that has not been subjected to heat treatment.

Cream does not need to be refrigerated, provided that it is processed at a dairy processing plant no later than 2 hours after milking.

Depending on the organoleptic physicochemical and microbiological characteristics cream is divided into grades as shown in Fig. 4.

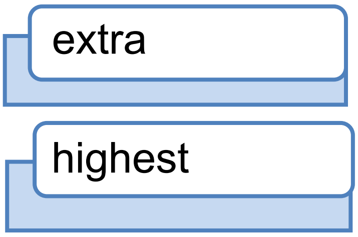


Fig. 4.2 – Grades of cream

The content of cream components of different mass fractions of fat is shown in Table 4.1.

Table 4.1 - Composition of cream

Mass fraction of fat, %	Mass fraction of, %				
	water	protein	lactose	cinder	MSNF
30	64,0	2,6	3,0	0,3	5,9
35	59,6	2,4	2,7	0,2	5,4
40	55,3	2,0	2,4	0,15	4,7

Organoleptic characteristics of cream

Flavor and smell	Creamy, clean, sweet, without foreign flavors and odors
Consistency	Homogeneous liquid without fat lumps and protein flakes
Color	White, with a creamy tint, homogeneous throughout

The mass fraction of cream fat should be between 15% and 40%. After separation, the cream should be cooled to a temperature not exceeding 6 °C. Depending on the type of dairy product produced at the enterprise, it is recommended, if technologically necessary, to select cream with heat resistance of at least group 2.

In terms of physical and chemical characteristics, depending on the mass fraction of fat, cream should meet the requirements set out in Table 4.2.

Table 4.2 – Physical and chemical characteristics of cream, depending on the mass fraction of fat

Indicator name, unit of measurement	Standard for cream with a mass fraction of fat, %		
	from 15 to 20	more then 20 to 30	more then 30 to 40
Titratable acidity, °T, for grades:			
extra	14,0..16,0	13,0…15,0	12,0…14,0

End of Table 4.2.

highest	14,0…17,0	13,0…16,0	12,0…15,0
Mass fraction of milk solids-not-fat (MSNF)%	7,0…6,7	6,7… 5,8	5,8… 5,0
Density, kg/m^3	1014,0…1008,0	1008,0…997,0	997,0…987,0

Raw cream should not contain inhibitors, antibiotics, formalin, hydrogen peroxide and other detergents, disinfectants and preservatives, baking soda, ammonia.

In terms of microbiological indicators, cream must meet the requirements listed in Table 4.3.

Table 4.3 - Microbiological parameters

Indicator name, unit of measurement	Standard for grades	
	extra	highest
The quantity of mesophilic aerobic and facultative anaerobic microorganisms (QMAFAnM), thousand CFU/cm^3	≤ 100	≤300
Quantity of somatic cells, thousand/cm^3	≤400	
Pathogenic microorganisms, including bacteria of the genus *Salmonella*, in 25 cm^3	Not allowed	
Staphylococusaureus, in 0,1 cm^3	Not allowed	
Listeriamonocytogenes, in 25 cm^3	Not allowed	

The content of toxic elements in cream should not exceed the maximum permissible levels given in Table 4.4.

Table 4.4 – Maximum permissible levels of toxic elements

Name of the toxic element	Maximum permissible level
Lead	10,0
Cadmium	10,0
Arsenic	50,0

End of Table 4.4.

Mercury	5,0

The content of aflotoxin, antibiotics, pesticides, nitrates and hormones, and radionuclides in cream must not exceed the permissible levels established by the current veterinary and sanitary standards for raw milk. Cream is used for the production of butter, butter with fillings and spreads.

The buttermilk is the cream plasma obtained during the processing of cream into butter. The nutritional and dietary value of the buttermilk necessitates its full collection and use for food reproduction whenever possible.

It is formed at the stages of cream churning or separation. For example, 1 ton of butter can produce up to 1.5 tons of buttermilk. Depending on the method of butter production, the following types of buttermilk are distinguished, as shown in Fig. 4.4.

- buttermilk obtained in the process of butter production by churning cream on periodic and continuous basis
- buttermilk obtained in the process of butter production by converting

Fig. 4.4 - Types of buttermilk

In addition, depending on the type of butter, a distinction is made between sweet and sour cream butter.

The raw butter should have the following organoleptic and physicochemical characteristics, as shown in Table 4.5.

Table 4.5 – Organoleptic and physicochemical parameters of raw butter

Name of the indicator	Characteristics of raw butter
Organoleptic characteristics	
Flavor and smell	Pure milky, specific for butter, slightly fodderish is allowed
Appearance	Homogeneous liquid without sediment and flakes
Color	From white to slightly yellow
Physico-chemical parameters	
Acidity: titratable ˚T, not more than	20
active (pH)	6,4…6,6
Dry matter, %, including:	7…9
fat, %.	0,4…0,7
proteins, %.	2,9…3,2
lactose, %.	4,7…4,8
mineral substances, %.	0,6…0,7
Cholesterol, mg%,	20,0…39,0
Phospholipids, mg%.	150,0…210,0
Density at temperature (20±2) ˚C, kg/m^{-3}, not less than	1027…1035
Viscosity, 10^{-3} Pa·s	1,65
Specific heat capacity, kJ/(kg·K)	3,94
Surface tension, N/m	40
Vitamins, mg %	
B_1	0,36
B_2	2,00

End of Table 4.5.

B_6	1,60
B_{12}	4,20
C	2,70
A	0,08
E	0,55
H	0,01
choline	466,0

The main and most valuable components of butter are proteins, carbohydrates (lactose), milk fat, as well as non-protein nitrogen compounds, mineral salts, enzymes, organic acids, and almost all compounds of whole milk. It also contains a complex of biologically active substances with minimal energy value and low content of overloaded atherogenic substances (fats, carbohydrates).

Buttermilk fat is favorably different from butter fat. Whereas the latter is dominated by oleic, palmitic, myristic and stearic fatty acids, buttermilk fat contains highly valuable linoleic, linolenic and arachidonic fatty acids, which have antisclerotic properties.

> *Buttermilk is a source of valuable protein, which includes amino acids with lipotropic properties, such as methionine, cystine, etc. Buttermilk contains vitamins B1, B2, B12, C, E, pantothenic acids and others, but in smaller amounts.*

The butter contains up to 5% lactose, which normalizes fermentation processes in the gastrointestinal tract and a full range of minerals, including all the trace elements that are part of whole milk.

The transition rate of milk fat is 14%. A distinctive feature of this fat is its high dispersion, the size of fat globules is 0.5...1.0 microns. A characteristic feature of buttermilk lipids is the high content of volatile and polyunsaturated fatty acids, which determine high biological properties.

The carbohydrate composition of buttermilk is almost identical to skimmed milk. Minerals in whole milk are also transferred to the buttermilk, with a 97.5% transfer rate.

In addition, as mentioned above, vitamins of groups B and C and biotin predominate in buttermilk. Buttermilk is especially rich in choline, which has anti-sclerotic properties. The composition and properties of butter depend on the production method and the type of butter.

The buttermilk should be free of pathogenic microorganisms, including Salmonella in 25 cm^3.

Methods of processing the butter, if necessary, for storage and transportation are determined depending on the butter production method. When butter is produced by the method of cream clotting, buttermilk is obtained at a temperature of 12...16 °C. It can be directly sent for processing, including bottling into containers with gradual cooling and storage at a temperature not exceeding 8 °C. When butter is produced by converting high-fat cream, a 70...80 °C butter is obtained. It is immediately cooled to a temperature not exceeding 10 °C and stored in closed tanks until it is processed or transported.

An effective indicator of control is the density of the buttermilk. With a dry matter content of 7...9 %, which characterizes the naturalness of the buttermilk, its density is in the range of 1021...1032 kg/m3. A decrease in density indicates dilution with water. Adulteration of buttermilk with water even by 3...5 % leads to a noticeable change in its physical and chemical properties, which complicates processing and significantly reduces its value as a food raw material.

If buttermilk is supplied by other enterprises, it is transported in closed containers (tankers) at a temperature not exceeding 10 °C when the compartments are fully loaded. It is allowed to store buttermilk before processing at dairy enterprises for no more than 36 hours at a temperature not exceeding 10 °C, no more than 6 hours at a temperature not lower than 6 °C

The amount of buttermilk obtained with the correct organization of the production process is determined by the fat content of the original cream and the plasma content in the butter.

In the case of changing the fat content of cream from 20 to 50 % when producing butter with a plasma mass fraction of 17.6, 20, 27.5, 38.5 %, we will get the amount of buttermilk that varies in very large ranges and is respectively 3228 and 659, 3031 and 578, 2720 and 456, 2156 and 233 kg per 1 ton.

The standard output of the buttermilk (M_{weight}) for the production of 1 ton of butter is determined by the formula

$$M_{weight} = M_{s.c}\left(\frac{F_m - F_{sk.m}}{F_c - F_{sk.m}}\right)\left(\frac{100 - B_1}{100}\right)\left(\frac{100 - B_2}{100}\right) - M_{mc}, 4.1$$

where M_{weight} is the normative output of the buttermilk, kg; $M_{s.c}$ standard consumption of milk per 1 ton of butter, kg; F_m, $F_{sk.m}$, F_c – mass fraction of fat, respectively, in milk, skimmed milk, cream, %; B1 – fat loss during milk separation, %; B2 – fat loss during butter production, %.

Buttermilk with a fat mass fraction of more than 0.7% must be separated or used to normalize milk in terms of fat and protein content in the production of dairy products. In doing so, the manufactured products are enriched with lipids and milk protein complex. Normalization calculations are based on the actual fat content of the buttermilk, which eliminates the need for separation. The buttermilk used for normalization should have an acidity of no more than 20 °T and a density of no less than 1027 kg/m³.

Before use, cool the buttermilk to the temperature of normalized milk. If long-term storage (more than 10 hours) or transportation is required, cool the buttermilk to 5...8 °C. To avoid foaming and fat clumping, fill the tanker compartments with the butter creamer completely, stirring gently.

To increase the dry matter content of spreads and butter, we use whole and skimmed milk powder that meets the requirements of the relevant regulatory documents.

Milk dry is included in spread formulations to increase the product's dry matter, provide appropriate organoleptic characteristics and as an emulsifier. Milk proteins interact with emulsified fat to form a complex. The main fraction of milk proteins is the casein complex (80%), the rest of the milk proteins (12...17%) are whey proteins: soluble fraction – lactoalbumin, insoluble lactoglobulin. Whey proteins contain more essential amino acids and are more complete from the point of view of nutritional physiology.

Dried dairy products are characterized by a high mass fraction of solids (up to 98.5%) and a low mass fraction of moisture (not exceeding 5%).

Dairy products are free-flowing powders. The lower the ratio of $F_p/MSNF_p$, the better the powder flowability – the time it takes for a product to spill out (in seconds) from a funnel of a certain diameter. This indicator is influenced by the granulometric composition of the product, its adhesive properties, and physical and mechanical properties. Flowability is related to the porosity index, the value of which is characterized by the volume of air between individual particles of the dry product. Air can also be contained in the middle of the particles. The mass fraction of air ranges from 10 to 60%, and its content depends on the degree of thickening and the drying method.

Dried dairy products can be thought of as polydisperse systems of individual particles, the size of which depends on the drying methods and parameters, the degree of milk condensation before drying, the place of sampling, etc.

According to organoleptic, physicochemical and microbiological parameters, dry products should meet the requirements given in Tables 4.6 - 4.8.

Table 4.6 – Organoleptic characteristics of dry products

Indicator	Characteristics
Flavor and smell	Peculiar to fresh pasteurized milk, without foreign flavors and odors
Consistency	Fine dry powder. The presence of lumps that easily crumble under mechanical action is allowed. Reconstituted – homogeneous liquid without sediment
Color	White with a light cream tint

Table 4.7 – Physical and chemical characteristics of whole and skimmed milk powder

Name of the indicator	Standard for milk powder	
	whole	skimmed
Mass fraction of moisture, %, not more than	4,0	4,0
Mass fraction of fat, %, not less than	26,0	1,5
Mass fraction of of protein, %, not less than	23,0	32,0
Titratable acidity of reconstituted milk, ˚T, not more than	18	19
Purity of reconstituted milk, group, not lower than	1	1
Mass fraction of iron, mg/100g, not more than	-	-

Table 4.8 – Microbiological parameters of whole and skimmed milk powder

Name of the indicator	Standard
The number of mesophilic aerobic and facultative anaerobic microorganisms in the product CFU/g, not more than	25000
Bacteria of the Escherichia coli group (coliforms) in 1 g	Not allowed
St. aureus in 1 г	Not allowed
Mold fungi, CFU/g, not more than	100
Yeast, CFU/g, not more than	50
Pathogenic microorganisms, including bacteria of the genus Salmonella in 25 g of product	Not allowed

According to the content of toxic elements, mycotoxins, antibiotics, pesticides, hormonal preparations, dried dairy products must meet the requirements given in Table 4.9.

Table 4.9 – Content of toxic elements, mycotoxins, antibiotics, pesticides, hormonal drugs in dried dairy products

Indicator	Accaptable standard
Mass fraction of toxic elements in the recovered product, mg/kg, not more than:	
mercury	0,005
cadmium	0,02
lead	0,05
arsenic	0,05
Mass fraction of pesticides in the recovered product, mg/kg, not more than	
DDT and other metabolites (sum of isomers)	0,005
Lindane, hexachlorane (sum of HCCH isomers)	0,005
Mercury-containing pesticides	Not allowed (<0,005)
Other pesticides	Not allowed

End of Table 4.9.

Mycotoxins in dry product, mg/kg, not more than	
aflatoxin B1	Not allowed (<0,001)
aflatoxin M1	Not allowed (<0,0005)
Antibiotics in dry product, units/g, not more than:	
tetracycline group	<0,01
penicillin	<0,01
streptomycin	<0,5
Hormonal preparations in dry product, mg/kg:	
diethylstilbestrol	Not allowed (<0,002)
estradiol-17B	0,0002

4.2 Characterization of vegetable oils, milk fat substitutes and functional blends

Vegetable oils are the main source of essential polyunsaturated fatty acids (PUFAs) ω-6 (linoleic, γ-linolenic, arachidonic) and ω-3 (α-linolenic, eicosopentaenoic, docosahexaenoic). Their physiological significance lies in the fact that they are essential for growth and metabolism in the human body, vascular elasticity. PUFAs play an important role in the synthesis of prostaglandins, they stimulate the body's protective functions and increase its resistance to radiation, which is very important for the population of Ukraine.

According to the classical theory of balanced nutrition, the need for fats is 80...100 g per day, which is satisfied by the consumption of animal fats and vegetable oils. The nutritional value of fats is determined by their energy value and physiological effect. Relevant indicators are presented in Table 4.10.

Table 4.10 – Energy value and digestibility of different types of fats

Fat	Energy value, kJ/g	Digestibility, %.
Coconut oil	37,38	94
Cottonseed oil	39,23	95…98
Sunflower oil	39,48	95…98

Vegetable fats and oils are an energy and structural and plastic material for humans. When 1 g of fat is oxidized in the body, 37.66 kJ are released. The recommended fat content in the human diet is 30...33%.

Prolonged restriction of fats in the diet or systematic consumption of fats with a reduced content of essential components leads to abnormalities in the physiological state of the body: the central nervous system is disrupted, immunity is reduced, and so on. However, excessive fat consumption is undesirable, as it leads to obesity, cardiovascular disease, and other negative consequences.

The main characteristics of vegetable oils are shown in Table 4.11.

Table 4.11 – Characteristics of vegetable oils

Oil	Indicators				
	Density (15°C), g/cm^3	Refractive index (20°C)	t freezing, °C	Iodine number, %	Saponification number, mg KOH/g
Cottonseed	0,918…0,932	1,472…1,476	5…6	90…117	189…199
Peanut	0,911…0,929	1,468…1,472	(-2,5)…3,0	82…92	187…197
Soybean	0,921…0,924	1,474…1,478	(-15)…(-18)	120…141	170…195
Olive	0,914…0,918	1,466…1,471	0…(-6)	72…89,9	185…200

End of Table 4.11.

Palm	0,925…0,935	1,453-1,475	40…41	48…58	196…210
Coconut	0,925…0,926	1,448-1,475	23…26	7…10,5	196…264
Palm kernel	0,925…0,935	1,449-1,452	19…24	12…20	240…257
Rapeseed	0,911…0,918	1,472-1,476	0-…(-10)	91…180	171…180

While palm oil is composed of triglycerides of high molecular weight fatty acids of the C_{16} to C_{18}, series, milk fat is represented by a wide range of low-, medium- and high-molecular weight fatty acids from C_4 to C_{18}. At the same time, palm oil contains up to 10% of palmitic acid triglycerides, which determines its high melting point 42°C.

Milk fat substitutes and functional mixtures are made on the basis of vegetable, animal, and fish fats, which are much cheaper, so their use as milk fat analogues can reduce production costs. The main raw materials for milk fat substitute (MFS) are sunflower, coconut, rapeseed and other vegetable oils, which have a high concentration of polyunsaturated fatty acids in triglycerides and contain virtually no trans-isomers, which makes them liquid at room temperatures. To “harden” liquid fats to bring them closer to the properties of milk fat, they are modified by hydrogenation, which involves partial saturation with unsaturated fatty acids and their trans-isomerization.

Depending on the fatty acid composition, the world's commonly used dietary supplements derived from natural and modified vegetable oils and fish oils can be divided into 6 main groups, as shown in Fig. 4.5.

The first 3 groups of hydrogenated milk fats are intended to replace milk fat in milk-containing products and their analogues, and the last 3 groups are intended to replace milk fat in spreads, ghee mixtures and other products and their analogues.

- with a reduced content of saturated fatty acids (no more than 30%), obtained on the basis of hydrogenated vegetable oils
- with a reduced content of trans-isomers (no more than 30%), obtained on the basis of hydrogenated vegetable fats and their mixtures with natural vegetable oils
- with a reduced content of saturated fatty acids (no more than 30%) and trans-isomers (no more than 30%), obtained on the basis of hydrogenated vegetable fats and their mixtures with natural vegetable oils
- with a reduced content of trans-isomers (no more than 8%), obtained on the basis of hydrogenated and (or) transesterified vegetable fats
- based on natural vegetable fats containing no more than 5% of trans-isomers
- based on hydrogenated fish oils

Fig. 4.5 – Main groups of MFS

Functional blends are characterized by an optimal balance of biological value, technological characteristics and cost. The soy protein they contain is balanced in terms of amino acids. The mixtures contain natural antioxidants: lecithin, isoflavones, vitamins with antioxidant properties, B vitamins, trace elements, and fiber. Functional and technological properties of the mixtures are manifested in the ability to emulsify and moisture binding.

The most common among the MFSs are MFS 1, Efko, Ecolact, Delikon, Acobland; and functional mixtures are Premix, Albolac, and others.

«MFS 1» is a special lauric fat based on fractionated palm and palm kernel oils produced by transesterification.

MFS is obtained from various types of vegetable oils with subsequent purification and deodorization. Physical and chemical parameters are presented in Table 4.12.

Table 4.12 – Physical and chemical parameters of MFS

Indicator	Standard
Melting point, °C	32…34
Solid phase content, %, at temperature:	
10 °C	45…50
20 °C	25…28
30 °C	5…8
35 °C	no more than3,0
Hardness by Kaminsky, g/cm	140…180
Free acid content, %, not more than	0,1
Peroxide number, ½ O mmol/kg, not more than	1,0
Fat content, % not less than	99,8
Moisture content, % not more than	0,2

In terms of organoleptic characteristics, MFS 1 meets the requirements given in Table 4.13.

Table 4.13 – Organoleptic characteristics of "MFS 1"

Name of the indicator	Characteristics
Consistency	homogeneous, plastic, hard
Color	from white to yellowish
Flavor and smell	pure taste, no foreign taste or odor. When flavors are added, it has a pronounced flavor due to the added flavoring agent
Transparency	transparent in the molten state

In the process of production of "SOYUZ" milk fat substitute, the components undergo refining, deodorization, fractionation and hydrogenation, as a result of which their glyceride composition affects the properties and quality of the product.

The fatty acid composition of MFS "SOYUZ-50" is given in table 4.14.

Table 4.14 - Fatty acid composition of MFS ***«***SOYUZ-50***»***

Fatty acids	«SOYUZ-50»
Saturated acids	50,0
Caprylic	1,5
Myristic	3,5
Palmitic	41,8
Stearic	3,2
Unsaturated acids	50,0
Palmitoleic	0,5
Oleic	40,0
Linoleic	9,3
Linolenic	0,2

In terms of organoleptic, microbiological parameters and the content of toxic elements, MFS «SOYUZ-50» meets the requirements given in Tables 4.15 - 4.17

Table 4.15 – Organoleptic characteristics MFS «SOYUZ-50»

Indicator	Characteristics
Flavor and smell	Pure, inherent in milk fat substitute, no foreign flavors and odors are allowed
Consistency	Homogeneous, thick, plastic
Color	White, yellow is allowed, homogeneous throughout the mass
Transparency	Transparent in molten form

Table 4.16 – Microbiological parameters

Name of the indicator	Value of the indicator
KMAFanM, CFU/g, not more than	-
Weight of the product, in g, in which they are not allowed: BCCP (coliforms)	0,001
Pathogenic, including Salmonella	25
Molds, CFU/g, not more than	$1*10^2$
Yeast, CFU/g, not more than	$1*10^3$

Table 4.17 – Content of toxic elements

Name of the indicator	Standard
Cd, mg/kg, not more than	0,03
Hg, mg/kg, not more than	0,03

The physicochemical parameters of MFS «SOYUZ-50» are shown in Table 4.18.

Table 4.18 – Physical and chemical parameters MFS «SOYUZ-50»

Name of the indicator	Standard
Mass fraction of fat, %, not less than	99,5
Mass fraction of moisture and volatile substances, %, not more than	0,5
Melting point, °C	31.5
Ratio of polyunsaturated fatty acids to saturated fatty acids, not less than	0,3
Mass fraction of linolenic and linoleic acids, %.	15,0-25,0
Ratio of linoleic acid to linolenic acid	from 5 to 15
Mass fraction of trans fatty acid isomers, %, not more than	5,0
Copper, mg/kg, not more than	0,1
Iron, mg/kg, not more than	1,5

End of Table 4.18.

Peroxide number (mmol of active oxygen/kg), not more than	2,0
Acid number, mg, KOH/g, not more than	0,3

4.3. Characteristics of emulsifiers, stabilizers, flavoring agents and antioxidants

The term **«emulsifier»** refers to a chemical substance that can (when dissolving or dispersing a liquid) form and stabilize an emulsion, which is achieved through its ability to concentrate at the interface and reduce interfacial surface tension. This ability is associated with surfactant properties. The main function of emulsifiers in spread technology is to form and maintain a homogeneous mixture of immiscible phases, such as oil and water, and in certain food systems, the use of such additives can be associated not only with emulsification but also with interaction with other food ingredients, such as proteins or starches. Other functions of emulsifiers include controlling the crystallization of fats; ensuring the stability of quality indicators; preventing moisture separation during long-term storage; and ensuring a stable consistency during freezing and thawing of the product.

Natural substances are used as food emulsifiers, namely gums, saponins, lecithin, etc. By chemical nature, the molecules of classical emulsifiers, which are surface-active substances, have a diphilic structure, i.e. they contain polar hydrophilic and non-polar hydrophobic groups of atoms, which, being connected through a linking agent, are separated from each other and located at opposite ends of the molecule. The former (hydrophilic) provide solubility in water, while the latter (hydrophobic) provide solubility in non-polar solvents.

Hydrocolloids are effective structure stabilizers in low-fat emulsions. In water, hydrocolloids disperse, swell or dissolve and form viscous solutions. In terms of chemical structure, hydrocolloids are mainly polysaccharides. The physicochemical properties of water solutions of polysaccharides must meet the requirements for the food products they are used to stabilize.

A wide range of structure stabilizers is used: starch, cellulose and their derivatives, pectins, Arabian gum, alginates, carrageenan, agar, guar gum, xanthan, etc.

Among the structure improvers, i.e. stabilizers and emulsifiers, Ester-P, Ester-A, distilled monoglycerides, polyglycerol polyricinoleate, steric acid triglyceride are widely used, the organoleptic and physicochemical characteristics of which are given in Table 4.19.

Table 4.19 – Organoleptic and physicochemical characteristics of emulsifiers and structure stabilizers

Name of the indicator	ESTER-P	ESTER-A	Distilled monoglycerols	Polyglycerol polyricinoleate	Steric acid triglyceride
Organoleptic characteristics					
Appearance	Powder	Viscous liquid	Powder, tiles or chips	Viscous liquid	Powder
Color	From white to light brownish-gray, homogeneous throughout the mass	Light yellow to brown	White to light brown for powder. Light yellow to light brown for tiles or chips	Light yellow to light brown, homogeneous throughout	From white to light yellow, without impurities, homogeneous throughout the mass
Consistency	Solid	Viscous oily liquid	Solid	Viscous oily liquid	Solid

End of Table 4.19.

Smell	Distinctive for this product (steric acid odor). No foreign odor is allowed	Distinctive for this product (oleic acid odor). No foreign odor is allowed	Distinctive for this product (steric acid odor). No foreign odor is allowed	Distinctive for this product (ricinoleic acid odor). No foreign odor is allowed	Distinctive for this product (steric acid odor). No foreign odor is allowed
Physical and chemical parameters					
Acid number, mg KOH/g, not more than	7	5	6	5	5
Saponification number, mg KOH/g, not more than	140	140	175	-	170
Melting point, °C, not less than	45	-	-	52	48
Iodine number, g J_2/100g	<3	60-80	72-105	<3	<3
Hydroxyl number	-	-	80-100	-	-

The free fatty acids in these dairy products play a crucial role in shaping the flavor and taste of butter, cream, and spreads. By adding the enzyme lipase to dairy products, the level of free fatty acids increases. This turns the product into a flavoring agent with a concentrated content of substances that provide a rich flavor.

When evaluating the quality of a spread, the most important indicator is always the taste. For most spread manufacturers, the taste standard is the taste of butter. The taste and smell of spreads are influenced by many factors: their recipe composition, the quality of milk and fat raw materials, methods of their preparation and processing, sanitary and hygienic production conditions, the choice of optimal equipment parameters and conditions for maturation and storage of the finished product. Vegetable fats used in the production of spreads should be neutral in taste and odor and be compatible with milk fat, including melting and solidification temperatures, without causing off-flavors and odors in the product.

> *When selecting **flavors** for spreads and margarines, it is worth considering their emulsion nature.*

It is important to determine which phase should be flavored. In high-fat products, it is advisable to use fat-soluble flavors, and to enhance the flavor profile of low-fat spreads, two flavors should be used: a fat-soluble flavor is added to the fat phase, and a water-soluble flavor is added to the water phase.

An analysis of the flavoring market shows that industrial production of natural food flavors in Ukraine is currently limited by the lack of advanced technologies. According to the research results, a significant part of flavors that are positioned as creamy or dairy do not meet these requirements, as they have an uncharacteristic flavor for sweet butter.

> ***Antioxidants** are added to fatty foods to prevent oxidation of essential nutrients.*

The use of antioxidants extends the shelf life of a food product by protecting it from spoilage caused by the action of air oxygen. The criteria that food antioxidants must meet include effectiveness at low concentrations, no impact on the organoleptic properties of the product, ease of use, and the availability of a food use permission. The list of antioxidants approved for use includes L-ascorbic acid (E300), its salts (E301-303) and esters (E304, 305), mixtures of natural and synthetic tocopherols (E306-309), gallic acid derivatives (E310-312), tert-butylhydroquinone (E319), butylhydroxyanosyl (E320), ethylenediaminetetraacetate (E385) and some others. Traditionally, tocopherols and synthetic antioxidants E320, E321, E385 are used in the technology of fat products. In addition, green tea extract, berry puree, etc. can be used as an antioxidant.

4.4. Fillers for butter and spreads of non-dairy origin

***Cocoa powder** in accordance with DSTU 4391:2005 (Cacao Powder General specifications) is produced by fine grinding of cocoa cake.*

In terms of organoleptic characteristics, cocoa powder must meet the requirements specified in Table 4.20.

Table 4.20 – Organoleptic characteristics of cocoa powder

Name of the indicator	Characteristics
Appearance	Powder from light brown to dark brown color, dull gray tint is not allowed.
Flavor and smell	Peculiar to this product, without foreign flavors and odors

In terms of physical and chemical characteristics, cocoa powder must meet the standards specified in Table 4.21.

Table 4.21 – Physical and chemical characteristics of cocoa powder

Name of the indicator	Standard
Mass fraction of moisture, %, not more than, including during storage of packaged cocoa powder for more than a month	7,5
Mass fraction of fat, %, not more than	According to the calculated content according to the recipes ±3.0

End of Table 4.21.

Degree of grinding – residue on a silk sieve № 38 according to GOST 4403 and on a metal sieve № 016 according to GOST 6613, %, not more than	1,5 When rubbing, there should be no lumps between the fingers
Dispersibility – the number of small fractions, %, not less than	90,0
pH value, not more than	7,1
Mass fraction of ash, %, not more than - in cocoa powder not treated with carbon dioxide alkalis - in cocoa powder treated with carbon dioxide alkalis	 6,0 9,0
Mass fraction of ash insoluble in a solution with a mass fraction of hydrochloric acid of 10%, %, not more than	0,2
Mass fraction of ferro-impurities (particles not exceeding 0.3 mm in the largest linear dimension), %, not more than	0,0003

The content of toxic elements in cocoa powder should not exceed the maximum permissible concentrations stipulated by SanPiN 42-123-4089 and indicated in Table 4.22.

