PHARMACEUTICAL BROMATOLOGY

LECTURES FOR ENGLISH-SPEAKING STUDENTS

The manual for students of higher schools

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The lectures contain the main theoretical material in pharmaceutical bromatology. The general characteristic of food products is given in accordance with the main nutrients. Quality parameters, nutritional values and drug-food interactions are given for all main food products. For the 4th year English-speaking pharmaceutical students.


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INTRODUCTION

Proper nutrition is the basis of the human health. It is the food we take that provides development and renewal of the body’s cells and tissues, physical and mental fitness; it is a source of energy that our body spends not only during exercise but also at rest. Food products are the sources of substances, from which enzymes, hormones, and other regulators of metabolic processes are synthesized.

The WHO now considers the nutrition of more than 70% of the world population (about 6 billion) to be inadequate. But the food is the basis of life, the basis of health, and the main factor that determines the longevity and efficiency. And the quality of food is one of the most important elements of proper nutrition.

This manual is intended for students of pharmaceutical higher schools and pharmaceutical faculties of medical higher schools. The book consists of 16 chapters, which describe the basic food groups, such as drinking and mineral water, milk and dairy products, eggs and egg products, meat, fish and seafood, fruits and fruit juices, vegetables, bread and bakery products, cereals, chocolate, tea, coffee, sugar, honey, alcoholic beverages, and food additives.

Each chapter provides the classification, chemical composition, methods of falsification; the quality parameters of each food group are described, as well as quality control of the main components.

One of the most important aspects of a successful pharmacotherapy is the prescription of drugs taking into account their possible interaction not only with other drugs but also with components of food and liquids used to take medicines. The interaction of drugs and different food products can significantly affect the pharmacological effect. The qualitative composition of food can both improve the effectiveness of the drug and provoke undesirable side effects. Therefore, one of the sections of each chapter is description of the pharmacist’s recommendations for the rational use of food described and different groups of drugs.

At the end of each chapter there are questions and tests for self-training. It gives the possibility to understand deeply and remember the information contained in the section, and to master the essence of the issues given in it.
CHAPTER 1

DEFINITIONS AND CONCEPTS OF BROMATOLOGY

Bromatology - (from the Greek “Broma” – food) – is the science about food products, studying the chemical composition of food products and their changes under the influence of various factors (chemical, physical, biochemical); it is engaged in the quality control of food products, including the raw material, semi-products and related materials, as well as the study of the relationship between the structure and properties of food substances with drugs, which is especially important for a pharmacist.

Food products are objects of animal or vegetable origin used in food in natural or processed form as a source of energy, food and flavouring substances.

Food products are divided into:
- products of mass consumption of traditional technology designed for regular use in nutrition of the general population;
- consumer products with the changed chemical composition (products with desired properties), including vitamin, low-fat (the fat content is reduced by 33% compared with conventional), low-calorie (calories less than 40 kcal/100 g) and others;
- medicinal (dietary) products are food products with a modified chemical composition and physical properties specifically designed for use in medical and preventive nutrition (for specific cohort or occupational group) and are recommended for this purpose by the health authorities, including products with a high content of proteins and other nutrients, dietary fibre products with a selectively reduced content of nutrients, including sucrose, protein, cholesterol, sodium, etc.;
- baby food - specially created for feeding healthy and sick children under 3 years old;
- special purpose food products for specific population segments (special contingent, those who work in the extreme conditions, etc.).

The main components of food

Food supplies all the chemical elements needed by the body, and the energy for its life. The composition of food includes such important "building materials" as proteins and amino acids, they contain electrolytes, vitamins and trace elements that determine the chemical reactions in the body.

There are seven basic food components: proteins, fats, carbohydrates, vitamins, minerals, fibre and water. Typically, proteins, fats and carbohydrates predominate in food. Ingredients of nutrients give the body the necessary physiological and mental performance, determine the activity and duration of the human life, its ability to reproduce.

Quality of food is a set of properties that reflect the product's ability to support the needs of the human body in nutrients, the organoleptic characteristics of the
product, its safety for the consumer's health, safety in terms of stability and saving of consumer properties.

**Medical and biological requirements for the quality of food products** is a set of criteria for determining the nutritional value of food raw material and food products.

**Nutritional value** is a concept integrally reflecting the completeness of useful properties of food products, including the degree of providing the human physiological needs in essential nutrients and energy by the product. Nutritional value is characterized primarily by the chemical composition of the food taking into account its consumption in conventional amounts.

**Biological value** is an indicator of the quality of food protein, which reflects the degree of correspondence of its amino acid composition to the body's needs in amino acids for protein synthesis.

**Biological effectiveness** is the quality value of fat food components reflecting the content of polyunsaturated fatty acids in them.

**Energy value** is the amount of energy (kcal, kJ) released into the body from food nutrients to provide its physiological functions.

**Physiological value** is determined by the ability of food affect the digestive, nervous, cardiovascular systems of a person and its resistance to disease. For example, tea, coffee, spices and other products have the physiological value.

**Food safety** is the absence of toxic, carcinogenic, mutagenic or any other adverse effect of products on the human body when using them in conventional amounts. It is guaranteed by maintenance and compliance of the regulated levels of (absence or limit the levels of maximum allowable concentration) of chemical contaminants and the biological nature and natural toxic substances for the specific product that are hazardous for health.

The consumption of poor quality or falsified products leads to a negative and dangerous impact on the human health. Hence the relevance of the food safety problem is increasing every year. Ensuring the safety of the food raw material and food products is one of the main factors that determine the health of people and the preservation of the gene pool.

All food products are subject to the state sanitary-hygienic expertise.

**State sanitary-hygienic expertise** is the activity of institutions, organizations and officials of the State Sanitary and Epidemiological Service aimed at the elimination of any negative impact on the health of the population by studying food products, food raw material and related materials. As the result, the safety criteria of products (values and maximum permissible concentrations of harmful substances) are set. Thus, the purpose of the examination is to exclude factor of the possible negative impact of production (objects of the expertise) on the health of the population.

Examination of food products, food raw material and related products, as well as normative documents (ND) for them, is one of the main directions of work practical, scientific and other institutions of the Sanitary and Epidemiological Service.

The expertise is carried out in 3 main cases:

1) At the stage of normative documents (ND) development for a product when it is scheduled for release as a completely new one, or if the technology of its
production is changed. Examination at this stage involves the study of materials with regard to their safety criteria to be met by products, technology of production, storage and use, labeling, and other features. In the case of such conducting examination the product can be represented as a test samples;

2) examination of products that are made by the appropriate technology where the indices of quality and safety of products guaranteed by the manufacturer are indicated. In this case the products that do not have indices of quality and safety can be carried out expertise of this is a pilot production, or a test sample, or new non-traditional raw material the change of properties, etc;

3) examination of products, which are imported. In this case the indices of quality and safety of products are declared by the manufacturer, who is responsible for their content, and during the expertise the safety criteria are set as required by the legislation of Ukraine.

The official document issued by the results of the examination is the "Conclusion of the state sanitary-hygienic expertise". It is a standard comprising description of the product, assessment of the product’s properties, and completeness of the materials of the research, the conclusion (positive or negative) concerning the quality of products identified during the examination.

The conclusion is the basis for the state registration of a products (registering it to the State Register), issuing of the Certificate of quality, preparing other documents required by law, as well as import and use it for purpose intended on the territory of Ukraine.

As a result of geographic, national and cultural peculiarities of individual countries, there are contradictions of the state normative base on food, which are removed by adoption of multilateral or bilateral agreements, national standards and Codex Alimentarius (Codex Alimentarius is the Specialized Committee on Standardization of the food raw material, also contains the list of dietary supplements approved to use, a collection of standard technologies and conditions of food production).

A specialized international organization – FAO – Food and Agricultural Organization, a specialized agency of the WHO on the food raw material and agriculture, is engaged in problems related to food products. The purpose of its creation is to get the common criteria for quality of food products in the countries of the Common Market for protection of public health and prevention of abuses in the production and sale of food products.

In a market economy at the market saturated with goods produced by the various enterprises and companies it is necessary to have the confirmation of the compliance of the goods to a certain level of quality specified in the standard.

This confirmation of conformity is given in the form of a certificate of conformity.

Certificate is a document confirming compliance with the requirements of the product quality standards composed under the rules of the certification system. It includes code, product type, company-manufacturer, place of manufacture, data of safety compliance, the relevant standards or regulations, data and approval of the results of the test laboratory, test certificate, data on the validity of the certificate of
registration in the register of the Company and the registration number of the Company.

Certification is the activity of independent authorized bodies of the state to validate the quality of products with the requirements of standards.

_The purposes of certification are:_
- to provide the sale of products that are safe for life, health and property of the citizens and the external environment;
- to assist the consumer in a competent choice of products;
- to create conditions for participation of businesses in the international economic, scientific and technical cooperation and international trade.

There is a group of products, the so-called special food (both domestic and foreign production) – medicinal, medicinal and preventive and dietary supplements, baby food and nutrition for sportsmen. This group requires a special attention during the examination: it is necessary to conduct toxicological, clinical and other studies to determine the safety criteria, food and biological value, as well as the effectiveness of this group of products.
QUESTIONS FOR SELF-CHECKING

1. Define the term “bromatology”.
2. What are the main groups, by which food is subdivided?
3. What is food safety?
4. What is the state sanitary-hygienic expertise and what are the cases, in which it is carried out?
5. How does the confirmation of compliance of a product to a certain level of quality is guaranteed?
6. Define the concept of the Codex Alimentarius.
7. Describe the medical and biological requirements for the quality of food products.
8. Describe the main components of food.
TASKS FOR SELF-CHECKING

1. Which group of food is intended for particular groups of people, for the people who work in extreme conditions?
A. Special food products
B. Products of the traditional technology
C. Medicinal (dietary) products
D. Products with the changed chemical composition

2. What is the specialized international agency of the WHO on the food raw material and agriculture?
A. National Commission of Ukraine on the Codex Alimentarius
B. State Sanitary and Epidemiological Service
C. Joint committee of FAO experts
D. The State Veterinary Service

3. The activities of independent authorities of the state in validation of the quality of products by the requirements set are:
A. standardization
B. declaration
C. customs procedure
D. certification

4. The quality indicator of dietary protein, which reflects the degree of its amino acid composition compliance to the body’s needs of amino acids for protein synthesis is:
A. biological value
B. biological efficiency
C. energy value
D. nutritional value
CHAPTER 2

DRINKING AND MINERAL WATER

Water is one of the basic nutrients that are essential for human life. It can be explained by the fact that human body contains from 55% to 78% of water depending on the weight and age.

Water in the human organism performs such functions:
- the function of the universal solvent, in which the main biochemical processes of an organism take place;
- transports nutrients;
- transports waste products out of cells;
- takes part in digestion;
- it is necessary for the utilization of the water-soluble vitamins;
- makes an osmotic pressure in cells and is essential for circulatory system;
- it is needed for the maintenance of proper body temperature;
- it is needed for the excretory functions.

Properties of water

Water without impurities is colourless (in small volume), tasteless and does not have smell (at standard conditions). At the standard atmosphere (760 mmHg, 101 325 kPa freezing point of water is 0° C; boiling point is 100° C.

Water is a good polar solvent. Water is unique solvent because it dissolves well both organic and inorganic substances and provides a high speed of chemical reactions. In natural conditions water always contains dissolved substances (salts, gases).

The molecule of water is neutral, but the charge is distributed unevenly: the hydrogen atoms are slightly positive and the oxygen atom carries a slight negative charge. As a result, water also can form intermolecular hydrogen bonds. Due to hydrogen bonds presence water has the unique properties.

Water has very high melting and boiling points because additional energy is needed to break hydrogen bonds. Only water can be present in three physical states at the same time. Other substances with similar chemical structure and molecular weight (hydrogen sulphide, ammonia) are gases at normal conditions. Due to hydrogen bonds water stays liquid at the wide temperature range.

Function of water in living organism

Unique properties of water let water be a solvent, a thermo regulator, keep the structure of cells and transport the substances.

The high heat capacity of water maintains the approximate constancy of temperature in a cell. Water can carry a large amount of heat, giving it where the temperature of tissues is lower and taking it away where the temperature is higher. Water evaporation contributes to considerable cooling.

Water support structure of living cells, as in the liquid state it is almost incompressible.
Water is involved in the hydrolysis process in the body. For example, the hydrolysis of fats, proteins and carbohydrate takes place during digestion, and by the hydrolysis of ATPA the energy is released to provide the needs of cells.

Physiological needs of the human body in water averages 2.5-3 liters per day (depending on temperature and humidity, physical activity, etc.): about 1.3-1.5 liters come from drinking, about 1 liter - from food, 0.2-0.4 liters of water is formed endogenously in the metabolism of organic compounds (fats, carbohydrates and proteins).

To maintain water balance and homeostasis daily excretion of water from the body must meet admission. Wherein, about 1.4-1.6 liters of water are excreted as the urine, about 0.5-0.7 liter is excreted by the lungs, 0.5-0.7 liter - through the skin and about 0.05-0.1 liter with the feces.

Without water, a person can live for 4-5 days maximum. Our body is extremely sensitive to the violation of water balance: the loss of moisture in the amount of 6-8% of body weight, it falls into a semiconscious state, 10% - a disturbance of the swallowing reflex, then hallucinations start, the blood thickens, causing disruption of the heart function up to the full stop of it; with the loss of more than 12% of water a person dies. Inadequate intake of water causes: obesity, digestive problems, dysfunction of organs and systems of the body, poisoning of organism by waste products (uric acid, urea, lactic acid, etc.).

**Water in food products**

Water is an important component of food products (Table 2.1). It is found in plant and animal products such as cellular and extracellular components, as a dispersion medium and the solvent, determines the consistency and structure of food products, also affects the appearance, taste and stability of the products during storage.

**Table 2.1**

<table>
<thead>
<tr>
<th>Product</th>
<th>Content of water</th>
<th>Product</th>
<th>Content of water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk</td>
<td>87</td>
<td>Fruit</td>
<td>75-95</td>
</tr>
<tr>
<td>Meat</td>
<td>75</td>
<td>Cereals</td>
<td>12-14</td>
</tr>
<tr>
<td>Fish</td>
<td>52-85</td>
<td>Legumes</td>
<td>2</td>
</tr>
<tr>
<td>Eggs</td>
<td>74</td>
<td>Chocolate</td>
<td>5</td>
</tr>
<tr>
<td>Butter, margarine</td>
<td>14-18</td>
<td>Honey</td>
<td>17</td>
</tr>
<tr>
<td>Bread</td>
<td>39-50</td>
<td>Coffee grains (roasted)</td>
<td>3</td>
</tr>
</tbody>
</table>

Many types of foods contain a lot of moisture, which negatively affects their stability during storage. Since water is directly involved into the hydrolytic process, its removal or binding by increasing the content of salt or sugar slows down a lot of reactions and inhibits the growth of microorganisms, thus increasing the shelf life of products. Moisture removal by drying or freezing also significantly affects the properties of the product.
Classification of natural water

Water covers about two-thirds of the Earth's surface. But the most of water is salty. Only 2.5% of the Earth's water is freshwater, of which two-thirds are icecaps and glaciers of Arctica and Antarctica. From the remaining amount about of 20% is in places difficult of access. People have at their disposal less than 0.08% of the Earth's water.

Today, one in five people in the world lack access to safe drinking water. In the whole world, the most common sources of pollution of water is wastewater, in particular by pathogenic bacteria and parasites contained in the feces. Because of diseases carried by contaminated water about 1.8 million people a year die. Therefore the important question is the supply of drinking water of appropriate quality, as well as control of water purification.

There are several ways of dividing the natural water by the groups:
1. According to their origin: surface (seas, waterways - rivers, streams, canals, reservoirs - lakes, ponds, storage ponds, swamps, geysers, springs, glaciers), atmospheric (sedimentary), underground (groundwater basins and aquifers) water.
2. On the number and nature of impurities water is divided into: fresh, saline, soft, hard, transparent, opalescent, cloudy, colored, smelling, etc.
3. By the way of usage water is divided into: drinking, mineral, household, technical, cooling, etc.

Drinking water

Drinking water should be safe in epidemiological terms, harmless by its chemical composition and have good organoleptic properties.

Preparation of drinking water includes 5 stages:
• mechanical filtration;
• settling;
• filtering through a layer of sand;
• aeration;
• disinfection.

In the case of heavy contamination water after its intake from the river undergoes pre-chlorination, and (or) ozonation:

Pre-chlorination is carried out in the case of heavy pollution and by using chlorine or sodium hypochlorite NaOCl. Disinfecting effect of chlorine is caused not by Cl₂ but hypochlorous acid:

\[ \text{Cl}_2 + \text{H}_2\text{O} \leftrightarrow \text{HClO} + \text{HCl} \]

Pre-ozonation is also carried out in the event of a heavy water pollution. As a strong oxidant, ozone oxidizes the chemical compounds causing taste, smell and color of the water, and metal impurities. Ozone is also a coagulant, turning part of the dissolved substances in suspension, which can then be more easily precipitated and filtered. The advantage of ozonation prior to chlorination is the lack of contact of chlorine compounds with the water.
1. Mechanical filtration through filter-grids.

2. Settling. To remove colloidal suspensions and finely dispersed suspensions such substances as calcium hydroxide, and then aluminum sulfate are added to water to precipitate these impurities. As a result of the reaction a gelatinous precipitate is formed which is slowly settling and capturing the finely dispersed in the water matter and most of the bacteria, causing minor suspensions form larger flakes.

\[ 3\text{Ca(OH)}_2 + \text{Al}_2(\text{SO}_4)_3 \rightarrow 3\text{CaSO}_4 \downarrow + 2\text{Al(OH)}_3 \downarrow \]

Then water flows into the settling tank, where impurities precipitate, forming a contact silt removed in sewage (partially silt is reused as a coagulant to precipitate impurities).

3. Substances that affect smell and taste of the water, and the remains of organic substances such as pesticides, are removed by filtration through activated carbon.

Filtering through layers of sand and hydroanthracite removes the remaining residues of suspended solids.

4. During aeration air closely contacts with water by spraying water in the air or by bubbling air through the water. Aeration is used for the oxidation of impurities, such as iron, manganese, or facilitates removal of dissolved gases such as carbon dioxide, hydrogen sulfide and methane from the water.

For better water treatment in the present conditions the ultrafiltration step can also be used. Ultrafiltration involves passing the water through a filter with the ultrafiltration membrane modules made from cellulose acetate membranes. The porosity of the membranes (0.01 μm) allows to clean the water from most microorganisms.

5. The final disinfection: chlorination or ozonation. The necessity of this step can be explained by the fact that after the water treatment water has to pass through the water supply system, and water substations where recontamination of water is possible.

**Epidemiological safety of water**

Requirements for microbiological parameters of drinking water determine (GOST 2874-82):
- the total number of microorganisms in 1 ml of water - less than 100;
- the number of E.coli bacteria in 1 liter of water - no more than 3.

**Toxicological parameters of water**

The toxicological parameters of water characterize the safety of its chemical composition and include standards for the substances:
- found in natural waters;
- added to water as reagents during the treatment process;
- emerging as a result of the industrial, agricultural, domestic and other sources of water pollution.

The concentration of chemical substances found in natural water or added to the water during its treatment should not exceed the standards listed in Table. 2.2.
The toxicological parameters of water

<table>
<thead>
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<th>Parameter</th>
<th>Limiting value, mg/l, not more than</th>
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<tr>
<td>Aluminium residual</td>
<td>0.5</td>
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<td>Berrilium</td>
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<td>Molibdenum</td>
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<td>Arsenic</td>
<td>0.05</td>
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<tr>
<td>Nitrates</td>
<td>45.0</td>
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<td>Poliacrylamide residual</td>
<td>2.0</td>
</tr>
<tr>
<td>Lead</td>
<td>0.03</td>
</tr>
<tr>
<td>Selenium</td>
<td>0.01</td>
</tr>
<tr>
<td>Strontium</td>
<td>7.0</td>
</tr>
</tbody>
</table>
| Fluorine for the climatic regions  
  I and II                          | 1.5                                  |
| III                                | 1.2                                  |
| IV                                 | 0.7                                  |

Organoleptic properties of water

The organoleptic properties of water are: smell, taste, smack, degree of colouration, degree of opalescence. These properties of water are influenced by a variety of chemical substances occurring in natural waters or added to the water during its treatment, as well as appearing as a result of the industrial, agricultural, domestic and other sources of water pollution.

The concentration of chemical substances that affect the organoleptic properties of water found in natural water or added to the water during its treatment should not exceed the standards of Table 2.3.

Table 2.3

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Limiting value, mg/l, not more than</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron</td>
<td>0.3</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.1</td>
</tr>
<tr>
<td>Copper</td>
<td>1.0</td>
</tr>
<tr>
<td>Poliphosphates residual</td>
<td>3.5</td>
</tr>
<tr>
<td>Sulfates</td>
<td>500</td>
</tr>
<tr>
<td>Dry residue</td>
<td>1000</td>
</tr>
<tr>
<td>Chlorides</td>
<td>350</td>
</tr>
<tr>
<td>Zinc</td>
<td>5.0</td>
</tr>
<tr>
<td>Hardness total</td>
<td>7.0</td>
</tr>
</tbody>
</table>

Nature of the manifestation of smell and taste of drinking water:
- should not be felt at all, or
- should not be felt by the consumer, but detected by laboratory research, or
- detected by the consumer, if to draw their attention.
The possible nature of taste: salty, bitter, sweet and sour. All other taste called smacks (e.g. alkaline, metallic).

Degree of colouration and degree of opalescence of water are determined by photometric methods.

**Hardness of water**

Water's hardness is determined by the chemical and physical properties of water and is defined as the presence of salts of calcium and magnesium as far as of other alkaline-earth metals.

*Hard* water is water that has high mineral content of alkaline-earth metals salts, *soft* water is water that has low mineral content of these salts.

Calcium usually enters the water as either calcium carbonate (CaCO$_3$), in the form of limestone and chalk, or calcium sulfate (CaSO$_4$), in the form of other mineral deposits. The predominant source of magnesium is dolomite (CaMg(CO$_3$)$_2$).