Table 4.22 – Content of toxic elements in cocoa powder

Name of the toxic element	Maximum permissible levels, mg/kg, not more than
Lead	1,0
Cadmium	0,5
Arsenic	1,0
Mercury	0,1

End of Table 4.22.

Copper	50,0
Zinc	70,0
Mycotoxins: aflatoxin	0,005

According to microbiological indicators, cocoa powder must meet the requirements specified in Table 4.23.

Table 4.23 – Microbiological parameters

Name of the indicator	Permissible level
The number of mesophilic aerobic and facultative anaerobic microorganisms, CFU per 1 g, not more than	$1{,}0 \cdot 10^5$
Bacteria of the group of Escherichia coli (coliform), in 1 g, not more than	0,01
Pathogenic microorganisms, including Salmonella, in 1 g, not more than	25,0
Pseudomonas, CFU in 1 g, not more than	$1{,}0 \cdot 10^2$

White sugar. According to DSTU 4623:2006 (White Sugar. The technical specifications), **sugar** is a food product that is purified and crystallized sucrose in the form of individual crystals (crystalline sugar) or individual pieces (pressed sugar).

Crystalline sugar is divided into four categories depending on its quality indicators: first, second, third and fourth; pressed sugar is divided into three categories: first, second and third. Powdered sugar is produced in the first, second and third categories.

Crystalline sugar is produced with crystal sizes from 0.2 mm to 2.5 mm. It is allowed to produce crystal sugar with other crystal sizes. For crystalline sugar, deviations from the minimum and maximum size limits of up to 5% by weight of crystals are allowed.

In terms of organoleptic characteristics, sugar must meet the requirements specified in Table 4.24.

Table 4.24 – Organoleptic characteristics of white sugar

Name of the indicator	Characteristics.
Smell and flavor	Sweet without foreign odors and flavors
Purity of the solution	The sugar solution should be transparent, without insoluble precipitate, mechanical and others
Consistence	Without impurities. For sugar of the third and fourth categories, opalescence is allowed.
Appearance	White, clean, without spots and impurities; a yellow tint is allowed for sugar of the third and fourth categories. Crystalline sugar must be free of lumps. For sugar of the third and fourth categories, lumps that disintegrate when lightly pressed are allowed.

In terms of physical and chemical characteristics, crystalline sugar should meet the standards specified in Table 4.25.

Table 4.25 – Physical and chemical characteristics of of crystalline sugar

Name of the indicator	Values by crystal sugar category			
	1	2	3	4
Mass fraction of sucrose (polarization), %, not less than	99,7	99,7	99,61	99,5
Mass fraction of reducing substances (in terms of dry matter), %, not more than	0,04	0,04	0,05	0,065
Mass fraction of moisture, %, not more than	0,1	0,1	0,14	0,15

End of Table 4.25.

Mass fraction of ash (in terms of dry matter), not more than:				
points	15,0	-	-	-
%	0,027	0,04	0,04	0,05
Color in solution, not more than:				
ICUMSA units	45,0	60,0	104,0	195,0
points	6	8	-	-
conventional units	-	-	0,8	1,5
Mass fraction of ferro-impurities, %, not more than	0,0003			
The size of individual particles of ferro-impurities, in the largest linear dimension, mm, not more than	0,5			

According to microbiological parameters, white sugar must meet the requirements specified in Table 4.26.

Table 4.26 – Microbiological parameters of white sugar

Name of the indicator	Standard
The number of mesophilic aerobic and optionally anaerobic microorganisms, CFU per 1 g, not more than	$1{,}0 \bullet 10^3$
Mold fungi, CFU per 1 g, not more than	1,0•10
Yeast, CFU per 1 g, not more than	1,0•10
Bacteria of the group of Escherichia coli (coliforms) in 1 g	Not allowed
Pathogenic microorganisms, including bacteria of the genus Salmonella, in 25 g	Not allowed

The content of toxic elements in white sugar should not exceed the permissible levels presented in Table 4.27.

Table 4.27 – Permissible levels of toxic elements

Name of the indicator	Permissible level, content, mg/kg, not more than
Mercury	0,01
Lead	0,5
Arsenic	1,0
Cadmium	0,05

The following types of **fruit and berry fillers** are used for the production of butter with a filler, which are shown in Fig. 4.28.

- natural fruit and berry syrups
- fruit and berry puree
- jam
- fruit and berry stews
- fruit and berry jam
- berry jam
- juices with freeze-dried pulp
- fruits and berries freeze drying
- fruit and berry confiture
- red food dye from dried red beets
- natural dyes are concentrated from the pomace of cherries and blackberries
- dessert fruit and berry syrups

Fig. 4.28 – Fruit and berry fillers

Organoleptic characteristics of fruit and berry fillers are presented in Table 4.28.

Table 4.28 – Organoleptic characteristics of fruit and berry fillers

Name of the product	Characteristics		
	Appearance and texture	Flavor and smell, aroma	Color
Natural fruit and berry syrups	Transparent syrupy liquid without sediment	Distinctly sweet or sour-sweet flavor, corresponding to the fruit and berry juices from which the syrup is made, without any off-flavors or odors.	Close to the natural color of fruit and berry juices from which the syrup is made
Fruit and berry syrups (from jam)	Homogeneous viscous liquid free of seeds and pips. Slight gelling is allowed.	Pleasant, characteristic of the type of fruit or berry from which the syrup is made. Cherry and grape syrup with vanilla flavor. A slight taste of caramelized sugar is allowed.	Homogeneous, close in color to the fresh fruit or berries from which the syrup is made.
Jam	Fruits or parts of fruits are uniform in size, retaining their shape, not wrinkled, evenly distributed in sugar syrup. Allowed: fruits or parts of fruits uneven in size, fruits with cracked skin but retaining their shape - no more than 25%, shriveled fruits - no more than 15%. Pitted fruits are allowed in the production of pitted jam. Rose petals must be straightened.	Explicitly expressed natural. Pleasant, characteristic of the fruits and berries from which the jam is made. The taste is sweet or sour-sweet. A slight bitterness inherent in the fruit is allowed in jam made from citrus fruits, mountain ash and honeysuckle. A less pronounced	Close in color to the fresh fruit or berries from which the jam is made, homogeneous; rose petal jam is light pink; walnut jam is dark yellow to dark brown with a purple tint.

		taste and smell, a slight aftertaste of of caramelized sugar.	
Fruit and berry puree	Homogeneous mass without seeds, peel, spreading over a horizontal surface. Gelling of the mass, slight separation of syrup is allowed.	Sour-sweet pleasant flavor characteristic of fresh fruits and berries.	Peculiar to fruits and berries from which canned food is prepared. A brown tint is allowed for strawberries and raspberries
Fruit and berry purees	A homogeneous, thick, mashed mass without seeds, stalks, and unmashed pieces of skin. The presence of seeds in berry stew and stony cells for pear and quince stew is allowed. Smeary, does not spread on a horizontal surface	Sweet and sour with the aroma of the fruits and berries from which the stew is made, without any foreign taste or odor. A bitter aftertaste is allowed for citrus jams, which is typical for citrus fruits	Corresponds to the color of the fruit and berries from which the stew is made. Light brown is allowed for fruits with light flesh, and a brownish tint is allowed for fruits with dark flesh

End of Table 4.28.

Fruit and berry jam	A jelly-like smeary mass of unmashed fruits and berries that does not spread on a horizontal surface. In jam of the first grade of all fruits and berries, a mass that slowly spreads on a horizontal surface is allowed. Sugaring is not allowed	Destinctive for the fruits and berries from which the jam is made. The taste is sweet or sourly sweet. Less pronounced taste and smell are allowed, as well as the presence of a slight aftertaste of caramelized sugar	Homogeneous, matching the color of the fruit and berries. For jam made from fruits and berries with light flesh - a light brown tint, and for fruits with dark flesh - brownish tints
Freeze-dried fruits and berries	***Before recovery***		
	Fruits and berries are whole or in slices, ripe, not damaged by agricultural pests, uniform in size, retaining the shape of fresh fruits and berries. Consistency is fragile	Characteristic of fresh ripe fruits and berries of this species	
	After recovery		
	Characteristic of fresh whole or cut fruits and berries. Soft, close to the consistency of fresh fruits and berries	Characteristic of fresh, ripe fruits and berries of this type. No foreign flavors or odors are allowed	
Juices with freeze-dried pulp	***Before recovery***		
	Fruits and berries in the form of powders, homogeneous. Consistency is fragile	Characteristic of natural juices of this type	
	After recovery		
	Characteristic of natural juices. Corresponds to the consistency of natural juices	Characteristic of this type of natural juices. Foreign flavors and odors are not allowed.	

> ***Gelatin** is a protein product that is a mixture of linear polypeptides with different molecular weights (50,000...70,000) and their aggregates with a molecular weight of up to 300,000, and is tasteless and odorless.*

The amino acid composition of gelatin includes up to 18 amino acids, including glycine (26...31%), proline (15...18%), hydroxyproline (13...15%), glutamic acid (11...12%), aspartic acid (6...7%), alanine (8...11%) and arginine (8...9 %).

Gelatin is soluble in water, oil, salt and sugar solutions at temperatures above 40 °C. Gelatin solutions have low viscosity, which depends on pH and is minimal at the isoelectric point. When a gelatin water solution is cooled, the viscosity increases and it becomes a gel. This is the so-called sol-gel transition. To form a gel, a sufficiently high gelatin concentration and a suitable temperature below the solidification point (approximately 30 °C) are required. Gelatin can be used without restriction. Typical doses that ensure the solution of technological problems are 1...6% by weight of the product. The gelatin is washed in running drinking water at a temperature of 5...20 °C, filled with water or oil and left to swell for 1...1.5 hours. Next, prepare a mixture of gelatin and cream in the following way: swollen gelatin is poured with cream (weighing up to 50% of the recipe), heated to 65...70 °C, kept for up to 30 minutes, and then cooled to a temperature of 40...45 °C.

Drinking water is used to manufacture the products (DSTU 7525:2014). According to the requirements of the standard, **water** should have the indicators shown in Fig. 3.7. Chlorophenolic odors in water are not allowed. Water should not contain aquatic microorganisms distinguishable by the without magnification and should not have a film on the surface.

The minerals in water are mainly bicarbonates and sulfates of magnesium and calcium. In addition to them, water may contain chlorides, nitrates, nitrites, phosphates and organic compounds in small amounts.

smell at 20 °C and during heating to 60 °C no more than 2 points

aftertaste at 20 °C no more than 2 points

the color on the scale no higher than 20 degrees

turbidity according to the standard scale no higher than 1.5 mg/dm^3

active acidity in the range of 6.5...9.0 units. pH

dry residue no more than 1000 mg/dm^3

Fig. 4.29 – Indicators of drinking water

Water should contain a minimum amount of decomposition products of organic nitrogenous substances (nitrates, nitrites, ammonia), organic compounds and inorganic substances that are easily oxidized. The presence of ammonia, nitrate, nitrite residues is allowed – no more than 40 mg/dm^3, oxidizability – no more than 3 mg O_2 per 1 dm^3, or 0.759 mg $KmnO_2$ per 1 dm^3. The chloride content is allowed to be no more than 350 mg/dm^3. Water is usually evaluated by hardness. Water hardness is caused by the presence of salts of alkaline earth metals, mainly Ca_2+ and Mg_2+ ions. Water hardness is expressed in milligram equivalents (mg-eq) of calcium and magnesium ions per 1 dm^3 of water: 1 mg-eq corresponds to 20.04 mg of calcium ions or 12.16 mg of magnesium ions. According to the standard, the total water hardness should not exceed 7 mg-eq/dm^3.

The water used at the enterprises must meet the requirements for drinking water in accordance with the requirements of the standard. There are no chemical composition standards for its use in the production of dairy products, except for casein.

SECTION 5.

TECHNOLOGIES FOR THE PRODUCTION OF FAT SPREADS AND MIXTURES

5.1. Requirements of the standard for fat spreads and mixtures

According to DSTU 4445:2005 “Spreads and fat blends. General specifications” (, a **spread** is a food fat product (water-in-fat emulsion) consisting of milk and vegetable fat with a mass fraction of total fat from 50 to 85% and in which the share of milk fat is not less than 25% of total fat, with a dense or soft consistency with (without) the addition of food additives, fillers, vitamins.

Fat mixture is a food fat product that is a mixture of milk and vegetable fats with a mass fraction of total fat of at least 99.0%, in which the share of milk fat is at least 25% of the total fat phase of the product with (without) the addition of colors, flavors, antioxidants, vitamins.

Sweet cream spread is made from pasteurized natural cream and/or processed cow's milk and/or cow's milk butter, ghee and vegetable fats and/or their compositions.

Sour cream spread is produced using pure cultures of lactic acid bacteria and/or food acids and/or flavors.

Salted spread – produced with the addition of table salt.

Spread with fillers – spread produced with the addition of fillers – cocoa powder, soluble chicory, concentrated fruit and berry juices, dill, parsley, green and dried garlic, onions, leeks, fresh bell peppers.

Depending on the mass fraction of total fat, products are divided into groups:

- ✓ spread with a mass fraction of total fat from 50% to 85% (Fig. 5.1).

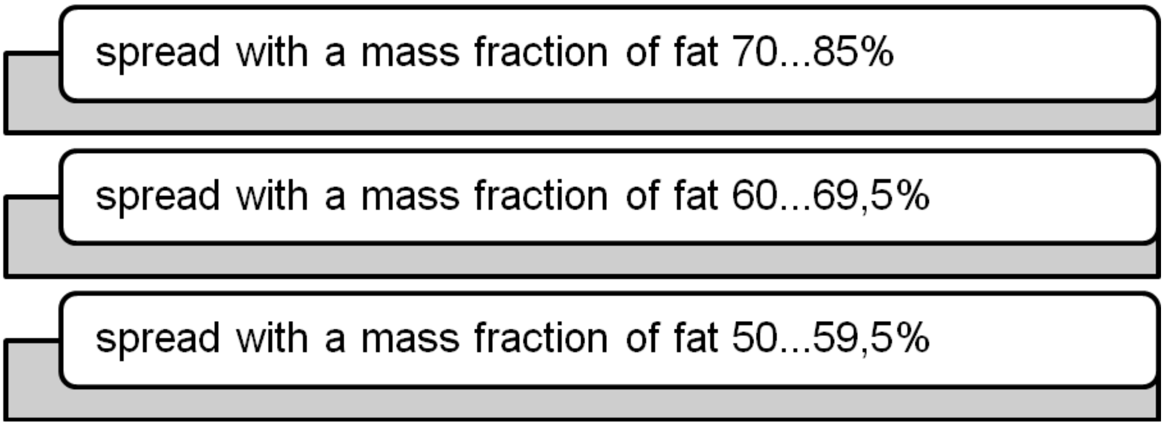


Fig. 5.1 – Classification of spreads by mass fraction of fat

✓ fat mixture.

Depending on the production technology and organoleptic characteristics, products are divided into the following types (Fig.5.2).

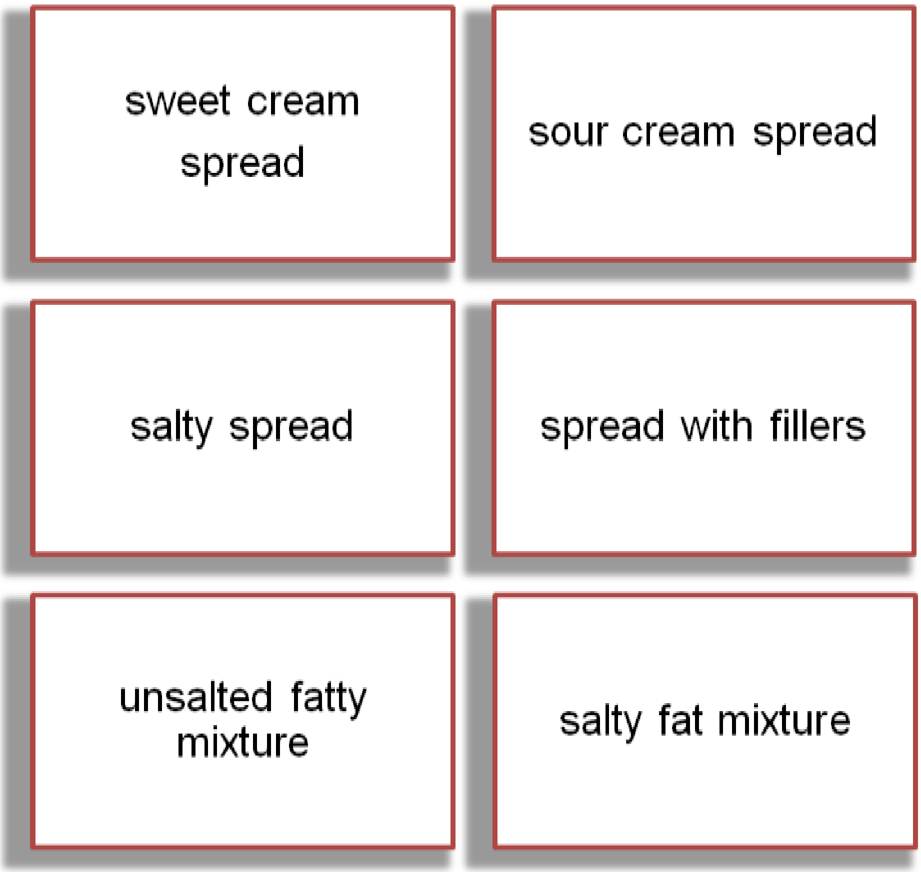


Fig. 5.2 – Types of fat spreads and mixtures

In order to prevent falsification of butter, it is prohibited to use the word “butter” directly or in phrases in the name of spreads and fat mixtures.

In terms of organoleptic characteristics, fat spreads and mixtures should meet the requirements given in Table 5.1.

Table 5.1 – Organoleptic characteristics of fat spreads and mixtures

Name of the indicator	Characteristics	
	Spreads	*Fat mixtures*
Flavor and smell	Pure creamy, sweet creamy or sour creamy (depending on the technology), with a pasteurization flavor. If fillers are used, the flavor characteristic of fillers. An insufficiently pronounced creamy, slight flavor of vegetable fats, and/or a slightly fodder flavor is allowed.	Specific flavor and odor of milk fat. A slight flavor of vegetable fats is allowed.
	Salty for salty spread and salty fat mixture	
Consistency and appearance	Consistency is uniform, plastic, dense or soft. Cut surface shiny or slightly shiny, dry in appearance. Minor defects are allowed: flouriness, brittleness; the surface is slightly matte with the presence of single small drops of moisture up to 1 mm in size	Homogeneous or granular, dense, transparent in the melted state, without sediment, slightly brittle

End of Table 5.1.

Color	Light yellow to yellow, homogeneous throughout the mass	
	From light yellow to yellow, uniform throughout. In case of using fillers, the color is determined by the color of the used fillers; for cocoa spreads, the presence of small particles of darker cocoa is allowed	

In terms of physical and chemical characteristics, fat spreads and mixtures must meet the requirements set forth in Table 5.2.

Table 5.2 – Physical and chemical characteristics of fat spreads and mixtures

Name of the indicator	Characteristics	
	Spreads	*Fat mixtures*
Mass fraction of total fat, %.	50,0…85,0	Not less than 99,0
Including milk fat, % of total fat, not less than	25,0	
Mass fraction of moisture, %, not more than	50,0	1,0
Plasma acidity: titratable, °T:		
• for sweet cream spreads, not more than	23,0	–

End of Table. 5.2.

• for sour cream spreads	26,0..55,0	–
active, pH		
• for sweet cream spreads, not less than	6,25	–
• for sour cream spreads	6,10…4,50	–
Acidity of fat phase, °K, not more than		
• for spreads without fillers and fat mixtures	2,5	
• for spreads with fillers	3,5	
Peroxide number of fat, mmol/kg ½ O not more than:		
• at the time of release from the enterprise at the end of the shelf life to	5	
• consumption	10	
Mass fraction of trans-isomers of oleic acid in fat, in terms of methyl ester, %, not more than	8,0	
Mass fraction of table salt (for salted spreads), %, not more than	1,5	
Melting point of fat, °C	27,0…36,0	
Product temperature at the time of release from the enterprise, °C, not higher than:		
• in a monolith	10,0	
• in consumer packaging	5,0	

Note 1: If used, the content of:

beta-carotene – its mass fraction is not more than 6 mg/kg (in terms of carotene);

annato – its mass fraction is not more than 10 mg/kg;

vitamin A - its mass fraction is not more than 15 mg/kg (in terms of dry matter);

benzoic acid or sodium benzoate (for benzoic acid) – not more than 1000 mg/kg;

sorbic acid or potassium sorbate (for sorbic acid) – not more than 800 mg/kg;

benzoic and sorbic acids or their salts (in combination) – not more than 800 mg/kg.

Note 2. It is allowed to determine the titratable or active acidity.

The mass fraction of other food additives approved for use in Ukraine is determined in accordance with the technological instructions and recipes to this standard.

In terms of microbiological indicators, fat spreads and mixtures must meet the requirements given in Table 5.3.

Table 5.3 – Microbiological indicators of fat spreads and mixtures

Microbiological parameters of spreads	Standard for groups				
	70,0..85,0 % of fat		*50,0..69,5 % of fat*		*Fat mixture*
	Sweet cream and salted sweet cream	*Sour cream and salted sour cream*	*Sweet cream and salted sweet cream*	*Sweet cream and salted sour cream*	
CUOMAFANM, not more than, CFU/g	$1,0\cdot10^5$	-	$5,0\cdot10^5$	-	$1,0\cdot10^3$

End of Table 5.3.

BCCP (coliforms), in 0.1 g of product	0,01	1,0
Pathogenic microorganisms, including Salmonella genus in g of product	25,0	-
Listeria monocytogenes is not allowed in g of product	25,0	-
Yeast, CFU in , not more than	100 in total	200
Mold fungi, CFU in, not more than		-

The content of toxic elements and mycotoxins in fat spreads and mixtures should not exceed the levels given in Table 5.4.

Table 5.4 – Content of toxic elements and mycotoxins in fat spreads and mixtures

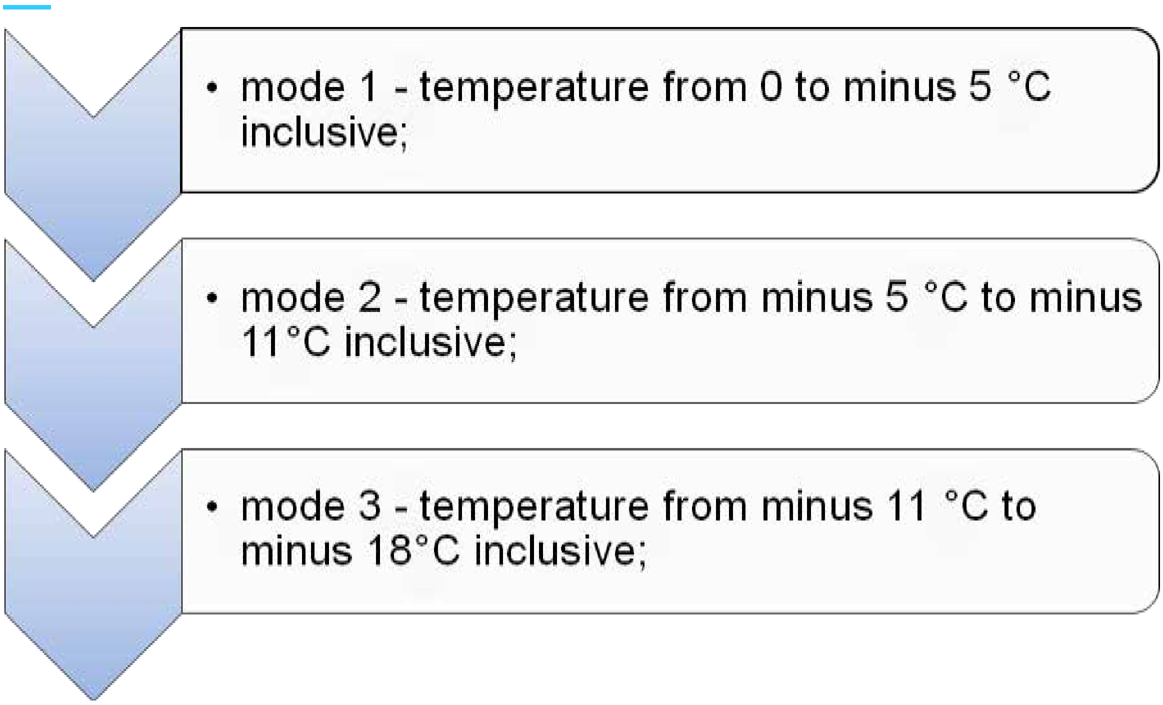
Name of the indicator	*Maximum permissible level, mg/kg, not more than*
Toxic elements:	
Lead (Pb)	0,10
Cadmium (Cd)	0,05
Arsenic (As)	0,10
Mercury (Hg)	0,05
Copper (Cu)	1,0 (0,4)
Zinc (Zn)	10,0

End of Table. 5.4.

Iron (Fe)	5,0 (1,5)
Mycotoxins:	
Aflatoxin B_1	0,005
Zearalenone	1,0

Notes. Indicators for long-term storage products are given in parentheses.

Fat spreads and mixtures are stored at manufacturing enterprises, oil depots, distribution refrigerators, in the retail network and restaurant business enterprises at a relative humidity of no more than (75 ± 5) % and at the temperature conditions shown in Fig. 5.3.



- mode 1 - temperature from 0 to minus 5 °C inclusive;
- mode 2 - temperature from minus 5 °C to minus 11°C inclusive;
- mode 3 - temperature from minus 11 °C to minus 18°C inclusive;

Fig. 5.3 – Storage modes of fat spreads and mixtures

Expiration dates of fat spreads and mixtures in transport containers are given in Table 5.5.

Table 5.5 – Expiration dates for consumption of fat spreads and mixtures in transport containers

Group name	*Expiration date, in months*		
	Mode1	Mode2	Mode3
Spread with a mass fraction of total fat from 70% to 85%	3	9	12
Spread with a mass fraction of total fat from 60% to 69,5%	2	2	3
Spread with a mass fraction of total fat from 50% to 59,5%	2	2	-
Spread with fillers	2	2	-
Fat mixtures	12	4	3

Note. The shelf life of products with a mass fraction of total fat of 70% and above at a storage temperature not exceeding minus 25 "C is 24 months (long-term storage).

The shelf life of products in consumer packaging at temperatures from 6 °C to 0 °C is no more than 3 days.

In the restaurant business and retail trade network, the products can be stored at temperatures from 6 °C to 0 °C and relative humidity of no more than 80%. The shelf life of fat spreads and mixtures in different packaging is shown in Fig. 5.6.

for spreads in a monolith	for fat mixtures in monoliths and transport containers in accordance with 9,7
• no more than 10 days	• no more than 15 days

Fig. 5.6. – Shelf life of fat spreads and mixtures in different packaging

It is not allowed to store and transport products together with food products that have a pungent specific odor.

The expiration dates of fat spreads and mixtures in consumer packaging are given in Table 5.6.

Table 5.6 – Expiration dates of fat spreads and mixtures in consumer packaging

Products and packaging	*Expiration dates, not more than*		
	Mode1	*Mode 2*	*Mode 3*
Spread with a mass fraction of total fat from 70% to 85%:	Days		
— sealed packaging with a net weight of up to 50 g	15	30	60
— sealed packaging with a net weight of 50 g or more	45	75	90
— unsealed packaging with a net weight of 50 g or more	35	60	75
Spread with a mass fraction of total fat from 50% to 69,5 %	Days		
Spread with fillers:	15	25	-
— sealed packaging with a net weight of 50 g or more	30	45	55
— leaky packaging with a net weight of 50 g or more.	15	20	25

End of Table. 5.6.

Mixtures of fat:	months		
— in glass jars	2	3	4
— in metal cans	12	6	-
— in leaky polymeric containers	1	2 -	3
— in sealed polymeric containers.	2	3	4

Note 1: The shelf life of products in B-grade parchment is no more than 15 days, regardless of storage conditions.

Note 2. The shelf life of products in transport containers is determined from the date of manufacture; in consumer packaging – from the date of packaging.

Note H. In the case of packaging in consumer packaging of products from a monolith that has already been stored, the date of manufacture during labeling must coincide with the date of packaging, and the shelf life of packaged products should not exceed the shelf life of products in the monolith.

5.2. Requirements of regulatory documents for children's spread

According to DSTU 4557:2006 “Fatty products for baby and dietary food. Baby spreads. Technical Specifications”, baby spread is a fatty food product (water-in-fat emulsion) with a mass fraction of total fat of 50% (including 40% milk fat and 10% oils), with a dense or soft consistency with or without the addition of the above ingredients. It is made from cow's milk and/or its processed products, oils with or without flavoring agents, agar and bifidobacteria.

The product is available in the following types (Figure 5.7).