There are total, temporary (carbonate), permanent (non-carbonate) types of hardness.

Total hardness is summary of Ca$^{2+}$ and Mg$^{2+}$ concentration in water.

Temporary hardness is a type of water hardness caused by the presence of dissolved calcium bicarbonate and magnesium bicarbonate (Ca(HCO$_3$)$_2$; Mg(HCO$_3$)$_2$). Temporary hardness can be removed by boiling. Boiling promotes the formation of carbonate from the bicarbonate and precipitates calcium carbonate and magnesium carbonate, leaving water that is softer. After cooling, if enough time passes (and precipitates will not be separated) the water will pick up CO$_2$ from the air and the reaction will again proceed from left to right, allowing the carbonates to “re-dissolve” in water.

*Permanent* hardness is caused by the presence of salts, which do not form precipitates by boiling, mainly by calcium and magnesium sulfates and/or chlorides (CaSO$_4$, CaCl$_2$, MgSO$_4$, MgCl$_2$). This is the part of total hardness which cannot be removed by boiling of water.

Hard water causes scaling of mineral deposits that are formed after the hard water had evaporated. Hard water forms lime scale by boiling (heating). The scale can clog pipes, ruin water heaters, coats the insides of tea and coffee pots. At the same time usage of softened water can lead to the corrosion of water pipes.

Consumption of hard or soft water usually is not dangerous to health. At the same time, the salts which remain on the hair and skin after washing by hard water make the hair dull and rigid, the skin dry and rough. There is evidence that the high hardness of water facilitates the formation of urinary stones, and low hardness slightly increases the risk of cardiovascular diseases.

The simplest method to determine the water hardness is soap-consuming capacity test of a water sample: foam is readily formed by shaking with soft water, unlike with hard water. Hard water prevents the lathering of soap but produces a white scum because soap components (e.g., sodium stearate) react with calcium ions:

$$2\text{C}_{17}\text{H}_{35}\text{COONa} + \text{Ca}^{2+} \rightarrow (\text{C}_{17}\text{H}_{35}\text{COO})_2\text{Ca} + 2\text{Na}^+$$
Hardness is often reduced by the addition of reagents (soda \( \text{Na}_2\text{CO}_3 \), slaked lime \( \text{Ca(OH)}_2 \), sodium phosphate \( \text{Na}_3\text{PO}_4 \)), by ion exchange resins and reverse osmosis method.

To express the water hardness the concentration of \( \text{Ca}^{2+} \) and \( \text{Mg}^{2+} \) is stated. The recommended SI unit for measuring of the concentration is mole per cubic meter (mol/m\(^3\)), but in practice different degrees of hardness are used for measuring of hardness.

Table 2.4 shows different degrees of hardness and conversion factors between the units.

<table>
<thead>
<tr>
<th>Unit</th>
<th>Symbol</th>
<th>Definition</th>
<th>dGH,</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degree of hardness (Russian)</td>
<td>°H, ( \text{mg} \cdot \text{eq/L} )</td>
<td>concentration of calcium (magnesium) equal to ( \frac{1}{2} ) mole, expressed in mg/L or g/m(^3)</td>
<td>2.8</td>
</tr>
<tr>
<td>Degree of general hardness</td>
<td>dGH</td>
<td>( 10 \text{ mg of CaO per litre of water} )</td>
<td>1</td>
</tr>
<tr>
<td>German degree</td>
<td>°dH</td>
<td>( 10 \text{ mg of CaO per litre of water} )</td>
<td>1</td>
</tr>
<tr>
<td>English degree or Clark degree</td>
<td>°e, °Clark</td>
<td>( 10 \text{ mg of CaO per litre of water} )</td>
<td>0.7986</td>
</tr>
<tr>
<td>French degree</td>
<td>°f</td>
<td>( 10 \text{ mg of CaCO}_3 ) per liter of water</td>
<td>0.5603</td>
</tr>
<tr>
<td>American degree</td>
<td>ppm</td>
<td>( 1 \text{ mg of CaCO}_3 ) per liter of water</td>
<td>0.0560</td>
</tr>
</tbody>
</table>

According to general hardness there are soft water (up to 2 °H), moderately hard water (2-10 °H), and hard water (more than 10 °H).

**Determination of total hardness content in drinking water**

Total hardness of water (\( \text{Ca}^{2+} \) and \( \text{Mg}^{2+} \) ions) is determined by complexometric titration in the medium of ammonia buffer solution, indicator is mordant black.

\[
\text{Ca}^{2+} + \text{H}_2\text{C} = \text{N} - \text{CH}_2\text{COONa} + \text{H}_2\text{C} = \text{N} - \text{CH}_2\text{COOH} + \text{NH}_4\text{OH} \rightarrow \text{H}_2\text{C} = \text{N} - \text{CH}_2\text{COONa} + \text{H}_2\text{C} = \text{N} - \text{CH}_2\text{COOH} + \text{Ca}^{2+} + 2\text{H}^+ \\
\text{Ca}^{2+} + \text{H}_2\text{C} = \text{N} - \text{CH}_2\text{COONa} + \text{H}_2\text{C} = \text{N} - \text{CH}_2\text{COOH} + \text{NH}_4\text{OH} \rightarrow \text{H}_2\text{C} = \text{N} - \text{CH}_2\text{COOH} + \text{H}_2\text{C} = \text{N} - \text{CH}_2\text{COONa} + \text{Ca}^{2+} + \text{H}_2\text{Ind}
\]

The salts of copper, zinc, manganese and high content of carbonates and bicarbonates prevent the determination of total hardness. Influence of these
compounds is eliminated during the analysis. Copper and zinc ions are precipitated by sodium sulphide; manganese is eliminated by addition of hydroxylamine hydrochloride. High alkalinity is removed by hydrochloric acid addition.

**Determination of chloride content in drinking water**

Before quantitative determination of chlorides their identification is carried out with silver nitrate solution and an approximate content of chlorides is estimated by the precipitate or opalescence, in accordance to the table 2.5:

\[ \text{Cl}^- + \text{AgNO}_3 \rightarrow \text{AgCl}↓ + \text{NO}_3^- \]

<table>
<thead>
<tr>
<th>Precipitate of opalescence</th>
<th>Chlorides content, mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Opalescence or faint turbidity</td>
<td>1-10</td>
</tr>
<tr>
<td>2. Intense opalescence</td>
<td>10-50</td>
</tr>
<tr>
<td>3. Flakes form, do not precipitate at once</td>
<td>50-100</td>
</tr>
<tr>
<td>4. A voluminous, white precipitate</td>
<td>More than 100</td>
</tr>
</tbody>
</table>

According to the results obtained in identification the corresponding method for quantitative determination is chosen — argentometry or mercurimetry:

1. At the content of chloride-ion in water of 10 mg/l and more assay is carried out using argentometric titration (by Mohr):

\[ \text{Cl}^- + \text{AgNO}_3 \rightarrow \text{AgCl}↓ + \text{NO}_3^- \]
\[ 2 \text{AgNO}_3 + \text{K}_2\text{CrO}_4↓ \rightarrow 2\text{KNO}_3 + \text{Ag}_2\text{CrO}_4↓ \]

2. At the content of chloride-ion in water less than 10 mg/l assay is carried out using mercurimetric titration, indicator is diphenylcarbazone.

\[ 2\text{NaCl} + \text{Hg(NO}_3\text{)}_2 \rightarrow \text{HgCl}_2 + 2\text{NaNO}_3 \]

**Determination of sulphate content in drinking water**

Sulphates can be determined by gravimetric (by weight), turbidimetric or complexometric methods

1. **Gravimetric method** is based by the precipitation of sulphates with barium chloride solution in the presence of hydrochloric acid, in the form of BaSO₄ and further gravimetric determination.

\[ \text{SO}_4^{2-} + \text{BaCl}_2 \rightarrow \text{BaSO}_4↓ + 2\text{Cl}^- \]

Before quantitative determination identification is carried out. Identification test is not only the mentioned reaction with drinking water to be analysed it allows to evaluate the approximate sulphate-ion content in the water.

2. **Turbidimetric method** - based on determination of sulphate-ion in the form of BaSO₄ in hydrochloric acid medium with ethylene glycol reagent (a solution of
barium chloride in a mixture of ethylene glycol and ethanol). Glycol introduced into the reaction mixture during the precipitation of barium sulphate stabilizes the resulting suspension and makes possible turbidimetric microdetermination of sulphates.

The determination is carried on a photoelectrocolorimeter at a wavelength of 364 nm. For this purpose a calibration graph is made according to the results of the measurement of absorbance of the solutions. The method is used at the content of sulphates in water within a 2-25 mg/l.

3. **Complexometric method** - is based on the precipitation of sulphate-ions by barium chloride. The precipitate of barium sulphate is dissolved in a titrated solution of sodium edetate, the excess of which is determined by titration with magnesium chloride solution (indicator — mordant black). Method is used at sulphate content in water within 2-25 mg/l.

\[
\text{SO}_4^{2-} + \text{BaCl}_2 \rightarrow \text{BaSO}_4 \downarrow + 2\text{Cl}^-
\]

- **Mineral water**

Mineral water is water containing in its composition dissolved salts, microelements and also some biologically active components. Mineral water must be bottled directly at the source.
Mineral waters have great balneological importance and they are widely used in spa treatment.

Natural mineral waters are waters extracted from the aquifers or water-bearing complexes protected from human impacts, preserving the natural chemical composition and related to food products, while at higher mineralization or high levels of certain biologically active components providing therapeutic and prophylactic action.

Mineral water should be clear, colorless or with tints from yellowish to greenish liquid, with the taste and odour characteristic for substances contained in it. A precipitate of mineral salts that water contains is possible.

**Classification of mineral waters**

I. By the total mineralization and the administration mineral waters are divided by table, medicinal-table, and medicinal.

1. *Table waters.*

   Total mineralization is less than 1 g/l. Small amounts of the biologically active components such as iodine, boron, etc. Table water healthy people can use without restrictions.


   Total mineralization is from 1 to 10 g/l. Medicinal-table waters are allowed to be consumed by healthy people without restrictions for a short period or from time to time.


   The total mineralization is greater than 10 g/l. However, mineral waters with lower mineralization may have the therapeutic effect at the presence in their composition of the biologically active components at high concentrations. Because of the high content of salts medicinal waters are not suitable for quenching thirst. They are used only when prescribed by a physician for treatment or prevention of certain diseases.

By the total mineralization mineral waters for internal use are also divided into the following groups:

- fresh water (mineralization of up to 1 g/ml);
- with very low mineral content (mineralization of 1-2 g/l);
- with low mineral content (mineralization of 2-5 g/l);
- with medium mineral content (mineralization of 5-15 g/l);
- with high mineral content (mineralization of 10-15 g/l)

Mineral waters used for external procedures have mineralization of 15 g/l and above, up to the brines with a mineralization of 150-300 g/l, preferably of sodium and chloride content, or have a lower mineralization if containing biologically active components - bromine, iodine, hydrogen sulfide, carbon dioxide, radon.
Waters with very low mineral content with mineralization up to 2 g/l make about a third part of bottled mineral waters, and about a half of that has mineralization of about 1 g/l.

II. Depending on the ionic composition mineral waters can be divided into several types (usually anions are basic for this classification). To choose the proper table or medicinal-table water for a certain disease you need to know what type it is. Knowledge of analogues will help you to choose an adequate substitute in the case of absence of needed water.

- **Bicarbonate waters**

  At hyperacid gastritis and peptic ulcer disease, which are accompanied by increased acid secretion of stomach the treatment by bicarbonate-sodium (alkaline) waters is prescribed. Replenishing the lack of carbonates in blood they increase the alkaline reserve of the blood. Under their influence the content of hydrogen protons, which together with chloride ions serve to generate hydrochloric acid, is decreased in the body. Neutralizing the acidic contents of the stomach alkaline waters contribute to its more rapid evacuation. As a result of taking alkaline waters heartburn, belching, feelings of heaviness in the epigastric region are eliminated.

  Carbon dioxide from the bottled mineral waters in the treatment of hyperacid gastritis is required to be removed because it has a stimulating effect on the gastric mucosa.

  When the pH of the stomach is increased one should take mineral water one and a half an hour to two hours before a meal, in this case it has time to be evacuated from the stomach. Having moved quickly into the duodenum in the little changed form, mineral water influences receptors in the mucosa and reflexively inhibits gastric acid secretion, reduces the production of hydrochloric acid, which determines the acidity of gastric juice. To reduce the time the action of water on the mucosa of the stomach it is recommended to drink it fast and gulps.

  Bicarbonate-sodium (alkaline) waters present a fairly large group. The most famous among them is the water "Borjomi" with a mineralization of 6 g/l.

  In the group of the Carpathian alkaline waters are "Luzhanskaya" (formerly "Margitskaya"), "Ploskovskaya", "Svaljava", "Poliana-Kvasova" - the concentration of salts (in order of - 7.5, 8.6, 9.7 and 10, 5 g/l) is higher than in the spring "Borjomi". Georgian alkaline waters - "Nabeglavi" with a mineralization of 7.2 g/l and "Utsera" containing 10.5 grams of salt per a liter are of bicarbonate-sodium type too.

  Mineral waters of Ukrainian springs with very low mineral content such as "Shepetovskaya", "Zhytomyr", "Berezovskaya" and "Kharkiv number 1" (Berezovsky Mineral Waters); "Kiev", "Regina" and "Naftusia number 2" of Truskavets resort, and "Badamlinskaya" in Azerbaijan are related to bicarbonate-sodium type with the mixed cation composition where calcium dominates, sometimes very significantly.

- **Sulphate waters**

  Due to sulphate waters, especially sulphate waters containing magnesium ions, liver cells increase the formation of bile, peristalsis of bile ducts increases, drainage
from the gall bladder and ducts improves, and the conditions that prevent the formation of stones are made.

Sulphate waters have an inhibitory effect on gastric secretion. Therefore, if the liver disease is accompanied by decreased secretion of the stomach, it is necessary to choose the water that contains chlorides (sodium chloride) along with sulphates. Methods for taking mineral waters depend on the acidity of gastric juice: at low acidity one should drink water 15 minutes before a meal, at normal acidity - 45 minutes before a meal, in the case of high acidity - half an hour before a meal. Compliance with this rule increases the effects of mineral water, which is required to be heated up to 40 ° C.

If intestinal disease is accompanied by a tendency to constipation, sulphate waters are prescribed because they possess not only choleretic but also laxative action. Sulfate waters are "Batalinskaya", "Bukovina", "Ivanovo". Children and teenagers must not take such water because sulphates inhibit the growth of bones binding the calcium from food.

- **Chloride waters**
  At gastritis characterized by inhibited motor function and decreased gastric acidity chloride-sodium waters are recommended. They enhance the secretion of digestive glands. In the stomach chloride-sodium waters enhance its motility stimulating the secretion of gastric juice. Hydrochloric acid stimulates the function of the pancreas and secretion of intestinal enzymes. All this helps to improve digestion and absorption of fats, proteins, carbohydrates.

  One should take such mineral water for gastritis with low acidity shortly before a meal - 10-15 minutes before a meal in a heated (30-40 ° C) form. You have to drink it slowly, in small sips. The water does not have time to leave the stomach and staying there with food and irritating receptors stimulates secretion thereby increasing digestive ability.

  Examples of chloride waters, namely chloride-sodium are "Mirgorod" and "Kuyalnik".

Most of the mineral water springs have a complex composition and therefore may have a many-sided effect on the organism. The waters of complex composition:

- **Bicarbonate-chloride waters**
  Mixed bicarbonate-chloride-sodium waters (hydrochloric-alkaline) are a kind of a combination of two types of water having the opposite way of the physiological effect. Thus, they may equally be recommended in diseases of the stomach, both with increased and with reduced secretion. A crucial role is played by the method of taking, which enhances the effects of some components, and reduces the effect of the other. If hydrochloric-alkaline water is taken 10-15 minutes before a meal, the effect of chlorides will be the dominant, and if you take the water an hour and a half to a couple of hours before a meal alkalis have the predominant influence. Thus, these waters will have a normalizing effect for any malfunction of the gastrointestinal tract.
Under the influence of orally taken bicarbonate-chloride-sodium water in parallel with the improvement of the secretory and motor functions of the stomach the amount of mucus is decreased, the processes of formation and excretion of bile are intensified. These waters also improve metabolism, they are successfully used also for various metabolic disorders (obesity, gout, diabetes).

Among the representatives of the alkaline-hydrochloric waters the most famous are waters “Essentuki number 4 and number 17”. By the chemical composition they are equal, hydrocarbonates are mainly soda. But the total content of salts and alkalies in the source "Essentuki number 17" is almost one and a half times higher than in the water "Essentuki number 4." Therefore "Essentuki number 17" is preferred to be administrated for gastritis with increased secretion and acid-forming function of the stomach.

"Crimea" water is of bicarbonate-chloride type, it has a low mineral content (2.1 g/l).

Waters "Kherson", "Burkut"from Svalyava, "Zaporozhye", "Melitopol", "Gogol" (village Shishaki, Butova mountain), "Berezhanskaya" are of bicarbonate-chloride type.

**Bicarbonate-sulfate waters**

Such waters as narzans from famous Kislovodsk springs are of bicarbonate-sulphate calcium-sodium (calcium-sodium-magnesium) type. These waters are also characterized by a high content of free carbon dioxide. Carbonated bicarbonate-sulphate-chloride calcium-sodium water "Narzan" from the drill N 5/0 with mineralization of 4.1 g/l is used for bottling.

Waters with very low mineral content "Kharkiv number 2", "Oleska", "Kishinev", "Fergana", "Jalal-Abad number 4", "Kzyyldzhan", "Essentuki number 20" are of bicarbonate-sulphate type.

**Chloride-sulphate waters**

Chloride-sulfate waters are used for diseases of the stomach mainly with insufficient secretion and acidity, while affection of liver and/or biliary tract. In such waters sodium (NaCl) has a stimulating effect on the reduced secretion and reduced gastric acidity restoring them to the standard. In addition, the sulphate components that have choleretic and laxative effect help to remove the pathological processes in the liver and biliary tract or intestine (at the tendency to constipation).

About half of all bottled water contains sulphates in significant quantities. Chlorides are mainly sodium chloride. In the mixed chloride-sulphate waters both of these components may prevail. Chloride-sodium waters from the Tajikistan spring "Shaambary number 2" (mineralization 16.5 g/L) contain 62% sulfates. The Crimean water "Theodosia" contains also a considerable proportion of sulphates, but this source has mineralization of 4 g/l.

Usually a bottle label provides the chemical composition of water in grams or milligrams per liter (dm ³).
III. By the presence of biologically active components and the gas composition the main groups of mineral waters are:

1. Carbonated waters. The mineral waters containing carbon dioxide 0.5 g/l ("Narzan", “Borjomi”, “Poliana Kvasova”, “Essentuki”, etc.) are taken as the standard of this type. Carbonated waters stimulate the secretory and motoric activity of the stomach and intestine and are prescribed for liver and biliary tract diseases with associated gastritis with secretory deficiency.

2. Hydrogen sulfide waters. Under the influence of hydrogen sulfide (sulfide) waters (“Macesta”, “Sinyak”, “Utly-Su”) the amount of sulfhydryl compounds in the liver increases, protein metabolism improves. However, the data are available about activation of inflammatory processes during their use so their usage in exacerbations of diseases should be cautious.

3. Ferriferous waters are prescribed for diseases of the digestive system along with anemia. The widely known ferriferous waters from Zheleznovodsk "Slavyanovskaya" and "Smirnovskaya" have 4-5 mg/l of iron, Odessa’s "Kuyalnik" - 8 mg/l; "Tursk-Su" and the narzan "Elbrus" - 27 mg/l, and the Transcarpathian "Luzhanskaya" mineral water – more than 50 mg/l.

4. Arsenious waters (“Kvasy”,”Avadhara”, “Karmadon”). Due to the active participation of arsenic in the blood formation such waters are prescribed for diseases of the digestive system along with anemia.

5. Siliceous waters ("Berezovskaya", "Kharkiv number 2" ,"Rye-Yelenovskaya”, “Shayan”) have adsorption, astringent, sedative, analgesic, anti-inflammatory action. They are prescribed for the pathology of the digestive tract, liver and biliary tract.


7. Iodine-containing waters (waters of Maikop, Akhtyrka springs, “Semigorskaya”) accelerate regeneration processes, are involved in oxidation-reduction processes, affect the function of the thyroid gland. Iodine helps to eliminate inflammation. These waters are prescribed for patients with pathology of the digestive system. The pharmacological effect is observed when the iodine concentration is 5 mg/l and more.

8. Boron-containing waters (“Poliana Kvasova”, “Dragovskaya”, “Svaljavskaya”, “Semigorskaya”). In highly mineralized waters iodine is often combined with boron; when waters with boron content of about 120 mg/l (e.g. water “Poliana Kvasova”) are used they decrease the amount of bile and cholesterol concentration therein.

9. Waters rich in organic matter (“Naftusia”, "Berezovskaya", some waters from Transcarpathian region and Bukovina). The therapeutic effect in this group is due to the presence of bitumen and humin (up to 80-90% of the total organic content). In the medicinal mineral waters content of organic substances should be not less than 30 mg/l, in the medicinal-table waters - not less than 10 mg/l. This group is indicated for treatment of pathology of the hepatobiliary system, bile formation
disfunction and other various disfunctions of the liver. Waters with a very low mineral content, which contain organic matter, successfully treat diseases of the kidneys and urinary tract, as well as a number of liver diseases associated with sand and stones formation when highly mineralized waters are strictly contraindicated.

10. Radon-containing waters are used mainly for the purposes of balneotherapy.

IV Depending on the pH mineral waters are divided into:

<table>
<thead>
<tr>
<th>Type</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>acidic</td>
<td>3.5-5.5</td>
</tr>
<tr>
<td>slightly acidic</td>
<td>5.5-6.8</td>
</tr>
<tr>
<td>neutral</td>
<td>6.8-7.2</td>
</tr>
<tr>
<td>slightly alkaline</td>
<td>7.2-8.5</td>
</tr>
<tr>
<td>alkaline</td>
<td>more than 8.5</td>
</tr>
</tbody>
</table>

Only slightly acidic, neutral and slightly alkaline waters are used for drinking.

The qualitative chemical composition of drinking mineral waters must meet the requirements of the standards.

*Organoleptic parameters* of mineral waters must meet the following requirements:
- Appearance - mineral water should be transparent, without foreign mechanical impurities, possibly with a slight natural sediment of mineral salts;
- colour - a colorless liquid or with a touch of yellow to greenish;
- taste and odour - characteristic to complex substances dissolved in water.

**Recommendations regarding the method of taking mineral waters**

The effect of drinking mineral water treatment depends not only on the correct choice of water, but the rules (method) of its administration (dose, frequency, interaction with food), temperature, etc., causing a different effect on the same water.

At administration the water orally firstly a type of water must be chosen, which effect on the body will help the expected changes of gastric secretion. In the case of reduced secretion (hypoacidity gastritis) waters with a stimulating effect on gastric secretion must be used, in the case of increased secretion (hyperacid gastritis) - waters with an inhibitory effect.

Correctly prescribed method of taking of mineral water (at a reduced secretion 10-20 minutes before a meal, and at increased secretion- an hour or two hours before a meal, in the case of normal secretion - 40 minutes before a meal) will provide the necessary therapeutic effect.

The hot water is used for hyperacidity gastritis and peptic ulcer disease. If the patient has bowel atony, a tendency to constipation the cold water is used (it increases peristalsis of the stomach and intestine). In all other cases, the temperature should be
33-44 ° C. The warm water has antispasmodic and analgesic effect (helps to relieve spasms and remove mucus).

When the concentration of salt is 2-10 g per liter (waters of low and medium mineralization) mineral waters are prescribed three times a day before meals, 200-250 ml (1-1.5 cups), but when the patient's body is impaired, one should start with a smaller dose - 50-100 ml (0.5 cups) followed by increasing it to normal.

Mineral water is usually carbonated before bottling by artificially introducing therein carbonic acid, which improves the taste and promotes water conservation. Carbonation is particularly appropriate for chloride-sodium waters, this increases their therapeutic effect. The presence of carbon dioxide in alkaline waters prescribed for patients with an increased secretion and acidity is undesirable. In this case, prior to use, one must heat the water to remove carbon dioxide. In a spa treatment lasts 24 days.

Pharmacist recommendations to patients and physicians for the rational combination of drugs and water

Most of the drugs should be taken with water. If the instruction for administration of the drug does not have specific guidance on the liquid used while taking medication, you should drink it with about 100 ml of boiled water. You can also use the liquid starch mucilage that protects the stomach lining from possible irritation of the drug.

To take medicines with mineral waters is recommended only in rare cases. It is advisable to take sulfonamides with alkaline mineral waters. Alkaline medium promotes the transformation of sulfonamides in the salt forms, which facilitates the capture of drug molecules by microbial cells. Also alkaline medium prolongs antibacterial action of sulfonamides, slows the acetylation in the metabolism. In the alkaline medium acetylated sulfonamides are dissolved and easily removed from the body, which excludes or reduces crystalluria.
QUESTIONS FOR SELF-CHECKING

1. What are the parameters of water quality regulated by the State Standard of Ukraine for drinking water?
2. Which parameters affect the organoleptic properties of drinking water?
3. Write the reactions and specify the features of the reactions for determination of chlorides and sulphates in drinking water.
4. What toxicological parameters are determined in drinking water?
5. What is hardness of water? What types of water hardness do you know?
6. Which units are used for measurement of water hardness? How hardness of water affects its organoleptic properties?
7. Describe the possible effects of water with a high concentration of salts of magnesium, iron, calcium, arsenic on the body.
8. What is meant by the term "total mineralization?"
9. How mineral waters are classified according to their application, chemical composition, total mineralization, temperature, and pH?
10. What types of mineral waters depending on the main ions do you know?
12. What recommendations for the rational combination of drugs and water can you give?
1. Physiological needs of the human body in water is:
   A. 2.5 litre per day
   B. 0.5 litre per day
   C. there is no need
   D. 5 litres per day
   E. 4 litres per day

2. Determination of the chlorides content in drinking water is carried out by the reaction with:
   A. zinc oxide
   B. magnesium sulfate
   C. ferric chloride
   D. barium chloride
   E. silver nitrate

3. What is mineralization of a table mineral water?
   A. total mineralization up to 1 g/l
   B. total mineralization from 1 g/l to 8 g/l
   C. total mineralization of 8 g/l to 12 g/l
   D. does not contain minerals
   E. total mineralization of 12 g/l

4. Determination of sulphates in drinking water is carried out by the reaction with:
   A. silver nitrate
   B. barium chloride
   C. magnesium sulfate
   D. zinc oxide
   E. ferric chloride

5. What is mineralization of a medicinal mineral water:
   A. total mineralization of 1 g/l
   B. total mineralization of 1 g/l to 8 g/l
   C. total mineralization of 10 g/l to 15 g/l
   D. does not contain minerals
   E. total mineralization than 15 g/l

6. According to their chemical composition mineral waters are classified depending on:
   A. the main ion
   B. temperature
   C. pH
   D. turbidity
   E. odour

7. Water hardness is determined by the content of the following salts:
A calcium and magnesium  
B. iron and phosphorus  
C. copper and zinc  
D. magnesium and sodium  
E. calcium and potassium

8. Which types of mineral water are used for treatment: 
A. alkaline waters  
B. slightly acidic waters  
C. acidic waters  
D. neutral waters  
E. slightly alkaline waters

9. Alkaline mineral waters should be taken with:  
A. NSAIDs  
B. antibiotics  
C. sulfonamides  
D. analgesics  
E. antipsychotics
CHAPTER 3
MILK AND MILK PRODUCTS

Milk is one of the most perfect food products created by nature. It is a complex biological fluid, which is formed in the mammary gland of female mammals and has a high nutritional value, immunological and bactericidal properties.

Since ancient times, mankind has used the milk of goats, sheep and cows for food. And although today the term "milk" is synonymous with the cow's milk, people consume milk of other animals as well.

The modern consumer market presents different kinds of dairy products. The main 5 groups of such products are shown in Fig. 3.1.

Milk is a polydisperse multicomponent system where all constituent substances are in a finely dispersed state, which provides a liquid consistency. The Technical Regulations defines milk as a product of normal physiological secretion of the mammary glands of farm animals obtained from one or more animals in lactation period at one or more milking.

The chemical composition of milk
Among all food products milk is considered to be the most complete and balanced in content of essential nutrients.

Milk is the heterogeneous system, in which the dispersed phase is emulsified fat globules and colloidal protein micelles, and the dispersion medium is the solution of proteins, lactose, minerals and vitamins.

The chemical composition of milk is not constant and depends on the breed and age of the animal, conditions of feeding and keeping, the level of productivity and the method of milking, the lactation period, and many other factors. Chemicals used in agriculture, treatment of the cattle diseases, as well as pollution lead to increase of the foreign substances content in milk.

Substances, which are the components of milk, are divided into several groups (Fig. 3.2).
Milk proteins are complete because they contain all essential amino acids in their composition. The amino acid composition of milk is shown in Table 3.1.

**Table 3.1.**

The amino acid composition (g / 100g of protein) of the total protein, casein, and whey protein

<table>
<thead>
<tr>
<th>Amino acid</th>
<th>Total protein</th>
<th>Casein</th>
<th>Whey protein</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alanine</td>
<td>3.7</td>
<td>3.1</td>
<td>5.5</td>
</tr>
<tr>
<td>Arginine</td>
<td>3.6</td>
<td>4.1</td>
<td>3.3</td>
</tr>
<tr>
<td>Valine</td>
<td>6.8</td>
<td>7.0</td>
<td>7.5</td>
</tr>
<tr>
<td>Glutamic acid</td>
<td>22.8</td>
<td>23.4</td>
<td>15.5</td>
</tr>
<tr>
<td>Glycine</td>
<td>2.2</td>
<td>2.1</td>
<td>3.5</td>
</tr>
<tr>
<td>Histidine</td>
<td>2.8</td>
<td>3.0</td>
<td>2.4</td>
</tr>
<tr>
<td>Isoleucine</td>
<td>6.2</td>
<td>5.7</td>
<td>7.0</td>
</tr>
<tr>
<td>Leucine</td>
<td>10.4</td>
<td>10.5</td>
<td>11.8</td>
</tr>
<tr>
<td>Lysine</td>
<td>8.3</td>
<td>8.2</td>
<td>9.6</td>
</tr>
<tr>
<td>Methionine</td>
<td>2.9</td>
<td>3.0</td>
<td>2.4</td>
</tr>
<tr>
<td>Proline</td>
<td>10.2</td>
<td>12.0</td>
<td>4.4</td>
</tr>
<tr>
<td>Serine</td>
<td>5.8</td>
<td>5.5</td>
<td>5.5</td>
</tr>
<tr>
<td>Phenylalanine</td>
<td>5.3</td>
<td>5.1</td>
<td>4.2</td>
</tr>
<tr>
<td>Threonine</td>
<td>4.8</td>
<td>4.4</td>
<td>8.5</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>1.5</td>
<td>1.5</td>
<td>2.1</td>
</tr>
<tr>
<td>Tyrosine</td>
<td>5.4</td>
<td>6.1</td>
<td>4.2</td>
</tr>
<tr>
<td>Cystine</td>
<td>0.8</td>
<td>0.3</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Milk proteins are divided into two main groups:

- caseins;
- whey proteins.
The total protein content of milk ranges from 2.9 to 3.5%. Their degree of uptake is 96-98%.

Caseins (α-, β-, γ- and other fractions) are 80-82% of the total protein content. Casein in milk is in the form of a complex with calcium salts of phosphoric acid:

![Casein bridge of calcium phosphate](image)

Caseins are thermostable and coagulated by the action of acids and rennet, and are easily digested. They are the source of essential amino acids, calcium, phosphorus and a number of physiologically active peptides. For example, in the stomach by the action of the enzyme chymosin on casein glycol- and phosphor-peptides are released, which regulate the gastric secretion, change the physicochemical properties of the protein, and affect the penetrability of cell membranes. Compared to whey proteins casein contains few sulfur-containing amino acids.

Whey proteins make up 18-20% of the total protein content. They are in a dissolved state, are easy to be attacked by proteolytic enzymes in the digestive tract and digested. Whey proteins are not coagulated by the action of acids and rennet. Compared to casein, whey proteins contain more of essential amino acids, including lysine, threonine, tryptophan, methionine and cysteine.

Whey proteins contain:
- β-lactoglobulin – transports the micro-, macro- elements, vitamins, and lipids;
- α-lactoglobulin – required for the synthesis of lactose in milk from galactose and glucose;
- immunoglobulins A, G, M – cause agglutination of microorganisms and other foreign cells;
- bloodserum albumin.

Milk contains a small amount (4-10%) of nonprotein nitrogenous compounds, including 2-3% of free amino acids that are important in production of dairy products as they are an important source of nutrition of lactic acid bacteria.

**Milk fat** is in a stable fat emulsion formed by fat globules (2 billion per 1 ml), which consist of lipids, proteins and mineral substances. Due to the high dispersion the particles of milk fat are absorbed without hydrolysis by lipolytic enzymes. Furthermore, the low melting point (28-31 °C) of milk fat contributes to a high degree of its absorption (98%). The fat content of the cow's milk is within the 2.7-6.0%. The fat content in milk for sale is from 1.5 to 6%.

Milk fat is composed of:
- triglycerides (98-99.5%);
- phospholipids: lecithin –up to 0.4%, cephalin - 0.4% sphingomyelin– up to 0.1%;
• free fatty acids: saturated substituted (palmitic, myristic and stearic) and monounsaturated (oleic);
• sterols: mainly cholesterol, and ergosterol, which under the influence of ultraviolet rays becomes vitamin D;
• liposoluble vitamins: A, D, E, K;
• flavouring and aromatic substances.

The disadvantage of milk fat is a negligible content (up to 0.09 mg) of polyunsaturated fatty acids (linoleic, linolenic and arachidonic), which excrete cholesterol and normalize the function of the liver. In addition, quite a high content of cholesterol in milk fat makes it necessary to limit the use of butter and fatty dairy products by elderly people and patients with diseases of the cardiovascular system.

**Carbohydrates.** The main carbohydrate of milk is milk sugar – lactose. Besides such amino sugars as D-glucosamine, D-galactosamine, sialic acid, D-glucuronic acid and sugar phosphates have been found.

Lactose is a carbohydrate of the disaccharide group that consists of residues of the molecules of glucose and galactose. Lactose is a source of energy and controls the exchange of calcium. Galactose, which is part of it, is the structural part of galactose lipids required for development of the central nervous system and the synthesis of vitamin B.

The characteristic of lactose is the slow absorption (digestion) by the walls of the stomach and intestines. Reaching the large intestine it stimulates the vital functions of bacteria that produce lactic acid, which lowers the pH, inhibits development of putrefaction processes and the growth of pathogenic microorganisms, normalizes the intestinal flora, and improves absorption of minerals. The digestion rate of lactose is 98%.

Hydrolysis of lactose occurs under the action of the enzyme lactase (β-galactosidase), which is produced by putresciy epithelial cells of the intestine and gut microorganisms (bifidobacteria, *E. coli*, lactobacilli, etc.). It has been proven that the lactobacillus strain *Lactobacillus acidophilus* possesses the highest activity of β-galactosidase. Enzymatic hydrolysis of lactose into glucose and galactose is shown in Scheme 3.1.

```
CH2OH
OH
OH
OH
CH2OH
OH
Lactose
Lactase
OH
HO
Galactose
Glucose
OH
OH
CH2OH
CH2OH
OH
CH2OH
```

**Scheme 2.1.** Enzymatic hydrolysis of lactose.

Newborns have the highest activity of lactase. It remains high during the human life if the milk is consistently included in the diet. At the same time some people have lactose intolerance, which is inability to digest lactose and causes disturbances in the digestive system (diarrhea, abdominal pain and bloating, nausea, vomiting). The cause is the deficiency or absence of lactase.
**Vitamins.** There are more than 30 vitamins in the composition of milk. Firstly, milk products are an important source of vitamins of B group and fat-soluble vitamins (A, D, E, K). The most important vitamins are vitamin B₂ and vitamin A, including β-carotene, giving a yellow colour to milk and butter. Milk contains small amounts of vitamin C providing production of vitaminized liquid milk. During transport, storage, and especially during high-temperature processing of milk vitamins are decomposed (especially C and B₁₂). Vitamin A and PP are thermostable.

Vitamin-like substances such as choline, inositol, para-aminobenzoic acid and orotic acid are also contained in milk.

**Mineral substances.** Milk contains more than 50 chemical elements. The main elements found in milk are Ca, P, K, Mg, Na, Cl. Their ratio in milk is the most beneficial for the body. The elements are in milk in a perfectly digestible form. Calcium and magnesium are present as salts of phosphoric and citric acids, wherein the majority of calcium phosphate is associated with casein. It is milk and dairy products that are an important source of calcium for the human body. Milk also can increase the uptake of calcium compounds from other products – cereals, vegetables and fruit.

The microelements of milk are Fe, Co, Mo, Cu, Zn, Mn, F, I, Se, B, Al, etc. They are bonded to fat globule membranes (Fe, Cu), casein and whey proteins (I, Se, Zn, Al), and are parts of enzymes (Fe, Mo, Mn, Zn, Se), and vitamins (Co). The amount of microelements in milk varies considerably depending on the composition of feed, soil, water, animal’s health, and the conditions of processing and storage.

**Enzymes and other biologically active substances.** More than 100 enzymes (oxidoreductases, transferases, hydrolases, lipases, isomerases and ligases) have been found in milk. Most of them are of the native origin (alkaline phosphatase, xanthine oxidase, protease, etc.) or formed as a product of the microbiological activity. Some enzymes negatively affect the milk quality. For example, during storage lipase hydrolyzes triglycerides to glycerol and free fatty acids (Scheme 3.2), including the low molecular weight ones (e.g., butyric acid) that are involved into formation of the rancid taste in dairy products.

![Scheme 3.2. Hydrolysis of triglycerides.](attachment:image)

Some enzymes are used to assess the quality (reductase, catalase), and efficiency of heat treatment (phosphatase, peroxidase) of milk.

From the class of hydrolases the enzyme lysozyme is particularly important: it destroys the bacterial cell walls by hydrolysis of peptidoglycan (particularly murein) and causes their death. Thus, lysozyme and peroxidase, immunoglobulins and leukocytes determine the bactericidal action of the fresh raw milk.

In addition, the bactericidal activity of milk is due to natural antibiotic substances – lactenins.
Milk contains such hormones as thyroxine, prolactin, adrenaline, oxytocin, insulin, estrogens. After appropriate treatment the quantity of hormones is reduced to very low levels.

The nutritional value is determined by the content of protein, fat, milk sugar, organic acids, vitamins, enzymes and several other components. The average data on the chemical composition of the cow's milk and certain dairy products are shown in Table 3.2.

### Table 3.2
The chemical composition and the energy value of milk products (per 100 g)

<table>
<thead>
<tr>
<th>Product</th>
<th>Water, g</th>
<th>Protein, g</th>
<th>Fat, g</th>
<th>Carbohydrates, g</th>
<th>Minerals, mg</th>
<th>Vitamins, mg</th>
<th>Energy, kkal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ca</td>
<td>P</td>
<td>K</td>
</tr>
<tr>
<td>Milk, 3.2% fat</td>
<td>88.5</td>
<td>2.80</td>
<td>3.2</td>
<td>4.7</td>
<td>120</td>
<td>90</td>
<td>146</td>
</tr>
<tr>
<td>Skimmed milk</td>
<td>91.4</td>
<td>3.0</td>
<td>0.05</td>
<td>4.7</td>
<td>126</td>
<td>95</td>
<td>152</td>
</tr>
<tr>
<td>Cream</td>
<td>72.8</td>
<td>2.8</td>
<td>20.0</td>
<td>3.7</td>
<td>86</td>
<td>60</td>
<td>109</td>
</tr>
<tr>
<td>Sour cream 20% fat</td>
<td>72.7</td>
<td>2.8</td>
<td>20.0</td>
<td>3.2</td>
<td>86</td>
<td>60</td>
<td>109</td>
</tr>
<tr>
<td>Fatty cottage cheese</td>
<td>63.2</td>
<td>14.0</td>
<td>18.0</td>
<td>2.8</td>
<td>150</td>
<td>216</td>
<td>112</td>
</tr>
<tr>
<td>Fat-free cottage cheese</td>
<td>77.2</td>
<td>18.0</td>
<td>0.6</td>
<td>1.8</td>
<td>120</td>
<td>189</td>
<td>117</td>
</tr>
<tr>
<td>Fatty kefir</td>
<td>88.3</td>
<td>2.8</td>
<td>3.2</td>
<td>4.1</td>
<td>120</td>
<td>95</td>
<td>146</td>
</tr>
<tr>
<td>Condensed milk</td>
<td>73.2</td>
<td>7.0</td>
<td>8.3</td>
<td>9.5</td>
<td>282</td>
<td>224</td>
<td>318</td>
</tr>
<tr>
<td>Cheese</td>
<td>41</td>
<td>23.2</td>
<td>29.5</td>
<td>0</td>
<td>880</td>
<td>500</td>
<td>88</td>
</tr>
</tbody>
</table>

Milk of females of different mammalian species have a different ratio of the main nutrients and biologically active materials due to the peculiarities of the species, age, physiological state of animals, and other factors.

**Goat's milk** is consumed in large quantities by the residents of the Caucasus and Central Asia. Distinctive features of the goat's milk are a higher content of protein, fat, calcium, carotene (a pale yellow colour), polyunsaturated fatty acids (linoleic and especially capric acid, which give it a specific odour). Its fat globules are twice smaller, and it contributes to the better assimilation. The casein micelles are bigger and contain few α-fractions; thus, during rennet coagulation loose curd is formed. It contains several times more vitamins A, C, D, PP, as well as Fe and Mg. It is less thermostable (stable at t = 130 °C for 19 minutes) since it contains more of ionized calcium, pH is 6.4-6.7. Raw goat's milk is less dangerous than cow milk because goats are more resistant to diseases.

**Sheep's milk** is used for food in Crimea, the Caucasus, Central Asia and the North Caucasus. In comparison with cow milk it contains 1.5 times more protein and fat, 2-3 times more vitamin A, B₁, B₂. Its fat contains a lot of caprylic and capric fatty acids (a specific odour), which limits its use in the form of raw milk. Most of it is used for cheese production (chanakh, Tushino, Ossetian) and dairy products (yogurt).
Sheep's milk is white with slight grayish tinge. Sheep are often ill with brucellosis, so it is better to boil their milk. Sheep’s cheese can be eaten after a month's storage as during this time brucella die.

*Horse milk* contains twice less protein, fat and minerals than cow milk, 1.5 times more lactose, 6 times more vitamin C, 1.5 times more cobalt, 2.5 times more copper. By the ratio of the protein fractions and the amount of lactose it is milk of the albumin group – casein therein is 50-60%; that is why it is similar to human milk. Fat milk has a low melting point – 21-23 ° C, it contains less low molecular weight fatty acids, but more saturated fatty acids, and the content of polyunsaturated fatty acids is 10 times more than in cow milk. Its acidity is pH of 6.6-7.0. It is white with a bluish tinge, sweet and a slightly tart taste. Horse milk is better to use in adults nutrition as a kumys.

*Asses (she-donkey) milk* like horse milk is of the albumin type; it is low in protein, fat and minerals, but rich in carbohydrates and vitamins. It is close to breast milk to the greatest extent by its properties and composition, and is the best substitute.

*Buffalo milk* is consumed in Georgia, Armenia, Azerbaijan, Dagestan, in the Kuban and the Black Sea coast of the Caucasus. Buffalo milk is a viscous white liquid with a pleasant taste and odour. It contains more fat, protein, calcium, phosphorus, vitamins A, C and group B vitamins.