- children's spread;
- children's spread with cocoa;
- children's spread with chicory;
- children's spread with bifidoflora;

Fig. 5.7 – Types of children's spreads

According to the organoleptic characteristics, children's spreads should meet the requirements given in Table 5.7.

Table 5.7 – Organoleptic characteristics of baby spreads

Name of the indicator	Characteristics
Flavor and smell	Baby spread and baby spread with bifidus flora is pure, with well-pronounced creamy flavor and a pleasant pasteurization flavor. For baby spread with cocoa – sweet with cocoa flavor and aroma. For baby spread with chicory – sweet with taste, aroma and light bitterness of chicory.
Consistensy and appearanse	Plastic, soft, homogeneous surface throughout, shiny on the cut, dry in appearance or with small droplets of moisture.
Color	Baby spread and baby spread with bifidus flora has white to light yellow color, homogeneous throughout. For baby spread with cocoa – from light brown to brown, homogeneous throughout the mass. For baby chicory spread – creamy, homogeneous throughout.

In terms of physical and chemical characteristics, children's spreads must meet the requirements set out in Table 5.8.

Table 5.8 – Physical and chemical parameters of children's spreads

Name of the indicator	*Standards for the spread*			
	Baby spread	*baby spread with bifidus flora*	*baby with cocoa*	*Baby spread with chicory*
Mass fraction of total fat, %, not less than	50	50	50	50
Mass fraction of oil, %, not less than	10	10	10	10
Mass fraction of moisture, %, not more than	42	42	35	36
Mass fraction of sugar, %, not more than	-	-	5	5
Amount of plasma: Titratable, T, not more than	23	50	-	-
Active, pH	Not less than 6,25	From 6,1 to 4,5		
Fat acidity, degrees Kettstofer, not more than	2,5	2,5	3,5	3,5
Peroxide number of fat, mmol/kg ½ O not more than				
- at the time of release from the enterprise	3	3	3	3

End of Table. 5.8.

- at the end of the shelf life	5	5	5	5

All oils used in the production of baby spreads must be refined and deodorized (sunflower oil, corn oil, soybean oil, peanut oil, cottonseed oil, mustard oil, rapeseed oil, linseed oil, olive oil, etc.)

The peroxide number of refined deodorized oils should not exceed 3 mmol of active oxygen per kg (mmol/kg ½ O).

The expiration date for consumption of baby spreads is given in Table 5.9.

Table 5.9 – Shelf life of baby spreads

Storage temperature, °C	*Consumer packaging*	
	unsealed	*sealed*
From 2 to 6	10	15
From 0 to minus 5	15	20

5.3. Main technological operations of spread production

Spreads can be produced according to the butter-making scheme, i.e. by whipping or converting high-fat cream, and according to the margarine scheme.

In the margarine spread production process, all components (vegetable fats, butter, milk powder, water, flavorings and other additives) are melted and mixed in special containers, where, under the influence of intensive thermomechanical treatment, a liquid fat/water emulsion is converted into a water/fat reverse emulsion system. The resulting system is then passed through an oiler to produce a spread.

The technological scheme of spread production by the method of converting high-fat cream and by whipping is shown in Fig. 5.8.

The technological process of producing a spread by whipping a mixture of milk and vegetable cream is carried out in the following sequence.

Natural cream is produced by separating milk. Skimmed or whole reconstituted milk is heated to a temperature of 45...55 °C. Milk fat (butter or ghee) is added to the prepared milk base and melted at the above temperature, stirring continuously.

The prepared mixture is processed using a dispersant or passed 2...3 times through a centrifugal pump until a homogeneous and stable emulsion is obtained. The cream is pasteurized at a temperature of 85...95 °C, cooled to a temperature of 8...15 °C and sent to a container for reconstituting the mixture of milk and vegetable cream.

Vegetable cream is made from a mixture of skimmed milk heated to 50...65 °C and vegetable oil preheated to the same temperature. The molten butter is fed into the mixture by gravity flow or by a pump, which prevents air from being introduced into the butter. Vegetable oil is added to skimmed milk with constant stirring and the temperature is maintained at 50...65 °C during the mixing process. The resulting mixture is processed in a homogenizer, disperser, or emulsifier (a centrifugal pump may be used) under conditions that exclude air. Processing is carried out until a homogeneous stable emulsion of vegetable cream is obtained. “Vegetable cream is pasteurized at a temperature of 85...95 °C, cooled to a temperature of 8...15 °C and sent to a container for making a mixture of milk and vegetable cream.

Pasteurized and cooled milk and vegetable cream are mixed in a container at a temperature of 8...18 °C in the proportion specified in the recipe.

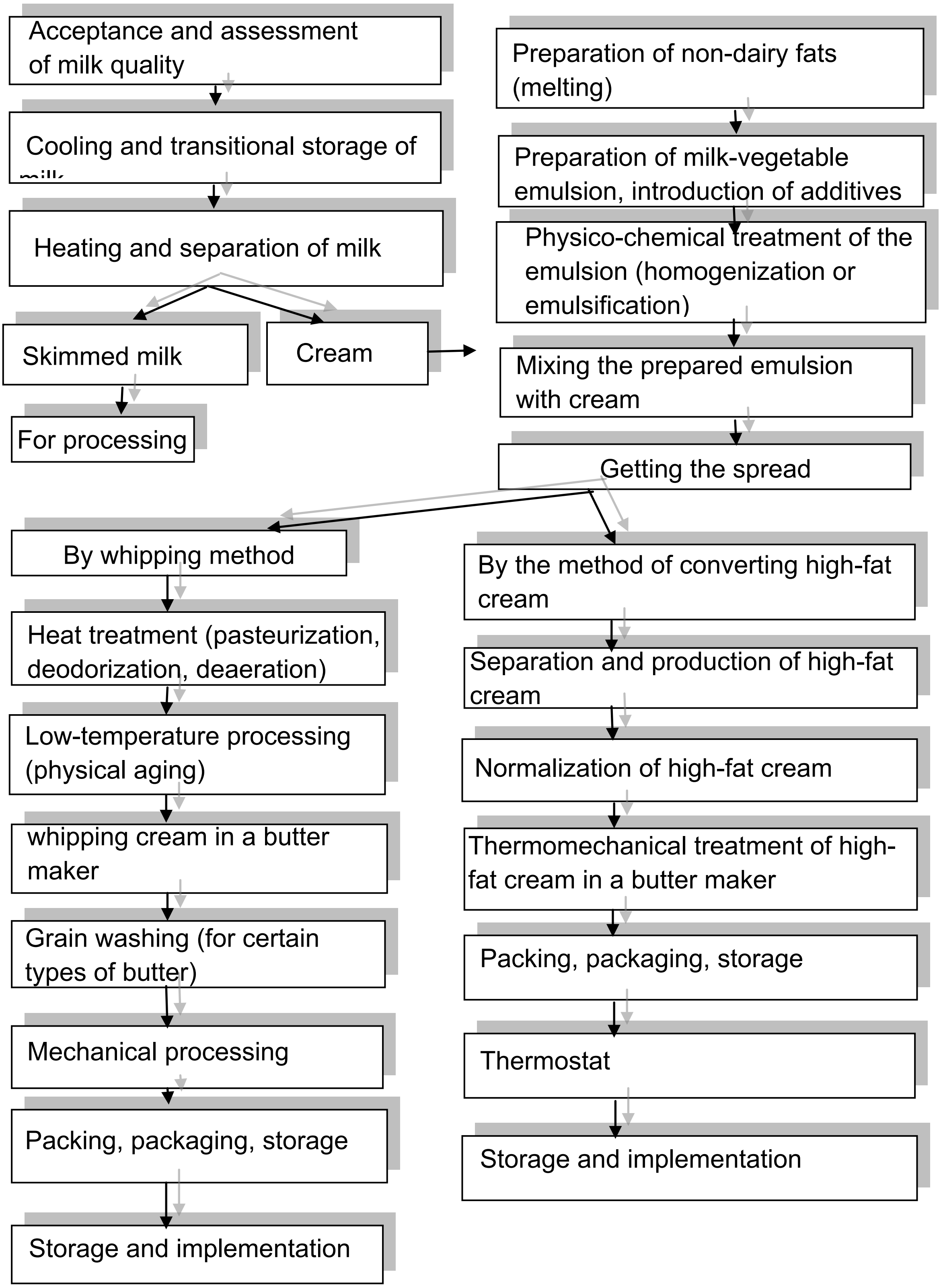


Fig. 5.8 – Technological scheme of spread production

The mass fraction of fat in the mixture for the method of batch whipping should be 28...35 %, and for continuous whipping - 38...42 %.

It is allowed to make a mixture of milk and “vegetable” cream before pasteurization. The resulting mixture is pasteurized at a temperature of 85...95 °C or at a temperature of 100...108 °C and cooled to 8...18 °C.

The pasteurized and cooled cream mixture is subjected to physical maturation. The ripening time for milk-plant cream is longer than for milk cream. The ripening temperature is 4...10 °C, the ripening time is 16...24 hours.

The ripened cream mixture is sent for whipping. Churning modes of the mixture are set depending on the design of the butter churn and the time of year. The duration of whipping of milk-plant cream is usually longer than that of dairy cream.

The technological process of producing spread by converting a mixture of milk and vegetable cream using special vegetable analogues of milk fat includes the following operations: production of high-fat cream; melting of vegetable fat; mixing of high-fat cream, skimmed milk and butter with molten fat; emulsification of the mixture, pasteurization (or without it), thermomechanical treatment, and packaging.

Milk is separated at a temperature of 38...42 °C to produce cream with a mass fraction of fat of 35...40 %.

The resulting skimmed milk is pasteurized at 72...95 °C. The cream is pasteurized at 90...105 °C and separated to obtain high-fat cream with the required mass fraction of fat.

High-fat cream, skimmed milk, and buttermilk obtained in the production of high-fat cream are mixed with vegetable fat melted at 63...67 °C. The mixture is emulsified in a special emulsifier at a pressure of 1.2 MPa for 10...15 min. The emulsification parameters are set depending on the amount of milk fat to be replaced. The high-fat emulsion is pasteurized at 85...95 °C (or without pasteurization) and sent for thermomechanical processing.

An example of a recipe for the production of 1000 kg of spreads with a mass fraction of fat of 72.5% by the method of converting high-fat cream (excluding losses) is presented in Table 5.10.

Table 5.10 – Recipes for the production of 1000 kg of spreads with a mass fraction of fat of 72.5%

Component composition	Quantity of components, kg, at the ratio of vegetable and milk fat, %				
	20/80	50/50	80/20	90/10	100
Milk fat substitute “Ecolact” with m.c.f. 99,9%	145,1	362,8	580,5	653,1	752,7
Sweet cream butter, with m.c.f. 82,5%	800	500	200	100	-
Skimmed milk with m.c.f. 0.05%.	53,40	134,2	215,0	242,4	269,3
Skimmed milk powder with m.c.f.	1,5	3,0	4,5	4,5	5,0
Total	1000	1000	1000	1000	1000

5.4. Technological calculations in the production of spreads

The components of spreads are prepared according to recipes. Typical recipes for spreads are given in Appendix. 4, Tables 7, 8. If you use raw materials that differ in composition from those specified in these recipes, the components of the mixture are calculated using the following formulas.

The weight of the finished product, kg, including losses, is determined by the formula:

$$m_{\mathrm{fp}} = \frac{m_{\mathrm{c}}(\mathrm{F_c} - \mathrm{F_b}\ )(1 - 0{,}01\mathrm{L_f})}{\mathrm{F_{fp}} - \mathrm{F_{ndf}} - \mathrm{F_b}}, \tag{5.1}$$

where m_c is the mass of cream, kg; F_c – mass fraction of fat in cream %; F_b – mass fraction of fat in buttermilk, %; $Ж_{сп}$ – is the mass fraction of fat in the finished product, %; F_{ndf} – is the mass fraction of non-dairy fat in the finished product, %; L_f – is the standard fat loss in the process of spread production by rolling, %.

Using formula (5.1), you can calculate the weight of cream for processing, kg:

$$m_{\mathrm{c}} = \frac{m_{\mathrm{fp}}(\mathrm{F_{fp}} - \mathrm{F_{ndf}} - F_{\mathrm{b}})}{(\mathrm{F_c} - \mathrm{F_b})(1 - 0{,}01\mathrm{L_f})}, \qquad (5.2)$$

Where L_{ndf} – is the standard loss of non-dairy fat during emulsion production and spread production, % (L_{ndf} =1,92 in the case of continuous-acting butter makers and i L_{ndf} =1,73 – in batch-acting butter makers).

The weight of non-dairy fat, kg, including losses, is determined by the formula:

$$m_{\mathrm{ndf}} = \frac{2m_{\mathrm{c}}\mathrm{F_c}(1 + 0{,}01\mathrm{L_{ndf}})}{3\mathrm{F_{ndf}}}, \qquad (5.3)$$

The mass of butter (skim milk), kg, for the preparation of the emulsion is calculated by the formula:

$$m_{\mathrm{b(s.m.)}} = \frac{m_{\mathrm{ndf}}(100 - \mathrm{F_e})}{\mathrm{F_e}}, \qquad (5.4)$$

where F_e – mass fraction of fat in the emulsion, % (determined according to the technological instruction and depends on the type of equipment used: F_e=40,0 % – n case of continuous-acting oil makers and F_e=35,0 % – batch-acting).

The weight of brine, kg, prepared with butter or skim milk, taking into account losses, is determined by the formula:

$$m_{\mathrm{s}} = \frac{m_{\mathrm{l}} m_{\mathrm{ts}}}{(\mathrm{C_b} - m_{\mathrm{ts}})(1 - 0{,}01\mathrm{L_{ts}})}, \qquad (5.5)$$

where m_s – is the weight of the table salt solution, kg, prepared with butter or skim milk or the capacity of the dosing pump, kg/h; m_l – is the weight of the spread layer, kg, or the actual line capacity, kg/h; C_b is the concentration of table salt in brine, %, % (C_b = 25 %);

m_{ts} – is the mass fraction of table salt in the finished product, %; L_{ts} is the loss of table salt, % (L_{ts} = 1,55 %).

The required mass fraction of formation moisture, kg, before injecting a solution of sodium chloride into it is determined by the formula:

$$B_{fm} = B_{fp} - \frac{m_c(100 - C_s - 6 - B_{fp})}{C_s - m_c}, \qquad (5.6)$$

where B_{fp} – is the mass fraction of moisture in the finished product, %; 6 is the mass fraction of solids in a saturated solution of sodium chloride.

The weight of carotene, kg, including losses, is calculated by the formula:

$$m_{car} = \frac{m_{нс} 0{,}1(1 + 0{,}01 L_{car})}{100}, \qquad (5.7)$$

where L_{car} – is the standard loss of carotene, %, during application and processing (L_{car} = 1,05 %).

The weight of the flavor, kg, including losses, is calculated by the formula:

$$m_f = \frac{m_p 0{,}01(1 + 0{,}01 L_f)}{100}, \qquad (5.8)$$

where L_f – standard losses of flavor, %, during application and processing (L_f=1,05 %).

The weight of the buttemilk obtained during the production of the spread is determined by the formula:

$$m_{b.e} = (m_{mix} - m_{fp})\frac{100 - L_b}{100}, \qquad (5.9)$$

where L_b – maximum permissible losses of the buttermilk in the process of spread production, % (see Attachment 4).

Example 1: Produce 1300 kg of cooking spread using a continuous oil maker with a capacity of 1000 kg/h. For production, use raw materials with the chemical composition shown in Table 5.11.

Table 5.11 – Chemical composition of raw materials for the production of salted culinary spread

Name of raw material	Mass fraction, %.			
	moisture	dry substances	including	
			fat	SNF
Cream	54,6	45,4	40,0	5,4
Non-dairy fat	0,3	99,7	99,7	–
Buttermilk	90,8	9,2	0,7	8,5

Solution. The required mass of cream is calculated using formula (5.2):

$$m_c = \frac{1300(79{,}2 - 31{,}7 - 0{,}7)}{(40{,}0 - 0{,}7)(1 - 0{,}01 \bullet 0{,}52)} = 1556{,}2kg$$

The weight of non-dairy fat, taking into account losses, is calculated using formula (5.3):

$$m_{ndf} = \frac{2 \bullet 1556{,}2 \bullet 40(1 + 0{,}01 \bullet 1{,}92)}{3 \bullet 99{,}7} = 424{,}2kg$$

The mass of butter (skimmed milk) for the preparation of the emulsion is calculated using formula (5.4):

$$m_{b(s.m)} = \frac{424{,}2 \bullet (100 - 40)}{40} = 636{,}3\text{ kg}$$

The mass of carotene is calculated using formula (4.7):

$$m_{car} = \frac{1300 \bullet 0{,}1(1 + 0{,}01 \bullet 1{,}92)}{100} = 1{,}325\text{ kg}$$

The weight of the flavoring is calculated using formula (5.8):

$$m_f = \frac{1300 \bullet 0{,}01(1 + 0{,}01 \bullet 1{,}92)}{100} = 0{,}132\text{ kg}$$

The weight of the mixture for the production of the spread is:

M_{mix}=1556,2+424,2+636,3+1,325+0,132=2618,16 kg.

The weight of the buttermilk obtained from production is calculated by formula (5.9)

$$m_{\text{b}} = (2618{,}16 - 1300)\frac{100 - 2}{100} = 1291{,}8\ \text{kg}.$$

Example 2: From 1600 kg of cream with a mass fraction of fat 40 %, a culinary spread is produced. The composition of raw materials for production is the same as in Example 1.

Solution. Using formula (5.1), calculate the weight of the finished product:

$$m_{\text{fp}} = \frac{1600(40 - 0{,}7)(1 - 0{,}01 \bullet 0{,}52)}{80 - 32 - 0{,}7} = 1322{,}4\text{kg}.$$

Using formula (5.3), we calculate the weight of non-dairy fat, taking into account losses:

$$m_{\text{ndf}} = \frac{2 \bullet 1600 \bullet 40(1 + 0{,}01 \bullet 1{,}92)}{3 \bullet 99{,}7} = 436{,}1\ \text{kg}.$$

Using formula (5.4), we calculate the mass of butter (skim milk) to prepare the emulsion:

$$m_{\text{b(s.m.)}} = \frac{436{,}1(100 - 40)}{40} = 654{,}24\ \text{kg}.$$

Using formula (5.7), we calculate the mass of carotene:

$$m_{\text{car}} = \frac{1322{,}4 \bullet 0{,}1(1 + 0{,}01 \bullet 1{,}92)}{100} = 1{,}348\ \text{kg}.$$

Using formula (5.8), we calculate the weight of the flavoring:

$$m_{\mathrm{f}} = \frac{1322{,}4 \bullet 0{,}01(1 + 0{,}01 \bullet 1{,}92)}{100} = 0{,}135\,\mathrm{kg}.$$

Weight of the mixture for the production of the spread

M_{mix}=1600+436,1+654,24+1,348+0,135= 2691,82 kg.

The weight of the buttermilk obtained from production is calculated by formula (5.9)

$$m_{\mathrm{b}} = (2691{,}82 - 1600)\frac{100 - 2}{100} = 1069{,}99\,\mathrm{kg}$$

Task 3: Familiarize yourself with the calculations in the production of spreads by converting high-fat mixtures.

Lay the components of spreads according to the recipes. Examples of recipes for culinary spreads are given in app. 4, Tables 7, 8. In case of using raw materials that differ in composition from those specified in these recipes, calculate the components of the mixture using the following formulas.

The weight of high-fat cream, taking into account losses, is calculated by the formula, kg,

$$m_{\mathrm{hfc}} = \frac{m_{\mathrm{fp}}(\mathrm{F_{fp}} - \mathrm{F_{nmf}})(1 - 0{,}01\mathrm{L_f})}{\mathrm{F_{hcf}}}, \tag{5.10}$$

where m_{fp} – is the weight of the finished product, kg;

$\mathrm{F_{hfc}}$ – mass fraction of fat in high-fat cream, %;

$\mathrm{F_{fp}}$ – mass fraction of fat in the finished product, %;

$\mathrm{F_{nmf}}$ – mass fraction of non-milk fat in the finished product, %;

$\mathrm{L_f}$ – standard fat losses in the process of spread production by converting high-fat cream, %.

The weight of non-dairy fat is calculated by the formula, kg,

$$m_{\text{ndf}} = \frac{2m_{\text{hfc}}\text{F}_{\text{hfc}}(1+0{,}01\text{L}_{\text{ndf}})}{3(100-V_{\text{ndf}})} \qquad (5.11)$$

where L_{ndf} – is the standard loss of non-dairy fat in the process of pasteurization and separation of the non-dairy fat emulsion (L_{ndf} = 1,27 %), %; V_{ndf} – mass fraction of non-dairy fat moisture, %.

The mass of butter (or skimmed milk), kg, for the preparation of the emulsion is calculated by formula (5.4).

The mass of salt, kg, including losses, is calculated by the formula:

$$m_{\text{s}} = \frac{m_{\text{fp}}\text{C}(1+0{,}01\text{L}_{\text{ts}})}{100}, \qquad (5.12)$$

where m_{fp} – is the weight of the finished product, kg; C is the mass fraction of table salt in the finished product, %; L_{ts} – втрати кухонної солі під час внесення та перероблення, % (L_{ts} = 1,05 %).

The weight of carotene, kg, including losses, is calculated by formula (4.7). The weight of the flavor, kg, including losses, is calculated by formula (4.8).

Example 3: Produce 500 kg of unsalted culinary spread, the chemical composition of the raw materials for the production of which is given in Table 5.12.

Table 5.12 – Chemical composition of raw materials for the production of unsalted culinary spread

Name of raw material	Mass fraction, %.			
	moisture	dry substances	including	
			fat	SNF
High-fat cream	16,0	84,0	82,4	1,6
Non-dairy fat	0,3	99,7	99,7	–
Buttermilk	91,0	9,0	0,5	8,5

The weight of high-fat cream is calculated by formula (5.10):

$$m_{\text{HFC}} = \frac{500(80{,}0 - 32{,}0)(1 + 0{,}01 \bullet 0{,}05)}{82{,}4} = 291{,}4\ \text{kg.}$$

The weight of non-dairy fat, taking into account losses, is calculated by formula (5.11):

$$m_{\text{ndf}} = \frac{2 \bullet 291{,}4 \bullet 82{,}4(1 + 0{,}01 \bullet 1{,}27)}{3 \bullet 99{,}7} = 162{,}6\ \text{kg.}$$

The mass of butter (skimmed milk) for the preparation of the emulsion is calculated using formula (5.4):

$$m_{\text{b(sk.m.)}} = \frac{162{,}6(100\ \ - 35)}{35} = 302{,}0\ \text{kg}$$

The mass of carotene is calculated by formula (5.7):

$$m_{\text{car}} = \frac{500 \bullet 0{,}1(1 + 0{,}01 \bullet 1{,}05)}{100} = 0{,}505\ \ \text{kg.}$$

The weight of the flavoring is calculated by formula (5.8):

$$m_{\text{f}} = \frac{500 \bullet 0{,}01(1 + 0{,}01 \bullet 1{,}05)}{100} = 0{,}051\ \ \text{kg}.$$

SECTION 6.

TECHNOLOGIES OF BUTTER PRODUCTION WITH FILLERS

6.1. Requirements of the standard for butter

Butter is an edible fatty product produced only from cow's milk and/or its processed products, with moisture and dry skimmed substances evenly distributed in the fatty medium.

Sweet butter is a butter produced from cream and/or milk processing products, which has a specific inherent taste, smell and plastic consistency at a temperature of (12 ± 2) °C, with a milk fat content of at least 61.5%, which is a homogeneous water-in-fat emulsion.

Butter, depending on the mass fraction of fat, is divided into the groups shown in Fig. 6.1.

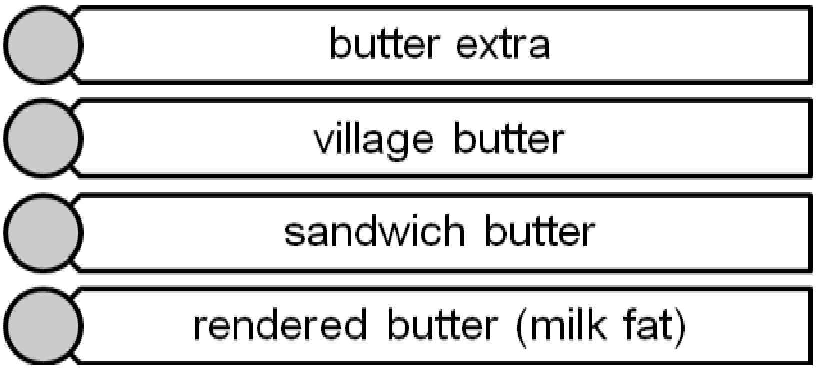


Fig. 6.1 – Groups of sweet butter

Butter, depending on the technological features and organoleptic characteristics, is divided into the types shown in Fig. 6.2.

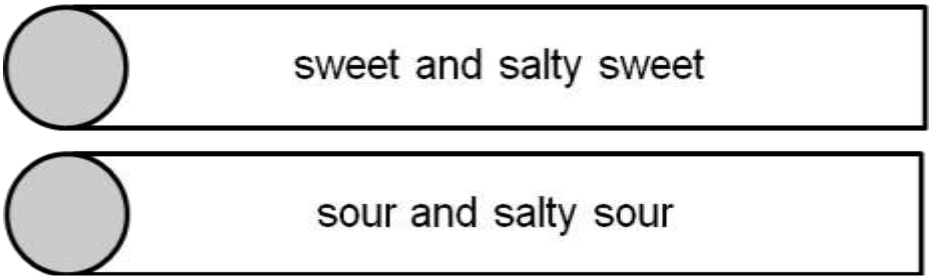


Figure 6.2 - Types of sweet butter

Sweet cream butter is a type of butter made from pasteurized natural cream.

Sour cream butter is a type of butter made from pasteurized cream fermented with pure cultures of lactic acid bacteria.

Salted butter is a type of butter made with the addition of table salt.

Rendered butter – a group of butter with a mass fraction of fat of at least 99.0%, obtained from butter, under cheese, raw butter or cream by removing almost all moisture and solids other than fat.

Milk fat is a fat with a mass fraction of at least 99.8%. It is produced as a food product by removing virtually all moisture and solids other than fat.

Extra butter is a group of butter with a mass fraction of fat from 80.0% to 85.0%.

Village butter is a group of butter with a mass fraction of fat from 72.5% to 79.9%.

Sandwich butter – a group of butter with a mass fraction of fat from 61.5% to 72.4%.

In terms of organoleptic characteristics, butter should meet the requirements given in Table 6.1.

Table 6.1 - Organoleptic characteristics of butter

<table>
<tr><th rowspan="2">Name of the indicator</th><th colspan="3">Characteristics for butter</th></tr>
<tr><th><i>sweet cream</i></th><th><i>sour cream</i></th><th><i>Rendered (milk fat)</i></th></tr>
<tr><td rowspan="4">Flavor and smell</td><td colspan="2">Pure, well-defined creamy</td><td rowspan="4">Clean, well-express, distinctive for for baked milk fat Allowed: lack of expression of the taste of baked milk fat</td></tr>
<tr><td>with a pasteurization aftertaste</td><td>fermented milk</td></tr>
<tr><td colspan="2">Allowed: insufficiently expressed or not expressed: creamy and (or) low-fat;</td></tr>
<tr><td>and (or) pasteurization flavor; and (or) – over-pasteurization; and (or) – rendered butter</td><td>and (or) fermented milk</td></tr>
<tr><td>Consistency and appearance</td><td colspan="2">Homogeneous, plastic, dense, cut surface shiny or sparkling, dry. Allowed: insufficiently dense and plastic, cut surface slightly matte with the presence of single small drops of moisture up to 1 mm</td><td>Dense, homogeneous or granular at a temperature of (12 ± 2) “C, in the melted state – transparent, without sediment. Allowed: for granular – insufficiently homogeneous, smeary with the presence of liquid fat; for homogeneous – mealy, soft</td></tr>
<tr><td>Color</td><td colspan="2">From light yellow to yellow, homogeneous throughout the mass</td><td>From light yellow to dark yellow, homogeneous throughout the mass</td></tr>
</table>

Note 1: Mass fraction of table salt for salted sweet and sour cream butter, not more than 1.0.

Note 2. If used:

- vitamin A – its mass fraction should not exceed 10 mg/kg (in terms of dry matter);
- beta-carotene – its mass fraction should not exceed 3 mg/kg (in terms of dry matter);

annatto extract – its mass fraction is not more than 10 mg/kg.

The titratable acidity or pH of the oil plasma is shown in Fig. 6.3.

not more than 23 °T or pH not less than 6.25 - for sweet cream;

from 26 °T to 55 °T or pH from 6.12 to 4.50 - for sour cream.

Fig. 6.3 – Titratable acidity or plasma pH of butter

The acidity of the fatty phase of the oil is not more than 2.5 °K (Kettstofer).

According to microbiological indicators, the oil must meet the requirements given in Table 6.2.

Table 6.2 – Microbiological parameters of butter

Name of the indicator	Standard for butter groups				
	cream extra and village		cream sandwich		bked (milk fat)
	sweet cream and salty sweet cream	sour cream and salty sour cream	sweet cream and salty sweet cream	sour cream and salty sour cream	
The number of mesophilic aerobic and facultative anaerobic microorganisms, not more than, CFU/g	$1{,}0 \cdot 10^5$	–	$5{,}0 \cdot 10^5$	–	$1{,}0 \cdot 10^3$

End of Table. 6.2.