*Camel milk* is consumed in some regions of Central Asia, Kazakhstan, in the Arab countries of the Arabian Peninsula. It has a sweeter and slightly salty taste (the high content of minerals and lactose), is white in colour with a slight yellowish tinge and has a slight odour of skin vapours. The casein content is less, but the amino acid composition is much richer. It is consumed both as fresh milk and in a variety of dairy products that have special names: katah (sour cream), chal (acid whey), ayran (like yogurt), shubat (similar kumys, Turkmenistan), etc.

**Production of milk and dairy products**

Only a small part of milk reaches the consumer without the treatment and certification. The technology of production of liquid milk includes such stages as receiving and determining the quality of the raw material, removal of mechanical impurities (purification), fat adjustment, heat treatment, cooling and bottling.

The purpose of **fat adjustment** is to achieve the required (by the standard) fat content in milk. For this purpose separation of cream is carried out, followed by mixing the raw material with a certain fat content and the calculated amount of skimmed milk or cream.

**Purification** is carried out by filtration or by separators - milk clarifiers.

**Homogenization** is the process of size reducing (dispersion) of fat globules under pressure. Homogenization is an obligatory process, which improves the properties of milk products. The homogenized milk is not separated into cream and skimmed milk, organoleptic properties and the degree of digestion are improved.

**Heat treatment** is carried out to kill pathogenic microorganisms, reduce the total number of microorganisms, and inactivation of enzymes. The most common types of heat treatment of milk are:
Thermization is the process, which involves heating under mild conditions, e.g., 57-68°C. The number of bacteria is reduced, e.g., for production of cheese.

Pasteurization is the thermal treatment of milk at a temperature below its boiling point. Different methods of pasteurization are applied. They are:
- holder process: $t^\circ = 60-63$ °C, 30 min;
- flash process: $t^\circ = 72-73$ °C, 15-20 s;
- short-time process: $t^\circ = 85-90$ °C, 3 s.

During this treatment vegetative forms of microorganisms are killed in the product, but spores remain in a viable state and in the case of a favourable environment they begin to multiply rapidly. Therefore, pasteurized products should be stored at low temperatures for a limited period of time.

Sterilization is a thermal treatment at temperatures above 100 °C. Both vegetative and spore forms of microorganisms are destroyed. Sterilized products keep their taste and nutritional properties fora long time.

Ultrahigh temperature treatment (UHT) involves heating milk at 135-145°C for 2-4 s followed by obligatory aseptic packaging. It is more gentle process for biologically active substances than sterilization.

Bactotherm process is a combination of centrifugal sterilization in bactofuges (65 to 70 °C) and UHT of the separated sediment (2-3% of the milk) followed by recombination. Since the total amount of milk is not heated in this process, the taste is improved. The shelf life is 8-10 days.

Although the processes of sterilization of milk is constantly being improved and are close to the possibility of manufacturing completely sterile products with the minimal loss of nutritional and biological value, yet the heat treatment changes a number of components in milk. Serum proteins undergo significant changes, namely solubility decreases, especially for fractions of immune globulins and albumins.

Furthermore, continuous sterilization of milk products at the temperature above 115 °C causes destruction of cysteineresidues with elimination of hydrogen sulfide (I), dimethyl sulfide (II) and cysteic acid (III):

\[
\text{H}_2\text{S} \quad \text{H}_3\text{C}\text{S} \quad \text{HO}_3\text{S} \quad \text{COOH} \\
\text{I} \quad \text{II} \quad \text{III} \quad \text{NH}_2
\]

When heating there is, a partial change of the casein-calcium phosphate complex into the insoluble form with precipitate formation ("milk stone").

Lipids are slightly changed. Almost all vitamins are destroyed, and the higher the temperature and the duration of treatment are, the greater are the losses.

When milk is heated above 100 °C, the partial destruction of lactose to lactic acid and formic acid takes place. Lactose may react with amino acids as well to form lactosamine. Lysine reacts most easily with it and forms a stable complex that reduces bioavailability of the milk proteins.

Enzymes are inactivated under the action of temperature. Acid phosphatase and lysozyme are the most thermostable, and lipase is the least.

Types of milk
1. **Standardized milk** is a product derived exclusively from milk with addition or removal of its components to bring the composition of the milk to the indicators set out in the national standards.

2. **Homogenized milk** is produced by extreme mechanical impact on the fat phase of milk by forcing with a high speed through narrow slits.

3. **Reconstituted milk** is milk obtained by adding water to dry or condensed milk to restore a specific ratio of solids and water. In terms of quality reconstituted and whole milk are identical, but different in taste.

4. **Recombined milk** is obtained by mixing milk fat and other components of milk with addition (or without) of water in specific proportions for a particular type of product’s characteristics and properties.

5. **Whole milk** is normalized or reconstituted milk with the fat content set.

6. **Fortified milk** is milk containing vitamin supplements – vitamins C, A and D.

7. **Protein milk** is a low fat milk enriched with protein due to addition of dry or skimmed milk.

8. **Baked milk** is the standardized milk with the fat content of 4-6% subjected to homogenization, pasteurized at a temperature not below 95°C for 3-4 hours. The product has a characteristic taste and smell, a creamy colour being a result of the lactose interaction with proteins and some free amino acids. The resulting melanoidins and sulfhydryl compounds are involved in changing the taste and colour of milk. The nutritional value of baked milk is lower than of pasteurized milk.

9. **Condensed milk** is a milk product derived from whole cow's milk, skimmed milk, dried milk, cream, sugar, milk sugar, and water. This product is produced mainly for a long-term storage. By increasing the sugar concentration the high osmotic pressure is created, which causes plasmolysis of bacterial cells. After cooking the raw material is pasteurized at high temperature (95 C°), then it is concentrated under vacuum for 2-2.5 hours with simultaneous addition of sugar syrup. During the process some vitamins (about 20%) are destroyed, and sugars react with amino acids to form melanoidins.

**Cream** is a milk product derived from whole milk by separating the fat fraction. Cream is usually produced pasteurized with the fat content of 10-20% (normal or coffee cream) and 30-35% (heavy cream). They contain 3.5% protein, 4.3% carbohydrates, mineral salts and vitamins (A, E, B₁, B₂, C, PP, etc.).

**Fermented milk products.** They include sour-milk drinks (sour milk, kefir, ryazhenka, kumis, acidophilus milk, etc.), cheese and its products, sour cream, etc. Fermented milk products are obtained from normalized, purified, homogenized, pasteurized and cooled to the required temperature milk or cream via fermentation by the corresponding starter cultures consisting mainly of lactic acid bacteria. These bacteria ferment lactose with the help of β-galactosidase enzyme to lactic acid (Scheme 3.3).

After the lactose hydrolysis (Scheme 3.1) the glucose formed is subjected to the enzymatic conversion to form pyruvic acid (Scheme 2.3). Galactose is also converted in pyruvic acid, which in the presence of lactate dehydrogenase enzyme is reduced to lactic acid.
Scheme 3.3. The enzymatic cleavage of lactose to lactic acid.

At each stage of lactic acid fermentation the by-products are produced, for example volatile acids (acetic, propionic, etc.), carbonyl compounds (diacetyl, acetaldehyde, etc.), alcohol, carbon dioxide and other substances involved in formation of flavour and taste of dairy products. By the same time the acid coagulation of the casein fractions of milk proteins takes place during lactic acid fermentation of lactose, and the structure of casein-calcium-phosphate complex with release of soluble calcium is disrupted.

Quite often lactic acid fermentation is accompanied with alcohol fermentation if there is milk yeast in the medium. In this case pyruvic acid formed from lactose (Scheme 3.4) under the action of pyruvate decarboxylase enzyme is cleaved to acetaldehyde and CO₂ (Scheme 3.4). Acetaldehyde is reduced to alcohol by aldehyde dehydrogenase.

Scheme 3.4. Alcoholic fermentation.

Finally of alcoholic fermentation of lactose can be presented as follows:

\[
C_{12}H_{22}O_{11} + H_2O \rightarrow 4 CH_3CH(OH)_2 + 4 CO_2
\]

The nutritional value of milk products is mainly determined by their content of protein, fat, calcium, phosphorus, and vitamins A, β-carotene and B₂. The value of dairy products is caused by the presence of microorganisms in their composition and their metabolic products that inhibit putrefaction processes in the human gastrointestinal tract. Dairy products are digested 3 times better than milk as in the process of their production many substances are broken down to simpler substances and lactic acid bacteria stimulate the secretory activity of the stomach and accelerate digestion of food. The products that are produced by fermentation such as lactic acid, carbon dioxide, alcohol have a beneficial effect on the digestive organs. Fermentation milk products promote the synthesis of vitamins in the intestine by the action of certain microorganisms. Substances produced by lactic acid bacteria inhibit diphtheria, typhoid, tuberculosis, and other diseases causative agents. Fermented
products are widely used in clinical nutrition to improve the gastric secretion and normalization of the intestinal motility in the treatment of colitis and gastritis.

In production of fermented milk drinks and sour cream milk is pasteurized in order to maximize removal of concomitant microorganisms, which can inhibit development of lactic acid bacteria cultures, and to improve formation of curd.

**Kefir** is a fermented milk product prepared from whole or skimmed milk fermented by both lactic acid and alcoholic fermentation using kefir starter – a symbiosis of several species of microorganisms: lactic streptococci and bacilli, acetic acid bacteria and yeast (about 20 species). Kefir contains a small amount of carbon dioxide. Kefir is quite widespread not only in Russia, Ukraine, Belarus, Kazakhstan, Baltic States, but also in Germany, Sweden, Norway, Finland, Hungary, Poland, Israel, the USA and Australia.

Kefir is different from other milk products by the unique set of bacteria and fungi, which number of CFU (colony forming units) per 1 g of the product over the shelf-life should be less than $10^7$, yeast - not less than $10^4$. Kefir can be a one-day, two-day and three-day, and it determines its quality and such characteristics as acidity, the degree of accumulation of carbon dioxide and alcohol, the degree of protein swelling. The percentage of ethanol reaches 0.07% (by the outdated technology using rennet enzymes it could be a few tenths of a percent) in the one-day kefir and 0.88% in the three-day kefir. In this regard, kefir, especially a three-day one, should be used carefully by small children as well as in certain diseases such as epilepsy.

Kefir is produced with a different fat content: from 0.5% (defatted) to 7.2%-8.9% (high-fat); classic kefir has 2.5% of fat. Kefir should be stored at 2-4°C.

Kefir like other dairy products has the probiotic effect and prevents development of intestinal pathogens. Kefir has the immune stimulating, sedative and a slight diuretic effect. In production of kefir bacteria produce a natural antibiotic nisin.

**Biokefir** is kefir with special starters consisting of thermophilic and mesophilic lactic streptococci, acidophilus bacilli (*Lactobacillus acidophilus*), bifidobacteria (*Bifidobacteriumbifidum*). Both acidophilus bacilli and bifidobacteria are not destroyed under the action of the gastric juice. Bifidobacteria are a natural component of the intestinal microflora.

**Sour milk** is a product obtained by fermentation of milk as a result of spontaneous souring caused by various lactic acid bacteria, or mesophilic microorganisms (*Lactococcuslactis L., cremoris L. diacetylactis, Leuconostoccremoris*) at 20 °C. Lactic acid, which is produced during fermentation, coagulates casein at pH 4-5. Sour milk contains 0.5-0.9% of lactic acid. Sour milk is produced mainly by the thermostatic method: the raw material prepared is dosed in consumption package; fermentation and maturing take place in a thermostat. Due to this, sour milk has unimpared, moderately dense curd without gas bubbles.

**Yogurt** is a fermented milk product with a high content of a dry fat-free residue produced using a mixture of microorganisms - thermophilic lactic streptococci and Bulgarian lactobacilli (*Streptococcus thermophilus and Lactobacillus bulgaricus*). Incubation is conducted by adding of 1.5-3% of the starter
culture at 42-45 °C for about 3 hours. The resulting product has pH of 4-4.2 and contains 0.7-1.1% of lactic acid. Special yogurt, "acidophilus" is produced by *Lactobacillus acidophilus* (37-38 °C) and contains 0.5-0.7% of lactic acid. Food supplements, fruits, vegetables and their products can be added. A dairy product can be called "bio" if it contains $10^6$-$10^7$ CFU/g (or cm$^3$) of the probiotic microorganisms (lactic bacteria and bifidobacteria). According to the standard a product containing bifidobacteria is called a *bifido-yogurt*. A bio-yogurt is a yogurt-based product, which additionally contains *Lactobacillus acidophilus* (acidophilus bacilli). The shelf life of a yogurt containing live organisms is about 14 days at a temperature of +4 to +6 ºC.

**Ryazhenka** is made by lactic acid fermentation from baked milk and cream, which gives it a distinctive taste and a creamy colour, and is soured by the same starter as a usual dairy product. Compared to other fermented milk products ryazhenkahas the highest calorie content.

**Sour cream** is obtained by fermentation of a normalized pasteurized cream by pure cultures of lactic streptococci. To make the cream the solid consistency, a pleasant “ripe” taste and smell it is kept for 1-2 days in refrigerators. Among other sour milk products sour cream has the increased caloric value. It is digested faster and easier than cream, and contains 7 - 10 times more of vitamins A and E than milk. Sour cream may have the following aroma defects: fodder flavours, bitter, sour, metallic, rancid, fatty taste; loose, stringy, expanded consistency, isolation of the serum.

**Cottage cheese** is the protein dairy product produced by fermentation of pasteurized milk with pure cultures of lactic acid bacteria and removal of whey. Cottage cheese is characterized by the significant content of fat (2-18%), proteins (14-16%), minerals and essential amino acids. Due to the presence of sulfur-containing amino acids (especially methionine) cottage cheese is used for dietary and medicinal nutrition. The degree of digestion of cottage cheese protein is higher than of meat protein.

There are several classifications of cottage cheese:
1. By the content of fat:
   • fatty (18%);
   • moderately fatty (9%);
   • fat-free cottage cheese (not more than 3%).
2. By the method of milk proteins coagulation:
   • the acidic cottage cheese is prepared mainly from skimmed milk, protein coagulation occurs under the action of lactic acid produced during fermentation.
   • The acid-rennet cottage cheese – for coagulation of milk proteins the rennet enzyme (or pepsin) and lactic acid bacteria starter are applied simultaneously.

The sell-by date for cottage cheese is not more than 36 hours from the end of the process. During this period the cottage cheese is stored at a temperature from 0 to 8 °C. Frozen cottage cheese can be stored at the temperature of - 18 °C for 4-6 months. Thawing is carried out at room temperature for 12-18 hours.

The types of cottage cheese:
1. With additives (raisins, dried fruit, nuts, etc.).
2. Curd mass is a product made of grated cottage cheese, flavoured (sugar, dried fruits, etc.). The mixture can be also thermally treated.

3. Calcined – such cottage cheese is produced with addition of calcium compounds (calcium chloride or calcium lactate).


**Cheese** is a food product obtained from milk using the milk-curdling enzymes and lactic acid bacteria, or by melting of various dairy products using salt-melters.

Today there is about 2,000 varieties of cheese, most of which is produced in limited quantities. The most famous are Cheddar, Dutch, Swiss, and Mozzarella (Pasta filata) comprising up to 80% of the total volume of the cheese produced.

Depending on the method of milk coagulation all varieties can be divided into:

- Rennet cheese (about 75% of the total) is prepared using rennet – the enzyme complex extracted from the stomach of young calves and lambs consisting of chymosin and pepsin. They can be hard, soft, pickle (ripening and stored in brine).
- Cheese with acid-thermal coagulation is produced from skimmed milk fermented by the lactic acid bacteria starter: Schabziger (green cheese – containing a special kind of herb – Trigonella caerulea); containing cottage cheese and non-ripening cottage cheese.

The chemical nature of the cheese production process is destruction of the protein component of the casein complex, protein molecules to amino acids, which are the nutrition medium for the subsequent development of beneficial microflora. To facilitate coagulation of milk calcium chloride can be added. If there is not enough calcium in milk, it coagulates by the enzyme slowly and the flabby curd that is difficult to further treatment is formed or it does not form at all. Adding to milk even the lowest dose of calcium chloride (10 g/100 kg of milk) shortens the rennet coagulation time twice. Furthermore, sodium or potassium nitrates can be added to suppress undesirable microorganisms and prevent swelling. In cheese production the necessary step is addition of bacterial starters with the various compositions depending on the type of cheese. The most common of these are *Streptococcus thermophilus* and *Lactobacillus lactis*. The aging of cheese (also called maturing) is the step of cheese production when the cheese achieves its taste, flavour and characteristics of the type. Maturing can last from several days to several months at a temperature not higher than 15 °C depending on the type of cheese. This step increases the content of free amino acids, which can subsequently undergo deamination to release ammonia and keto acids, and oxidative deamination to form ammonia, carbon dioxide and aliphatic aldehydes. Hydrolysis of triglycerides into fatty acids takes place actively. Fatty acids under the action of enzymes, air, and minerals can decompose to aldehydes and ketones. Lactose is converted to lactic acid and carbon dioxide (Scheme 3.3, 3.4) as well as to a number of by-products – acetic acid, diacetyl, acetoin, etc. During maturing lactic acid is decomposed, it stays unchangeable only for 0.4-1.3% depending on the cheese type. Vitamins and minerals remain almost unchanged. As a result of maturing a cheese curd becomes of a yellowish colour, distinctive taste that is characteristic for each type of cheese,
texture and pattern. Young unripened cheese is tasteless and not fragrant, has a thick consistency. The optimum storage temperature of cheese is from +5 °C to +8 °C.

Due to its composition and the special production technology, cheese is one of the most useful and valuable food products. The product has a high protein (26%) and fat (60%) content, vitamins A, D, E, B₁, B₂, B₁₂, PP, pantothenic acid and others, as well as inorganic salts and amino acids. It has the lack of sulfur – containing amino acids and vitamin C, as well as relatively high cholesterol content. Cheese is a highly nutritious dairy product, in which fats and proteins retain the properties of natural milk. Cheeses contain high amounts of calcium in the most easily digestible form as part of it changes to the more soluble calcium lactate form.

**Processed cheese** is produced by melting of natural cheese (75-95 °C) with adding cottage cheese, sour cream, milk, butter, spices and excipients (cocoa powder, coffee, vanilla, etc.), as well as emulsifying salts reducing the melting point of cheese. As emulsifying salts orthophosphoric acid salts or citric acid salts, as well as sodium tripolyphosphate, etc., are used, usually mixed with each other. On average, salts are added up to 3% by weight of cheese.

**Acidophilus products** are acidophile, acidolact, acidophilus milk, and acidophilus-yeast milk. They are prepared from pasteurized or sterilized milk fermented by a pure culture of *Lactobacillus acidophilus* with addition of different types of lactic acid bacteria and yeast. Some types of acidophilus bacteria give the product a little mucous, delicate texture. *Lactobacillus acidophilus* helps to produce antibiotic substances in products, so they have the curative and prophylactic properties.

**Butter** is a food product obtained by whipping or converting the high fatty cream. Butter is a "water-in-oil" emulsion (in contrast to cream - "oil-in-water"). It has a high content of milk fat (50-82.5%, in ghee – about 99%), which has valuable biological and gustatory properties. It includes a balanced complex of fatty acids (mainly saturated), is a source of cholesterol (about 200 mg/100 g), contains significant amounts of phosphatides (400 mg%) and fat-soluble vitamins (A, D, E), has a low melting point (32-35 °C) and freezing point (15-24 °C), is easily digested by the body (90-95%). Butter contains the substances of milk: milk proteins, carbohydrates, some water soluble vitamins, minerals and water (this part is called butter plasma. Butter has a high calorific value. Non-uniform colour can be observed because of the uneven distribution of dye added to butter during the winter period or when mixing butter of different colours. The second type of colour is topiness – a dark yellow layer on the surface of butter with an unpleasant odour and taste. It is formed by oxidation of butter fat.

Depending on the type of cream butter is divided into:
• sweet-cream made of pasteurized fresh cream;
• sour-cream made of pasteurized cream fermented with the lactic acid starter cultures (it gives the butter a specific taste and aroma).

Depending on the presence or absence of table salt butter is divided into salted and unsalted.
Butter with excipients is made of a fresh cream with addition of flavouring and aromatic substances such as cocoa powder, honey, vanilla, sugar, and fruit juices.
Ghee is prepared from butter by heating it to 75 °C - 80 °C and clarifying. It contains not less than 98% of fat, but almost does not contain biologically active substances.

Spread is a food product, which comprises a mixture of dairy and vegetable fat with a content of the total fat from 50% to 85%, wherein the percentage of the milk fat is not less than 25% of the total.

Margarine is a product obtained from vegetable oils, hydrogenated fish oil, or from their compositions, with or without addition of the animal fat and milk products, surfactants, and flavour and aromatic additives. To obtain stable emulsions different emulsifiers are used; they are phosphatides, milk powder, synthetic emulsifiers. Vegetable oils and margarines obtained from them contain no cholesterol. The margarine consistency may be plastic or liquid. Vegetable oils used for production of margarine can be in natural form – sunflower, soybean, rapeseed, palm oils, as well as in a fractionated, transesterified or hydrogenated form.

Hydrogenation is the process of converting liquid vegetable oils into solid or semi-solid fats by addition of hydrogen to the double bonds of the unsaturated fatty acid residues.

During transesterification the fat consistency is also changed from liquid to solid. Transesterified fat is obtained from a mixture of vegetable oils and animal fats in the presence of catalysts (sodium methoxide, ethoxide and aluminosilicates). The proper selection of the raw material and catalysts the transesterification, in contrast to the hydrogenation, yields margarine without trans-isomers.

Trans-isomers are the "wrong" or modified fatty acid molecules. The human body cannot distinguish between cis-fats and trans-fats and involving them in all biological processes. Therefore, the harmful compounds can be formed in a human organism as far as cardiovascular diseases can develop.