Bacteria of the group of Escherichia coli (coliforms), not allowed, in g of product	0,01		0,01	1,00
Staphylococcusaureus, not allowed, in g of product	1,0	0,1	0,1	–
Yeast, CFU in 1.0 g, not more than	100 in total		100 in total	200
Mold fungi, CFU per 1.0 g of product, not more than				–
Pathogenic microorganisms, in particular bacteria of the genus *Salmonella,* not allowed in g of product	25		25	25
Listeria monocytogenes, not allowed in g of product	25		25	–

The content of toxic elements in the oil should not exceed the levels given in Table 6.3.

Table 6.3 – Maximum permissible levels of toxic elements

Name of toxic element	*Permissible level, mg/kg, not more than*
Lead	0,10
Cadmium	0,03
Arsenic	0,10
Mercury	0,03
Copper	0,5 (0,4)
Zinc	5,0
Iron	5,0 (1,5)

Notes. Indicators for butter intended for long-term storage are given in parentheses.

Butter is stored in refrigerators, cold rooms or special rooms at a relative humidity of no more than 80% and at the temperature conditions shown in Fig. 6.4.

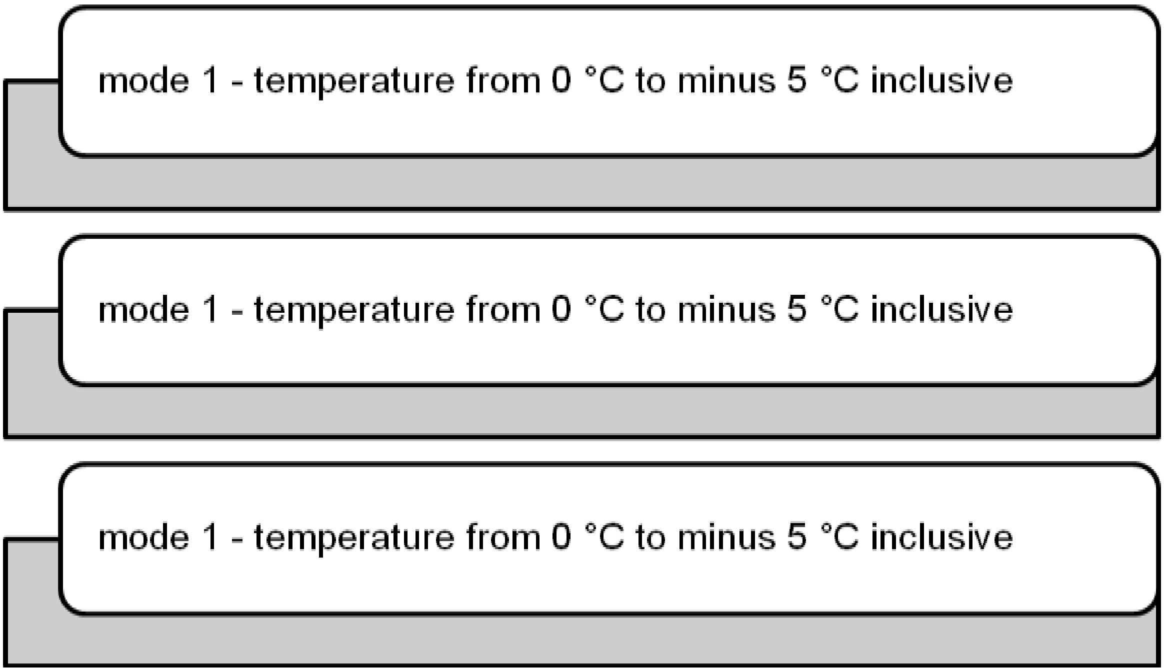


Fig. 6.4 – Temperature regimes of butter storage

Expiration dates for the consumption of butter by a monolith in a transport container are given in Table 6.4.

Table 6.4 - Expiration dates for butter in a monolith transport container

Name of the butter group	Expiration date, by month		
	Mode 1	Mode 2	Mode 3
Extra and village butter (except salted)	3	9	12
Sandwich butter (except salted)	2	2	3
Salted butter	2	4	6
Rendered (milk fat)	12	4	3

The expiration dates of butter in consumer packaging are given in Table 6.5.

Table 6.5 – Expiration dates of butter in consumer packaging

Group of butter and packaging	Expiration dates for consumption, not more than		
	Mode1	Mode2	Mode3
Extra and village butter:	days		
✓ sealed airproof packaging with a net weight of up to 50 g,	15	30	60
✓ sealed packaging with a net weight of 50 g or more;	45	75	90
✓ unsealed packaging	35	60	75
Sandwich butter:	days		
✓ airproof packaging with a net weight of up to 50 g,	15	25	–
✓ airproof packaging with a net weight of 50 g or more;	30	45	55
✓ unsealed packaging	15	20	25
Bked (milk fat):	months		
✓ in glass jars;	2	3	4
✓ in metal cans;	12	6	–
✓ in permeable polymeric containers;	1	2	3
✓ in airproof sealed polymeric containers	2	3	4

Note 1: The shelf life of butter in B-grade parchment, according to Standard 1341, is no more than 15 days, regardless of storage conditions.

Note 2. The shelf life of butter in transport containers is determined from the date of manufacture; in consumer packaging – from the date of packaging.

Note 3. In the case of packaging of stored butter from a monolith into consumer packaging, the expiration date of the packaged butter should not exceed the final date of consumption of butter in the monolith.

Butter may be stored in consumer packaging at a temperature not exceeding 6 °C for no more than 3 days.

In the restaurant business and in the retail trade network, butter may be stored at a temperature not exceeding 6 °C and relative humidity not exceeding 80%. Its shelf life from the moment of reception at the specified temperature is shown in Fig. 6.5.

for butter in a monolith - 10 days

for baked butter in transport containers - 15 days

Fig. 6.5 – Expiration date of butter

The nutritional and energy value (caloric value) of 100 g of butter is given in Table 6.6.

Table 6.6 – Nutritional and energy value (caloric value) of 100 g of butter

Name of butter group	*Proteins, g*	*Fats, g*	*Carbohydrates, g*	*Minerals, g*	*Vitamins, mg*					*Phospholipids*	*Energy value (caloric value), kcal (kJ)/100g*
					A	*β- carotene*	*E*	*B_2*	*PP*		
Butter extra	0,5	82,5	0,8	0,12	0,59	0,38	2,20	0,10	0,01	0,32	748 (3140)

End of Table. 6.6.

Extra butter	0,6	80,0	0,9	0,15	0,48	0,35	2,20	0,11	0,01	0,32	726 (3049)
Village butter	0,7	78,0	1,0	0,18	0,45	0,33	2,13	0,11	0,03	0,38	709 (2978)
	0,8	72,5	1,3	0,20	0,40	0,32	2,35	0,11	0,03	0,38	661 (2776)
Sandwich butter	0,8	72,0	1,3	0,25	0,40	0,30	1,5	0,12	0,05	0,39	657 (2759)
	1,0	62,0	2,5	0,28	0,40	0,30	1,2	0,12	0,05	0,39	572 (2402)
Baked butter	0,1	99,0	0,3	-	0,60	-	-	-	-	traces	892 (3746)
Milk fat	-	99,8	-	-	0,60	-	-	-	-	-	898 (3771)

6.2. Requirements of the standard for butter with fillers

According to DSTU 4592:2006 “Butter with fillers. Technical specifications” butter cream with fillers is a butter produced only from cow's milk and (or) its processed products with the addition of fillers, with (without) food additives and vitamins and a mass fraction of milk fat from 61.5% to 65,0 %.

Depending on the technological features and organoleptic characteristics, butter is divided into the types shown in Figure 6.6.

- butter with cocoa – «chocolate»;
- butter with coffee
- butter with chicory
- fruit and berry butter
- honey butter

Figure 6.6 – Types of butter with fillers

By organoleptic characteristics, butter with fillers should meet the requirements given in Table 6.7.

Table 6.7 – Organoleptic characteristics of butter with fillers

Name of the indicator	Characteristics
Flavor and smell	Creamy, sweet, with the taste and aroma of the fillers. No foreign flavors and odors.
Consistency and appearance	Homogeneous, plastic. The surface of the butter on the cut is dry in appearance or with the presence of single small drops of moisture. Light flouriness is allowed for cocoa butter.
Color	Determined by the color of the used fillers. For cocoa butter, a heterogeneous color is allowed

By physical and chemical characteristics, butter with fillers should meet the requirements given in Table 6.8.

Table 6.8 – Physical and chemical characteristics of butter with fillers

Name of the indicator	Standard
Mass fraction of fat, %	From 61,5 to 65,0
Mass fraction of moisture, %, not more than	25,0
Mass fraction of sucrose, %, not more than	10,0
Temperature of the butter at the time of release from the manufacturer, °C, not higher than:	
in consumer packaging	5
in a monolith	10

Note 1: If used, the content is:

- beta-carotene – no more than 3 mg/kg (in terms of carotene);
- vitamin A – not more than 10 mg/kg (in terms of dry matter);
- benzoic acid or sodium benzoate (in terms of benzoic acid) – not more than 1000 mg/kg;
- sorbic acid or potassium sorbate (in terms of sorbic acid) – not more than 800 mg/kg;
- benzoic acid and sorbic acid or their salts (in combination) – not more than 800 mg/kg.

Note 2. The mass fraction of fillers – as required by technology.

According to microbiological indicators, butter with fillers must meet the requirements given in Table6.9.

Table 6.9 - Microbiological parameters of butter with fillers

Name of the indicator	Standard
The number of mesophilic aerobic and facultative anaerobic microorganisms, not more than, CFU/g	$5 \cdot 10^5$
Bacteria of the E. coli group (coliforms), not allowed in 1 g of product	0,01
Pathogenic microorganisms, in particular bacteria of the genus *Salmonella*, are not allowed in 1 g of	25

End of Table. 6.9.

Pathogenic microorganisms, in particular bacteria of the genus Listeriamonocytogenes, are not allowed in 1 g of product	25
Yeast, CFU per 1 g, not more than	100 in total
Mold fungi, CFU per 1 g, not more than	100 in total

The content of toxic elements in butter with fillers should not exceed the levels given in Table 6.10.

Table 6.10 – Content of toxic elements in butter with fillers

Name of the toxic element	Maximum permissible levels, mg/kg, not more than
Lead	0,1 (0,3)
Cadmium	0,03 (0,2)
Arsenic	0,1
Mercury	0,03
Copper	0,5(1,6)
Zinc	5,0
Iron	5,0 (10,0)

Notes. Indicators for butter with cocoa are given in brackets.

Butter with fillers is stored at manufacturing enterprises and in the retail network at a relative humidity of no more than (75 ± 5) %.

Shelf life of butter with fillers at temperatures from 0 °C to 6 °C is shown in Fig. 6.7.

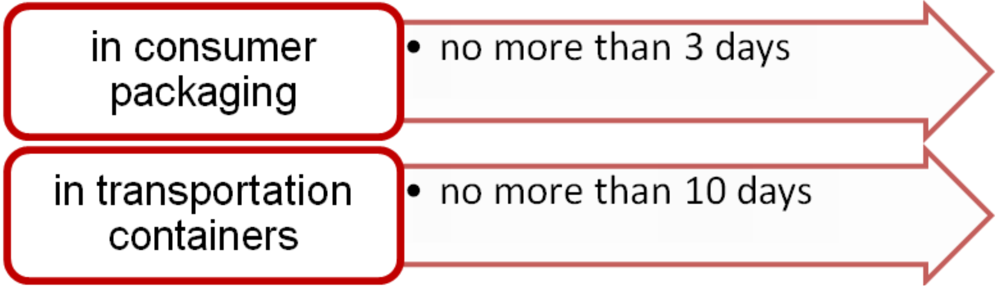
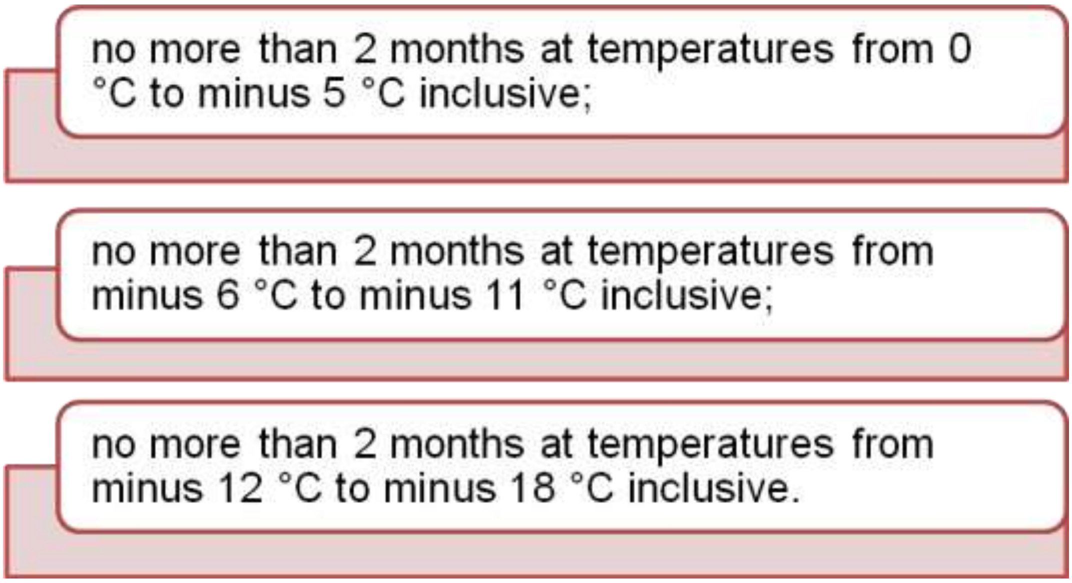


Fig. 6.7 – Shelf life of butter with fillers at temperatures from 0 °C to 6 °C

The shelf life of butter with fillers in transport containers is shown in Fig. 6.8.



no more than 2 months at temperatures from 0 °C to minus 5 °C inclusive;

no more than 2 months at temperatures from minus 6 °C to minus 11 °C inclusive;

no more than 2 months at temperatures from minus 12 °C to minus 18 °C inclusive.

Fig. 6.8 – Expiration dates of butter with fillers in transport containers

Expiration dates of butter with fillers in consumer packaging are presented in Table 6.11.

Table 6.11 – Expiration dates of butter with fillers in consumer packaging

Type of packaging	Expiration date, days, not more than	
	at temperatures from 0 °C to minus 5 °C inclusive	at temperatures from minus 6 °C to minus 11 °C inclusive
Sealed packaging with a net weight of up to and including 100 g	15(20)	25 (30)
Sealed packaging with a net weight of more than 100 g	30 (35)	45 (50)
Permeable packaging	15(20)	20 (25)

Note 1: Expiration date of butter made with preservatives is indicated in parentheses.

Note 2. The shelf life of butter in B-grade parchment according to Standard 1341 is no more than 15 days, regardless of storage conditions.

Note 3. The shelf life of butter in transport containers is determined from the date of manufacture; in consumer packaging – from the date of packaging.

Note 4. In the case of packaging of butter from a monolith that has already been stored, the date of manufacture when labeling must coincide with the date of packaging, and the shelf life of the packaged products must not exceed the shelf life of the products in the monolith.

6.3. Main technological operations of butter and butter with fillers production

The technological process by the ***method of periodic churning*** is carried out in the following sequence:

> *Separation of milk means its division into two fractions of different density: high-fat (cream) and low-fat (skimmed milk).*

Whole milk intended for butter production is separated on cream separators at 35...40 °C, the mass fraction of fat in the resulting cream should be within 32...37 %.

> *Pasteurization of cream – neutralization of pathogenic microorganisms, maximum reduction of residual microflora, inactivation of enzymes, formation of taste and aroma of butter.*

In the production of butter, first-grade cream is pasteurized at a temperature of 85...90 °C in summer, and in winter and when processing second-grade cream, the pasteurization temperature is increased to 92...95 °C.

As the mass fraction of moisture in the butter increases, the original cream is pasteurized at higher temperatures.

Physical ripening of cream. After pasteurization, the cream is rapidly cooled and kept at low temperatures to convert part of the liquid fat into a solid state (the optimal degree of solidification is 32...35 %).

> *Physical ripening of cream – solidification of the optimal amount of fat and formation of structural bonds between fat globules.*

When whipping the ripened cream, a butter granule is obtained, consisting of semi-destroyed aggregates of fat globules.

The cream is cooled to a temperature of 4...20 °C. The choice of cream ripening modes depends:

- on the composition of milk fat,
- the season of the year,
- the mass fraction of fat in the cream, etc.

For the conditions of Ukraine, two periods have been established for adjusting the technological modes of butter production in terms of the content of the solid phase and the iodine number: above 34.5 (May-October), below 34.5 (November-April). Accordingly, the following modes of cream preparation for churning are proposed (Table 6.12).

Table 6.12 – Modes of cream ripening by periods of the year

Mass fraction of fat in butter, %	*Temperature, °C*	*Holding time, h, not less than*
May - October (iodine number above 34,5)		
80,0–85,0	4–5	5
72,5–79,5	5–9	7
61,5–72,0	6–10	8
November - April (iodine number below 34,5)		
80,0–85,0	5–7	7
72,5–79,5	6–10	8
61,5–72,0	7–11	10

Within 3...5 minutes, if necessary, the ripening time can be extended to 15...17 hours.

In the *period from May to October*, milk fat is dominated by low-melting glycerides containing an increased amount of unsaturated fatty acids. Butter produced from such cream using a one-stage physical ripening regime may be characterized by too soft a texture and low heat resistance. Therefore, at the first stage, it is advisable to set the ripening temperature at 13...15 °C with a holding time of at least 3 hours, which will promote the solidification of high-melting and partially medium-melting glycerides that form the basis of the crystal lattice. At the second stage, a ripening temperature of 4...6 °C with a holding time of at least 3 hours ensures the crystallization of low-melting and the rest of the medium-melting glycerides. After that, the cream is heated to the clotting temperature in a water bath at 27 °C.

Between November and April, milk fat contains an increased amount of high-melting glycerides. Butter made from such cream can become too hard and brittle. Therefore, to improve it, it is necessary to create conditions for the solidification of low-melting glycerides and partially medium-melting glycerides in the first stage, and high-melting glycerides and the remaining medium-melting glycerides in the second stage. The ripening temperature at the first stage should be 5...7 °C with ageing for at least 2...3 h (with 2-3 times stirring for 3...5 min). After that, the cream is slowly (for 40...60 min) heated to a temperature of 13...15 °C in a warm water bath (the temperature of the water for heating should not exceed 27 °C) and kept on the second stage for at least 3 h at this temperature with stirring every 1.0...1.5 h for 3...5 min. At the end of the aging, the cream is quickly cooled to the churning temperature.

Cream churning. Prepared cream is slowly heated to the temperature of the clotting, the temperature of the water for heating should not exceed 27 °C, the process duration is 30 minutes.

The recommended modes of cream churning for butter production are shown in Table 6.13.

Table 6.13 - Recommended modes of of cream clotting

Mass fraction of fat in butter, %	Temperature, °C, season
May - October (iodine number above 34.5)	
80,0–85,0	10,5–13,5
72,5–79,5	11,5–14,5
61,5–72,0	12,5–15,5
November - April (iodine number below 34.5)	
80,0–85,0	13,5–17,0
72,5–79,5	14,5–18,0
61,5–72,0	15,5–19,0

Before starting work, the butter maker is sequentially treated with hot and cold water, for which it is filled to 10...15 % of the volume with water at a temperature of 75...80 °C, turned on at the operating speed for 1...2 min; the generated steam is released through a special valve after every 1-2 revolutions. Then, the hot water is drained, and the butter churn is filled with 30...40 % cold water, the temperature of which is 2...3 °C lower than the temperature of cream churning, and turned on again for 2...5 min at the operating speed. Cold water is removed from the butter churn immediately before filling it with cream. If the water discharged from the butter churn has a temperature higher than the cream churning temperature, the cold water treatment is repeated.

The cream is then fed into the creamer. The optimum level of filling the butter creamer container is 35...50 % (the minimum required level is 25 %).

Turn on the butter fryer at the operating speed. In the first 3...5 minutes, the oil extractor is stopped 1-2 times to release air. Then, the butter is churned until a 3...5 mm butter granule is obtained. After that, the buttermilk is released by filtering it through a filter.

The total duration of the churning process is on average 40...60 minutes. The process is stopped when a butter granule of 3...5 mm in size is formed. The sight glass becomes transparent. The buttermilk is removed through a special tap; to prevent fat loss, it is recommended to drain the buttermilk through a layer of gauze.

It is necessary to determine the weight of the buttermilk, its temperature, and the mass fraction of fat (when using batch butter makers, the mass fraction of buttermilk fat should not exceed 0.4 %).

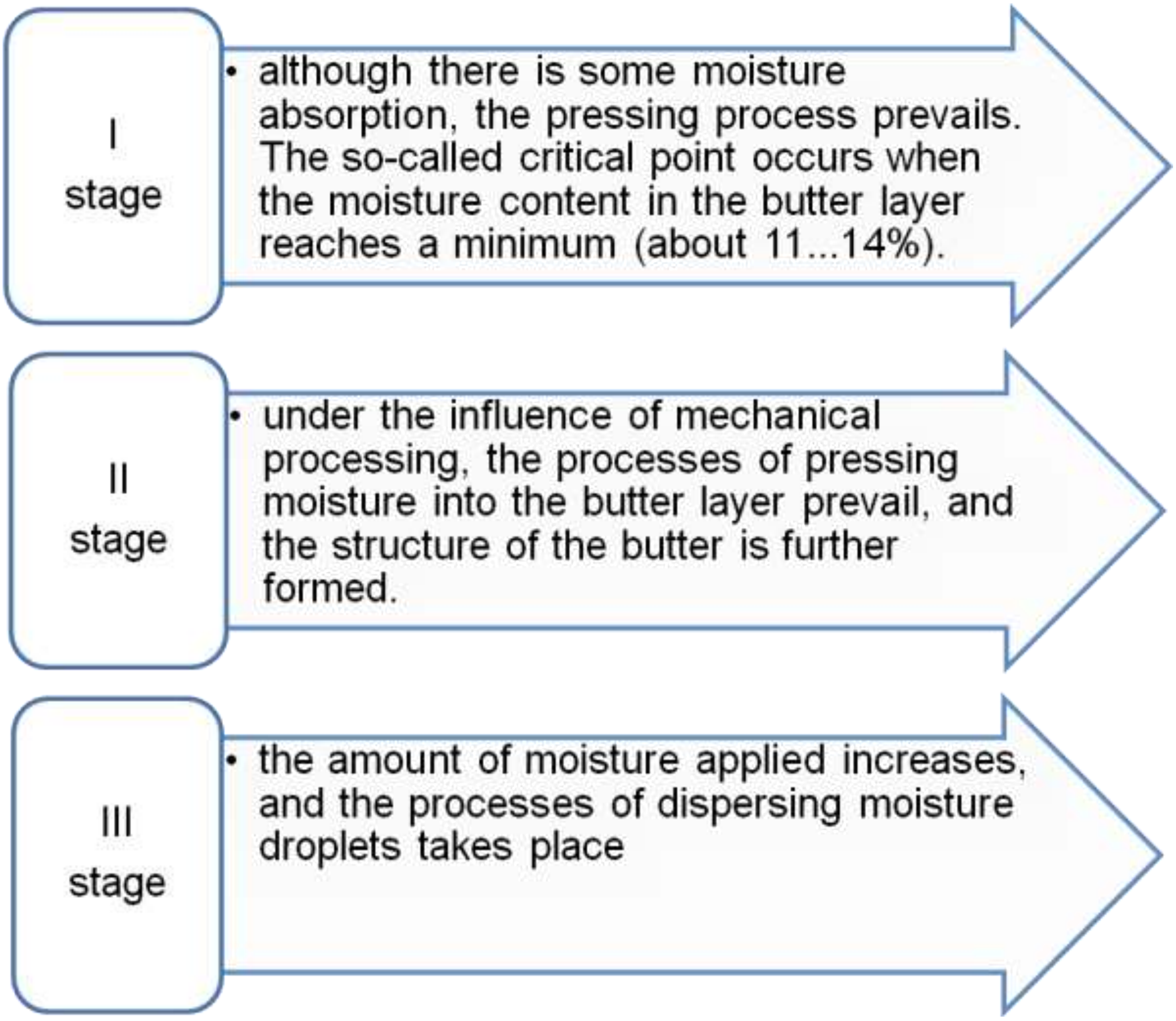
Washing of the butter granules. The purpose of butter granules washing is to remove foreign flavors and odors that are concentrated in the cream plasma. When butter is produced from first-grade cream, the butter granules are not washed.

The frequency of washing depends on the quality of the cream. The water used for washing the butter creamer and washing the butter granules must meet the requirements for drinking water. The total amount of flushing water should be 50...60% of the cream volume, the temperature of the flushing water should be -5...8 °C. Usually, washing is carried out twice.

With a normal consistency of the butter granules, the temperature of the washing water should be 1...2 °C lower than the temperature of the butter at the outlet of the butter maker.

Mechanical processing of the butter granules, adjustment of the butter composition.

The entire process of mechanical processing of butter granules is conditionally divided into three stages (Fig. 6.9), at first the butter granules are combined into a loose layer.



- although there is some moisture absorption, the pressing process prevails. The so-called critical point occurs when the moisture content in the butter layer reaches a minimum (about 11...14%).

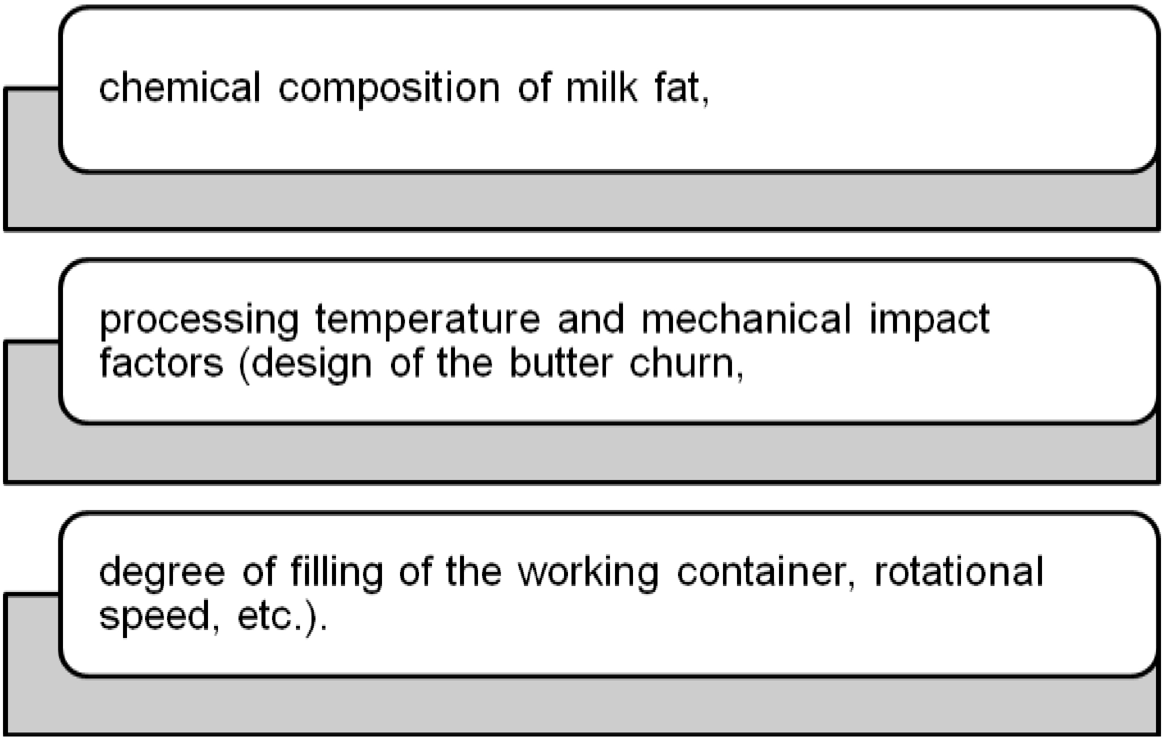
- under the influence of mechanical processing, the processes of pressing moisture into the butter layer prevail, and the structure of the butter is further formed.

- the amount of moisture applied increases, and the processes of dispersing moisture droplets takes place

Fig. 6.9 – The process of mechanical processing of butter granules

At the first stage, although some moisture is absorbed, the pressing process prevails. There comes a so-called “critical” moment when the moisture content in the butter layer reaches a minimum (about 11...14 %). At the second stage, under the influence of mechanical processing, the processes of moisture pressing into the butter layer prevail, and the structure of the butter is further formed. At the third stage of processing, the amount of moisture incorporated increases, and moisture droplets are dispersed.

The processing time depends on the factors shown in Fig. 6.10.



chemical composition of milk fat,

processing temperature and mechanical impact factors (design of the butter churn,

degree of filling of the working container, rotational speed, etc.).

Fig. 6.10. – Factors of processing time

The duration of butter processing is about 15...25 minutes in the period from May to October and 25...50 minutes, respectively, in the period from November to April.