The most important step in production of margarine is emulsification of the fat base with milk or water.

To give the flavour and the taste of butter to margarine the ghee with a high acidity; fermented milk where the aromatic substance diacetyl is formed, special aromatic mixtures, synthetic diacetyl; and citric acids are used. The vegetable colourants – carotenoids, annatto, and curcuma are used for colouring of margarine. Benzoic and sorbic acids are used as preservatives.

The main difference between spread and margarine is in the proportional ratio of milk fat and vegetable oil. Spreads also are limited for amount of hydrogenated fats, whereas margarine has no such limitation.

Adulteration of milk and dairy products

When selling of dairy products the following defects can occur: development of fungal microorganisms, biochemical processes (increased acidity, souring of milk, etc.), physical processes (adsorption, desorption).

Adulteration of milk usually reduces to dilution of milk with water, addition of raw milk to pasteurized milk, addition of preservatives (formaldehyde) or baking soda to reduce the acidity, decrease in the fat content, addition of foreign components, renovation of sour milk, etc.
There are cases where milk and dairy products are falsified by introducing foreign substances. Most often, these substances are added to the product to give a normal appearance and flavour (flour, starch) or to reduce its acidity (soda). In such cases the quality control of milk must also determine the presence of impurities.

**Methods for detection of water in milk**
1. Mix milk and alcohol in the ratio of 1:2. Shake the mixture for some time and quickly pour into a saucer. If milk is not diluted, no later than in 5-7 seconds flakes will form in the liquid. If flakes are formed in a grater period of time, milk is diluted with water. The more water milk contains, the more time is required for flakes formation.

2. Milk mixed with water forms a wide bluish ring near the walls of glassware. It does not form a convex drop on a nail of a person, and the drop runs. If it has also solid admixtures (flour, chalk, potash, etc.), the sediment remains on the nail.

**Methods for detection of adulterated milk and dairy products** (for the presence of starch, chalk, soap, soda, lime, boric or salicylic acid, gypsum, washing powder)

**Milk:**
1. Filter the milk through a paper filter and add a few drops of vinegar or citric acid solution; bubbles of carbon dioxide (soda) appear.
2. The chemical impurities are determined the litmus test: if milk is not diluted, the blue litmus paper turns red, and the red one becomes blue.
   If an acid (boric or salicylic acid) is added to milk the blue litmus paper turns red, and the red one does not change its colour.
3. If milk is thick near the bottom of the vessel, it contains starch or flour. When boiling the precipitate it turns into a flour paste. If you add a few drops of iodine solution, milk will turn blue.
4. **Determination of soda in milk:**
   *Qualitative determination* is carried out by the change of colour of bromothymol blue indicator.
   *Quantitative determination (assay)* is carried out after ignition of the milk sample and determination of basic properties of the residue by the back acid-base titration (phenolphthalein as an indicator):
   \[
   \begin{align*}
   \text{HCO}_3^- + \text{HCl} & \rightarrow \text{Cl}^- + \text{CO}_2 \uparrow + \text{H}_2\text{O} \\
   \text{CO}_3^{2-} + 2\text{HCl} & \rightarrow 2\text{Cl}^- + \text{CO}_2 \uparrow + \text{H}_2\text{O} \\
   \text{HCl} + \text{NaOH} & \rightarrow \text{NaCl} + \text{H}_2\text{O}
   \end{align*}
   \]

**Sour cream:**
1. Put a teaspoon of sour cream into a glass of boiled water. The poor quality sour cream will precipitate or give lumps. The good quality sour cream will dissolve completely.
2. Add several drops of *Lugol* solution to a teaspoon of sour cream and mix. The appearance of a blue colour means the presence of starch.

**Cheese:**
Grind a piece of cheese and moisten it with the solution of iodine. A blue colour means the presence of starch.

**Butter:**
1. Prepare a mixture of alcohol and concentrated sulfuric acid in the ratio of 2:1. Add some melted butter to the mixture in the ratio of 2:1. Heat the mixture to boiling and smell it after cooling. If the cooled mixture has a pleasant pineapple smell it is not faked butter. If the mixture has an unpleasant smell, it is margarine.

2. Put some butter in the test tube and heat from above so that the butter goes down. Thereafter, heat the butter to boiling from below. If butter is natural, it will turn black and starts slowly emitting bubbles. If it is margarine, it will brighten and boil rapidly spilling outside.

Indicators of dairy products quality

The standard defines the requirements for 28 types of pasteurized milk, baked milk, protein milk, milk fortified by vitamin C, milk containing cocoa powder and coffee, as well as sterilized, low-fat or with the fat content of 1 to 6% milk. All types of dairy products are controlled by the following indicators of quality:

1. *Organoleptic characteristics*: appearance, consistency, colour, odour, taste.

2. *Physicochemical properties*:

   - *Milk-cream products*: the relative density, temperature, acidity, the content of fat and dry matter, the pasteurization efficiency.
   - *Sour-milk products*: acidity, the content of moisture, fat, alcohol, sugar and sodium chloride.

   The same parameters, with the exception of alcohol, are determined for canned milk products.

   - *Cheese*: the content of moisture, fat, sodium chloride, the degree of maturing.
   - *Butter*: the content of moisture, fat, sugar, sodium chloride, dry matter; thermal stability, the level of fat globuli dispersion, the chemical composition of milk fat.

3. *Medicobiological requirements*: the content of toxic elements, mycotoxins, tetracycline antibiotics, hormones, pesticides; microbiological parameters (for all types of dairy products).

**Physicochemical properties**

*Relative density* is a ratio of the mass of a certain volume of milk at the temperature of 20 °C to the mass of an equal volume of water at the temperature of 4 °C. Density is one of the most important parameters of natural milk and depends on the content of protein, fat and carbohydrates. Density is also used for determination of a type of adulteration.

Density is determined with an areometer or with a pycnometer and is measured in g/cm³, kg/m³ and areometer degrees (° A).

*Stability* of milk characterizes its ability to stay unchangeable for some time during boiling and its resistance to the putrid microflora. The degree of stability can be judged by the amount of dissolved oxygen therein, and other gases (nitrogen, hydrogen, carbon dioxide) formed as a result of the activity of microorganisms. The low concentration of oxygen and the high content of other gases indicate the high content of bacteria and contamination of milk.

*The freezing point* of milk is determined to characterize its natural origin. Fresh whole milk has a constant freezing point.

*Acidity* is an indicator of freshness of milk and one of the main criteria for assessing its quality. When storing the milk acidity increases due to formation of
lactic acid by lactic acid fermentation. Acidity also depends on the presence of proteins, citric acid, carbonic acid, acidic salts, phosphates and citrates. Milk with the increased acidity curdles by heating. Acidity can be reduced as a result of milk adulteration (dilution with water, addition of soda), and in certain diseases of animals. In milk, titratable acidity and active acidity are determined.

**Active acidity** is determined by the concentration of free hydrogen ions and is expressed as $\text{pH} = \log \left( \frac{1}{c} \right)$, where $c$ is the concentration of free hydrogen ions. In fresh milk $\text{pH} = 6.68$. Active acidity is determined by the potentiometric method using a pH-meter.

**Titratable acidity** is measured in Turner degrees ($^\circ\text{T}$) and shows the amount of 0.1 M solution of alkali, which is needed to neutralize 100 ml of milk or 100 g of the product with the double portion of distilled water in the presence of the phenolphthalein indicator. The end-point is the appearance of a slightly pink colour, which does not disappear within 1 minute.

**Determination of protein in milk and dairy products:**

- **Kjeldahl method** is determination of nitrogen by sulfuric acid digestion. The liberated ammonia is trapped into the receiver with boric acid. The titrant is the solution of hydrochloric acid. Blank titration is carried out.

\[
\begin{align*}
\text{R} & \rightarrow \text{COOH} \\
\text{H}_2\text{N} & \rightarrow \text{H}_2\text{SO}_4 \\
\text{NH}_4\text{HSO}_4 + 2\text{NaOH} & \rightarrow \text{NH}_3 \uparrow + \text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O} \\
\text{H}_3\text{BO}_3 + \text{NH}_3 & \rightarrow \text{NH}_4\text{BO}_2 + \text{H}_2\text{O} \\
4\text{H}_3\text{BO}_3 + 2\text{NH}_3 & \rightarrow (\text{NH}_4)_2\text{B}_3\text{O}_7 + 5\text{H}_2\text{O} \\
(\text{NH}_4)_2\text{BO}_2 + \text{HCl} + \text{H}_2\text{O} & \rightarrow \text{H}_3\text{BO}_3 + \text{NH}_4\text{Cl} \\
(\text{NH}_4)_2\text{B}_3\text{O}_7 + 2\text{HCl} + 5\text{H}_2\text{O} & \rightarrow 4\text{H}_3\text{BO}_3 + 2\text{NH}_4\text{Cl} \\
\end{align*}
\]

- **Colorimetric method** is based on the xanthoproteic reaction and measurement of the solution absorbance compared to the absorbance of distilled water. To carry out the xanthoproteic reaction nitric acid is added to the solution of milk and heat till a yellow colour appears. The coloration is observed because of nitration of aromatic rings of amino acid residues being the parts of proteins. With further addition of an alkali solution an orange color is observed caused by formation of nitronic acids with the quinoid structure of conjugate double bonds.

\[
\begin{align*}
\text{H}_2\text{C}-\text{CO-} & \rightarrow \text{Na} \\
\text{N} & \rightarrow \text{Na} \\
\text{O} & \rightarrow \text{O} \\
\end{align*}
\]

The coloured solution should be filtrated and its absorbance should be determined in the UV-range.
- **refractometric method** (for raw milk) is the measurement of the refractive index of milk and the protein-free milk serum obtained from the same sample of milk. The difference of refractive indexes is proportional to the content of protein.

**Determination of fat in milk and dairy products**
- **gravimetric method** is based on fat extraction from ammonia-alcohol solution of milk by ether followed by solvents evaporation and weighing of the residue;
- **acidic method** is based on the extraction of fat from milk or a dairy product by concentrated sulphuric acid and isoamyl alcohol followed by centrifugation and measurement of the fat volume;
- **turbidimetric method** is based on the measurement of the degree of light beam weakening of scattering by the layer of fat globuli of milk.

Fat is an indicator of good quality of milk and dairy products; in the case of cream removing or milk dilution with water or milk whey its content is reduced, and it affects the quality of the product. It is the main indicator for butter.

**Determination of lactose in dairy products:**
- **iodometric method** is based on the lactose ability to be oxidized by the iodine excess in the alkaline medium. Iodine oxidizes lactose to lactobionic acid and glucose, which is produced during the sucrose inversion, to gluconic acid. The process of titration can be presented as follows:

\[
I_2 + 2NaOH \rightarrow NaI + NaO\text{H} + H_2O
\]
\[
R-C=H + NaO\text{H} + NaOH \rightarrow R-C^=O\text{Na} + NaO\text{H} + H_2O
\]
\[
NaI + NaO\text{H} + H_2SO_4 \rightarrow Na_2SO_4 + I_2 + H_2O
\]
\[
I_2 + 2Na_2S_2O_3 \rightarrow 2NaI + Na_2S_4O_6
\]

- **polarimetric method** (for dairy products containing sugar) is based on polarimetric determination of glucose and the ability of lactose to be decomposed under the action of calcium oxide.

**Tests for the pasteurization efficiency:**

**Determination of peroxidase:**
- the reaction with \( p \)-phenylenediamine chloride is based on decomposition of hydrogen peroxide by the peroxidase enzyme present in milk and dairy products. Active oxygen produced during hydrogen peroxide decomposition oxidizes \( p \)-phenylenediamine with formation of a blue colour;

\[
R-C\equiv \text{H} + \text{NaO\text{H}} + \text{NaOH} \rightarrow R-C=\text{O\text{Na}} + \text{NaO\text{H}} + H_2O
\]

- the reaction with starch and potassium iodide is based on decomposition of hydrogen peroxide by the peroxidase enzyme present in milk and dairy products. Active oxygen produced during hydrogen peroxide decomposition oxidizes potassium iodide. Iodine is produced and gives a blue colour with starch:

\[
2\text{KI} + H_2O_2 \xrightarrow{\text{peroxidase}} I_2 + 2\text{KOH}
\]

**Determination of phosphatase:**
- the reaction with 4-aminoantipyrine is based on hydrolysis of phenylphosphoric acid disodium salt by phosphatase. The phenol produced is oxidized into quinine, which in the presence of an oxidizing agent gives a pink colour with 4-aminiantipyrine:

\[
\text{C}_6\text{H}_5\text{-O-P-O(ONa)}_2 + \text{phosphatase} \rightarrow \text{OH} \quad \text{OH} \quad \text{COO}^-
\]

- the reaction with sodium phenolphthalein phosphate is based on hydrolysis of sodium phenolphthalein phosphate by phosphatase. The phenolphthalein produced in the alkaline medium gives a red colour:

\[
\text{O} \quad \text{O} \quad \text{H} \quad \text{O} \quad \text{C} \quad \text{CH}_3 \quad \text{CH}_3 \quad \text{O} \quad \text{N} \quad \text{O} \quad \text{CH}_3 \quad \text{CH}_3
\]

**Determination of thermal stability by the alcohol test** is based on the alcohol action on milk and cream proteins, which denature completely when mixing equal volumes of milk or cream with alcohol.

**Determination of aldehydes in butter (fat rancidity)** is based on formation of a purple-violet dye during the reaction of aldehydes with *Shiff’s* reagent (aqueous solution of fuchsine sulphuric acid).

\[
\text{O} \quad \text{H} \quad \text{O} \quad \text{C} \quad \text{H}_2 \quad \text{O} \quad \text{H} \quad \text{O} \quad \text{S} \quad \text{O} \quad \text{H} \quad \text{O} \quad \text{S} \quad \text{O} \quad \text{H} \quad \text{O} \quad \text{S} \quad \text{O} \quad \text{H} \quad \text{O}
\]

**Determination of ammonia** is based on coloration of milk whey obtained after addition of acetic acid with *Nessler* reagent:

\[
\text{NH}_3 + 2 \text{K}_2\text{[Hgl}_4] + \text{KOH} \rightarrow \text{I}^- + \text{5Kl} + \text{H}_2\text{O}
\]

**Determination of sodium chloride in dairy products**  
The assay of sodium chloride is carried out by the methods of argenometry:
- back argentometry (Volhard method), the indicator is ferric ammonium sulphate:

\[
\text{NaCl} + \text{AgNO}_3 \rightarrow \text{AgCl} \downarrow + \text{NaNO}_3
\]

\[
\text{AgNO}_3 + \text{NH}_4\text{SCN} \rightarrow \text{AgSCN} \downarrow + \text{NH}_4\text{NO}_3
\]

\[
3\text{NH}_4\text{SCN} + \text{Fe(NH}_4\text{)(SO}_4\text{)}_2 \rightarrow \text{Fe(SCN)}_3 + 2(\text{NH}_4\text{)}_2\text{SO}_4
\]

- direct argentometry (Mohr’s method), the indicator is potassium chromate:

\[
\text{NaCl} + \text{AgNO}_3 \rightarrow \text{AgCl} \downarrow + \text{NaNO}_3
\]

\[
2\text{AgNO}_3 + \text{K}_2\text{CrO}_4 \rightarrow \text{Ag}_2\text{CrO}_4 \downarrow + 2\text{KNO}_3
\]

Milk must meet strict sanitary requirements. Depending on the type of packing the total quantity of bacteria and the quantity of \(E.\ coli\) are limited. Pasteurized and sterilized milk must not contain pathogenic microorganisms.

**Defects of milk are:**
colours (blue, yellow);
odour (cattle, fodder, putrid);
taste (bitter, salty, fodder, fish, sour);
consistency (watery, slimy, sticky, curdled).

The cause of many defects of milk is low-quality forage. Bacteria can cause souring, rotting, rancidity, mustiness, give sticky consistency to milk. If dirty vessels not intended for milk are used, milk may acquire unusual smacks and smells and be stored badly. The milk obtained in the end of lactation period is (7-10 days before the end of lactation) and colostrum (the first 7 days after calving) is unsuitable for industrial processing. Such milk is characterized by changes in the chemical composition and properties.

**The pharmacist’s recommendations to patients and physicians for the rational combination of drugs and milk**

Drugs irritating the mucous membrane of the digestive tract but not binding to milk proteins and calcium from milk and not changing their activity at the pH of milk (6.4) should be taken with milk. Such medicines include: calcium - containing drugs, steroids (prednisolone, dexamethasone), non-steroidal anti-inflammatory drugs (phenylbutazone, indomethacin). Milk increases the rate and completeness of absorption of these drugs, therefore, they are recommended to be taken 30-40 minutes before meals with milk.

One should not drink antibiotics with milk – tetracyclines, penicillins, cephalosporins, fluoroquinolones, viral protease inhibitors (nelfinavir) since it reduces the rate and completeness of absorption due to chelation with calcium caseinate contained in milk, as well as to lowering the pH of the gastric juice.

Milk enhances absorption of vitamin D, which overdosage is dangerous primarily to the CNS.

Caffeine intake and the simultaneous consumption of milk lead to binding of about 30% of the drug by milk protein. Its liberation from the complex formed is very slow.
Dairy products limit absorption of iron salts by formation of unsoluble compounds. A large quantity of milk can reduce the gastroprotective properties of bismuth medicines.

During treatment by drugs with a acid-resistant cover milk causes the danger of early dissolution of the cover (potassium salts, pancreatin, pankurmen, bisacodyl) that leads to early liberation of the active substances.

Most cheeses (except cottage cheese), sour cream, and yoghurt contain large amounts of tyramine and should not be combined with monoamine oxidase inhibitors (MAOIs). Tyramine as far as serotonin contained in these kinds of food can seriously affect the pharmacodynamics of MAOIs, antidepressants, psychostimulants, isoniazid; reduce their therapeutic efficacy and cause the side effects in the form of a hypertension crisis, a sharp increase in toxicity, and seizures (the so-called "cheese effect"), till a fatal outcome.
QUESTIONS FOR SELF-CHECKING

1. Which main groups of dairy products do you know?
2. Explain the following terms: normalization, homogenization, thermization, pasteurization, sterilization, separation.
3. What is the nutritional and biological role of milk and dairy products? What are the norms of their daily consumption?
5. Which vitamins and minerals are contained in milk and dairy products?
6. What is the difference of the chemical composition of milk of various species of animals?
7. Which types of bacteria are used for production of dairy products? How do they affect the human body?
8. What are the conditions of storage and shelf life of milk and dairy products?
9. Which methods of determining phosphatase and peroxidase in milk do you know?
10. Which indicators are the parts of the medicobiological requirements (MBR) for the quality control of dairy products?
11. How ammonia and hydrogen peroxide are determined in milk according to the State Standard of Ukraine? Explain the causes for their occurrence and write the chemical reaction.
12. Explain the meaning of the qualitative and quantitative determination of sodium bicarbonate in milk.
13. What is the purpose of starch addition to milk and dairy products, and by what method is it determined?
14. What recommendations can you give for the rational combination of drugs and dairy products?
1. Casein of milk coagulates under the action of:
   A. water
   B. alkalis
   C. light
   D. temperature
   E. acids

2. How is milk sugar called?
   A. lactose
   B. glucose
   C. mannose
   D. ribose
   E. sucrose

3. What gastric enzyme promotes the release of glyco- and phospholipids from milk casein:
   A. pepsin
   B. globulin
   C. chymosin
   D. hydrochloric acid
   E. phosphatase

4. Which fatty acid causes a rancid taste of milk:
   A. butyric
   B. linoleic
   C. tartaric
   D. oleic
   E. arachidonic

5. By what method of heat treatment the nutritional value of dairy products is almost unchanged?
   A. pasteurization
   B. sterilization
   C. ultra heat treatment
   D. thermization
   E. bacthoterm process

6. What is the method of determining the content of protein in dairy products:
   A. acidimetric
   B. complexometric
   C. permanganometric
   D. argentometric
   E. Kjeldahl method
7. What group of drugs cannot be taken with milk because of formation of complexes with calcium caseinate:
   A. alkaloids
   B. calcium supplements
   C. NSAIDs
   D. antibiotics
   E. steroid hormones

8. What vitamin absorption enhances milk and that may adversely affect the central nervous system:
   A. vitamin B₁
   B. vitamin C
   C. vitamin D
   D. vitamin D₃
   E. vitamin B₁₂

9. The "Cheese" syndrome may develop when dairy products contain:
   A. tyramine
   B. histamine
   C. casein
   D. calcium
   E. unsaturated fatty acids

10. When taking drugs there is a risk of early dissolution of the cover. What are these drugs?
    A. with cover resistant to alkalis
    B. with gelatinous cover
    C. uncoated
    D. with the acid-resistant cover
    E. milk does not affect the stability of drug covers
CHAPTER 4

EGGS AND EGG PRODUCTS

Eggs and egg products

Eggs have been used in the human diet since ancient times. They are one of the natural complete protein products, because they contain essential amino acids and well-balanced nutrients. Eggs of poultry (hens, quails, ducks, geese, turkeys) by their structure, food and biological value are not significantly different. Currently, the term "egg" with no corresponding attribute applies only to hen’s eggs. The main groups of egg production are shown in Figure 1.

Fig. 1. The main groups of egg production.

The egg anatomy. A hen’s egg consists of a shell (10% of the total mass), shell membrane (less than 1%), egg white (approximately 57%) and yolk (33%). The average weight of an egg is in the range of 40-60 g. The egg membranes separate at the large end of the egg to form an air cell. The air cell is approx. 5 mm in diameter in fresh eggs and increases in size during storage, because of intensification of the processes of respiration and evaporation; hence, it can be used to determine the age of eggs.

The chemical composition and nutritional value of eggs.

The main components of the edible part of an egg are water (74%), protein (12%), fat (11%), carbohydrates (0.7%) (Table 3.1). The energy value of 100 g is 656.9 kJ or 157 kcal.

<table>
<thead>
<tr>
<th>Part</th>
<th>Total weight</th>
<th>Dry matter</th>
<th>Protein</th>
<th>Fat</th>
<th>Carbohydrates</th>
<th>Minerals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shell</td>
<td>10,3</td>
<td>98,4</td>
<td>3,3</td>
<td>-</td>
<td>-</td>
<td>95,1</td>
</tr>
<tr>
<td>Egg white</td>
<td>56,9</td>
<td>12,1</td>
<td>10,6</td>
<td>0,03</td>
<td>0,9</td>
<td>0,6</td>
</tr>
<tr>
<td>Egg yolk</td>
<td>32,8</td>
<td>51,3</td>
<td>16,6</td>
<td>32,6</td>
<td>1,0</td>
<td>1,1</td>
</tr>
</tbody>
</table>

The chemical composition of hen’s eggs, %

The egg white (albumen) is an aqueous, yellowish, gel-like liquid consisting of three fractions that differ in viscosity. The chemical composition of the egg white is fully balanced by the content of essential amino acids (lysine (0.9%), methionine...
(0.5%), tryptophan (0.2%), that is why it is a global standard for assessing of the protein quality of various products.

Albumen is 10% aqueous solution of various proteins. Other components are present in very low amounts. The pH of albumen of a freshly laid egg is 7.6–7.9 and rises to 9.7 during storage due to diffusion of solubilized CO₂ through the shell. For example, the pH of 9.4 was recorded after 21 days of storage at 3–35 °C.

Albumen digestibility is high (up to 98%). After the heat treatment egg white is absorbed better than in the raw condition because of the presence of antitryptase inhibiting the protein cleavage by the enzyme trypsin proteolysis in the small intestine. This property of the raw egg white is used in therapeutic nutrition to reduce the function of the digestive glands in duodenal ulcer. Eggs cooked soft-boiled are digested best of all.

The main protein of the egg white is ovalbumin, which represents glycoprophosphoprotein, and its content reaches 54%. It was one of the first proteins isolated in the pure form in 1889. During eggs storage ovalbumin coagulating at 84.5 °C forms the more heat resistant S-ovalbumin coagulating at 92.5 °C. The content of S-ovalbumin in fresh eggs is 5% and increases to 81% during 6 months of storage. The egg white also contains ovotransferrin or conalbumin (12-13%), which gives it the ability to form foam when whipping. Ovotransferrin has the antibacterial effect and has anti-bacterial synergism in combination with lysozyme (its content reaches 3.4-3.5%). The bactericidal properties of lysozyme reduce during the aging of eggs. Ovomucin and ovomucoid are non-complete proteins.

In addition, the egg white contains minor amounts of riboflavin (vitamin B₂).

The raw egg white contains the glycoprotein avidin, which binds to biotin (vit. H) in the intestine to form a biologically inactive complex. Therefore, the frequent use of raw eggs can lead to vitamin H deficiency. Heating to 80 °C leads to inactivation of avidin.

The egg yolk is an emulsion of the "oil-in-water" type containing about 50% of dry matter. An egg yolk is composed of fat (65%), protein (31%) and carbohydrates (44%), vitamins and minerals. The main component of the egg yolk is lipoproteins with the low molecular weight (up to 68%), the amount of lipoproteins with the high molecular weight reaches 16%. The content of livetins is 10%, the content of the phosphoprotein phosvitin is up to 4%.

Fats of the egg yolk are mainly triglycerides (66%), and phospholipids (28%). The low melting point and the property to be easily emulsified contribute to their easy digestion and a good digestibility – up to 96%. The egg yolk contains the essential polyunsaturated fatty acids, mainly oleic and linoleic acids.

The egg yolk contains phospholipids, and the main phospholipids are cephalin and lecithin, the latter contains the vitamin-like compound – choline in its structure. Eggs contain significant amounts of cholesterol (0.57%). 2–2.5 eggs a day provide the daily intake of cholesterol recommended for a healthy adult, and it causes restriction of the egg yolk use in atherosclerosis.

But it should be noted that cholesterol in eggs is favourably balanced with the substances inhibiting development of atherosclerosis – lecithin, linoleic acid, and vitamins.
The egg yolk is a source of fat-and water-soluble vitamins (except for vitamin C). Mainly they are vitamins A, D, B₂, B₆, B₁₂, B₉, B₁₂.
The egg yolk is a significant source of P, S, Zn, Cu, and other well absorbed (except iron) micro- and macroelements.
The egg yolk as nutrition is more valuable than the egg white, it stimulates the function of the digestive system and has the choleretic effect.
The presence of sulfur-containing amino acids and lecithin in eggs has a beneficial effect on the nervous system.

Quail eggs are rich in vitamins, microelements and essential amino acids. Compared with hen’s eggs, quail eggs contain 2.5 times more vitamins, 4.5 times – P, K, Fe.
Quail eggs are recommended to use in anemia, high or low blood pressure, severe headaches, the lowered immunity, asthma, tuberculosis intoxication, diseases of the gastrointestinal tract, particularly ulcer, gastritis, and pancreatitis.

**Egg products**

Frozen egg products are used in the food industry and public catering when food is thermically treated: baking, production of mayonnaise, ice cream, sausages. Frozen egg products include egg mélange, frozen egg white and egg yolk.

Egg powder (mélange) is a dried mixture of the egg yolk and egg white in a natural proportion. To preserve the nutritional value and to ensure good solubility of the egg powder the protein denaturation should not be allowed in the drying process. Since protein denatures at 52-60 °C, the mass is dried at a temperature not exceeding 60 °C. However, at such temperature not all vegetative forms and especially spores of microorganisms die. To prevent the massive growth of the residual microflora in the powder the process stages that include keeping the product in warm moist premises must be excluded. In addition, the products of the egg powder should be subjected to the prolonged heat treatment (omelets, etc.). After properly conducted drying the egg powder is instant and keeps all the initial properties of eggs. During denaturation of the protein in the drying process or after a prolonged storage the egg powder solubility decreases. The fat of the egg powder, which is easily oxidized by atmospheric oxygen, undergoes changes most rapidly, and it leads to rancidity and occurrence of a fishy odour due to formation of oxidized trimethylamine of lecithin having a fishy odour.

**Quality parameters of egg products.**  
Hen’s eggs are divided into:

dietary – eggs with the weight of not less than 45 g, which are offered for sale within 7 days after they are laid (they should have the stamp with the date of laying).
table – eggs that are not less than 45 g, which are offered for sale within 25 days after sorting or which have been stored in a refrigerator for not more than 120 days.

Dietary and table eggs depending on the mass are divided into three categories (the weight of one egg):
• best (O) – not less than 65 g;
• first (1) – no less than 55 g;
• second (2) – at least 45 g.
Eggs weighting from 35 to 45 g belong to small and are used in food industry. Forage that is used to feed the poultry, of course, affects the quality of eggs: a fragile shell is due to the lack of calcium, a pale yolk is explained by the lack of beta-carotene, the lack of the egg white density is because of too rapid growth.

Quality indicators of egg products are as follows.
1. **Organoleptic parameters** (appearance, consistence, colour, odour, taste).
2. **Main physicochemical indicators:**
   - *Hen’s eggs:* mass, the storage period, the state of the shell and the air cell, the height of the air cell, location and mobility of the egg yolk.
   - *Liquid egg products:* mass, the content of moisture, fat, protein, pH.
   - *Dry egg products:* mass, the content of moisture, fat, protein, loss on ignition, solubility, and acidity.
3. **Medico-biological requirements:** the content of toxic compounds – toxic elements (lead, cadmium, arsenic, mercury, copper, zinc), aflatoxin B₁, tetracycline antibiotics, streptomycin, hormones, pesticides, and [microbiological indicators](#).

**Organoleptic parameters**

The quality of eggs is determined by their appearance and the examination with the help of an ovoscope. Eggs with defects are divided into defective (used for baking) and technical (not used for food).

The defective eggs include eggs with the following defects: the height of the air cell is more than 1/3 of the egg height; the damage of the shell without signs of leakage, leakage and partial mixing of the yolk and the white (during ovoscopy contents of the egg has a yellowish colour); the smell – foreign odours; a small spot under the shell; the still stains of the overall size of not more than 1/8 of the egg surface; stuck yolk – the yolk is dried to the shell.

The technical eggs include the following defects: a complete mixing of yolk-protein with egg-white by breaking of yolk membrane; the "blood-rings" – the presence of blood vessels in the form of a ring on the surface of the yolk as a result of the embryo development; a great spot – the spot under the shell of the overall size of more than 1/8 of the total size of the egg; the content of egg is opaque due to the development of bacteria or mold; a moldy or putrid smell; the unfertilized eggs removed from the incubator; full or partial leakage of the content.

The types of eggs defects are as follows:
- **Small spot** - an egg with one or more fixed spots under the shell of the overall size of less than 1/8 of the surface;
- **Great spot** – an egg with the presence of spots under the shell of the overall size of more than 1/8 of the surface of the eggs;
- **Gingery albumen** – an egg with a uniform gingery colour of the contents;
- **Leak** – an egg with a damaged shell and membrane stored for more than one day, not including the day of the laying;
- **Blood spot** – an egg with the presence of a red blood inclusion on the surface of the egg white that is visible in ovoscopy;
- **Stale egg** - an egg adsorbed the odour of mold or having a mouldy surface;
Black rot – an egg with the spoilcontent under the influence of molds and putrefaction bacteria. During ovoscopy the egg is opaque, the contents have a putrid smell;

Green rot – an egg with a green albumen and a sharp, unpleasant smell;
Unfertilized egg – an egg removed from the incubator unfertilized;
Odorous egg – an egg with a foreign smell;
Discharging – an egg with a partial mixing of the yolk and white;
Stuck yolk – an egg with the yolk dried to the shell.

**Physicochemical indicators of egg products**

**Determination of fat:**
- *the method with the use of a separating funnel* is based on fat extraction from the sample with the mixture of chloroform and ethanol and subsequent separation of the extract from the solid residue;

**Determination of dry matter** (for liquid egg products) is based on drying in an oven to the constant mass.

**Determination of protein:**
- *Kjeldahl method* – determination of nitrogen by sulphuric acid digestion (mineralization) in the presence of copper sulfate, potassium sulphate and selenium. The liberated ammonia is collected in a receiver with boric acid. The excess of boric acid is titrated with hydrochloric or sulphuric acid solution. The indicator is the alcoholic solution of bromcresol green and methylene red; the blank titration is carried out.

\[
\begin{align*}
  R\text{NH}_2\text{COOH} &\xrightarrow{\text{H}_2\text{SO}_4} \text{CO}_2 + \text{H}_2\text{O} + \text{NH}_4\text{HSO}_4 \\
  \text{H}_3\text{BO}_3 + \text{NH}_3 &\rightarrow \text{NH}_4\text{BO}_2 + \text{H}_2\text{O} \\
  4\text{H}_3\text{BO}_3 + 2\text{NH}_3 &\rightarrow (\text{NH}_4)_2\text{B}_4\text{O}_7 + 5\text{H}_2\text{O} \\
  (\text{NH}_4)\text{BO}_2 + \text{HCl} + \text{H}_2\text{O} &\rightarrow \text{H}_3\text{BO}_3 + \text{NH}_4\text{Cl} \\
  (\text{NH}_4)_2\text{B}_4\text{O}_7 + 2\text{HCl} + 5\text{H}_2\text{O} &\rightarrow 4\text{H}_3\text{BO}_3 + 2\text{NH}_4\text{Cl} \\
\end{align*}
\]

- *the photocolorimetric method* is based on hydrolysis of protein and the reaction with Nessler reagent, and following measurement of absorbance of the coloured product.

**Determination of fatty acids** is based on extraction of fat by the alcohol-ether mixture followed by its separation by drying and titration with an alcoholic solution of sodium or potassium hydroxide in the presence of the phenolphthalein indicator.

**Determination of solubility of egg products:**
- *the method of refractometry* is based on measurement of the refraction index of the solution of the egg powder with sodium chloride, and the reference solution, with the following calculation of the dissolution index in %.

**Determination of pH** is performed by the potentiometric method.

**Determination of eggs freshness by the yolk index** is based on determination of the ratio of the height of the poured yolk measured by a micrometer, to its diameter
measured by a compass. The coefficient of flattening or the yolk index is an indicator of the degree of eggs freshness.

**Eggs age determination** is based on the behaviour of an egg when immersed in 10% sodium chloride solution. A new-laid egg sinks and lies horizontally. An egg of four or seven days after laying rises at the sharp end forming the angle of 30 °. An egg of four weeks after laying rises vertically at the sharp end. An egg of more than four weeks after laying floats in the solution. A rotten egg floats on the surface.

**Adulteration of eggs and egg products** is possible in the following ways:
- violation of the conditions of storage;
- introduction of foreign agents;
- introduction of high doses of antibiotics added in the forage or water; as a result antibiotics accumulate in the body of the hen and transfer into its eggs.

**Epidemiological safety of eggs**

Eggs may cause infectious diseases and food poisoning. Although there is the system for mechanical and chemical protection of eggs, microorganisms can penetrate into eggs by endo- or exogenous route.

The endogenous infecting occurs due to penetration of microorganisms into the middle of an egg during its formation in the ovary of a sick bird or during passage through the oviduct. In this way, hen’s, goose and duck eggs can become infected with *Salmonella, Mycobacterium tuberculosis, E. coli, Pseudomonas, Proteus, Staphylococcus*, etc.

Goose and duck eggs are particularly dangerous in terms of salmonellosis occurrence in human.

Currently, the risk of salmonellosis after eating hen’s eggs increased in connection with the use of microbial contaminated ground bone, groundmeat and fish additives to chicken feed. The eggs of hens infected with tuberculosis can cause the benign disease in human.

The exogenous infecting of the egg contents occurs in the case of shell contamination of the afterbirth, soil, or litter. Microorganisms on the shell can multiply and penetrate through the pores into the middle of the egg, due to temperature fluctuations, eggs moistening, cracks or other defects in the outer cover of the shell. Eggs with cracked shells are often infected with pathogenic and conditionally pathogenic microorganisms, so their use in the raw form may cause disease.

Duck, goose and hen’s eggs from the infectious diseases-problem farms are prohibited to:
- be used for production of cream and confectionery, ice cream, mayonnaise, mélange, egg concentrates;
- be taken by public catering without prior boiling;
- be sold in shops and markets.

**Egg storage**

Egg storage at increased temperatures and under the action of enzymes causes autolysis, which can lead to egg spoiling even without the participation of microorganisms. The long-term storage of eggs is possible in a refrigerator under conditions preventing their deterioration: at the constant temperature and relative
humidity; in the atmosphere of carbon dioxide and its mixture with nitrogen, application of protective coatings that prevent penetration of bacteria and molds in the middle of an egg, such as mineral oil, vaseline, vegetable oil, carboxymethyl cellulose, etc.

In retail, the deadline for selling of dietary egg is 7 days from the day of laying, after which the eggs are transferred to the category of table eggs. The shelf life of table eggs is up to 30 days from the date of laying. Eggs should not be stored together with products that have a sharp or specific odour.

Egg powder should be stored at the temperature from +10 to -2 °C and a relative humidity of 70% in non-pressurized containers up to 8 months. In airtight containers (tin, paraffin or packaging film materials) – up to 12 months. In shops the egg powder is stored in a cool, dry place.
QUESTIONS FOR SELF-CHECKING

1. Name the main groups of egg products.
2. Describe the chemical composition of the egg white.
3. Describe the chemical composition of the egg yolk.
4. What foods are products of eggs treatment?
5. List the main indicators of quality of egg products, describe the main ones.
6. In what ways is adulteration of eggs and egg products possible?
7. What is the epidemiological safety of eggs?
TASKS FOR SELF-CHECKING

1. Which protein of the egg white has the bactericidal activity that is lost with aging eggs?
   A. ovoalbumin
   B. globulin
   C. lysozyme
   D. riboflavin
   E. bilirubin

2. What fat-like substance is found in the yolk of eggs?
   A. cholesterol
   B. butyric acid
   C. lysozyme
   D. riboflavin
   E. bilirubin

3. Which types are eggs divided into?
   A. dietary and table
   B. medicinal and table
   C. dietary and medical
   D. best grade and farmers
   E. medicinal and farmers

4. Which toxic elements content in eggs is strictly regulated by GOST?
   A. lead
   B. sodium
   C. chlorine
   D. potassium
   E. magnesium

5. What disease can be caused by eating eggs?
   A. diphtheria
   B. salmonella
   C. tetanus
   D. brucellosis
   E. bartonellosis
CHAPTER 5

MEAT AND MEAT PRODUCTS

Meat and meat products

The modern market receives meat products in a various range. The main groups of the products are presented in Fig. 5.1.

Fig. 5.1. The main groups of meat products

Meat is one of the most valuable foods because of its good organoleptic properties, nutritional and biological value.

Meat is a complex of tissues of warm-blooded animals composed of muscular, connective and adipose (fatty) tissue. The meat has a high digestibility, saturation and is easy to be cooked. Most of the meat consumed by a human is produced by the slaughter of animals of the specialized meat breeds in slaughterhouses. More than nine tenths of all raw meat is of 4 types: beef, pork, lamb and poultry. Meat of other species (buffalo, horse, camel, reindeer, etc.) is specific to individual regions depending on availability of different varieties of meat and the traditions of cuisine.

The chemical composition of meat

The composition and quality of the raw meat depend on many factors such as breed, age, gender, conditions of feeding, the pre-slaughter care, etc.

The chemical composition of meat is presented in Table 5.1.

Table 5.1.

The chemical composition of meat

<table>
<thead>
<tr>
<th>Type of meat</th>
<th>Content, %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Protein</td>
</tr>
<tr>
<td>Beef</td>
<td>18.6</td>
</tr>
<tr>
<td>Pork</td>
<td>14.4</td>
</tr>
<tr>
<td>Lamb (mutton)</td>
<td>15.6</td>
</tr>
<tr>
<td>Rabbit</td>
<td>21.1</td>
</tr>
<tr>
<td>Chicken</td>
<td><strong>21.7</strong></td>
</tr>
</tbody>
</table>
The muscular tissue is the main part of the meat. It is 50-70% by weight of the whole carcass.

The connective tissue is 16% of the meat carcasses. Its distribution and qualitative composition (collagen, elastin and retikulin fibres) are very diverse, and it largely determines the edible quality of meat.

The adipose tissue is from 1 to 40% of the meat carcasses. The content and location of the adipose tissue accumulation depend on the species, age, breed, gender and the method of animals feeding. The adipose tissue determines the organoleptic properties of the meat.

The nutritional value of meat depends on the ratio of muscular, connective and adipose tissue, and the content of extractable (taste) substances. The more muscular and adipose tissue meat contains, the higher is the nutritional value and the level of nutrients digestion.

The protein content in the meat of different animal species ranges from 14 to 20%. The most valuable proteins are meat muscular sarcoplasmic proteins, soluble in water – myogen, myoalbumin, globulin, and myoglobin. These proteins are characterized by a balanced content of essential amino acids. The exception is the muscular tissue of poultry (Table 5.2).

### Table 5.2.

**The amino acids composition of the muscular tissue protein of some types of meat**

<table>
<thead>
<tr>
<th>Aminoacid</th>
<th>Beef</th>
<th>Pork</th>
<th>Lamb</th>
<th>Chicken</th>
<th>Rabbit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Histidine</td>
<td>3.8</td>
<td>4.0</td>
<td>3.1</td>
<td>2.7</td>
<td>3.0</td>
</tr>
<tr>
<td>Isoleucine</td>
<td>5.1</td>
<td>4.9</td>
<td>4.8</td>
<td>3.6</td>
<td>4.1</td>
</tr>
<tr>
<td>Leucine</td>
<td>8.4</td>
<td>7.5</td>
<td>7.2</td>
<td>7.8</td>
<td>8.2</td>
</tr>
<tr>
<td>Lysine</td>
<td>8.1</td>
<td>7.8</td>
<td>7.9</td>
<td>8.7</td>
<td>10.4</td>
</tr>
<tr>
<td>Methionine + cysteine</td>
<td>3.8</td>
<td>3.6</td>
<td>4.1</td>
<td>3.8</td>
<td>3.6</td>
</tr>
<tr>
<td>Phenylalanine + tyrosine</td>
<td>7.2</td>
<td>7.1</td>
<td>7.3</td>
<td>7.6</td>
<td>6.6</td>
</tr>
<tr>
<td>Threonine</td>
<td>4.4</td>
<td>5.1</td>
<td>4.4</td>
<td>4.9</td>
<td>4.3</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>1.1</td>
<td>1.4</td>
<td>1.3</td>
<td>1.6</td>
<td>1.5</td>
</tr>
<tr>
<td>Valine</td>
<td>5.7</td>
<td>5</td>
<td>5.3</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

Myogen is easily extracted with water and forms foam on the surface of the broth after coagulation. The colour of meat and meat products depends on the content of chromoproteids – myoglobin and hemoglobin. Myoglobin is the main colorant. It is the complex organic compound having as a prosthetic group the heme, which is the...
complex of the tetapyrrole cycle and Fe\(^{2+}\). After the slaughter of the animal myoglobin in the surface layer on the cut of meat reacts with the oxygen of the air and forms oxymyoglobin of a bright red colour. During the prolonged exposure to oxygen or nitrogen oxides brown metmyoglobin is formed when Fe\(^{2+}\) changes into Fe\(^{3+}\). During heat treatment and salting of meat a similar process takes place with formation of metmyoglobin. The mass fraction of myoglobin in beef is 2.5 times more than in pork, in the meat of old animals is in 2-8 times higher than in the meat of young animals.

Myofibrillar proteins are myosin, actin, actomyosin, tropomyosin, etc. Myosin is the major protein of the muscular tissue (40% of the total muscular protein) possessing the water-retaining function.

The proteins of the connective tissue – collagen, elastin (3-4%), reticulin are less valuable. They lack the essential amino acid tryptophan, but characterized by a high content of glycine, proline and lysine. Although collagen is noncomplete protein, it can be almost completely absorbed after heat treatment improving the overall amino acid composition of the product. In practice, the ratio of tryptophan, which characterizes the valuable protein content, and hydroxyproline, which characterizes the connective tissue content, is used in assessing the nutritional value of meat.