When the moisture release stops, the butter creamer is shut down, a sample of butter is taken, and the mass fraction of moisture is determined.

If necessary, the mass fraction of moisture is increased by adding water or butter.

The mass of butter (water) to be added is calculated using the following formula:

$$M_{\mathrm{b(w)}} = \frac{M_{\mathrm{by}}(\mathrm{B_m} - \mathrm{B_{mbl}})}{\mathrm{B_{bm(w)}} - \mathrm{B_m}} - \mathrm{B_{mw}}, \text{ kg} \quad (6.1)$$

where $M_{b(w)}$ – is the mass of buttermilk (water) to be added, kg;

M_{by} – theoretical butter yield, kg;

B_m –the required mass fraction of moisture in the butter, %;

B_{mbl} –the mass fraction of moisture in the resulting butter layer, %;

$B_{bm(w)}$ –the mass fraction of moisture in the buttermilk (water), %;

B_{mw} – is the mass of moisture located on the walls of the butter maker, kg; it is determined experimentally for a particular butter maker.

The theoretical butter yield is determined by the following formula:

$$M_{by} = \frac{M_c \bullet (F_c - F_{bm})}{F_b - F_{bm}}, \text{ kg} \qquad (6.2)$$

where M_{by} – theoretical butter yield, kg;

F_c, F_{bm}, F_b – mass fraction of fat, respectively, of the original cream, the resulting buttermilk and butter, %.

$$F_b = 100 - (B_b + MSNF_b), \% \qquad (6.3)$$

where MSNF is the mass fraction of dry skimmed milk butterfat residue, % (it is possible to approximately take 10 % of the mass fraction of moisture in the butter).

The calculated amount of buttermilk (water) is sprayed over the surface of the butter layer and further processing is carried out until the required mass fraction of moisture in the butter is achieved and the plasma droplets are sufficiently dispersed.

The degree of dispersion is determined visually or with the help of indicator paper (moisture distribution is considered satisfactory if a 15-by-20-mm section of a butter sample does not contain more than 5 moisture droplets with a diameter of up to 1 mm).

The temperature of packaging should be maintained at 12...16 °C from May to October and 13...17 °C from November to April.

The technological process **of high-fat cream conversion** is carried out in the following sequence. *Milk separation, cream production and pasteurization* are carried out similarly to butter production by batch cream churning. For butter production by the method of high-fat cream conversion, cream with a mass fraction of fat of 32...37% and plasma acidity of no more than 25 °T is used.

Production of high-fat cream. Prepared cream at a temperature of 60...80 °C is sent for separation. The separator capacity is adjusted so that the moisture content in high-fat cream is 0.6...0.8 % lower than in butter, and the fat content of the buttercream does not exceed 0.4 %. In high-fat cream, the mass fraction of moisture and dry skimmed milk residue is determined.

Normalization of high-fat cream. The resulting high-fat cream is normalized, if necessary, by the mass fraction of moisture in the dry skimmed milk and fat.

> *Normalization of high-fat cream is the process of standardizing the composition of butter components in terms of moisture content and MSNF.*

For normalization, butter, pasteurized whole milk or cream, milk fat, low-fat high-fat cream, dry or condensed whole or skimmed milk, dry or condensed butter are used. Skimmed milk or water is not recommended.

Normalization of high-fat cream by *mass fraction of moisture* is carried out as follows. Calculate the weight of the normalizing component using the formula:

$$M_{\mathrm{nc}} = \frac{M_{\mathrm{hfc}} \bullet \mathrm{K} \bullet \mathrm{H}_{\mathrm{m}}}{100}, \text{ kg} \qquad (6.4)$$

where M_{nc} is the weight of the normalizing component (butter, whole milk, cream), kg;

M_{hfc} – weight of high-fat cream to be normalized, kg;

K – normalization coefficient, which determines the mass of the normalizing component to be added for each 100 kg of high-fat cream to increase its mass fraction of moisture by 1%, kg;

H_m – is the mass fraction of moisture that is missing in high-fat cream, %.

The numerical value of the normalization factor is determined by the formula:

$$K = \frac{100}{B_{nc} - B_m}, \text{ kg} \tag{6.5}$$

where B_{nc} – is the mass fraction of moisture of the normalizing component, %;

B_m – mass fraction of moisture in butter, %.

The mass fraction of moisture lacking in high-fat cream is defined as the difference between the mass fraction of moisture in butter and high-fat cream adjusted for underevaporated moisture and is calculated by the formula:

$$H_m = B_b - B_{hfc} - Z_m \tag{6.6}$$

where B_{hfc} – is the mass fraction of moisture in high-fat cream, %;

Z_m – Correction for underevaporated moisture, %

When determining the mass fraction of moisture in high-fat cream, not all of the moisture evaporates, so the mass fraction of moisture in high-fat cream is set lower than in butter. The amount of under-evaporated moisture in high-fat cream is a variable quantity, depending on the quality of the cream and the chemical composition of milk fat, and ranges from 0.2 to 0.8%. Therefore, the absolute value of the mass fraction of moisture in HFC is specified by comparing this indicator in HFC and butter produced from them.

Example. In high-fat cream, the mass fraction of moisture is 14.5 %. Determine the mass fraction of moisture that is missing in high-fat cream if the required mass fraction of moisture in the butter is 15.8 %. Make a correction for incomplete moisture evaporation of 0.6 %.

The mass fraction of moisture missing in high-fat cream is calculated by formula (6.6) and is

$$H_m=15{,}8–14{,}5–0{,}6=0{,}7\ (\%).$$

Example. Perform calculations for the normalization of 400 kg of high-fat cream based on the conditions of the previous example, if butter with a mass fraction of dry matter of 9.1% is used as a normalizing component.

The normalization coefficient is calculated by formula (6.5) and is:

$$K_b=\frac{100}{90{,}9-15{,}8}=1{,}33,\ \text{kg}$$

The mass of the butter churn required for the normalization of high-fat cream is calculated using formula (6.4):

$$m_b=\frac{400\bullet 1.33\bullet 0{,}7}{100}=3{,}72,\ \text{kg}$$

To normalize high-fat cream, the buttercream is usually taken directly from the separator and added to the high-fat cream. After thorough mixing, the mass fraction of moisture is determined in the normalized cream.

Normalisation of high-fat cream by mass fraction of skimmed milk powder.

If the mass fraction of skimmed milk powder is lower than required, normalize high-fat cream with whole or skimmed milk powder, skimmed milk, or buttermilk.

The weight of the dry (baked) normalizing component is calculated using the following formula:

$$M_{nc}=\frac{M_{hfc}\bullet(C_b-C_{hfc})-K_{nc}\cdot(C_{nc}-C_b)}{C_{nc}-C_b}\ \text{kg} \qquad (6.7)$$

where M_{nc} – is the weight of the normalizing component (whole milk powder or condensed whole milk, skimmed milk or butter), kg;

M_{hfc} – weight of high-fat cream to be normalized, kg;

Кс – normalization coefficient;

C_{hfc}, C_b, C_{nc} – mass fraction of dry skimmed milk residue, respectively, of high-fat cream, butter and normalizing component, %.

The normalization factor is determined by the formula:

$$K_{nf} = \frac{100 - C_{hfc} - L_{hfc}}{100 - C_b - L_b} \qquad (6.8)$$

The weight of the buttermilk for dissolving the normalizing agent is determined by the formula:

$$M_{bm} = \frac{M_{hfc} \bullet (C_b - C_{hfc}) - M_{nc} \cdot (C_{nc} - C_{smp})}{C_{smp} - C_b}, \text{kg} \qquad (6.9)$$

where $C_{мас}$ – is the mass fraction of skimmed milk powder residue of the buttermilk, %.

Example. Calculate the normalization of 400 kg of high-fat cream with a mass fraction of moisture of 30.6% and a milk solids-not-fat of 2.8%. It is known that the mass fraction of moisture in butter should be 34.6 %, and the mass fraction of skimmed milk powder should be 3.5 %. For normalisation, skimmed milk powder with a mass fraction of skimmed milk powder of 95% and butter with a mass fraction of solids of 8.4% are used..

The normalization factor is calculated by the formula (6.8):

The weight of skimmed milk powder is calculated by formula (6.9):

$$M_{smp.} = \frac{400 \bullet (3{,}5 - 2{,}8) - 1{,}076 \bullet (95{,}0 - 3{,}5)}{95{,}0 - 3{,}5} = 2{,}2 \text{ kg.}$$

The mass of the buttermilk for dissolving skimmed milk powder is calculated by formula (6.9) and is as follows:

$$M_{\text{bm.}} = \frac{400 \bullet (3{,}5 - 2{,}8) - 2{,}75 \bullet (95{,}0 - 8{,}4)}{8{,}4 - 3{,}5} = 18{,}26 \text{ kg.}$$

Accordingly, the butter yield is:

$$M_b = 400 + 2{,}2 + 18{,}26 = 420{,}46 \text{ (kg).}$$

The calculated amount of skimmed milk powder (2.2 kg) is dissolved in a small amount of warm (30...35 °C) butter, filtered and mixed with the bulk of the hot butter and added to high-fat cream.

The degree of milk fat demulsification is determined in high-fat cream.

Converting high-fat cream into butter. After normalization, high-fat cream is subjected to thermomechanical processing in special machines – butter creamers.

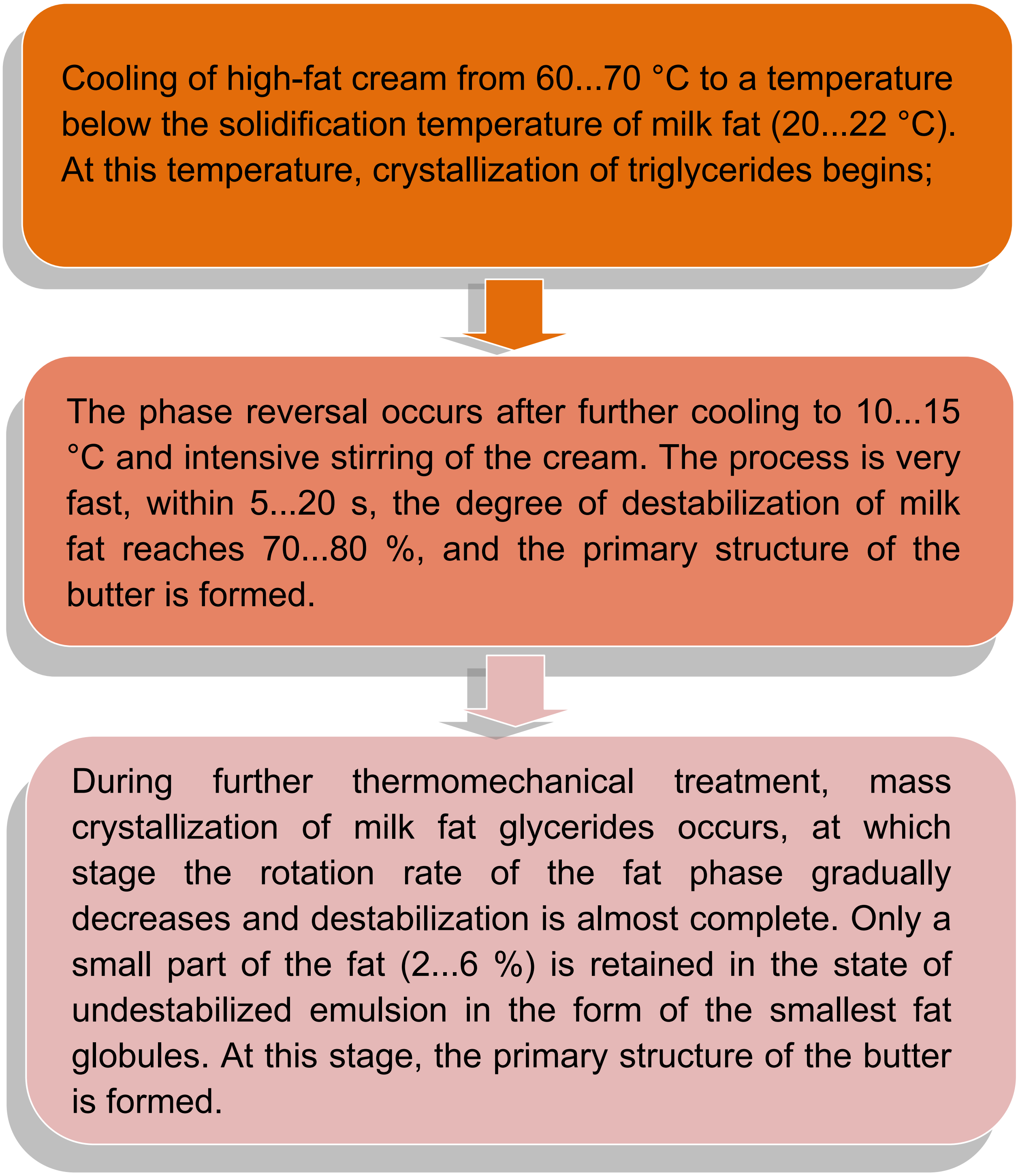
> *Conversion of high-fat cream into butter is a butter-making process that involves the conversion of fat-in-water emulsion phases (high-fat cream) into water-in-fat emulsion (butter) during thermomechanical treatment of HFC.*

The transformation of high-fat cream into butter occurs during intensive cooling and mechanical processing.

The degree of fat phase conversion is characterized by the content of demulsified fat. The transition from the stage of fat phase conversion to the stage of primary structure formation begins at a solid fat content of 4...7 % and demulsified fat

60...85 %. At the end of the process, the amount of demulsified fat reaches 96%.

The process of butter formation can be divided into three stages (Fig. 6.11).



Cooling of high-fat cream from 60...70 °C to a temperature below the solidification temperature of milk fat (20...22 °C). At this temperature, crystallization of triglycerides begins;

The phase reversal occurs after further cooling to 10...15 °C and intensive stirring of the cream. The process is very fast, within 5...20 s, the degree of destabilization of milk fat reaches 70...80 %, and the primary structure of the butter is formed.

During further thermomechanical treatment, mass crystallization of milk fat glycerides occurs, at which stage the rotation rate of the fat phase gradually decreases and destabilization is almost complete. Only a small part of the fat (2...6 %) is retained in the state of undestabilized emulsion in the form of the smallest fat globules. At this stage, the primary structure of the butter is formed.

Fig. 6.11. – Stages of the butter formation process

The process of forming the structure of butter in the butter maker is not complete. The final structure formation occurs after the butter leaves the machine. Therefore, it is mandatory to thermostat butter before storage.

Butter is packed in parchment-lined boxes. The packaged butter is sent to the thermostat for final structure formation. At the first stage, the freshly made butter is kept at a temperature of 14...15 °C for 2...3 hours, and then at a temperature of +5...+10 °C for 2...3 days. During thermostatting, the final formation of the butter structure occurs, and after thermostatting, the butter is sent for storage.

Butter with fillings is produced mainly by ***converting high-fat cream***. A normalized mixture for the production of butter with fillers is prepared according to recipes, taking into account the loss of components during butter production.

The following are used as fillers: cocoa powder, natural coffee, soluble chicory, juices, extracts and syrups of fruits and berries, honey, sugar. The following ingredients are used as auxiliary components: whole milk powder and (or) skimmed milk, whole milk condensed with sugar or skimmed milk condensed with sugar, plastic cream, emulsifiers (distilled monoglycerides, soft monoglycerides, MFT emulsifier), stabilizers (corn and potato starch, carboxymethyl starch, sodium carboxymethyl cellulose, pectin, gelatin), preservatives (sorbic acid, sodium (potassium, calcium) salts of sorbic acid, benzoic acid, sodium salt of benzoic acid), acidity regulators (lactic acid and citric acid).

White sugar is sifted. In the production of cocoa butter, it is recommended to mix it with sugar beforehand and then sift it. In the production of cocoa butter, up to 50% of sugar may be replaced with hydrolyzed lactose syrup (HLS). The syrup is filtered and fed directly into high-fat cream.

Sugar and cocoa may be dissolved in butter or skimmed milk at a temperature of 50...90 °C before being added to the liquid cocoa paste, and may be added to the liquid cocoa paste through an ejector or by dispersing them on the surface.

In the production of butter with milk-protein fillers, they are sifted and fed to the recovery unit, which simultaneously receives butter or skimmed milk. The finished mixture is filtered and fed into a bath with prepared high-fat cream.

If condensed dairy products are used, they are filtered and sent to a bath with high-fat cream.

The prepared mixture is mixed and pasteurized at a temperature of 83...87 °C using tube-type pasteurizers, after which the pasteurized mixture is sent to the normalization bath. It is allowed to pasteurize the mixture directly in the normalization bath at a temperature of 75...85 °C with ageing for 12...18 min.

Coffee, chicory, vanillin, and fruit and berry additives are added directly to high-fat cream without preliminary preparation, last but not least after pasteurization of the mixture.

Honey is filtered before being added to high-fat cream. In case of increased viscosity, it is heated to a temperature of 45...50°C.

To improve the consistency of butter, stabilizers may be used, which are added before pasteurization after preliminary dissolution in high-fat cream. Carboxymethyl starch is added simultaneously with dry additives.

6.4. Thermal operations in the production of rendered butter

Preparation of raw materials for rendered butter production is carried out as follows. The butter to be processed is removed from the boxes, freed from the packaging material, and, if necessary, cleaned of surface damage.

The production of rendered butter using the *settling and separation method* is carried out in the following sequence.

Melting of the raw butter and partial settling of the fat. The butter is kept in a water bath until it is completely rendered. The melt of the raw butter is kept for about 1 hour in a melting tank at a temperature of 50...60°C to partially separate the fat fraction from the plasma. The plasma is drained into a separate container and filtered.

Plasma separation. The purified plasma is fed to a cream separator, which receives hot water at a temperature of about 60°C in the amount of 50 % of the plasma mass. The fat fraction obtained during the separation process is collected in a container. The mass fraction of fat in the separated plasma should not exceed 0.2 %.

Pasteurization, washing and settling of fat. The fat fraction separated from the plasma is heated to a temperature of 90...95 °C and kept for at least 2 hours.

In cases of processing raw materials with pronounced flavor and odor defects, they are washed by irrigation with water at a temperature of at least 85 °C in an amount of 10...25 % by weight of the raw material.

The plasma separated during melt ageing is collected in a separate container, sequentially cleaned and separated.

The quality of the molten fat is checked by a clarification test. If the melt in the glass is transparent, the ageing is complete.

Packaging and cooling of rendered butter. rendered butter is packed in glass jars and airproof sealed.

To obtain *rendered butter* with a granular structure:

- the product is placed in a refrigerator with a temperature of 4...6 °C (10...12 °C is allowed) and kept for 2...3 days, after 6...12 hours, in rolling barrels and flasks.

To obtain a homogeneous (dense) structure:

- *rendered butter* is left in a room with a temperature of 20...22 °C and kept for 14...18 hours, after which it is placed in a chamber with a temperature of 10...12 °C for 1 day.

The production of *rendered butter* by the settling method is carried out in the following sequence.

✓ *Melting of raw butter*

First, potable water is added to a specially prepared container in the amount of 15 % by weight of the butter and heated to a temperature of 50...60 °C. Add the raw butter to the heated water and hold it until it is completely melted.

Pasteurization of the melt and plasma deposition. The butter melt is heated to a temperature of 70...90 °C and kept for at least 2 hours. To ensure more complete plasma deposition, add 4...5 % sodium chloride to the melt, scatter it over the surface, and leave it alone until it is completely clarified, preventing the temperature from dropping by more than 15 °C. After that, the melt is drained and cooled.

Separation of fat from the plasma. The plasma generated during the production of rendered butter is collected in a separate container. The plasma is pasteurized at a temperature of 90...95 °C and kept at this temperature for 3 hours. The fat is separated from the plasma similarly to the method of settling and separation.

Packaging and cooling of rendered butter is carried out similarly to the production of rendered butter by the settling method.

6.5. Technological calculations in butter production and with fillers

Fat balance in butter production.
Calculations for milk separation

When calculating butter, it is necessary to determine the weight of raw materials, semi-finished products, secondary raw materials (by-products) and finished products for a change in the month of maximum raw material reception. Calculations should be made according to material balance formulas and recipes, taking into account consumption rates and maximum permissible losses of raw materials, semi-finished products and finished products established and approved by the relevant orders and other applicable regulatory documents.

Butter and spreads are calculated from raw materials to finished products (formula 6.10). The corresponding formulas are presented in Table 6.14.

Table 6.14 – Calculation formulas for the production of butter and spreads

Number	Formula	Designation
6.10	$M_m \cdot F_m = M_c \cdot F_c + M_{s.m} \cdot F_{s.m} + L_f \cdot 100$	fat balance equation
6.11	$M_c = \frac{M_m(F_m - F_{s.m})}{F_c - F_{s.m}} \bullet \frac{100 - L_f}{100}$, kg	mass of cream
6.12	$M_{s.m} = \frac{M_m(F_c - F_m)}{F_c - F_{s.m.}} \bullet \frac{100 - L_{s.m}}{100}$, kg	mass of skimmed milk
6.13	or $M_{s.m} = (M_m - M_c) \bullet \frac{100 - L_{s.m}}{100}$, kg	
6.14	$M_m = \frac{M_c(F_c - F_{s.m})}{F_m - F_{s.m}} \bullet \frac{100}{100 - L_{s.m.}}$, kg	weight of raw materials (whole milk)

First, determine the amount of cream obtained by separating whole milk using the fat balance equation. The symbols are shown in Table 6.15.

Table 6.15 – Symbols and notations

Designation	Name
M_m	weight of whole milk sent for separation, kg;
F_m	mass fraction of fat in whole milk, %;
M_c	weight of cream obtained during separation, kg;
F_c	mass fraction of fat in cream, %;
$M_{s.m}$	weight of skimmed milk obtained during separation, kg;
$F_{s.m}$	mass fraction of fat in skimmed milk, %;
L_f	fat loss during separation, %;
$L_{s.m}$	skimmed milk losses during separation, %.

Based on Equation 6.10, the weight of cream and skimmed milk obtained during separation or the weight of whole milk is determined using Formulas 6.11 (weight of cream), 6.12, 6.13 (weight of skim milk), and 6.14 (weight of raw milk).

According to the current Order, the fat content of cream used for butter production is determined by the method of its production and is shown in Figure 6.12.

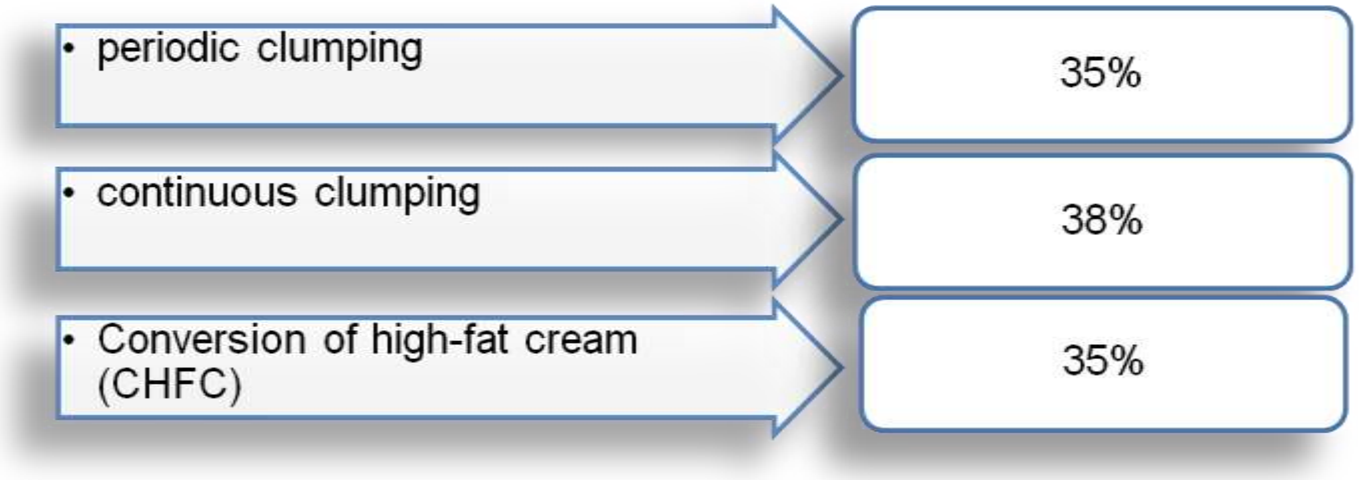


Fig. 6.12 - Fat content of cream

The standard for losses in the production of cream at processing plants and separation departments in accordance with current regulations is **0.38%** (see Attachment 1).

The standard for skimmed milk losses during separation in accordance with Order No. 1025 of December 31, 1985 is 0.4%.

Example 1: At a butter-making enterprise, 60,000 kg of whole milk with an average fat content of 3,6 %. The received milk is supposed to be used for the production of butter by the method of continuous churning. Determine the amount of cream and skimmed milk obtained by separating the specified amount of whole milk.

According to the condition, the cream obtained during separation will be used for the production of butter by the method of continuous churning, and, as mentioned above, the fat content of cream in this method must be at least 38 %.

Taking this into account, we determine the weight of cream using Formula 6.11:

$$M_c = \frac{60000\,(3{,}6 - 0{,}05)}{38 - 0{,}05} \bullet \frac{100 - 0{,}38}{100} = 5591{,}32\ \text{kg}$$

Determine the weight of skimmed milk:

$$M_{s.m} = (60000 - 5591{,}32) \bullet \frac{100 - 0{,}4}{100} = 54191{,}05\ \text{kg}$$

Consequently, 5,591.32 kg of cream with a fat content of 38% will be used to produce butter.

Calculation of butter

The calculation of butter takes into account the method of its production (continuous or batch churning, transformation of high-fat cream) and the type of packaging (large blocks or small briquettes).

When butter is produced in different ways, the corresponding formulas are used (Table 6.16).

Table 6.16 – Calculation formulas for butter production by different methods

Number	Formula	Indicator
6.15	$M_b = \frac{M_c (F_c - F_{bm})}{F_b - F_{bm.}} \bullet \frac{100 - B_{MC}}{100}$, kg	weight of butter (by the method of cream formation)
6.16	$M_{hfc} = \frac{M_c (F_c - F_{bm.})}{F_{hfc} - F_{hfc.}} \bullet \frac{100 - B_{hfc}}{100}$, kg	weight of high-fat cream
6.17	$M_{bm.} = (M_c - M_b) \bullet \frac{100 - B_{bm.}}{100}$, kg	mass of buttermilk

End of Table 6.16

6.19	$M_{ts} = \frac{M_b \bullet C_b К}{100}$, kg	mass of table salt
6.20	$M_{sour.} = \frac{M_c(T_d - T_c)}{T_{sour.} - T_d}$, kg	weight of the sourdough (in the production of sour cream butter with short-term cream fermentation)
6.21	$M_{sour.} = \frac{a \bullet M_b}{100}$, kg	weight of the sourdough (when added to the butter layer)
6.22	$F_{rm} = 100 - (B_{rm} + MSNF + M_{ts})$,	mass fraction of fat of raw materials for the production of rendered butter
6.23	$M_{mel} = \frac{M_s \quad F_{rm}}{F_{mel}} \quad \frac{100 - B_{f.mel.}}{100}, kg$	weight of rendered butter

The symbols used in the formulas are shown in Table 6.17

Table 6.17 – Symbols and notations

Symbols	Notation
M_b	weight of butter, kg;
F_b	mass fraction of fat in butter (planned value, set in accordance with the current regulatory documents in force in butter production), %;
M_c	weight of cream, kg;
F_c	mass fraction of fat in cream, %;
$F_{bm.}$	mass fraction of fat in buttermilk, % (accepted depending on the production method in accordance with the current order, see Table 6.15);

Continuation of Table 6.17

$в_f$	maximum permissible fat losses in butter production by the churning method, % (set by the current order depending on the production method and type of packaging, see Attachment 2).
M_{hfc}	weight of high-fat cream, kg;
F_{hfc}	mass fraction of fat in high-fat cream, %;
M_c	weight of cream, kg;
F_c	mass fraction of fat in cream, %;
B_{hfc}	maximum permissible fat loss during cream separation to obtain high-fat cream, % (set by the current order depending on the method of production and type of packaging, see Attachment 2).
$B_{bm.}$	maximum permissible losses of the buttermilk during butter production, %.
$M_{sour.}$	weight of the sourdough, kg;
T_d	desirable titratable acidity of cream after adding the sourdough, °T;
T_c	titratable acidity of cream before adding the sourdough, °T;
$T_{sour.}$	titratable acidity of the sourdough, °T;
a	the desired mass fraction of the sourdough, %.
M_{ts}	mass of salt, kg;
$C_{s.m}$	mass fraction of salt in butter, % (set in accordance with applicable regulations);
К	correction factor that takes into account salt losses due to the removal of excess salt plasma of the butter during its processing (K = 1.03...1.08).
F_{rm}	mass fraction of fat of raw materials for rendered milk production, %;
B_{rm}	mass fraction of moisture of raw materials, %;
MSNF	mass fraction of dry skimmed milk residue of raw materials, %;
M_{ts}	mass fraction of table salt, %;

End of Table 6.17

M_{mel}	weight of melted butter, kg;
M_{rm}	weight of raw materials for melted butter production, kg;
F_{mel}	mass fraction of fat in rendred butter, % ($Ж_{топл}$=99,0%);
$B_{f.mel}$	standard fat losses in rendered butter production, % ($B_{f.mel}$=0,48%).

When butter is produced by the rolling method, the mass of butter is calculated by Formula 6.15.

The mass fraction of fat in the butter in the production of butter by various methods is given in Table 6.17.

Table 6.17 – Mass fraction of fat in the butter in the production of butter by different methods

Name of butter	*Mass fraction of fat in the buttermilk (%) in the production of butter by the method:*		
	periodic churning	*continuous churning*	*CHFC*
Butter extra	0,4	0,7	0,4
Peasant butter	0,5	0,7	0,4

In the production of butter by the process of high-fat cream production, the mass of high-fat cream is calculated by formula 6.16. The mass of cream is determined by formula 6.11. The mass of butter is determined by formulas 6.17 and 6.18.

According to the current order in force in the butter industry, the maximum permissible losses of butter in the production of butter are determined by the method of its production (Table 6.18).

Table 6.18 – Maximum permissible losses of the buttermilk during butter production

Method of butter production	*Maximum permissible losses of the buttermilk, %*
periodic churning	4,0
continuous churning and CHFC	2,0

The weight of table salt in the production of salted butter is determined by formula 6.19.

The mass fraction of table salt in sweet or sour cream extra salted butter is 0.8 %, in village salted butter – 1.0 %.

In the production of sour cream butter with short-term fermentation of cream, the weight of the starter is determined by formula 6.20. When the starter is added to the butter layer, its weight is calculated by Formula 6.21.

The raw materials for the production of rendered butter are butter, serum butter, and plastic cream. In each batch of raw materials, the mass fraction of fat is determined by Formula 6.22.

The mass of rendered butter is determined by the following formula 6.23.

Example 2: 70,000 kg of whole milk with a fat content of 3.4 % is used for the production of butter by the continuous churning method. It is planned to produce extra sweet cream butter with a mass fraction of fat of 82.5 % from 40 % of the cream, and village butter with a mass fraction of fat of 72.5 % from the rest. The extra butter is to be packed in briquettes of 200 g, and the village butter in blocks of 20 kg. Determine the weight of both types of butter and the total amount of butter obtained during churning.

First, determine the total mass of cream (Mwt) obtained during separation, taking into account that in the production of butter by the method of continuous churning, the mass fraction of fat in cream should be at least 38%.

$$M_{total} = \frac{70000\,(3{,}4 - 0{,}05)}{38 - 0{,}05} \bullet \frac{100 - 0{,}38}{100} = 6155{,}7 \text{ kg}$$

According to the condition, 40% of the cream produced is used for the production of extra sweet cream butter, which will amount to:

$$M_{c\_in\_b} = \frac{40 \bullet M_{total}}{100} = \frac{40 \bullet 6155{,}7}{100} = 2462{,}3 \text{ kg},$$

The village butter remains to produce butter sweet cream butter

6155,7 – 2462,3 = 3693,4 kg of cream.

The indicators necessary for further calculations are determined in accordance with applicable regulations and entered in the table (see Attachment 3):

Determine the mass of extra sweet cream butter (M_{be}) using formula 3.15

$$M_{be} = \frac{M_c(F_c - F_{bm})}{F_b - F_{bm.}} \bullet \frac{100 \quad B_b}{100} = \frac{2462{,}3\,(38 - 0{,}7)}{82.7 - 0{,}7} \bullet \frac{100 - 0{,}58}{100} = 1113{,}5\ \text{kg}$$

Determine the mass of the butter churn obtained in the production of sweet cream butter extra ($M_{bm.e}$), using formula 6.17

$$M_{bm.e} = (M_c - M_b) \bullet \frac{100 - B_{bm.}}{100} = (2462{,}3 - 1113{,}5) \bullet \frac{100 - 2}{100} = 1321{,}8\ \text{kg}$$

Determine the weight of village butter (M_{bp}).

$$M_{bp} = \frac{M_c(F_c - F_{bm})}{F_b - F_{bm.}} \bullet \frac{100 - B_b}{100} = \frac{3693{,}4\,(38 - 0{,}7)}{73{,}1 - 0{,}7} \bullet \frac{100 - 0{,}50}{100} = 1893{,}3\ \text{kg}$$

Determine the weight of the butter churn obtained in the production of village sweet cream butter ($M_{bm.p}$).

$$M_{bm.p} = (M_c - M_b) \bullet \frac{100 - B_{bm}}{100} = (3693{,}4 - 1893{,}3) \bullet \frac{100 - 2}{100} = 1764{,}1\ \text{kg}$$

The total weight of the resulting buttermilk in the production of both types of butter will be:

1321,8+ 1764,1 = 3085,9 kg.

Example 3: 50,000 kg of whole milk with a fat mass fraction of 78.0% by the method of converting high-fat cream are used to produce sweet cream butter with a fat content of 3.4%. Determine the mass of butter and the resulting buttermilk.

Determine by formula 6.11 the mass of cream of medium fat content (Mc) obtained during separation, taking into account that in the production of butter by the CHFC method, the mass fraction of fat in cream should be at least 35 %.

$$M_{total.} = \frac{50000\,(3{,}4-0{,}05)}{35-0{,}05} \bullet \frac{100-0{,}38}{100} = 4774{,}3 \text{ kg}$$

The indicators necessary for further calculations are determined in accordance with applicable regulations and entered in the table (see Attachment 3).

Determine the weight of butter.

$$M_b = \frac{M_c(F_c - F_{bm})}{F_b - F_{bm.}} \bullet \frac{100 - B_b}{100} = \frac{4774{,}3\,(35-0{,}4)}{78{,}3-0{,}4} \bullet \frac{100-0{,}46}{100} = 2110{,}8 \text{ kg}$$

Determine the weight of the buttermilk obtained during cream separation.

$$M_{bm.} = (M_c - M_b) \bullet \frac{100 - B_{b.}}{100} = (4774{,}3 - 2110{,}8) \bullet \frac{100-2}{100} = 2565{,}5 \text{ kg}$$

Calculation of butter with fillings

Butter with fillings is produced by converting high-fat cream The calculation is carried out according to the recipes given in Attachment 4.

When using raw materials with other physical and chemical characteristics than those specified in the recipes, to obtain a product with standard physical and chemical characteristics (Attachment 5), calculations are made according to the formulas given in Table 6.19.

Table 6.19. – Calculation formulas for butter production by different methods

№	Formula	Designation
6.24	$M_{hfc} = \frac{M_{pr} \cdot F_{pr}}{F_{hfc}} \bullet B_1, \text{kg}$	weight of high fat cream
6.25	$M_f = \frac{M_{pr} \cdot \text{Ч}_f}{S_f} \bullet B_2,$	filler weight
6.26	$M_b = (M_{pr} - M_{hfc} - M_f) \bullet B_3,$	mass of buttermilk
6.27	$M_{df} = (M - M_{hfc} - M_f) \bullet B_4$	weight of dairy fillers containing MSNF
6.28	$M_{pf} = \frac{M_{pr} \quad MSNF_{pr} \quad M_{HFC} \quad MSHF_{HFC} \quad M_{df} \quad MSNF_{df}}{MSNF_{pf} \quad MSNF_{df}} \quad B_5$	weight of protein filler
6.29	$M_{sm} = (M_{df} \quad M_{pf}) \quad B_6$	weight of skimmed milk

The symbols are shown in Table 6.20.

Table 6.20 – Symbols and notations

Symbol	Name
M_{pr}	weight of the finished product, kg;
F_{pr}	mass fraction of fat in the finished product, %; (in the calculations, F_{pr}= 57,3% for butter with a mass fraction of fat of 57%, F_{pr}=52,3% for butter with a mass fraction of fat of 52%), %;
F_{hfc}	mass fraction of fat in high-fat cream, %;
B_1	a coefficient that takes into account losses during production and packaging of the product (B_1=1,001).
M_f	weight of the filler, kg
J_f	mass fraction of the filler in the finished product, %;
S_f	mass fraction of solids in the filler, %;
B_2	coefficient that takes into account the loss of the filler (during the laying of sugar – 1.033, cocoa – 1.025, other components – 1.01).
B_3	a coefficient that takes into account the loss of the buttermilk (B_3=1,01).
B_4	coefficient that takes into account the loss of milk fillers, (B_4=1,01).
$MSNF_{pr}$	mass fraction of skimmed milk powder in the product, %;
M_{HFC}	calculated weight of high-fat cream, kg;
$MSNF_{HFC}$	mass fraction of skimmed milk powder of high-fat cream, %;
M_{mf}	total weight of flavoring fillers containing MSNF, kg;
$MSNF_{mf}$	mass fraction of skimmed milk solids in milk fillings ($MSNF_{mf}$=8,2%);
$MSNF_{pf}$	mass fraction of skimmed milk solids in milk powder or condensed milk (butter, milk protein powder additive MPA), %;
B_5	coefficient that takes into account the loss of protein fillers (B_5=1,01).

The mass of high-fat cream (M_{HFC}) taking into account losses, is determined by Formula 6.24.

The weight of the added filler (M_f) is calculated by formula 6.25.

The required weight of the buttermilk (M_b) is calculated by formula 6.26.

The mass of milk fillers (M_{mf}), containing skimmed milk powder (MSNF) is calculated by the following formula 6.27

The calculation of the weight of protein fille (M_{pf}) is carried out according to the following formula 6.28.

The calculation of the mass of skim milk for the preparation of the mixture (M_{sm}) is calculated by Formula 6.29.

Example 4. It is necessary to obtain 500 kg of cocoa butter with a mass fraction of fat of 57 %. The mass fraction of moisture in high-fat cream is 20 %, and the MSNF is 2.0 %. For normalization, fresh buttermilk is used with a mass fraction of fat 0.4 %, MSNF – 7.8 %.

First, calculate the weight of high-fat cream (M_{HFC}) taking into account losses, according to formula 6.24:

$$M_{HFC} = \frac{500 \cdot 57,3}{78} \cdot 1,001 = 367,66 \text{ kg;}$$

The weight of sugar (M_s) taking into account losses, is calculated by formula 6.25:

$$M_s = \frac{500 \cdot 10}{100} \cdot 1,033 = 51,65 \text{ kg;}$$

The weight of cocoa (M_c) taking into account losses, is calculated by formula 6.25:

$$M_c = \frac{500 \cdot 2,5}{100} \cdot 1,025 = 12,81 \text{ kg;}$$

The mass of the buttermilk (M_b) for normalization is calculated by formula 6.26:

$$M_b = (500 - 367,3 - 50 - 12,5) \cdot 1,01 = 70,9 \text{ kg.}$$

To verify the calculations, a balance sheet is drawn up for the mass fraction of dry matter, fat, and weight.

Example 5. You need to produce 500 kg of cocoa butter with a mass fraction of fat of 57%. The mass fraction of moisture in high-fat cream is 20.0%, and the MSNF is 2.0%. Skimmed milk powder with a mass fraction of moisture of 7.0% and the MSNF of 93.0% is used as a milk protein filler, and buttermilk with a mass fraction of fat of 0.4% and MSNF of 7.8% is used as a component for normalization.

The recipe for butter with cocoa with a mass fraction of fat of 57%, taking into account the balance of moisture, solids and fat, is presented in Attachment 6.

First, calculate the weight of high-fat cream (M_{HFC}) taking into account losses, according to formula 6.24:

$$M_{HFC} = \frac{500 \bullet 57{,}3}{78} \bullet 1{,}001 = 367{,}7 \text{ kg};$$

The weight of sugar (M_s) including losses is calculated by formula 6.25:

$$M_s = \frac{500 \cdot 5}{100} \cdot 1{,}033 = 28{,}41 \text{ kg};$$

The weight of cocoa (M_K) taking into account losses, is calculated by formula 6.25:

$$M_c = \frac{500 \cdot 2{,}5}{100} \cdot 1{,}025 = 12{,}81 \text{ kg};$$

The weight of dairy fillers (M_{df}), containing MSNF is calculated by formula 6.27:

$$M_{df} = 500 - 367{,}7 - 27{,}5 - 12{,}5 = 92{,}3 \text{ kg};$$

The weight of the protein filler (M_{pf}) taking into account losses, is calculated by formula 6.28:

$$M_{pf} = \frac{500 \bullet 10 - 367{,}7 \bullet 2{,}0 - 124{,}74 \bullet 7{,}8}{93 - 7{,}8} \bullet 1{,}01 = 42{,}0 \text{ kg};$$

The mass of the buttermilk (M_b) for normalization with regard to losses is calculated by formula 6.26:

$$M_b = (124,74 - 39,4) \cdot 1,01 = 86,90 \text{ kg;}$$

To verify the accuracy of the calculations, a balance sheet is drawn up by mass fraction of dry matter, fat, and weight.

Example 6. Get 500 kg of chicory butter with a mass fraction of fat of 52%. The mass fraction of moisture in high-fat cream is 20.0%, and the MSNF is 2.0%. Condensed skimmed milk with a mass fraction of moisture of 56.0% and the MSNF of 44.0% is used as a milk protein filler, and butter with a mass fraction of fat of 0.4% and the MSNF of 7.8% is used for normalization.

First, calculate the weight of high-fat cream (M_{HFC}) taking into account losses, using Formula 6.24:

$$M_{HFC} = \frac{500 \cdot 52,3}{78} \cdot 1,001 = 335,59 \text{kg;}$$

The weight of sugar (M_s) including losses is calculated by formula 6.25:

$$M_s = \frac{500 \cdot 5,0}{100} \cdot 1,033 = 28,41 \text{ kg;}$$

The weight of chicory (M_{chic}) aking into account losses, is calculated by formula 6.25:

$$M_{chic} = \frac{500 \cdot 0,7}{70} \cdot 1,01 = 5,05 \text{ kg;}$$

The weight of dairy fillers (M_{df}), containing MSNF is calculated by formula 6.27:

$$M_{df} = 500 - 335,26 - 27,5 - 5 = 132,24 \text{ kg;}$$

The weight of the protein filler (M_{pf}) taking into account losses, is calculated by formula 6.28:

$$M_{pf}=\frac{500\cdot 11,8-335,26\cdot 2,0-132,24\cdot 7,8}{44-7,8}\cdot 1,01=117,3\ \text{kg};$$

The mass of the buttermilk (M_b) for normalization with regard to losses is calculated by formula 6.26:

$$M_b=(132,24-116,0)\cdot 1,01=16,4\ \text{kg};$$

To verify the correctness of the calculations, a balance sheet is drawn up by mass fraction of dry matter, fat, and weight.

Calculation of functional butter

Functional butter is produced by adding pectin, inulin and cryopowders of edible vegetable products from red beet, carrot, Jerusalem artichoke, black currant buds and other specially processed plant components to high-fat cream. The physical and chemical characteristics of these types of butter are given in Attachment 5.

Functional butter is calculated according to standard formulations in accordance with DSTU, given in Attachment 4.

When using raw materials that differ in composition from those specified in these recipes, the components of the mixture are calculated using the same formulas as in the production of butter with fillers.

Example 7. To produce Pectin butter from 2500 kg of cream with a mass fraction of fat of 35.0%.

First, determine the mass of high-fat cream (M_{HFC}) using formula 6.24:

$$M_{HFC}=\frac{2500\cdot(35,0-0,4)}{77,0-0,4}\cdot\frac{100-0,16}{100}=1127,4\ \text{kg}$$

The weight of all other components and the weight of the finished product are calculated according to the recipe in proportion to the weight of the resulting high-fat cream:

The mass of the buttermilk for the production of Pectin butter (M_b) is calculated by formula:

$$M_b = \frac{59{,}9 \cdot 1127{,}4}{938{,}9} = 71{,}92 \text{ kg}$$

The weight of dry pectin for the production of Pectin butter (M_{pec}) is calculated by formula:

$$M_{pec} = \frac{4{,}2 \cdot 1127{,}4}{938{,}9} = 5{,}04 \text{ kg}$$

The weight of the mixture for the production of Pectin butter (M_{mix}) is calculated by formula:

$$M_{mix} = \frac{1003{,}0 \cdot 1127{,}4}{938{,}9} = 1204{,}37 \text{kg}$$

The correctness of the calculations is checked using the formula:

$$M_{mix} = M_{hfc} + M_{pec} + M_b$$

$$M_{mix} = 1127{,}4 + 71{,}92 + 5{,}04 = 1204{,}37 \text{ kg}$$

The weight of the finished product (M_{pr}) is:

$$M_{pr} = \frac{1000 \cdot 1127{,}4}{938{,}9} = 1200{,}76 \text{kg;}$$

To verify the calculations, a balance by mass fraction of solids, fat, and weight is drawn up. A typical recipe for Pectin butter, taking into account the balance of moisture, solids and fat, is presented in Attachment 10.

SECTION 7.

BASIC METHODS FOR DETERMINING QUALITY INDICATORS OF SPREADS, BUTTER AND FILLER

7.1. Methods for determining the quality of raw milk

Determination of the mass fraction of fat in cream is carried out in the following sequence. Weigh 5 g of the product into a clean cream fat meter. Then add 5 cm3 of water and 10 sm3 of sulfuric acid with a density of 1800...1810 kg/m3 and 1 sm3 of isoamyl alcohol along the wall of the slightly tilted fat meter with a dispenser. Fill the fat meter 4...5 mm below the base of the neck of the fat meter. Further fat determination and counting is carried out as for milk.

Determination of cream acidity is carried out in the following sequence. Pour 20 cm3 of distilled water into a conical flask with a capacity of 100...150 cm3, add 10 cm3 of cream with a pipette, rinse with the mixture 3-4 times. Then add 3 drops of phenolphthalein solution. The mixture is titratable with a solution of 0.1 n. sodium (potassium) hydroxide until the color becomes slightly pink, disappearing within 1 min, and corresponds to the color of the reference standard.

To prepare the color standard, 20 cm3 of water is added to a 100...250 cm3 flask, 10 cm3 of cream is added with a pipette, rinsing the pipette with the mixture 3-4 times, and 1 sm of 32.5 % cobalt sulfate solution is added for cream with a fat content of up to 20 % or 2 cm3 for cream above 20 %.

The acidity according to Turner's scale is equal to the number of milliliters of 0.1 n. Of hydroxide (potassium) solution used to neutralize 10 cm3 of the product multiplied by 10.

The active acidity of cream is determined in the following sequence. About 40 cm3 of cream is taken into a beaker, the electrodes are immersed in it, and after 10...15 seconds, the device readings are taken.

For faster readings, the pH of low-fat cream is measured while it is continuously stirred.

The results of pH measurements are presented as the arithmetic mean of three measurements.

The readings on the device are read when the arrow stops. After each measurement, the sensor electrodes are rinsed with distilled water.

The acidity determination for cream plasma is carried out in the following sequence. Based on the results of determining the acidity of cream by titration, the acidity of cream plasma can be calculated by the formula:

$$A = \frac{(100 * Ac)}{(100 - F)} \qquad (7.1)$$

where A is the acidity of cream plasma, °T; Ac is the acidity of cream, °T; F is the mass fraction of fat in cream, %.

The acidity in the aqueous part or cream plasma at the same titratable acidity will be higher in higher-fat cream.

Determination of cream density is carried out in the following sequence. The density of low-fat cream is determined in the same way as milk. The density of cream with a high mass fraction of fat is determined by an areometer (densimeter) with an appropriate scale or by a pycnometer.

The pycnometric method is based on the accurate weighing of cream and distilled water in the same pycnometer at a temperature of 20 °C and the determination of the ratio between them by weight.

The pycnometer determination is carried out as follows: a dry, clean pycnometer is weighed to within 0.0001 g (10 cm3 capacity) and to within 0.001 g for 50 cm3, after which distilled water is added to the mark, closed with a stopper, placed in a thermostat or water bath at exactly 20 °C for 30 minutes and weighed.

The same operations are performed with the cream under test. The density of cream, kg/m3, is calculated by the formula:

$$D := \left(\frac{M_3 - M_1}{M_2 - M_3}\right) \cdot \left(D_{air} - D_w\right) + D_{air} \qquad (7.2)$$

where M1, M2, M3 are the masses of the pycnometers, respectively, empty, with water and with cream, kg;

D_w is the density of water at 20 °C and normal pressure equal to 1.04 × 105 Pa, D_w = 998.20 kg/m3;

D_{air} is the density of air at 20 °C and normal pressure, D_{air} is 1.2 kg/m3.

To simplify the calculations, use the formula:

$$D = \frac{M_3 - M_1}{M_2 - M_1} 0{,}99823, \tag{7.3}$$

where 0.99823 is the empirical coefficient.

<u>The temperature of milk and other dairy raw materials</u> is measured with a glass liquid and digital thermometer.

The method of measuring temperature with a glass liquid (non-mercury) thermometer is based on measuring the volume of liquid in a glass shell depending on the temperature of the measured medium.

Glass liquid thermometers have a measuring range of (0...50) °C, (0...100) °C with a division value of (0.5...1) °C, margin of error ±1 °C according to GOST 27544-87.

The temperature of the raw milk is measured directly, the liquid is thoroughly mixed before measuring the temperature. The thermometer is immersed in the liquid to the lower digital mark and kept there for at least two minutes. Readings are determined with the thermometer immersed in milk, rounding up to the nearest whole number.

Measurement of raw milk temperature with a digital thermometer TS-101 is performed in accordance with the rules of its operation.

<u>Determination of milk purity</u> group is carried out in the following sequence. To determine the degree of milk purity, a special device for determining the milk purity group is used.

A 250 cm3 sample of milk heated to a temperature of 35...40 °C is poured into the device's container and filtered through a cotton filter. After filtering, the filter is removed from the device and placed on a sheet of paper and dried in air.

The purity group of milk is determined by comparing the filter with a standard by the number of mechanical inclusions. Depending on the intensity of mechanical contamination, milk is divided into 3 groups.

Determination of milk density is carried out in the following sequence. Milk density is the mass per unit volume at 20 °C (kg/m3) determined by the areometric method. The density depends on the temperature of the milk and its components. Due to the variability of milk composition, it ranges from 1026 to 1032 kg/m3. Milk density changes during the lactation period and under the influence of other factors. In the first days after calving (colostrum), the density reaches 1400 kg/m3.

The density of milk from sick animals is lower than that of normal milk. When water is added to milk, its density decreases (10% water addition reduces the density by an average of 3 kg/m3). Removing cream or diluting with skimmed milk increases the density.

Density determination is carried out no earlier than 2 hours after milking, as freshly milked milk contains many air bubbles that interfere with the determination.

Before determination, the sample with the settled cream layer is heated to a temperature of 30...40 °C to dissolve it, stirred and cooled to a temperature of 18...22 °C. A sample of milk in a volume of 0.25 or 0.5 dm3 is thoroughly mixed and poured carefully over the wall of a dry, clean cylinder, being careful not to form foam, and the cylinder should be held at a slight angle. If foam forms on the surface, it is removed with a stirrer.

The areometric method is performed in the following sequence. Before determination, the cylinder is placed on a flat horizontal surface. A dry, clean areometer is placed in the cylinder with the milk sample and left in a free-floating state, with the areometer not touching the walls of the cylinder. Readings on the temperature and density scales are started no earlier than 3 minutes after the areometer has settled to a stationary position.

If the temperature of the milk was other than 20 °C, the density measurement results are converted to a temperature of 20 °C according to the reference tables.

The pycnometric method for determining milk density is carried out in the following sequence. In preparation for the analysis, pycnometers (at least two) are washed with detergent solutions and rinsed thoroughly with distilled water. After that, they are dried in an electric oven at 100...120 °C for at least 30 min, removed and kept at room temperature for at least 30 min, and weighed.

Then the pycnometers are placed back in the electric furnace and kept at the same temperature for at least 15 minutes, removed from the electric furnace, kept in the room for at least 30 minutes, and weighed. The difference between the results of two weighings of each pycnometer should not exceed 3-10-7 kg for scales of the 2nd accuracy class and 5-10-6 kg for scales of the 4th accuracy class. If this condition is not met, the drying must be repeated.

The arithmetic mean of the results of two weighings m1 is taken as the mass of the weights balancing each empty pycnometer. The pycnometers are filled with a syringe with boiled and cooled to room temperature distilled water, slightly above the mark on their neck and closed with stoppers, immersed in a glass of water so that the water covers the filled part of the pycnometers, and the glass into is lowered into the thermostat. The pycnometers are kept in the thermostat at (20 ± 0.05) °C for 30 min. The water temperature is monitored with a thermometer with a division value of 0.01 °C, lowered into the thermostat. The pycnometers are removed from the thermostat, and the water level is brought to the mark on the neck (along the upper edge of the meniscus) using a syringe and filter paper. The inner surface of the pycnometer neck above the mark is thoroughly blotted with filter paper without touching the water level in the pycnometer, wiped dry outside and left in the balance for at least 20 minutes. After that, the pycnometers are weighed. The experiment is repeated at least 3 times for each pycnometer. The arithmetic mean of the results of all weighings m2 is taken as the mass of the weights balancing each pycnometer with water. The value of the mass of the weights balancing the empty pycnometer and the pycnometer with water is determined repeatedly for each pycnometer after 20 determinations of milk density. Pour the water out of the pycnometers and dry them.

The milk sample is heated to 38...42 °C, kept for 4...6 minutes and cooled to 18...22 °C. The pycnometers prepared for measurement (at least two) are filled with a syringe with a thoroughly mixed test sample of cow's or skimmed milk, slightly above the mark on their neck, and closed with stoppers. The pycnometers are placed in a thermostat and the level of the test sample is brought to the mark with a pipette. The weight of the scales balancing each pycnometer with milk is taken as the arithmetic mean of the results of two weighings m3.

After the measurements are made, the product is poured out of the pycnometers, washed, dried, corked, and stored until new tests are performed. The density of milk ρ1 (kg/m3) at 20 °C and a normal pressure of 0.1 MPa is calculated by the formula:

$$\rho_1 := \left(\frac{m_3 - m_1}{m_2 - m_1}\right) \cdot \left(\rho_w - \rho_{air}\right) + \rho_{air,\%} \qquad (7.4)$$

Where m_1, m_2, m_3 are the weights of the scales balancing an empty pycnometer, a pycnometer with water, and a pycnometer with milk, respectively, kg; ρ_w is the density of water (ρ_w = 998.20 kg/m3); ρ_{air} is the density of air (ρ_{air} = 1.2 kg/m3).

Similarly, the density ρ_2 of the same milk sample is determined using a second pycnometer. The permissible discrepancy between the two density results should not exceed 0.3 kg/m3 in absolute value for milk. If the discrepancy exceeds the permissible value, new control measurements of density are carried out.

The density ρ_{am} of milk at 20 °C is taken as the arithmetic mean of the results of two determined values of milk density ρ_1 and ρ_2 at 20 °C. The result of determining the density of milk at 20 °C is written in the formula:

$$P_{am} \pm \Delta\rho_e, \qquad (7.5)$$

where ρ_{am} is the arithmetic mean value of the density at 20 °C, obtained by the pycnometric method, kg/m3; $\Delta\rho_e$ – margin of error of determination of density by the pycnometric method: ± 0.2 kg/m3 for milk.

The titratable acidity of milk is determined in the following sequence. Titratable acidity is measured according to Turner's degrees. Turner's degrees are defined as the number of milliliters of 0.1 n. alkaline solution used to neutralize 100 cm3 of milk. The titratable acidity of fresh milk is on average 16...18 °T.

The titratable acidity of milk from individual animals can vary widely. It depends on the feeding rations, breed, age, individual characteristics of the animal, lactation period, etc. In the first days after calving, the acidity of milk (colostrum) is very high (up to 50 °T) due to the higher content of proteins and salts. Old milk (obtained at the end of lactation) has a low acidity (up to 10 °T). Milk from cows with mastitis also has a low titratable acidity.

In a conical flask with a capacity of 150...200 cm3, 10 cm3 of milk is measured with a pipette, 20 cm3 of distilled water and 3 drops of a 0.1% alcohol solution of phenolphthalein are added, the mixture is thoroughly mixed and titratable with 0.1 mol/dm3 sodium hydroxide (potassium) solution until a slightly pink color appears, which corresponds to the color reference standard and does not disappear within 1 minute.

The acidity of milk in Turner's degrees is equal to the volume in cm3 of 0.1 mol/dm3 of sodium hydroxide (potassium) solution used to neutralize 10 cm3 of milk multiplied by 10. The difference between parallel determinations should not exceed 1 °T.

To prepare the *color control standard*, 10 cm3 of milk, 20 cm3 of water and 1 cm3 of 2.5 % cobalt sulfate solution are pipetted into the same 150...200 cm3 flask. The standard is prepared for use during one shift. For longer storage, one drop of formalin can be added to the standard.

The active acidity, or hydrogen index (pH), is expressed by the concentration of hydrogen ions. The hydrogen index is the negative decimal logarithm of the concentration of hydrogen ions in a solution. The hydrogen index of fresh natural milk, determined by the potentiometric method using a pH meter, is on average 6.6...6.7.

Changes in pH occur due to changes in the concentration of individual components of milk or due to a shift in phase equilibrium.

Its value changes with dilution (increases) or concentration (decreases) of milk, and with heat treatment (slight decrease). Changes in milk pH are most significantly affected by the metabolic processes of lactic acid bacteria.

In production environments, pH measurements should be carried out in cases where the concentration of hydrogen ions has a decisive impact on the quality and yield of dairy products.