The meat of young animals contains less collagen, so it is more soft and gentle. On the one hand, consumption of meat rich in the connective tissue stimulates the motor function and excretion of the intestine, but on the other hand, an excessive amount of the connective tissue adversely affects the kidney function. The meat of young poultry is different from the meat of animals by the delicate texture due to the lower content of the connective tissue, therefore, it is recommended to children. The meat of turkey and chicken are especially valuable, since contains more of complete proteins. The meat of duck and geese is dense, the connective tissue is rougher, the melting point of fat is higher, so the meat of these birds are digested worse. The muscular tissue of poultry can be of a different colour depending on species and the part of the carcass. In the chicken and turkey breast muscles are white and the rest is dark (red). Typically, white meat contains little more proteins and extractable substances and less fat.

Pork proteins are digested better than other kinds of meat, so lean pork is the most suitable for the diet of the elderly people and dietary food. In diets with a gentle regiment the treatment means the use of gelatin – a product of incomplete hydrolysis of collagen. Gelatin is incomplete by its amino acid composition, but the jelly products prepared of it are digested without straining secretion of digestive organs.

Fat in meat is from 5% in lean beef to 30-40% in fatty pork. Fat varies in the composition of fatty acids, and hence in the physical properties, digestibility, storage stability, etc. Beef and mutton fat contains twice more saturated fatty acids – stearic, palmitic, oleic – than pork fat. Chicken fat contains few saturated acids. Therefore, pork and chicken fat are softer and have lower melting points. Pork and chicken fat have a higher biological value because they contain 5-6 times more polyunsaturated fatty acids (linoleic, linolenic and arachidonic) than beef fat. The ratio of saturated, mono- and polyunsaturated fatty acids in the adipose tissue of pigs is 3:4:1, which is
close to the optimal 3:6:1. The pigments carotene and xanthophyll give colour to fat. When evaluating the bioavailability of fat one should consider the content of fat-soluble vitamins, phospholipids and cholesterol (see Table 5.3 and 5.5).

### Table 5.3

<table>
<thead>
<tr>
<th>Fat</th>
<th>Triglycerides</th>
<th>Fatty acids</th>
<th>Phospholipids</th>
<th>Cholesterol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef</td>
<td>14.88</td>
<td>15.1</td>
<td>0.9</td>
<td>0.08</td>
</tr>
<tr>
<td>Mutton</td>
<td>15.3</td>
<td>15.3</td>
<td>0.88</td>
<td>0.07</td>
</tr>
<tr>
<td>Pork</td>
<td>26.9</td>
<td>26.41</td>
<td>0.8</td>
<td>0.06</td>
</tr>
</tbody>
</table>

Fat of turkeys and chickens have lower melting points compared to the fat of other species, therefore, such meat is easier to digest, it is more completely assimilated and is important for the diets.

More than half of the total phospholipid content is lecithin (1), which is due to the choline fragment has lipotropic properties and prevents the fatty degeneration of the liver. Mutton and beef fat have the biggest phospholipid content.

![Chemical structure of lecithin](image)

1

Cholesterol is found in all cells and tissues as it has the structural function, but the muscular tissue contains 5 times lower cholesterol than the adipose tissue. Therefore, to reduce dietary cholesterol it is recommended to consume less fatty meat. Furthermore, increasing the amount of fat somewhat reduces the protein content, and more significantly the water content. Meat of animals of medium fatness (meat of category II) is the most valuable as it is characterized by the optimum content of protein, fat and carbohydrates.

The closer the melting point of fat (mutton fat – 44-55 °C, beef fat – 42-52 °C, pork fat – 35-46 °C) to the temperature of the human body is, the higher is digestibility of fat in meat products.

**Carbohydrates** in meat are glycogen (0.1-1%) which is found mainly in muscles and the liver. Carbohydrates also contain small amounts of glucose-6-phosphate and glucose. After slaughter glycogen is broken down to form mainly lactic acid. Many biochemical processes affecting the consistency and taste of meat depend on the content of lactic acid. In addition, the acidic medium caused by the accumulation of lactic and phosphoric acid prevents the accumulation of the putrid microflora. Poultry contains few carbohydrates (0.5%).

**Minerals** are macronutrients – K, P, Na, Cl, Mg, Ca and trace elements – Fe, Zn, Cu, Mo, Cr, Mn, Co, V, F, I, Sb, Al (Table 5.4). They are concentrated in the
muscular and bone tissue both in a dissolved state and bound with proteins form. Importantly, in contrast to the minerals in plant products the minerals of meat are present in an easily digestible form. For example, iron is absorbed from the meat products three times better than that of the plant.

**Table 5.4.**

<table>
<thead>
<tr>
<th>Type of meat</th>
<th>K</th>
<th>Ca</th>
<th>P</th>
<th>Na</th>
<th>Mg</th>
<th>Fe</th>
<th>I</th>
<th>Zn</th>
<th>Cu</th>
<th>Co</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef</td>
<td>355</td>
<td>10.2</td>
<td>188</td>
<td>73</td>
<td>22</td>
<td>2900</td>
<td>7.2</td>
<td>3240</td>
<td>182</td>
<td>7</td>
</tr>
<tr>
<td>Lamb</td>
<td>329</td>
<td>9.8</td>
<td>168</td>
<td>101</td>
<td>25.1</td>
<td>2090</td>
<td>2.7</td>
<td>2820</td>
<td>238</td>
<td>6</td>
</tr>
<tr>
<td>Pork</td>
<td>316</td>
<td>8</td>
<td>170</td>
<td>65</td>
<td>27</td>
<td>1940</td>
<td>6.6</td>
<td>2070</td>
<td>96</td>
<td>8</td>
</tr>
</tbody>
</table>

**Vitamins.** Meat is an important source of B vitamins (B₁, B₂, B₃, B₄, B₆, B₉, B₁₂ and biotin). The content of riboflavin (vit.B₂), nicotinic acid (vit.PP or B₃), folic acid (vit.B₉) and biotin (vit. B₇) in beef, pork and lamb is about the same. Beef and lamb contains 2-3 times more vitamin B₁₂ than pork, which is richer in vitamins B₁, B₆, B₃. The content of vitamins C and A is low in meat (Table 4.5). Poultry contains small amounts of vitamins, in particular A, B₁, B₂ and PP.

The vitamin content of meat can vary depending on storage conditions, temperature and time of cooking. For example, vitamin B₁ is destroyed during boiling by 15-40%, frying – 50-70%, canning – 50-70%. Vitamins B₂ and PP are more stable: the loss during boiling is 15%. Vitamin B₆ is unstable (50%). Vitamins B₃, B₉, B₁₂ and biotin are stable. Only 10-15% of water-soluble vitamins are extracted in broths. The smallest loss of nutrients occurs during stewing, baking and using meat in the form of cutlets.

**Table 5.5.**

<table>
<thead>
<tr>
<th>Type of meat</th>
<th>A</th>
<th>E</th>
<th>C</th>
<th>B₆</th>
<th>B₁₂</th>
<th>B₁</th>
<th>B₂</th>
<th>B₉</th>
<th>Choline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef</td>
<td>0.20</td>
<td>1.3</td>
<td>traces</td>
<td>0.37</td>
<td>2.6</td>
<td>0.06</td>
<td>0.15</td>
<td>8.4</td>
<td>70</td>
</tr>
<tr>
<td>Lamb</td>
<td>0.06</td>
<td>0.5</td>
<td>traces</td>
<td>0.3</td>
<td>-</td>
<td>0.08</td>
<td>0.14</td>
<td>5.1</td>
<td>90</td>
</tr>
<tr>
<td>Pork</td>
<td>0.01</td>
<td>1.7</td>
<td>traces</td>
<td>0.40</td>
<td>-</td>
<td>0.6</td>
<td>0.16</td>
<td>4.4</td>
<td>75</td>
</tr>
</tbody>
</table>

**Extractable substances.** The organoleptic properties of meat dishes depends on the content of nitrogen-containing (urea, uric acid, ammonium salts, creatine, dipeptides carnosine and anserine, glutathione, purine bases, amino acids, in particular glutamic acid, etc.) and nitrogen-free (glycogen, glucose, maltose, lactic acid, pyruvic acid, succinic acid, etc.) extractable substances, as far as vitamins and organic phosphates (ATP, ADP, etc.). The taste of the cooked meat is explained by glutamic acid. Tyrosine worsens the meat flavour. Serine and glycine positively influence on the flavour of pork. Carnosine and anserine stimulate the secretion of digestive glands. Choline increases peristalsis. The strength of the broth is evaluated
by the content of creatine. Glutathione activates enzymes in meat improving the meat consistency.

Extractable substances are easily transferred to the broth and are potent stimulators of the gastric secretion and appetite; they increase digestibility of meat. Boiled down meat does not contain such substances, and therefore, is widely used in diets. Meat of adult animals contains more extractable substances than meat of young animals, but the content of purine, on the contrary, is significantly higher in meat of young animals and poultry, especially in the internal organs. Purine compounds in the organism are metabolized into uric acid (Scheme 5.1). Uric acid complicates the work of the liver and kidneys, and is contraindicated for people with gout.

The chemical composition of meat is affected by a number of causes:
1. Lifetime – type, breed, gender, age, forage, etc.
2. After slaughter – rigor, maturation, autolysis, hydrolysis and oxidation of fat, putrefaction, etc.
3. Technological processes – salting, grinding, boiling, frying, smoking, etc.
4. Storage conditions – temperature, relative humidity, storage time.

An important factor affecting the quality of meat and is responsible for its nutrition and biological value, organoleptic properties and resistance to microbial denaturation is the **process of maturation**.

The process of maturation of meat is divided into two phases: rigor after slaughter and maturation. During *rigor mortis* glycogen, kreatin phosphate, and adenosine triphosphate breakdown occurs, as far as coupling of actin and myosin in the actomyosin complex. As a result of these processes, lactic acid accumulates in the muscular tissue, the pH is reduced from 7 to 5.7, and the water-binding capacity of meat decreases.

Maturation of meat is a set of properties associated with the process of autolysis, by which the meat acquires a distinct taste, aroma and high absorbency.

Autolysis of meat is a process of spontaneous changes in the chemical composition, structure and properties of the raw meat after slaughter under the influence of its own enzymes. As a result of autolytic processes, decomposition of tissue components takes place, meat quality characteristics (mechanical strength,
level of water-binding capacity, taste, colour, and odour) and its resistance to microbiological processes are changed. Change of the properties of meat is in a certain sequence in accordance to the basic stages of autolysis:
1. Fresh meat (poultry up to 30 minutes, beef to 2-4 h after slaughter) is characterized by the soft texture, high water-binding capacity, pH 7.2. After cooking fresh meat is tender and juicy, but the taste and odour are not expressed enough.
2. Rigor meat (3 hours after slaughter) – pH 5.5-5.6, color and odor deterioration, meat loses elasticity, becomes rigid and difficult to cut (is hard also after boiling).
3. Maturation – muscles relaxation, the strength of meat reduces, water binding capacity increases. However, the culinary characteristics of meat (tenderness, juiciness, flavour, odour and digestibility) still do not reach the optimal level. They improve during the further development of autolytic processes: for beef at 0-10 °C during 12 days, at 8-10 °C during 5-6 days, and at 16-18 °C during 3 days.

Organoleptic properties of matured meat differ from the properties of fresh meat due to the fact that meat accumulates the products of autolysis of proteins and peptides (amino acids – glutaminic, threonine, cystine, methionine, leucine, isoleucine, histidine), nucleic acids (inosinic and isanylic acid), and the products of further decay: nitrogen-containing extractable substances and carboxylic acids (lactic, pyruvic, formic, acetic, butyric, caproic, etc.).

To speed up the process of maturation and improve the tenderness of the meat the animal prior to slaughter obtains adrenaline, proteolytic enzymes of the plant origin – papain, ficin, bromelain. With the same purpose meat can be treated by ultrasound. The process of maturation improves quality and digestibility of all kinds of meat, particularly the beef, which is rigid by nature.

The meat of young animals is tenderer, but is digested worse. The more muscular and adipose tissue is, the higher is the nutritional value and the level of digestibility of meat. Conversely, the higher the content of the connective tissue is, the lower is the nutritional value and the level of digestibility.

**Meat by-products** are used for the human consumption. They are the internal organs (liver, kidney, tongue, etc.), as well as heads, limbs, tails, udders, meat trimmings with having valuable biological properties.

Veal and beef organs are highly valued foods. Tongues, liver, brain, heart by their caloric and nutritional value are not inferior to meat (Table 5.6). Some by-products, especially liver, kidneys, heart are superior to meat by the content of vitamins.

### Table 5.6. Nutritional value of variety meats

<table>
<thead>
<tr>
<th>Type</th>
<th>Protein</th>
<th>Fat</th>
<th>Extractable substances</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tongue</td>
<td>13.6</td>
<td>12.1</td>
<td>2.2</td>
</tr>
<tr>
<td>Liver</td>
<td>17.4</td>
<td>3.1</td>
<td>5.3</td>
</tr>
<tr>
<td>Brains</td>
<td>9.5</td>
<td>9.5</td>
<td>0.8</td>
</tr>
<tr>
<td>Kidneys</td>
<td>12.5</td>
<td>1.9</td>
<td>1.9</td>
</tr>
<tr>
<td>Heart</td>
<td>15.0</td>
<td>3.0</td>
<td>2.0</td>
</tr>
</tbody>
</table>
Liver of various animals differ not only in taste, but also in composition. The liver is rich in:
• proteins and amino acids: methionine, lysine, tryptophan;
• B vitamins (B₆ and B₁₂), vitamins A, E, D, K, PP and folic acid;
• minerals: Ca, Na, Mg, P, Fe, Cu, etc.;

Beef liver is useful for people suffering from diseases of the kidneys and the central nervous system, for different infections, for injuries and burns, it maintains the hemoglobin level. Chicken liver is particularly rich in folic acid.

Animal liver is rich in creatine, which is referred to as an extractable substance, it is not recommended for elderly people. Beef and veal liver is especially valued, lamb liver is valued a little bit less. Pork liver differs by its slightly bitter taste.

Tongue is inferior to meat by the protein content. However, it is well digested (contains little connective tissue) and has relatively few extractable substances, thereby it is used in diets. Tongue contains minerals (Mg, Fe, Ca, K, Na, Cu, Mn, Co) and a number of vitamins B₁, B₂, B₆, PP.

Brains contain little proteins, but a significant amount of fat, phosphorus salts and phosphatides (lecithin, cholesterol). They are a good source of iron, potassium and vitamin PP.

Kidneys are rich in vitamins of group B and PP. They have a specific unpleasant taste and smell, and the high content of mineral salts. To remove the odour and taste they should be soaked for 2-3 hours in cold water.

Heart has a high content of complete protein. It is rich in minerals, including iron and phosphorus. In comparison with the beef meat, heart contains 1.5 times more iron, has a low percentage of fat (4 times less), contains 6 times more vitamin B₁, B₂, and a small amount of extractable substances. Heart is rich in vitamins A and PP.

Many meat by-products are a good source of collagen, gelatin, glutin that activate digestion by stimulating the secretion of the gastric juice, the motor activity of the stomach and intestine providing a beneficial effect on the intestinal microflora. Large amounts of collagen, however, have the negative effect on the renal function. In addition, the consumption of meat by-products should be limited because of the relatively high content of heavy metals (such as lead and cadmium). Therefore, they are recommended to be included in the menu not more than twice a month.

Sausage products are products made from the ground meat (with a cover around it), treated thermally, dried, or smoked until ready for use. Sausages have a special place in human nutrition as they have a high caloric value and are rich in proteins and fats. The nutritional value of meat products is higher in comparison with meat as in the process of production they acquire special organoleptic properties; the content of the connective tissue is decreased, the beef fat with the high melting point is replaced by the pork fat with the low-melting point. It affects the level of digestion. All meat products are characterized by a significant decrease of the biological value due to the loss of thermo-labile water-soluble and fat-soluble vitamins (A, E, C, group B, P). Furthermore, the use of salting during processing of the raw meat reduces the amount of water-soluble proteins, which pass into the brine or disintegrate. Smoking promotes densification of meat proteins as heat and smoke components lead to its denaturation, coagulation, and dewatering. These processes
increase the taste properties, but reduce digestibility because meat becomes less accessible to the enzymes attack. Sanitary purity is reduced because new substances, which are used in the process, are added to meat. Smoked foods are processed with the help of smoke containing benzopyrene and its derivatives, thereby the carcinogenic nitrosamine content increases. At the same time smoking increases the resistance to microbial denaturation.

*Sausage products are classified by:*
1. the product’s type and method of processing – cooked sausages, cooked smoked sausages, dry sausages, stuffed sausages, hot dog sausages, small cooked sausages, liver sausage, blood sausage, sausage loaves, pastes, brawns, and meat jellies;
2. the type of meat – beef, pork, lamb, horse, poultry, from the meat of other animals and their mixtures;
3. the composition of the raw material – meat, meat by-products, blood;
4. the quality of the raw material – top, first, second and third grades, without grade;
5. the type of cover – natural or artificial, or without shell;
6. the appearance of the cut – with a homogeneous structure or with the inclusion of pieces of bacon, tongue, coarsely minced tissue;
7. the purpose – sausages for mass consumption, dietary and baby food.

The composition of sausage meat depending on the formulation comprises, besides the basic material (meat), fat, serum, blood plasma, protein stabilizer, skimmed milk, egg products, spices or their extracts, seasonings, flour and starch as binders, sodium nitrite, phosphates (they increase juiciness and tenderness of sausages, water-holding capacity, act as emulsifiers and stabilizers), etc. The yield of finished sausage products is higher than the mass of the raw meat material as water, spices, starch, phosphates, sodium caseinate, etc., are added to the minced meat. Additives reduce the nutritional value of sausages, so their number is strictly regulated.

By nutritional value sausages are not equal, since their composition depends upon the formulation. Table 5.7 illustrates the nutritional value of different groups of sausages.

**Table 5.7.**

<table>
<thead>
<tr>
<th>Type</th>
<th>Content, %</th>
<th>Caloric value of 100 g</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Protein</td>
<td>Fat</td>
</tr>
<tr>
<td>Cooked sausages</td>
<td>10 – 14</td>
<td>14 – 30</td>
</tr>
<tr>
<td>Cooked smoked sausages</td>
<td>15 – 23</td>
<td>18 – 45</td>
</tr>
<tr>
<td>Dry sausages</td>
<td>20 – 30</td>
<td>30 – 60</td>
</tr>
<tr>
<td>Liver sausage</td>
<td>10 – 16</td>
<td>15 – 35</td>
</tr>
<tr>
<td>Hot dog sausages</td>
<td>12 – 13</td>
<td>20 – 31</td>
</tr>
<tr>
<td>Brawns</td>
<td>10 – 16</td>
<td>10 – 30</td>
</tr>
</tbody>
</table>
Risk factors that affect the epidemic safety and sanitary quality of sausage products are:

- grinding of meat (homogenization) that promotes colonization and development of microorganisms;
- use of conditionally suitable meat after disinfection;
- use of meat by-products as a raw material, which are more bacterially contaminated;
- addition of water or ice that cannot be in accordance to the standard;
- use of sodium nitrite to impart a specific colour to sausages and provide bacteriostatic and antioxidant effects. The quantity of sodium nitrite depends on the quality of the raw material, i.e. the content of myoglobin and hemoglobin. Sodium nitrite forms nitric oxide pigments, which are resistant to oxidation. After addition of sodium nitrite to the minced meat hydrolysis takes place:

\[ \text{NaNO}_2 + \text{H}_2\text{O} = \text{HNO}_2 + \text{NaOH} \]

Nitrous acid under the influence of tissue and bacterial enzymes is decomposed to nitrogen oxide and dioxide:

\[ 2\text{HNO}_2 = \text{NO} + \text{NO}_2 + \text{H}_2\text{O} \]

Nitrous oxide reacts with myoglobin to form nitrosomyoglobin.

The reaction of nitrosomyoglobin formation occurs intensely at pH of 5.5-6.0. During salting and cold smoking 40-50% of MbNO is forming, when heating to 70-72 °C – 85-95%. Table salt also contributes to formation of nitric oxide pigments. Under the high temperatures nitrosomyoglobin turns into globin and nitrosohemochromagen, which causes a pink-red colour of sausage products and is more stable since it does not dissolve in water.

**Adulteration of meat and meat products**

The sale of meat with defects occurs very often. *Defects of meat are:*

**Bone sour corruption** is appearance of a sour smell, grey-red or brownish-red colour with a greenish tint in the muscle layer and the change in some areas of the meat carcasses the consistency of meat till loose in the first days after slaughter. It can be because of improper cooling and the lack of ventilation.

**Sliming** is a sticky slime worsening the appearance of meat, its taste and smell. This defect is caused by bacteria. Bacteria break up proteins to polypeptides that form the slime with water. Slime appears on the surface of spoiled meat.

**Mold formation** is formation of areas of a white-grey or grey-green colour with a musty odour. Mold rarely penetrates more than 2 cm into the tissue. The areas affected by mold are removed. Proteolytic enzymes secreted by the mold work in the acidic medium. Organic bases are accumulated, and the medium becomes more alkaline creating a favourable environment for development of putrefactive bacteria.

**Rotting** is putrefaction of meat starting from the surface. It is caused by aerobic bacteria. During rotting meat at first becomes pale, then it acquires a greenish tint due to formation of sulfomyoglobin. At the beginning of the putrid process a musty smell appears, then it becomes unpleasant with a sour tinge. At a deep deterioration the smell is clearly putrid.
During rotting the reaction for ammonia is positive, during bone sour corruption it is negative. The medium is alkaline during putrefactive processes and neutral or acidic during bone sour corruption.

Putrefactive fermentation is obtaining an unpleasant sour smell by meat as a result of fermentation of carbohydrates by anaerobic bacteria in the case of insufficient draining of blood and slow cooling. Meat softens and becomes grey.