Other production parameters also depend on the pH value: the colloidal state of milk proteins and the stability of the milk polydisperse system; conditions for the development of beneficial and harmful microflora and its impact on the fermentation and ripening processes; the state of equilibrium between ionic and colloidal calcium phosphate and the resulting heat resistance of protein substances; enzyme activity; the rate of formation of typical components of taste and odor of certain dairy products; and the cleaning and disinfecting properties of detergents and disinfectants. Thus, pH is a quality indicator for milk and a factor in controlling technological processes.

Determining the acidity of milk by measuring pH (active acidity) is carried out in the following sequence. The acidity of milk can be expressed by the pH value at a temperature of 20 °C. This method is most commonly used to control the acidity of milk in production conditions, for which purpose tables of the ratio of pH and titratable acidity are used. The need for such a comparison is due to the fact that the acidity of milk in the current technological instructions and DSTU is expressed in units of titratable acidity. The average ratios of pH and titratable acidity for whole milk are shown in Table 7.1.

Table 7.1 – Average ratios of pH and titratable acidity for whole milk

Titratable acidity, °T	Raw whole milk	
	pH (fluctuations)	The average pH value
16	6,75...6,72	6,73
17	6,71...6,67	6,69
18	6,66...6,61	6,64
19	6,60...6,55	6,58

End of Table 7.1.

20	6,54...6,49	6,52
21	6,48...6,44	6,46
22	6,43...6,39	6,41
23	6,38...6,34	6,36
24	6,33...6,29	6,31
25	6,28...6,24	6,26
26	6,23..6,19	6,21
27	6,18...6,14	6,16

To determine the active acidity, use a pH-340 device and a universal ionizer EV-74.

Before starting work, check the correctness of the device readings with buffer solutions. Take about 40 cm3 of raw milk (temperature 18...22 °C) into a beaker, immerse the electrodes in it, and take readings on the scale of the device after 10...15 seconds.

To quickly establish the pH of the raw milk, the sample is continuously mixed slightly. The pH measurement results are the arithmetic mean of at least three parallel measurements.

Readings on the scale of the device are taken after the arrow stops. After each measurement, the sensor electrodes are rinsed with distilled water.

The acidity of milk is caused mainly by the presence of acid salts and proteins and is characterized by titratable and active acidity.

Protein determination by the colorimetric method is performed in the following sequence. Pipette 1 cm3 of milk into a glass test tube, add 20 cm3 of dye solution, and, closing the tube with a rubber stopper, mix the contents by inverting the tube 2 to 10 times.

Shaking should be avoided, as this creates a hard-to-destroy foam.

Place the tube in a centrifuge and process it at 1000 rpm for 20 min.

Take 1 cm3 of the supernatant with a pipette, place it in a 50 cm3 volumetric flask, add water to the mark, and mix the contents.

Dilute the dye solution 50 times in the same way.

Measure the optical density of the diluted dye solution with respect to the diluted contents of the measuring flask using a photocolorimeter.

The mass fraction of protein (P) %, is calculated by Eq:

$$P := 7.78 \cdot D - 1.34 \tag{7.6}$$

where D – measured optical density, units of optical density; 7.78 – empirical coefficient of optical density; 1.34 – empirical coefficient%.

The limit of margin of error of the measurement result is ± 0.1% of the mass fraction of protein with a confidence probability of 0.80 and the discrepancy between the two parallel measurements is not more than 0.013 units of optical density or not more than 0.1% of the mass fraction of protein.

The final result is the arithmetic mean of the calculation results of two parallel observations, rounding the results to the second decimal place.

The refractometric method for determining the mass fraction of protein in milk on the AM-2 device is carried out in the following sequence. The determination is based on measuring the limiting angle of refraction on the analyzer scale. To determine the mass fraction of protein, the difference of measurements is taken on the "PROTEIN" scale for milk raw materials and protein-free milk whey.

The device is designed for production control of milk composition with acidity up to 28 ° T.

To determine the mass fraction of protein, measure 5 cm3 of milk into a 10 cm3 vial, add five to six drops of a 4% solution of calcium chloride, close the vial with a rubber stopper and shake slightly. At the same time, two or three more parallel samples are prepared in numbered vials. Vials with plugs are placed in a water bath and boiled for 10 minutes (the water level in the bath should reach half the height of the vials). The vials were then cooled for 2 minutes in a cold water bottle. After that, the vials are removed from the bath, wiped with a napkin and shaken so that the isolated whey mixes with drops of condensate that formed on the inner walls of the vial.

The vials are centrifuged for at least 10 minutes. The resulting transparent serum is pipetted and one or two drops are applied to the measuring prism of the refractometer. The measuring flask is closed. Observing in the eye of the refractometer, a special corrector eliminate the coloring of the border of light and shadow. To improve the sharpness, the measurement limit is carried out 1 minute after the whey is applied to the flask, since during this time air is removed from the sample and the surface of the flask of the device is better wetted.

At least three observations are performed on the PROTEIN scale. The whey is removed from the refractometer flask, washed with water and wiped with filter paper.

Two drops of the examined milk are placed on the measuring flask and at least five observations are made on the PROTEIN scale, since the sharpness of the light and shadow boundary is worse in milk than in whey.

Study of the results. Arithmetic mean of observation results for whey and milk is calculated.

The weight fraction of protein in whole and skimmed milk in percent is calculated by the formula:

$$P = P_m - P_s, \quad (7.7)$$

where Pm, Ps is the arithmetic mean of the results of the study on the PROTEIN scale, respectively, for milk and protein-free whey.

<u>The accelerated method</u> of determining the mass fraction of moisture and solids in milk is carried out in the following sequence. Metal sample bottle with two circles of gauze at the bottom is dried with an open lid at 105 ° C for 20... 30 minutes, then, having closed the lid, cooled in a desiccator for 20... 30 minutes and weighed.

Pipette the test product into the prepared bottle in an amount of 3 cm3, distributing it in a uniform layer over the entire surface, close the lid and weigh with an accuracy of 0.001 g. Then open the sample bottle and put it together with the lid in a drying cabinet, where drying is carried out for 60 minutes, after which the bottle is removed, close the lid, cool in a desiccator and weigh with an accuracy of 0.001 g. Then place the sample bottle in a drying cabinet and continue drying through (20... 30) min, until the difference in weight is ≤0,001 g. dry residue on the surface of gauze should have a uniform light yellow color.

The weight fraction of moisture Mr, in percent, is calculated by the following formula:

$$B=\frac{(M\text{-}M_1)\cdot 100}{M\text{-}M_0},\%, \qquad (7.8)$$

where W0, W, W1 - the weight of the empty sample bottle with the product solution before drying, with the product solution after drying, g.

Mass fraction of dry substances D, in%, is determined by the formula:

$$D = 100 – Mr, \%. \qquad (7.9)$$

Determination of the weight fraction of fat in milk (Gerber's acid method) is carried out in the following sequence. The method is based on the isolation of fat from milk under the action of concentrated sulfuric acid and isoamyl alcohol in the form of a continuous layer and measuring its volume.
10 cm3 of sulfuric acid with a density of 1810... 1820 kg/m3 are poured into a pure milk fat meter, trying not to wet the neck of the fat meter. Pipette 10.77 cm3 of the prepared milk sample. 1 cm3 of isoamyl alcohol is added to the dispenser. The fat meter is closed with a stopper, introducing it a little more than half into the neck of the fat meter, mixed until the protein substances are completely dissolved. Next, the fat meter is placed in a water bath with a temperature of 65... 67 ° C with a cork to the bottom, where it is maintained for 5 minutes. Fat meters are removed from the bath, put in centrifuge cartridges with the working part to the center, placing one symmetrically to the second. With an odd amount of fat meters, a fat meter filled with sulfuric acid and isoamyl alcohol in the same ratio as for analysis is placed in the centrifuge instead of milk. Centrifuge cover is closed and processed for 5 min at rotation frequency 17... 20 s-1. After centrifugation, the fat meters are removed from the centrifuge, the column of fat is adjusted with the movement of the rubber plug so that it is in the outlet part and again placed in the water bath with a temperature of 65... 67 ° C for 5

minutes. The water level in the bath should be slightly higher than the level of the column of fat in the fat meter. After 5 minutes, the fat-meter scale is quickly counted.

The fat meter reading corresponds to the percentage of fat in the milk.. The difference between the two parallel definitions should not exceed 0.1%.

Determination of total bacterial contamination of milk raw materials is carried out in the following sequence. Samples of milk and other milk raw materials for microbiological research and dishes are prepared separately by the laboratory assistant before each lesson.

Bacterial contamination of raw milk is determined by reductase sampling. This test is an indirect indicator of bacillus contamination of raw milk..

The method is based on the ability of reductases – enzymes produced by microorganisms – to discolor (restore) the indicator (methylene blue or resazurin) into their colorless compounds. Bacterial contamination of milk raw material is evaluated by duration of mixture discoloration.

The procedure for determining the reductase sample with blue methylene is carried out in the following sequence. For testing, 1 cm3 of a working solution of blue methylene diluted 10 times and 20 cm3 of the tested milk raw material with a temperature of 20 ° C are poured into sterile tubes. Close with a tight stopper and mix the contents with a three- to fivefold inversion of the tube. Then the tubes are placed in a reducer or on a water bath with a temperature of 37... 40 ° C. The water level in it should be higher than the liquid level inside the test tubes. No light may enter the test tubes during the test. Instead of a water bath, you can use a thermostat with a temperature of 37 ° C. The moment of tube loading into the reducer is considered the beginning of the experiment. Observe the color change at the intervals indicated in Table 2.4, and accordingly determine the milk class and the approximate number of bacteria. The moment of the end of the experiment is considered to be the discoloration of the mixture inside the tubes.

A small annular colored layer on top, or a slight color at the bottom of the tube (width not more than 1 cm) are not taken into account. The appearance of color inside the test tubes after shaking is not taken into account. Depending on the duration of discoloration, blue methylene milk is assigned to one of four classes (see Table 7.2).

Table 7.2. – Milk classes depending on the duration of discoloration of blue methylene

Class of milk	Duration of discoloration, h	Approximate number of bacteria in 1 cm^3 of milk
Higher	Over 3,5	Up to 300 thousand
I	3,5	300... 500 thousand
II	2,5	500 thousand.... 4 million
III	0,6	4…20 млн4... 20 million

Determining the total bacterial contamination of milk raw materials with blue methylene requires a long time. In order to accelerate the reaction, a number of measures are proposed (replacing blue methylene with other dyes, reducing the volume of milk and blue methylene), the most successful method – replacing blue methylene with resazurin.

The reductase sample is determined using resazurin in the following sequence. In fresh milk, resazurin gives a blue-steel color, when restored by the enzymes of microorganisms contained in milk, its color first changes from purple to pink, and then the pink color disappears:

$$C_{12}H_7NO_4 \xrightarrow{D} C_{12}H_7NO_3 \overset{+2H}{\leftrightarrow} C_{12}HNO_3$$

Compared to blue methylene, the reduction reaction (depending on the amount of microflora) with resazurin requires from 1 to 1.5 hours.

Add 10 cm^3 of milk raw material under study, 1 cm^3 of resazurin working solution into sterile tubes, close with sterile rubber plugs and slowly turn over three times, preventing shaking. Milk is painted in blue-steel color. Test tubes, as in the previous experiment, are placed on a water bath protected from light or in a thermostat with a temperature of 37 ° C and mark the beginning of the experiment.

The color change is observed after 1 and 1.5 hours. After 1 hour, tubes with discolored samples of milk raw materials are removed; tubes ranging from gray-lilac to lilac with a grayish tint of color, once inverted and left in a water bath for another 30 minutes. Milk quality is estimated according to Table. 7.3.

Milk of class I, which after 1.5 hours of aging has a color, is attributed to the highest class.

Table 7.3. – Milk classes depending on the duration of discoloration with resazurin

Class of milk	Duration of discoloration,h	Color of milk	Approximate number of bacteria in 1 cm^3 of milk
Higher	1,5	Gray-lilac to lilac with a grayish tint	Up to 300 thousand
I	1	Gray-lilac to lilac with a faint grayish tint	300 - up to 500 thousand
II	1	Gray with a pink tint or bright pink	500 thousand - 4 million
III	1	Pale pink or white	4... 20 million

77.2. Methods for determining the quality of spreads, butter and butter with fillers

The degree of milk fat demulsification is determined in the following sequence. The degree of demulsification of milk fat is determined visually. To do this, weigh 10 g of a sample of high-fat cream or butter, place in a beaker and add a small amount (20... 30 cm3) of distilled water at a temperature of 70... 80 ° C, mix until a homogeneous mixture is obtained. After that, the mixture is quantitatively transferred to a measuring cylinder with a volume of 100 cm3 and brought to the top with hot water of the same temperature. The cylinders are placed in a thermostat and kept at a temperature of 60-65 ° C for 60 minutes until the fat phase is completely separated.

After exposure, determine the volume of the extracted fat phase and mark the appearance of the water phase.

The degree of demulsification of milk fat (D) is determined by the formula:

$$D := \left(\frac{F_{hfc} - V_f \cdot 10}{F_{hfc}} \right) \cdot 100, \% \tag{7.10}$$

where F_{hfc} – mass fraction of fat of initial high-fat cream,%;
V_f - volume of fat phase isolated during thermostating, cm^3.

Determination of titratable acidity of butter is carried out in the following sequence. The acidity of the butter is expressed in Kettstofer degrees, which means the volume of 0.1 mol/dm3 of sodium hydroxide (potassium) solution necessary to neutralize 5 g of oil multiplied by 2.

Weigh 5 g of butter into a conical flask with a capacity of 50 or 100 cm3, slightly heat it in a water bath at a temperature of 45... 55 ° C to melt the butter. Then add 20 cm3 of neutralized alcohol-ether mixture, 3 drops of 1% alcohol solution of phenolphthalein and titrate with constant stirring 0.1 mol/dm3 with sodium hydroxide (potassium) solution to obtain a slightly pink color, which does not disappear for 1 min and corresponds to the color standard.

To prepare a standard, 1 cm3 of 2.5% cobalt sulfate is added to 20 cm3 of the neutralized alcohol-ether mixture, after which the solution is thoroughly mixed.

Determination of the mass fraction of moisture in the butter with the help of special dairy product scales of the brand SMP-84 is carried out in the following sequence. The scales should be in balance when a single 10 g weight is placed on the cup and two small reiterators are suspended from the scale thread with the number ‘0’, one by the hook of the other. If the balance is not in equilibrium, it is balanced by moving the balancing screws along the screw thread.

For weighing 5 g, hang rider on the hook, and on a cup of scales instead of a weight in 10 g put 5 g Check the balance. If necessary, adjust with balancing screws, remove the weight and put the product, the amount of which corresponds to the weight of the removed weight. Removing the glass and holding it with forceps, slowly heat it on the fire. First, the butter melts, and then boils with a characteristic crackle. The end of evaporation can be determined by the cessation of crackling, by the sweating of a cold mirror or watch glass and a slight browning of proteins.

After evaporation, remove the glass from the heating device, cover with a watch glass, cool and place on a cup of scales. Balance the scales by moving the riders to the right. Numbers at the cutting where the riders are located are added. This value is the moisture content in the oil or other product in percent. If you take a weight of 5 g, the sum of the readings of the riders, multiplied by 2, also corresponds to the moisture content.

Determination of the mass fraction of moisture in the butter using technical weights is carried out in the following sequence. Weigh 5 or 10 g of the studied oil into a dry aluminum glass with an accuracy of 0.01 g. The oil is gently heated, maintaining a uniform boiling, preventing foaming and spraying. The glass is held with a special metal holder. The end of evaporation is determined by sweating the glass, which is held over the glass, stopping foaming, crackling and the appearance of light browning. After drying, the glass is covered with lid, cooled and weighed.

Weight percentage of moisture is determined by the formula:

$$B := \left(\frac{W - W1}{W0} \right) \cdot 100 \tag{7.11}$$

where W, W1 – weight of the aluminium beaker with the solution before and after drying, g;

W0 – product solution, g.

The difference between the parallel definitions should not exceed 0.1% for baked butter and 0.2% for cream butter. The arithmetic mean of two parallel determinations is taken as the final result.

Determination of the mass fraction of dry defatted substance in butter using weights of special dairy product SMP-84 is carried out in the following sequence. Mass fraction of dry defatted substance in butter is determined after determination of mass fraction of moisture in it.

The residue in the aluminum glass is heated until the mass melts and then add 50 cm3 of gasoline or ethyl ether. The mixture is thoroughly mixed with a stick and left at rest for 3-5 minutes to separate the precipitate. Particles that are contained on the surface of the solution indicate incomplete evaporation of moisture. In this case, the determination is repeated.

After settling, the clear solution is carefully, preventing scalding, drained, leaving 1-2 sm3 of the solution in the glass. The treatment of the precipitate is similarly repeated three times.

The residue in the beaker is gently heated in a water bath in a fume hood until complete removal of gasoline or ethyl ether, which is determined by the friability of the precipitate, stirring with a stick. The beaker is cooled to room temperature and weighed on a balance, having previously put a weight of 9 grams.

The mass fraction of skimmed milk powder in percentage is determined by the formula:

$$FSMP = (10 - 9 - 0{,}1 \cdot R)\ 10, \qquad (7.12)$$

where R - readings of weights after bringing them into equilibrium.

Determination of the weight fraction of dry defatted substance in butter using technical weights is carried out in the following sequence. The test butter – 10 g of butter or 20 g of ghee - is weighed into a beaker to the nearest 0.01 g. The mass fraction of moisture is determined. After that, the fat is removed and weighed again on a technical scales. Moisture weight fraction is determined. Then fat is removed and weighed again on technical scales.

The mass fraction of skimmed milk powder in percentage is determined by the formula:

$$DDMR := \left(\frac{W - W1}{W - W0}\right) \cdot 100, \qquad (7.13)$$

where W0, W, W1 – the mass of the glass glass with a glass stick is respectively empty, with a solution of butter and with a fat-free substance after removing the fat, g.

The weight fraction of fat in the butter is determined in the following sequence. Weight fraction of fat in butter in percents is determined by calculation method by formulas:

for unsalted butter:

$$Woil = 100 - (M + DDMRoil), \%, \qquad (7.14)$$

for salted butter:

$$Woil = 100 - (M + D\mathit{DMRoil} + S), \%, \qquad (7.15)$$

where Woil – mass fraction of fat in oil,%;

M – mass fraction of moisture in oil,%;

DDMRoil – mass fraction of dry defatted milk residue of butter,%;

S – mass fraction of salt in butter,%.

Determination of heat resistance of spreads and butter is carried out in the following sequence. The heat resistance test is based on the ability of the butter or spread sample to keep its shape at elevated temperatures (30 ° C).

A sample of cylindrical shape with height of 20 mm and diameter of 20 mm is removed from a monolith of butter or a spread by a sampler. Carefully place the samples on a glass plate with sample numbers 20 to 30 mm apart. The plate with samples is placed in an air thermostat, where it is kept at a temperature of 29... 31 ° C for 2 hours.

At the end of the test, the plates with samples are carefully removed from the thermostat, placed on a sheet of paper with millimeter divisions and the lower diameter of each cylinder is determined (Fig. 7.1)

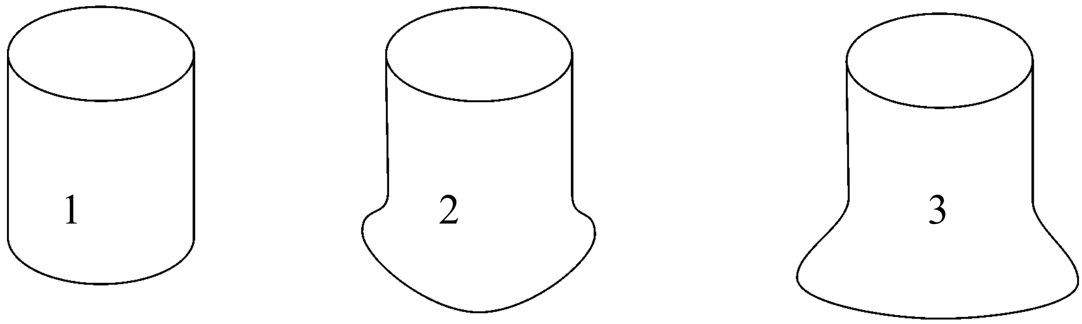


Fig. 7.1. – Scale for determining the heat resistance of butter and spreads:
1 - good; 2 - satisfactory; 3 – unsatisfactory

If the cylinder base has an elliptical shape, the maximum and minimum diameter are measured and the average value is calculated.

The thermal stability of butter is characterized by a coefficient of deformation (Kd), which is defined as the ratio of the initial diameter of the base of the cylinder Do to its diameter after thermostating D:

$$Kd = \frac{Do}{D} \tag{7.16}$$

If the deformation coefficient value is close to one, the butter or spread is characterized by high heat resistance. If this value differs significantly from one, the sample is characterized by low heat resistance. To assess the thermal stability of the samples, the following scale was adopted (Table 7.4.).

Table 7.4. – Scale of assessment of heat resistance of butter and spreads

Evaluation of heat resistance	*Strain factor value*
Good	1,0…0,86
Satisfactory	0,85…0,70
Unsatisfactory	less than 0.70

Assessment of the consistency of butter and spreads of the cut sample is carried out in the following sequence. From the prepared sample of butter or spread with a sharp spatula cut a slice 1.5... 2.0 mm thick 50... 70 mm long and tested for bending and deformation. The scale of visual assessment of the butter consistency by the slice is shown in Fig. 7.2.

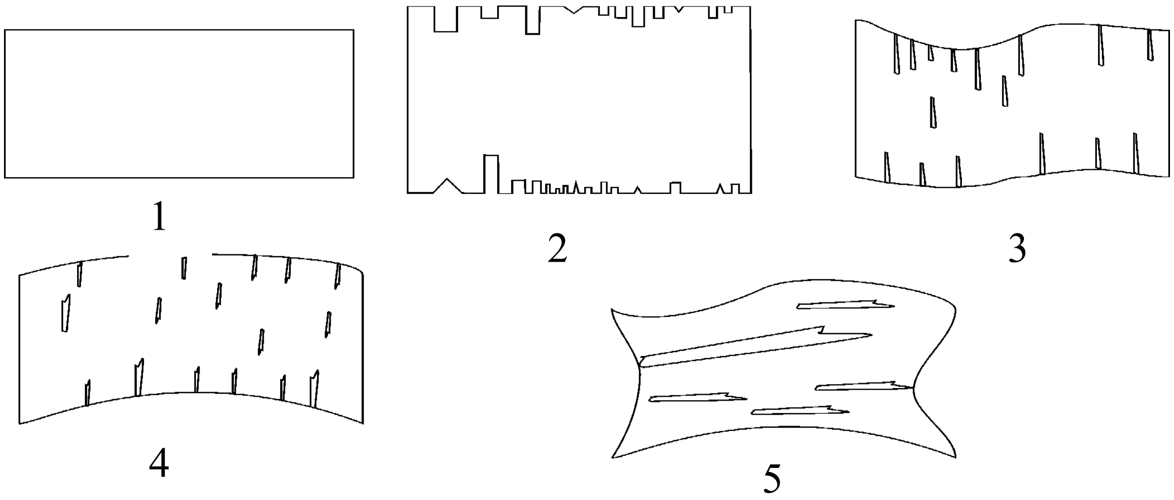


Fig. 7.2. – Scale of visual assessment of butter and spreads of the sample on the cut, consistency:
1 – excellent consistency; 2 – good; 3 – satisfactory;
4 – brittle; 5 – layered consistency

<u>*Determination of moisture distribution and size of its drops in butter and spreads*</u> is carried out in the following sequence. According to the moisture distribution and the size of drops in such products, a conclusion is made about the effectiveness of mechanical processing.

The method is based on changing the color of the bromphenolblau solution upon contact with plasma droplets.

Evaluation of butter and spreads

Evaluation of consistency	*Properties of the plate*
Good	The surface and edges are dense, even, the slice bends when pressed

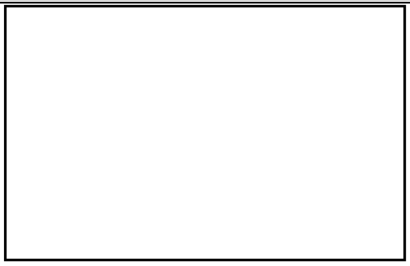
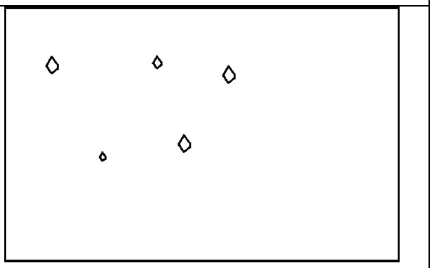
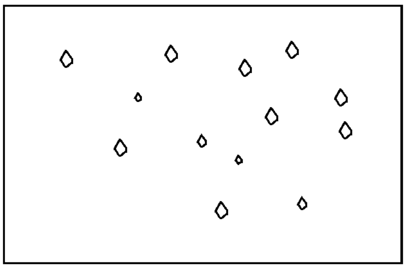
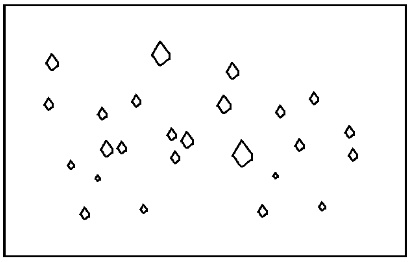
Satisfactory	Withstands a small bend, then breaks
Weakly fragile	The edges are uneven, with easy bending breaks
Fragile	When cutting the slice breaks into pieces
Layered	When cut and bent, it breaks into layers
Too soft	When pressed, it is easy to deform (crumple), the surface is greasy

To determine the fresh cut of butter or spread with forceps it is necessary to apply indicator paper percolated with bromphenolblau and kept for 15... 30 s. Then the indicator paper with forceps lowered into the molten dewatered paraffin to fix the resulting prints of plasma droplets, after hardening of paraffin, quantity and value of moisture droplets are determined. By the number of blue-violet droplets or spots, their size, as well as by the nature of their distribution over the surface of the sample, the distribution of moisture in the product is measuted (Table 7.5).

According to the standard (Table 7.5) in terms of droplet size and distribution, the product is classified as one of four classes.

The nature of the moisture distribution in butter and media is shown in Table 7.5

Table 7.5 - Nature of moisture distribution in butter and spreads

A class	Nature of moisture distribution	Prints on indicator paper	Visualization
I	Good	Not visible	
II	Satisfactory	A small number (3... 5) of evenly distributed drops with a diameter of 0.3... 1.0 mm	
III	Unsatisfactor	More than 5 drops of different sizes with a diameter of more than 1.0 mm	
IV	Unsatisfactory	Many drops and spots with a diameter of more than 3 mm	

Determination of point estimation of butter and spreads by organoleptic indices, quality of marking and marking is carried out in the following sequence. Evaluation of butter and spreads is recommended on a 20-point scale. Evaluation is carried out in the following sequence: first, the quality of packaging and labeling is examined, then organoleptic indicators are determined.

The distribution of points between the individual groups of indicators is given in Table 7.6.

Table 7.6 – Point score of butter and spreads

Name of indicators	*Score, points*
Taste and smell	10
Consistency and appearance	5
Color	2
Packaging and marking	3
Total	20

The total number of points for each group of indicators may vary depending on what shortcomings in determining the quality of packaging and labeling, as well as defects in butter or spreads were identified. The scale of the point score of butter and spreads is given in Table. 7.7.

Table 7.7 – Butter and spreads score scale

№	Name and characteristics of the indicator	Score, points	
Taste and smell (10 points)			
1.1	Excellent	10	10
1.2	Good	9	9
1.3	Pure but not sufficiently expressed	8	8
1.4	Unexpressed (empty)	7–6	7–4
1.5	Low-fodder	6–4	3–2
1.6	Slightly burnt	4	–
1.7	Taste of melted oil	3	–
1.8	Slight bitterness	3	3–2

Table 7.7 continued.

1.9	Sour taste for sweet cream butter and too sour for sour cream	3	–
1.10	Uneven brackish (for salted butter)	3	–
1.11	Slightly stale	2	2
1.12	Weakly expressed greasy	2	2
Consistency and appearance (5 points)			
2.1	Excellent	5	5–
2.2	Good: homogeneous, but not plastic enough and dense, with the presence of small drops of moisture on the cut for butter and spread; insufficient granular for melted butter	4	4
2.3	Satisfactory: small drops of moisture on the cut of butter; weakly expressed, fragile, for village oil; slightly heterogeneous and flour, the presence of liquid fat - for ghee	3	3
2.4	Slightly expressed for salty and unsalted butter and extra spread: fragile chubby	 2 3	 – –
2.5	Weakly expressed: stratification, flour, soft for butter and village spread.	3–2	–
2.6	Loose and brittle for butter and village spread, heterogeneous for ghee	2	2
2.7	Weak, greasy	2	–
2.8	Large drops of moisture on the cut for butter and spreads	1	–
2.9	Insoluble salt in salted butter	1	–
2.10	Melted butter surface	1	–

End of Table 7.7.

Color (2 points)			
3.1	Homogeneous	2	–
3.2	Heterogeneous	1	–
Packing and marking (3 points)			
4.1	Appropriate	3	–
4.2	Satisfactory: small, single cavities inside the monolith, small defects in the processing of packaging material	2	–
4.3	Deformation of monolith surface	1	–

It is not allowed to sell butter and spreads characterized by rancid, moldy, putrid, curd, fishy taste and smell, taste and smell of petroleum products, medicines, as well as with pronounced fodder, impure, stale, metallic, salty, oily taste and smell. If these defects of taste and smell are detected, butter or spread cannot be further evaluated.

It is not allowed to sell butter and spreads in dirty damaged containers, in violation of the labeling rules on consumer or transport containers.

7.3. Specific methods for determining the indicators of spreads and butter

Determination of optical number by O.G. Chernova is carried out in the following sequence. The method is based on the selective ability of unsaturated compounds to refract and absorb light in the visible region of the spectrum.

The optical number is a conditional constant that characterizes the optical properties of milk fat to refract and absorb light in the visible region of the spectrum. It is necessary for the qualitative characteristics of fat, as well as for finding the degree of its saturation.

Milk fat in a melted state is placed in a cuvette with a layer of 1 cm thick, thermostated at temperature 55... 60 ° C for 5... 10 minutes and the optical density isdetermined using a photoelectrocolorimeter or spectrophotometer at a wavelength of 450 nm with respect to distilled water. For each sample, 3... 4

readings are taken, preventing fat cooling above 30 ° C and finding the average value of optical density D.

To determine the refractive index of milk fat, the cuvette is removed from the device, fat is taken out of it with a pipette or a glass stick and 3... 4 drops are applied to the prism of a pre-heated universal refractometer to determine the refractive index of milk fat (P). Measurements are carried out at a temperature of 50 ± 0.1 ° C.

Counting in units of the device scale is carried out by thermostating the fat in the device for 3... 5 minutes.

For each sample, take 3-4 samples and take average values (P^{50}). Optical number is calculated from obtained values of optical density and indices of fat refraction:

$$\text{o.n.} = D + P^{50}$$

O.n. is directly dependent on the iodine number, which characterizes the amount of unsaturated triglycerides of milk fat.

For non-colorless unsaturated fatty acids in the locations of double bonds, optical isomerism is characteristic – the ability to refract light, and for unsaturated compounds stained with natural pigment (carotene), light absorption is characteristic.

Determination of iodine number of milk fat by the Ganus method

The method is based on the fact that unsaturated fatty acids have the ability to attach halides bromine and iodine at the double bonds. The ability of halides to saturate double bonds under certain conditions allows us to quantify the degree of fat saturation..

When determining the iodine number by the Ganus method, a solution of iodine bromide in anhydrous acetic acid is used:

$$I_2 + Br_2 \xrightarrow{CH_3COOH} 2BrI$$

Iodine bromine is reacted with fat dissolved in chloroform or carbon chloride as follows:

$$CH_3(CH_2)_7 - CH = \mathrm{CH}(CH_2)_7 - COOH + BrI \rightarrow$$
$$\rightarrow CH_3(CH_2)_7 - CHBr - CHI(CH_2)_7COOH$$

Iodine bromine is maintained with fat for 0.5... 1 hour, then potassium iodine solution and distilled water are added. At the same time, free iodine is released from iodine bromine that has not reacted with fat:

$$KI + BrI = KBr + I_2$$

The separated iodine is titratable with 0.1 N hyposulfite solution:

$$I_2 + 2NaS_2O_3 = 2NaI + Na_2S_4O_6$$

In parallel, a control experiment is carried out with the same solutions, but without fat. By the difference between the results of the first and second titration, the amount of iodine reacted with fat is found.

About 0.5 g of transparent fat melted at a temperature of 50... 60 ° C and filtered through a dry filter is measured on an analytical scale into a flask with a ground glass stopper, into which 10... 15 cm3 of chloroform is added. From the pipette Ganus solution is poured into the flask after dissolving the fat 25 sm^3. The flask is closed with a stopper, and left in a dark place for 30 minutes, periodically shaking. Then add 10... 15 cm^3 of the CT solution to the flask, mix thoroughly and add 100 cm^3 of freshly boiled and cooled water, rinsing the cork with it. The mixture is shaken and the separated iodine, not bound to fat, is titratable with 0.1 N hyposulfite solution, adding it gradually with constant shaking until a slightly yellow color appears.

After that, a few drops of 1% starch solution are added and titration is continued dropwise until the blue color disappears. Before the end of titration, the flask is closed with a stopper and shaken until iodine is detected.

In parallel, a control experiment is conducted with all reagents in the same amount, but without fat.

Iodine number:

$$x = 1.269\frac{V_0 - V_1}{G} \tag{7.17}$$

where 1.269 – exactly 0.1 N titer of the hyposulfite iodine solution multiplied by 100; – volume of 0.1 N hyposulfite solution used for iodine titration in the fat solution and in the control sample, mL; G – weight of the fat solution, g.

Determination of the iodine number by the accelerated method with an alcohol solution of iodine (Margoshes method) is carried out in the following sequence. The method is based on the hope of an alcoholic iodine solution in the presence of water:

$$I_2 + HOH = HI + IOH$$
$$CH_3(CH_2)_7 - CH = CH(CH_2)_7 - COOH + IOH \rightarrow$$
$$\rightarrow CH_3(CH_2)_7 \bullet CHI \bullet CH(OH)(CH_2)_7COOH$$

Under normal conditions, the reaction between iodine and water hardly passes, but when IOH is applied to an attaching of double bond in place, the reaction is easy and fast. Unreacted iodine is titratable with 0.1 N hyposulfite solution without addition of potassium iodide. The iodine number is determined by the difference between the iodine content in the control and working experiments, it is determined per 100 g of fat.

Weigh 0.3... 0.4 g of fat into a dry conical flask with an accuracy of 0.001 g, add 30... 40 cm^3 96% alcohol and place in a water bath heated to a temperature of 40... 50 ° C, until the fat is completely dissolved. To avoid alcohol losses, the flask is closed with a cork stopper with a long glass tube of about 0.5 m. After dissolving the fat, the flask is removed from the bath and allowed to cool to room temperature. Then 25 cm^3 0.2 N of alcohol iodine solution and 200 cm^3 of distilled water with temperature 20 ° C are added from pipette to fat solution. The flask is closed with a stopper, the solution is shaken and left at rest for 5 minutes. after 5 minutes, the iodine solution is titratable with 0.1 N hyposulfite solution.

Titration is carried out rapidly. To do this, first, the hyposulfite solution is poured from the flask until the fat is colored yellow, then added as an indicator 0.5 cm^3 of 1% starch solution and titratable with hyposulfate dropwise until complete discoloration of the solution.

At the end of titration, a flask with a grated stopper is measured with 30... 40 cm^3 of a 96% alcohol solution, 25 cm^3 of a 0.2 N iodine solution and 200 cm^3 of water under the same conditions as in the experiment. The resulting liquid is titratable with 0.1 N sodium sulfate solution in the presence of 0.5 cm^3 of a 1% starch solution.

Iodine number:

$$I = \frac{(a - b) * 0{,}01269 * 100}{c} \qquad (7.18)$$

where a, b is the volume of 0.1 N sodium thiosulfate solution, for titration of iodine in a blank sample and a sample with fat, mL;
0.01269 – weight corresponding to 1 ml of exactly 0.1 N solution, g;
c – weight of fat solution, g.

The refraction number is determined in the following sequence. The determination is made in a special butter or universal refractometer at a certain temperature. For milk fat set temperature 40 ° C, which is maintained in the refractometer during the entire experiment.

In a special butter refractometer, the amount of refraction is determined as follows: set the refractometer and heating the prisms with a stream of water to a temperature of 40 ° C, use a glass stick to apply 3 drops of filtered milk fat to the horizontally installed surface of the lower prism, then press it to the top, closing with a lid.

The light beam is directed by a mirror to the refractometer prism and, if necessary, moving the eyepiece up or down, the divisions of the scale through which the boundary line passes, separating the left illuminated part of the field of view from the right dark one, are counted. Pointer of micrometer screw divisions must stand at 0. If the boundary line does not coincide exactly with the division of the scale, this must be achieved by turning the micrometer screw. In this case, it is necessary to add tenths counted on the screw to the integer number of divisions.

When working with a universal refractometer, in which the fat prism is applied in the same way as in an butter refractometer, the determination is carried out in a similar way, but only on the scale the refractive index value is counted, which, if necessary, is converted to the number of refraction according to Table 7.8.

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Table 7.8 – Conversion of fat refractive index values to refraction numbers

Optical distortion coefficient	Index of refraction	Fourth decimal mark									
		0	1	2	3	4	5	6	7	8	9
1	2	3	4	5	6	7	8	9	10	11	12
1,45	36	7	8	0^x	1^x	2^x	4^x	5^x	7^x	8^x	9^x
1,451	38	1	2	3	5	6	7	9	0^x	2^x	3^x
1,452	39	5	6	7	9	0^x	1^x	3^x	4^x	6^x	7^x
1,453	40	9	0^x	1^x	3^x	4^x	5^x	7^x	8^x	0^{xx}	1^{xx}
1,454	42	3	4	5	7	8	0^x	1^x	3^x	4^x	6^x
1,455	43	7	9	0^x	2^x	3^x	4^x	6^x	7^x	9^x	0^{xx}
1,456	45	2	3	5	6	7	9^x	0^x	2^x	3^x	4^x
1,457	46	6	7	9	0^x	2^x	3^x	5^x	6^x	7^x	9^x
1,458	48	0	2	3	5	6	8	9	1^x	2^x	4^x
1,459	49	5	7	8	0^x	1^x	2^x	4^x	5^x	7^x	8^x
1,46	51	0	1	3	4	6	7	9	0^x	2^x	3^x

End of Table 7.8.

1,461	52	5	7	8	0^{x}	1^{x}	3^{x}	4^{x}	6^{x}	7^{x}	9^{x}
1,462	54	0	2	3	5	6	8	0^{x}	1^{x}	3^{x}	4^{x}
1,463	55	6	7	9	0^{x}	2^{x}	3^{x}	5^{x}	6^{x}	8^{x}	9^{x}
1,464	57	1	3	4	6	7	9	0^{x}	2^{x}	3^{x}	5^{x}
1,465	58	6	8	9	1^{x}	2^{x}	4^{x}	5^{x}	7^{x}	8^{x}	0^{xx}
1,466	60	2	3	5	6	8	9	1^{x}	2^{x}	4^{x}	5^{x}
1,467	61	7	8	0^{x}	2^{x}	3^{x}	5^{x}	6^{x}	8^{x}	9^{x}	1^{xx}
1,468	63	2	4	5	7	8	0^{x}	2^{x}	3^{x}	5^{x}	7^{x}
1,469	64	8	0^{x}	1^{x}	3^{x}	4^{x}	6^{x}	7^{x}	9^{x}	1^{xx}	2^{xx}
1,47	66	4	5	7	8	0^{x}	2^{x}	3^{x}	5^{x}	7^{x}	8^{x}
1,471	68	0	1	3	4	6	7	9	1^{x}	2^{x}	4^{x}
1,472	69	5	7	9	0^{x}	2^{x}	3^{x}	5^{x}	7^{x}	8^{x}	0^{xx}
1,473	71	1	3	4	6	8	9^{x}	1^{x}	2^{x}	4^{x}	5^{x}
1,474	72	7	9	0^{x}	2^{x}	3^{x}	5^{x}	7^{x}	8^{x}	0^{x}	0^{x}
1,475	74	3	5	6	8	0^{x}	1^{x}	3^{x}	5^{x}	6^{x}	8^{x}
1,476	76	0	1	3	5	7	8	0^{x}	2^{x}	3^{x}	5^{x}
1,477	77	7	9	1^{x}	2^{x}	4^{x}	6^{x}	7^{x}	9^{x}	1^{xx}	2^{xx}
1,478	79	4	6	8	0^{x}	1^{x}	3^{x}	5^{x}	6^{x}	8^{x}	0^{xx}

The following rules apply when using Table 7.8. In the 1st vertical row, refractive index numbers obtained using a refractometer are indicated, while the 4th decimal mark is placed in the upper horizontal row above the digits. The refractive integers are opposite to the corresponding refractive index numbers vertically. The 1st decimal mark of the refraction number is found at the intersection of the horizontal line from the refractive index number located in the lateral part of the table and the vertical line from the 4th decimal mark of the refractive index located at the top of the table.

If the found digit of the 1st decimal place of the refraction number has one asterisk, the whole number of refraction is taken in the order of reference; if there are two asterisks, the whole number of refraction is taken through one in order of reference. For example, the refractive index of 1.4693 corresponds to a refractive index of 65.3.

The peroxide number (simplified iodometric method) is determined in the following sequence. When storing butter, oxidative processes occur in it, as a result of which peroxides are made. In fresh fat, peroxides are absent, but they appear relatively quickly with the access of oxygen.

The method is based on the interaction of fat containing organic peroxides, iodine is released with iodic acid, which is titratable with hyposulfite. Hydroiodic acid results from a reaction between potassium iodide and acetic acid:

$$KI + CH_3COOH \leftrightarrow HI + CH_3COOK$$

$$P - CHOOH - CH = CH - P + 2HI \underset{I_2}{\leftrightarrow} P - CH(OH) - CH = CH - P - H_2O$$

Into a flask with a capacity of 100 cm3 add 1 g of molten fat, dissolve it in 6 cm3 of chloroform and acetic acid taken at a ratio of 2:1, add 1 cm3 of an aqueous solution of potassium iodide saturated in cold, and, closing the flask with a stopper, shake for 3 minutes.

The separated iodine is titratable with 0.01 N sodium thiosulfate solution using 3... 5 drops of 1% starch solution as an indicator. Simultaneously, a control sample is carried out, repeating the determination, but without fat.

The peroxide number is expressed by the number of milliliters of 0.01 N sodium thiosulfate solution used for titration of iodine oxidized with peroxides from 1 g of fat and calculated by the formula:

$$P = (a - b) * C \qquad (7.19)$$

where a, b is the volume of 0.01 N sodium thiosulfate solution used for titration of 1 g of fat and in the control test, ml; C – coefficient up to 0.01 N of sodium thiosulfate solution.

The peroxide number can be expressed in grams of iodine per 100 g of oil, then the calculations are carried out according to the formula:

$$P = (a - b) * 0,001269 \tag{7.20}$$

$$100 = (a - b) * 0,1269 \tag{7.21}$$

where 0.001269 is the mass of iodine in 1 g, which corresponds to 1 cm30.01 N of sodium thiosulfate solution.

<u>Determination of degree of milk fat spoilage by reaction with neutral red according to A.G. Chernova</u> is carried out in the following sequence. The method is based on the ability of free fatty acids to enter into a color reaction with neutral red.

A sample of butter weighing 15... 15 g is melted in a cup at a temperature of 55... 60 ° C. The separated fat is drained into another glass, dehydrated by adding 0.3... 0.5 g of anhydrous sodium sulfate and filtered in a thermostat at a temperature of 55... 60 ° C through a dry folding filter. Purified fat in a volume of 0.5... 1.0 cm3 is poured into a small porcelain mortar and cooled in a refrigerator to a temperature of 0... 5 ° C. Sufficiently cooled fat is considered to have a solid consistency and when cut with a knife gives an even and sharp edge. At the same time, a 0.01% solution of neutral red is prepared on boiled water and placed in a refrigerator to cool to 0... 5 ° C. Cooled fat in a mortar is poured 1... 2 cm3 of freshly prepared neutral red solution and triturated for 1 minute at room temperature. The solution is then drained. The remaining drops are washed off with cold water and the color of the treated fat is determined. The degree of fat damage is determined by color using the information from Table 7.9.

Table 7.9 – Degree of fat damage

Color of fat	Quality of fat	Degree of freshness
Lemon yellow, pale lemon yellow, yellow	Fresh	I
Pale yellow, pale honey, straw yellow	Fresh, not subject to storage	II
Yellow-orange, purple-yellow, cream, light yellow	Doubtful freshness	III
Pink with different shades	Spoiled	IV

<u>Note.</u> The degree of spoilage of milk fat, determined by the color with neutral red, practically corresponds to the degree of oxidative spoilage established by the peroxide number.

The method of establishing the spoilage of milk fat by reaction with neutral red along with the second indicators characterizing the degree of spoilage, partly with the acidity of fat, is recommended to supplement and clarify the organoleptic characteristics of butter, ghee and other fat-containing dairy products.

<u>The degree of use of fat</u> is carried out in the following sequence. Determine the degree of use of fat, showing how much of the fat of the raw material (cream) has passed into the finished product (butter or spread). The degree of fat use,%, is calculated by the formula:

$$DFU := \frac{(Wc \cdot Woil - Wmass \cdot Fmass) \cdot 100}{Wc \cdot Woil} \quad (7.22)$$

where DFU – degree of fat use,%; Wc, Woil - weight of cream and buttermilk, kg, respectively.

The results are fat balance:

$$Wc \cdot Woil := Wmc \cdot Fmc + Msk \cdot Fsk + Lactualf \quad (7.23)$$

Where $L_{actualf}$ – actual fat loss, kg;

Calculate the fat loss as a percentage of the weight of fat in the original cream (L_f):

$$Lf := \left(\frac{Lactualf}{Wc \cdot Woil} \right) \cdot 100 \tag{7.24}$$

The obtained results are analyzed, possible sources of excess fat losses and ways of their reduction are explained.

Determination of acidity of butter plasma is carried out in the following sequence. In a dry clean chemical glass with a capacity of 200... 300 cm3 weigh about 150 g of butter. The glass is placed on a water bath and heated to a temperature of 55... 60 ° C, kept until complete melting and separation of butter into fat and plasma. Next, the glass with the capacity is removed from the water bath and the layer of fat is carefully drained. The plasma remaining in the glass is pipetted into a fat meter, which is tightly closed with a rubber stopper, placed in a centrifuge and processed for 5 minutes.

After centrifugation, the fat meter with the capacity is placed in a measuring glass with cold water, held until the milk fat solidifies, which was separated from the plasma during centrifugation. Fat-free plasma is carefully poured into a dry clean glass and thoroughly mixed with a glass stick. In two other clean glasses or flasks with a capacity of 100 cm^3, pipette 5 cm^3 of butter, add 10 cm^3 of water with a pipette.

The resulting mixture is washed 3-4 times with a pipette, 3 drops of phenolphthalein are added and titrated with 0.1 N sodium hydroxide (potassium) solution until a slightly pink color does not disappear for 1 minute.

The acidity in Turner degrees is equal to the number of milliliters of 0.1 N hydroxide solution (potassium), which was spent on neutralizing 5 cm3 plasma multiplied by 20.

Free liquid fat is discharged in the following sequence. The amount of fat that has leaked (M_{LF}) characterizes the ability of the spread structure to hold it. A sample of the spread in the form of a cube with a rib length of 3.5 cm (samples can be of other shapes and sizes) is placed on 5 layers of filter paper laid in a Petri dish (a Petri dish with filter paper is weighed). Further, in a thermostat at a temperature of 25 ° C, the "cubes" are kept for 30 minutes and the remnants of the spread are carefully removed from the paper. The amount of leaked fat (%) is determined by the formula:

$$M_{LF} = (c - a) * 100 / (b - a), \qquad (7.25)$$

where a, b, c is the mass of the Petri dish with filter paper, with filter paper and spread cube, with fat-percolated filter paper, respectively.

Butter mold resistance is determined in the following sequence. To do this, a sample is taken from the butter monolith with a forceps, from which pieces 3... 4 cm long are cut off with a spatula and put in flask. Flask with butter is placed in a desiccator, at the bottom of which a small amount of water is added.

The desiccator is tightly closed with a lid and placed in a dark place (at a temperature of 20 ° C). Every day, inspect the surface of the test oil samples and note the appearance of mold. The absence of mold after 14 days indicates the relative resistance of the butter to mold.

Determination of the degree of spoilage of milk fat by reaction with neutral red is carried out in the following sequence. A sample of butter weighing 10... 15 g is melted in a cup at a temperature of 50... 60 ° C and left alone to separate the butter into fat and plasma. Melted fat is drained into a dry glass, dehydrated by adding 0.3... 0.5 g of anhydrous sodium sulfate and filtered in a thermostat at temperature 50.. 60 ° C. The obtained milk fat in an amount of 0.5... 1.0 cm3 is poured into a porcelain mortar, placed in a refrigerator with a temperature ranging from 0 to 5 ° C and maintained until hardening. Fat should have a solid consistency and when cut with a knife give even, sharp edges.

Cooled fat in mortar is poured into 1... 2 sm^3 of freshly prepared 1.01% solution of neutral red on tap water (pH 7.0... 7.2), cooled to temperature 0... 5 ° C, and triturated in mortar for 1 min at room temperature. Then the solution is drained, the drops are washed off with cold water and the degree of fat damage is determined by the acquired color (Table 7.10).

Table 7.10. – Degree of fat damage

Coloring	Freshness of fat
Lemon yellow, pale lemon yellow	Fresh
Pale yellow, pale honey, lemon yellow	Fresh but not for storage
Yellow-orange, orange-yellow, cream, light yellow	Doubtful freshness
Pink with different shades	Spoiled

The procedure for determining the consistency of the butter by cutting is carried out in the following sequence. For the study, a sample of butter weighing 100... 200 g is taken, cooled and maintained at minus temperature during the day to complete the processes of crystallization of fat and structure formation. If the experiment received butter after cold storage, the exposure to sub-zero temperatures is not required.

A sample of frozen butter prepared for analysis is defrosted at room conditions to a temperature of 5 ° C and a sample is cut off from it in the form of a bar 5... 7 sm long and 2... 3 sm thick and additionally kept in a refrigerator at 5 ° C for 1 hour. A butter slice 1.5... 2 mm thick, 5... 7 sm long is cut off from the prepared sample with a sharpened spatula and examined for bending and deformation. By the appearance of the cut surface and the nature of the deformation of the slice, the consistency is established according to the scale given in Table. 7.11.

Table 7.11 – Rating scale

Consistency	Characteristics of the cut
Good	Dense, flat surface of the cut, with a slight pressure, the oil plate bends, withstands a slight bend, slowly breaks
Weakly fragile	The butter slice has uneven edges, with a slight bend breaks
Fragile	When cut, the slice breaks into pieces
Layered	When cut and bent, the butter slice is divided into layers
Too soft	Butter slice under pressure is easily deformed (crumpled), the surface looks greased

To detect the degree of low-melting capability of butter, the rest of the sample is kept at room conditions to achieve 15 °C temperature. Then cut off the slices with a thickness of 1.5... 2.0 mm and check them for elasticity, plasticity and bending. If, with a slight pressure, the butter slice crumples and the edges at room temperature (20... 24) °C melt – the oil is excessively soft, prone to melting.

Using this method, each batch of oil obtained is controlled at the butter plant. Machining should be considered complete if the pattern of the indicator paper corresponds to class I and II.

Attachments

ATTACHMENT 1

Loss rates during cream production at plants and in separator departments

Operations	Loss rate at separator capacity of 5000 kg of milk per 1 hour or more, %
Weighing and cleaning milk at the time of acceptance	0,02
Heating and separation of milk	0,17
Cream cooling	0,08
Storage of cream, filling of tanks	0,07
Analysis and evaluation of cream quality	0,04
Total...	**0,38**

ATTACHMENT 2

Loss rates during cream processing into butter

Operations	Loss rates during butter production			
	by the method of processing high-fat cream on equipment with a capacity of 600 kg of butter per 1 hour or more	by the method of churning on butter-making machines		
		continuous operation with a capacity of 1000 kg of butter per 1 hour or more during packaging in:		batch operation with a capacity of 5000 dm^3 or more
		blocks	briquettes	
Weighing and cleaning cream	0,02	0,02	0,02	0,02
Cooling and storage of cream	0,13	–	–	–
Pasteurization of cream	0,06	0,09	0,09	0,09
Cream separation	0,16	–		–
Processing of cream in butter makers	0,05	–	–	–
Cooling and maturation of cream	–	0,13	0,13	0,13
Cream churning	–	0,10	0,10	0,04
Analysis and evaluation of cream and butter quality	0,04	0,04	0,04	0,04
Butter discharging	–	–	–	0,01
Packing of butter	–	0,12	0,20	–
Total...	0,46	0,50	0,58	0,33

ATTACHMENT 3

Target indicators of butter

Name of the indicator	*Type of butter*		
	extra	*village*	
Target fat content in butter (selected in accordance with the current order), %.	82,7	73,1	78,3
Mass fraction of fat in butter, %.	0,7	0,7	0,4
Mass fraction of fat in cream, %.	38,0	38,0	35,0
Maximum permissible fat losses (%) in butter production by the method of churning, processing of high-fat cream	0,58*	0,50*	0,46
Maximum permissible fat loss (%) in butter production by the following method: churning, processing of high-fat cream	2,0	2,0	2,0

Notes. * – 0.58% – maximum permissible fat loss in butter production in case of small packaging, 0.50% - maximum permissible fat loss in butter production in case of its packaging in blocks.

ATTACHMENT 4

Results of calculations

Name of raw materials	*Weight of components for the production of Pectin butter*	
	per 1000 kg	*per actual weight*
High-fat cream (mass fraction of fat 77.0%)	938,9	1127,4
Butter (mass fraction of fat 0.4%)	59,9	71,92
Pectin	4,20	5,04
Total of the mixture	1003,00	1204,37
Product yield	1000,00	1200,76

SUBJECT INDEX

GLOSSARY

Absolute weight – the weight of 1000 grains in grams.

Cream –fatty emulsion obtained from milk by separation, settling or other means.

Pasteurized cream – cream with a mass fraction of fat of at least 8%, processed under appropriate temperature conditions.

Raw cream – homogeneous fat emulsion of milk fat in plasma obtained from raw milk by separation, cooled, and intended for further processing.

Maturation – process during which physical and chemical transformations occur to form the structure, aroma, taste and other characteristics characteristic of a particular type of product.

Homogenization –processing of milk (cream), which consists in dispersing fat globules by applying significant external forces to milk.

Electrodialysis –transfer of ions from one solution to another through a membrane under the influence of an electric field created by electrodes located on both sides of the membrane.

Pasteurization efficiency – ratio of the number of bacteria killed by pasteurization to the number of bacteria in the original milk expressed as a percentage.

Sourdough starter, sourdough starter preparation – single, multi-component or symbiotic combinations of microorganisms.

Freezing – separation of ice crystals from a solution, which changes the physical and chemical properties of milk and dairy products.

Contamination – presence of undesirable impurities in the grain, which reduces the nutritional value of the grain and worsens the taste.

Butter churning – production method based on the formation of butter grains and their transformation into a layer of butter.

Reverse osmosis – separation of solutions through semipermeable membranes with pores less than 50 nm in size at a pressure of 1...10 MPa.

Legumes – group of crops that includes peas, soybeans, beans, peanuts, etc.

Grain impurities – broken and gnawed grains of the main crop (if half a grain remains)

Calibration – separation of fruits by size.

Cream butter – butter made from cream and/or milk processing products, which has a specific inherent taste, smell and plastic consistency at a temperature of (12±2) °C, with a milk fat content of at least 61.5%, which is a homogeneous emulsion of the "water in fat" type.

Butterfat formation – complex of physical and chemical processes (milk fat solidification, phase transformation, structure formation) that occur during cooling and mechanical processing of cream.

Buttermilk – product of milk processing, which is a cream plasma obtained during the processing of cream into butter.

Dietary buttermilk – fermented milk drink produced by fermenting natural fresh buttercream (obtained in the production of sweet cream butter from pasteurized cream) with a mixture of lactic acid streptococci and acidophilus bacillus of mucous races.

Buttermilk – cream plasma obtained during the processing of cream into butter.

Skimmed milk – part of milk that is obtained after cream separation.

Milk powder – dry dairy products obtained by condensation and subsequent drying to a mass fraction of solids in the dry product of at least 95%.

Raw milk – milk without removal and/or addition of any substances and/or certain components, subjected to preliminary physical cleaning from mechanical impurities, cooling and intended for further processing.

Milk raw materials – milk that has been subjected to preliminary physical processing (filtration, cooling), as well as any dairy products that contain exclusively milk components and can be used in the production of other products.

Hopped wort – complex polydisperse system (dispersed colloids, suspensions, emulsions and molecularly soluble substances).

Cooling – process of reducing the temperature of a product to meet the requirements of technological processes.

Milk purification – separation of mechanical impurities and/or microorganisms from milk.

Pasteurization – process of heat treatment of milk at a temperature that reduces the number of microorganisms in milk.

Beer – low-alcohol beverage produced from malt and ungerminated cereals (barley, wheat, corn, rice, triticale, etc.) by alcoholic fermentation of the hopped wort with brewer's yeast..

Milk ingredients – milk fat, proteins, lactose, vitamins, salts, water, etc.

Spread – fatty food product (water-in-fat emulsion) consisting of milk and vegetable fat with a mass fraction of total fat from 50 to 85% and in which the share of milk fat is not less than 25% of total fat, with a dense or soft consistency with (without) the addition of food additives, fillers and vitamins.

Heat treatment – one of the main technological operations of milk processing, which is carried out to produce dairy products that are safe in terms of microbiological indicators.

Technology – set of knowledge about modern methods of processing raw materials to produce a high quality finished product at the lowest cost.

Ultrafiltration – pressure filtration using semi-permeable membranes made from synthetic polymeric (cellulose acetate, polyamide, polysulfone) and ceramic materials.

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