Darkening is the change in the concentration of pigments as a result of intensive evaporation of moisture during storage of chilled and frozen meat, or formation of metmyoglobin.

Pigmentation is the appearance of spots of different colours on the surface of meat formed by colonies of aerobic bacteria: red – by Serratiamarcencens (miracle organism), green – by Pseudomonas fluorescens, blue – by Pseudomonas aeruginosa, a white colour is the thin coat because of fermentation.

Burns (spots of a whitish-grey colour on the surface of the frozen meat) is the result of evaporation of moisture or an optical effect due to formation of small water crystals during rapid freezing.

Darkening and rancidity of fats occurs most often in fat stored for a longer time than it is possible at a given temperature. Increased storage temperature, air oxygen and exposure to light accelerate deterioration of fat.

Adulteration of meat, as well as the sale of meat with defects occurs very often, so you need to know the signs by which you can identify these defects.

Adulteration of meat and meat products is possible in the following ways:

1. By freezing – bad smell does not occur in a frozen meat. You have to cut a piece of meat and boil it in the pan with aclosed lid. If the meat is not fresh, the broth and meat emit an unpleasant odour. You can also make the knife red-hot and plunge it into the thickness of the inspected meat. If the meat is not fresh, the cut and knife emit an unpleasant odour. Besides, the weight of the meat placed in water for several hours can be increased by 25% (the ice is soldalong with meat by the same price).

2. The expensive types of meat are replaced by other cheaper types (beef – by horse meat, venison –by lamb, pork –by dog meat, rabbit –by cat meat, etc.) It is possible to determine reliably the origin of meat either in a special laboratory or by the whole carcass, not a separate fragment.

3. Old meat is rather dry, has a dark colour, poor in fat, and this fat is yellow. Old meat is not harmful, but has less flavour and nutritional value than the young. Usually old meat goes for production of sausages, therefore, it is consumed in a highly ground form, with addition to the various seasonings.

   To distinguish the old poultry from the young you can do it by big flakes on feet and rough skin with a yellowish tint.

4. Feeding the poultry with antibiotics that are deposited in its bone marrow. As many antibiotics contain nitroso groups, hemoglobin reacts with them to form red compounds during boiling or frying in the grill. In healthy hens bones are grey, in hens with antibiotics bones are painted in a cherry-red colour, and sometimes the attached meat tissue is also colored. Only healthy people can eat such chicken meat, and for patients with immune disorders and children it is strictly prohibited.
5. Feeding the poultry with hormones, the excess of which is deposited in its legs. The extra hormones can disrupt the hormonal balance and have a negative impact on the human organism.

6. Inflation of poultry carcass by air, which gives the meat a plump, nice, appetizing appearance. It is easy to identify such meat: you should touch the carcass of a chicken by your fingers. Inflated meat does not have a firm texture, but has a fluid and easy to move mass.

7. Meat of transgenic animals is characterized by less bright colour, its fat has lower melting point. The fat melts in theminced meat of sausage products because it contains more polyunsaturated fatty acids.

8. To give the poultry a yellow colour it is rubbed bya carrot or yellow dyes. In order to whiten the blue, thin chicken the carcass is placed for 1-2 seconds in a boiling solution of baking soda and bleach. Soda getting into the subcutaneous layer increases its volume, the skin becomes opaque and the muscular tissue cannot be seen. Thus, the colour becomes whiter and a small layer of the subcutaneous fat gives yellowness to the carcass.

9. Any meat in the shop should not be stored for more than 3 days, and then it must be utilized. To eliminate a bad smell the meat might be soaked in citric acid solution. After that it can be pickled.

10. Introduction of antibiotics to prolong the shelf-life of meat in the water that is frozen together with animal carcasses or chicken legs.

Pay attention to the colour of the meat. Pork should be pale pink, but not bright red or pale. Veal should be pink and smooth to the touch. The meat of young animals should have a bright red colour with an almost white fat, of the old animals – dark red with a yellow fat. Re-frozen meat has a pink fat.

In order to make sure that the meat is fresh, you need to press it with your finger. The fresh meat returns back to its initial formquickly. If a pit is forming and does not disappear or disappears during a long period of time, the sample of meat is not fresh and possibly soaked in the solutions of additives or acids.

Adulteration of sausage products.

Current manufacturers have learned to cook sausage products practically without meat. They can be made of up to 50 percent of starch and soy protein. Sausages can contain additives with a meat flavour, taste improvers, soy, milk protein, flour, starch, bones, skin trimmings, crystalline cellulose, meat by-products (skin, tendons, and cartilages), and food additives.

Sausages can be undercooked, moist, have a soiled, slimy or mouldy surface, a broken cover, grey spots on the cut, large voids, etc. All these defects begin to form as early as in the factory or when transporting to the shop. Sausage with defects should be utilized. Producers of sausages can increase the sales of their products by diluting the sausage minced meat with water, blood, non-traditional raw material, soy (often modified), etc. Food additives are added to minced meat to make the taste, colour and smell more appetizing.

The stale meat can be substituted by the fresh meat; and the natural meat can be substituted by vegetable protein. Other types of adulteration are introduction of
various non-conventional raw materials, use of the beet juice or artificial colorants to colour sausages, violation of the formulation, introduction of foreign additives, preservatives, and antibiotics, violation of technological processes and storage modes.

To keep water in sausages a syringe injection of water-binding agents (starch, gums, and dextrins) is used.

When boiling, hot dogs or small sausages water sometimes is coloured pink indicating the presence of a dye in sausages. It is necessary to put a piece of sausage into alcohol: if sausages have colorants, alcohol will obtain the corresponding colour. If dyes are added to the sausage, they dissolve in fat and begin to colour it.

An unpleasant and even putrid smell can be easily masked by smoking of sausages.

The connective tissue is clearly visible on the cut of a sausage and can be seen in the form of white or yellow spots. The more of these points are, the more of trimmed meat are added to the sausage.

A grey colour of a sausage instead of pink does not indicate that the sausage is stale. This may be due to a reduced amount of salt or sodium nitrite. A bright red colour indicates a significant content of sodium nitrite.

If a sausage has a wine or sour smell, this sausage is considered to be unfit for consumption because of the risk of botulism poisoning.

A slimy surface and a thin coating on the sausage indicate staleness. Sausages or hot dogs are packed into an artificial cover to be kept longer, so try to buy sausage products in the natural cover. The fresh or cooked sausages can be stored for not more than 72 hours at the temperature of +6 °C, and the shop refrigerator must have a thermometer.

Indicators of the quality of meat and meat products are:

1. **Organoleptic parameters** (appearance, colour, smell, taste, texture).

2. The main **physicochemical indicators**: the content of protein, tryptophan, hydroxyproline, fat, moisture, sodium chloride, sodium nitrite, starch, phosphorus; pH.

3. **Medicobiological requirements**: the content of toxic compounds – nitrosamines, pesticides, radioactive substances, hormones, nitrates, antioxidants, toxic elements, mycotoxins; and **microbiological indicators**.

**Organoleptic parameters** determining the freshness of meat are the main, they must meet and comply with traditionally established tastes and habits of the population and do not cause complaints from consumers. In many cases, the properly conducted organoleptic research can be used to determine the freshness of meat. The organoleptic parameters of fresh meat according to GOST 7969 - 79 “Meat. Sampling methods and the methods for determining the organoleptic freshness” are presented in Table 5.8.
### Table 5.8

**Organoleptic characteristics of meat freshness**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Characteristics of meat or meat by-products</th>
<th>fresh</th>
<th>questionable freshness</th>
<th>stale</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Appearance and colour of the carcass surface</strong></td>
<td>The surface has a drying crust of a pale pink or pale red colour; in thawed carcasses it is red, with a soft fat partially coloured bright red</td>
<td>Partially wet, slightly sticky, darkened</td>
<td>Strongly dried up, covered with a greyish slime or mold</td>
<td></td>
</tr>
<tr>
<td>Muscles on the cut</td>
<td>Slightly wet, do not leave wet spots on the filter paper, have a colour characteristic to this type of meat: for beef – from light red to dark red, for pork – from light pink to red, for lamb — from red to cherry-red, for lamb – pink</td>
<td>Wet, leaving a spot on the filter paper, slightly sticky, of a dark-red colour. For thawed meat – the slightly turbid meat juice is dripping from the cut</td>
<td>Wet, leaving a wet spot on the filter paper, sticky, of a reddish-brown colour. For thawed meat – the turbid meat juice is dripping from the cut</td>
<td></td>
</tr>
<tr>
<td>Consistency</td>
<td>Meat is dense and elastic on the cut, a pit formed by pressing with a finger returns back to its initial form quickly</td>
<td>Meat is less dense and less elastic on the cut; a pit formed by pressing with a finger disappears during a long period of time (for 1 min.). Fat is soft, fat of thawed meat is slightly loosened</td>
<td>Meat is loose; a pit formed by pressing with a finger does not disappear. Fat is soft, fat of thawed meat is loose</td>
<td></td>
</tr>
<tr>
<td>Smell</td>
<td>Specific, peculiar to each type of fresh meat</td>
<td>Slightly sour with a hint of mustiness</td>
<td>Sour or musty, or slightly putrid</td>
<td></td>
</tr>
<tr>
<td>Fat condition</td>
<td>Beef fat has a white, yellowish or yellow colour, firm consistency, during crushing it crumbles; pig fat has a white or pale pink colour, it is soft, elastic; lamb fat is white, with thick consistency. Fat should not have a rancid odour</td>
<td>It has a grey-matte tinge, is slightly sticky to the fingers, and may have a slight rancid odour</td>
<td>It has a grey-matte tinge, during crushing it spreads, pork fat may be covered with a small amount of mold. The smell is rancid</td>
<td></td>
</tr>
<tr>
<td>Tendons condition</td>
<td>Tendons are elastic, dense; the surface of the joints is smooth and shiny. Thawed meat has soft, loose, bright red tendons</td>
<td>Tendons are less dense, of an opaque white colour. The articular surface is slightly covered with slime</td>
<td>Tendons are softened, of a greyish colour. The articular surfaces are covered with slime</td>
<td></td>
</tr>
<tr>
<td>Clarity and aroma of the broth</td>
<td>Transparent and fragrant</td>
<td>Clear or turbid with the smell unusual for a fresh broth</td>
<td>Turbid, with a large amount of flakes cereal with a pungent, unpleasant odour</td>
<td></td>
</tr>
</tbody>
</table>
Physicochemical indicators of meat and meat products

**Determination of protein:**

- *Kjeldahl method* (determination of nitrogen by sulphuric acid digestion), the liberated ammonia is collected in a receiver with boric acid. The excess of boric acid is titrated with hydrochloric or sulphuric acid solution; the blank titration is carried out.
- *photometric method.*
  
  Control of the protein content is necessary to determine the type of adulteration when meat is partially changed by non-meat materials (starch, flour, soy, etc.).
  
  The content of the muscular tissue is determined by the presence of amino acid tryptophan.
  
  The content of hydroxyproline is monitored to detect violations of the formulation such as changes in the ratio of the muscular and connective tissue.

**Determination of fat:**

- *the method with the use of a filter separating funnel;*
- *gravimetric method after fat extraction with chloroform and ethanol.*

Control of the fat content is necessary to determine the type of adulteration when meat (proteins) is partially changed by fat. Such control is especially important in the production of cooked sausages, which by their structure are protein/fat emulsions.

**Determination of the moisture content** is carried out by drying in an oven at various temperatures.

Water forms the organoleptic properties of meat products; it is a solvent of proteins; it promotes formation of emulsions, increases juiciness, tenderness of products, as well as their yield, but reduces bioavailability and the period of storage.

**Determination of the sodium chloride content** is based on removal of proteins from the meat sample following with titration of chlorides by silver nitrate solution:

- back argentometry by *Volhard* – the excess of silver nitrate is determined by titration with ammonium thiocyanate using ferric ammonium sulphate as an indicator:

\[
\text{NaCl} + \text{AgNO}_3 \rightarrow \text{AgCl} \downarrow + \text{NaNO}_3
\]

\[
\text{AgNO}_3 + \text{NH}_4\text{SCN} \rightarrow \text{AgSCN} \downarrow + \text{NH}_4\text{NO}_3
\]

\[
3\text{NH}_4\text{SCN} + \text{Fe(NH}_4)_2\text{(SO}_4)_2 \rightarrow \text{Fe(SCN)}_3 + 2\text{(NH}_4)_2\text{SO}_4
\]

- direct argentometry by *Mohr* method is based on titration of sodium chloride in the neutral medium with silver nitrate using potassium chromate as an indicator:

\[
\text{NaCl} + \text{AgNO}_3 \rightarrow \text{AgCl} \downarrow + \text{NaNO}_3
\]

\[
2\text{AgNO}_3 + \text{K}_2\text{CrO}_4 \rightarrow \text{Ag}_2\text{CrO}_4 \downarrow + 2\text{KNO}_3
\]

Sodium chloride is used in the formulations of meat products for the organoleptic properties formation and providing of the bacteriostatic activity, and inhibiting oxidation of fats. The control of the sodium chloride content is aimed at preventing of organoleptic characteristics deterioration of the final product.

**Determination of starch in sausage products:**

*Identification* is based on appearing a blue or black-blue colour on the surface after placing of some *Lugol’s* solution (iodinated solution of potassium iodide) on it.
**Assay** is based on titration of the mixture obtained after hydrolysis of the meat sample. The meat sample is boiled with hydrochloric acid and neutralized with the alkali. Then it reacts with the cupric reagent. By this the aldehyde groups of monosaccharides produced after hydrolysis of starch are oxidized. The excess of copper sulphate is determined by iodometry: after addition of potassium iodide in the presence of hydrochloric acid iodine is produced, and it is titrated by sodium thiosulphate solution. The indicator is starch. The blank titration is carried out.

Starch and flour increase the viscosity of minced meat. Their main function is the ability to swell and to retain moisture after the heat treatment as a result of flour paste formation. They affect the quality of finish products, increase their yields, reduce the biological value and price.

**Determination of nitrites** is based on the photocolorimetric determination of the intensity of coloration of the coloured complex produced after the interaction of nitrite-ion with amide of sulphanilic acid and N-1-naphthylethylenediamine dihydrochloride.

Nitrites are previously reduced to nitrates with the help of porous cadmium.

**Determination of tin in canned meat products** is based on the photocolorimetric determination of the intensity of coloration of the coloured complex produced after the interaction of tin salts with quercetin.

**Determination of phosphates.** This standard is used for cooked sausages, meat loaves, hot dogs, small sausages. The content of phosphorus is determined by:

- **gravimetric method**, which is based on mineralization of the sample by nitric and phosphoric acids, precipitation of phosphates in the form of phosphomolibdate of quinoline and determination of the mass of the precipitate.

- **photometric method**, which is based on the reaction of phosphates with ammonium molybdate in the presence of hydroquinone and sodium sulphite, with formation of the coloured compound. The optical density is measured by a spectrophotometer or photocolorimeter.

Phosphates contribute to swelling of proteins, retain moisture during cooking, increase juiciness and the product yield, provide resistance of fat emulsions, inhibit the oxidation of fats, etc. The excessive addition of phosphate changes the pH of the
minced meat, which causes an unpleasant taste, increased hardness, etc. Therefore, a mixture of basic, neutral and acidic phosphates is used in the industry.

**Determination of pH in meat**

- *colorimetric method:*

  In the laboratory, the fastest and easiest method of pH determination in meat is to use the litmus paper. The skin-deep cuts in the muscular tissue of meat are made where a strip of the red litmus paper and a strip of the blue litmus paper moistened with water are placed and pressed to the meat by a glass rod. In 10 min the strips of the litmus paper are transferred to a white surface, and compared with the colour of the control pieces of paper moistened with water. Fresh meat is characterized by the acidic medium, it is indicated by a red colour of the blue litmus paper. Meat with signs of autolysis has the neutral medium, as indicated by a violet colour of the blue litmus paper. A blue colour of the red litmus paper is typical for stale meat with obvious signs of rotting.

- *express method* with the use of the indicator paper “Rifan”;

- *potentiometric method* with the use of a pH-meter.

**Determination of ammonia and ammonium salts** is based on coloration or formation of a precipitate after addition of Nessler’s reagent.

\[
\text{NH}_3 + 2\text{K}_2[\text{HgI}_4] + \text{KOH} \rightarrow \text{I}^-\text{Hg}\text{I}_2\text{NH}_3\text{I}^- + 5\text{KI} + \text{H}_2\text{O}
\]

**The Pharmacist’s recommendations to patients and physicians for the rational combination of drugs and protein-containing food products**

Foods rich in proteins can enhance or reduce the process of absorption of various drugs.

The consumption of food with the high protein content together with β-blockers (e.g., propranolol) increases their bioavailability. It increases the side effects such as bradycardia, hypotension, and due to the non-selectivity towards β₁-adrenoceptors – a bronchospasm.

Besides, the high-protein diet may reduce the concentration and efficiency of levodopa and theophylline reducing as a result the therapeutic concentration of the drug and the disease is exacerbated.

Proteins can bind drugs reducing their concentration, e.g., in patients with diabetes who have tried to reduce the level of cholesterol by metformin, protein food after meal caused an increase in the blood glucose level because the level of metformin decreases while receiving large amounts of protein. Such drugs as levothyroxine, digoxin, and penicillins interact similarly with proteins.

The list of food that is rich in protein, which can affect the activity of drugs:

1. Pork, lamb (fatty food) weaken the effect of drugs is as follows: phenyl salicylate, griseofulvin, neomycin sulfate.

2. A patient should exclude ham, sausages and smoked meat products when taking anorectics, antidiabetics, biguanides, MAO inhibitors, tetracyclines and chlorpromazine because of the possible formation of carcinogenic nitrosamines.
3. Food that is high in protein decreases the intestinal absorption of oxacillin, ampicillin, isoniazid; decreases the concentration of tetracycline in the human serum by approximately 50%.

4. To prevent complications while taking corticosteroids and steroid hormones that cause the change in water-salt, protein, carbohydrate and fat metabolism it is reasonable to increase proteins in the diet by eating lean meat.

5. During the long-term treatment by cholestyramine to lower the cholesterol level one should exclude fatty meat from the diet.
QUESTIONS FOR SELF-CHECKING

1. What are the main groups of meat products?
2. What is the nutritional and biological role of meat and meat products? What are the norms of their daily consumption?
4. What vitamins and minerals are found in meat?
5. Describe the concept of autolysis of meat. What are the main steps of this process?
6. Which types of by-products are used in cooking; describe their chemical composition, nutritional and biological value.
7. What are the sausage products, give their classification.
8. What indicators are used in determining the medium of meat and sausage products?
9. What is the method of determining peroxidase in meat?
10. Which indicators are the parts of the medicobiological requirements (MBR) for the quality control of meat products?
11. How is ammonia determined in meat according to the State Standard of Ukraine? Explain the causes for their occurrence and write the chemical reaction.
12. What is the purpose of starch addition in sausages, how is it determined?
14. What recommendation can you give for the rational combination of drugs and meat products?
TASKS FOR SELF-CHECKING

1. The muscular pigment that affects the colour of the meat and meat products is:
   A. myoglobin
   B. myosin
   C. collagen
   D. elastin
   E. tryptophan

2. What protein belongs to the connective tissue proteins?
   A. myosin
   B. methmyoglobin
   C. hemoglobin
   D. collagen
   E. actin

3. Which substance belongs to nitrogen-free extractive substances?
   A. lecithin
   B. lactic acid
   C. creatine
   D. purine bases
   E. glutamic acid

4. Which type of meat by-product has the largest iron content?
   A. stomach
   B. brains
   C. kidney
   D. tongue
   E. heart

5. What substance that is harmful for the liver and kidneys is formed from purine compounds?
   A. creatine
   B. lecithin
   C. uric acid
   D. glutamic acid
   E. glycogen

6. During salting the meat myoglobin becomes:
   A. collagen
   B. oxyomyoglobin
   C. hemoglobin
   D. creatinine
   E. metmyoglobin
7. What are the essential amino acids absent in proteins of the connective tissue?
A. threonine and valine  
B. phenylalanine and hydroxyproline  
C. isoleucine and leucine  
D. lysine and methionine  
E. tryptophan and tyrosine

8. The process of spontaneous changes in the chemical composition, structure and properties of the raw meat after slaughter is called:
A. acid hydrolysis of meat  
B. alkaline hydrolysis of meat  
C. autolysis of meat  
D. oxidation of meat  
E. meat spoilage

9. The interaction of myoglobin and sodium nitrite forms:
A. nitrosomyoglobin  
B. oxymyoglobin  
C. metmyoglobin  
D. hemoglobin  
E. nitrosamine

10. To prevent development of complications effects it is advisable to increase the lean meat complete proteins part in the diet when taken?
A. corticosteroids and steroid hormones  
B. NSAIDs  
C. alkaloids  
D. anti-TB drugs  
E. antibiotics
CHAPTER 6

FISH

Fish and fish products are among the most common foods having a high nutritional and biological value. The technical Regulations defines fish products as products of fish, echinoderms, mollusks, crustaceans, fish eggs seized from their habitat, living, in natural or processed (wet) form intended for human consumption.

Fish products
The food industry produces a wide range of different fish products shown in Fig. 6.1.

Fig.6.1. The main types of fish products

Classification of fish

Fish can be categorized according to the environment, in which it lives:
- sea fish, which can live only in salty sea or oceanic water (herring, mackerel, sole, mullet, horse mackerel, cod families, etc.);
- migrating fish, which can live and spawn in both environments (salmon and sturgeon families, eels);
- freshwater fish, which can live and spawn in fresh water (carp family: bream, European carp, carp, tench, sea roach, Caspian roach; zander, perch, sheatfish, pike, etc.).

Seafood is widely used along with fish. It includes all varieties of edible inhabitants of the seas and oceans, except for vertebrates (whales, fish). Seafood includes:
- crustaceans (sea crayfish, lobsters, shrimps, crabs);
- mollusks: bivalves (scallops, mussels, oysters); cephalopods (octopus, squids);
- echinoderms (sea urchin, sea cucumbers).

The chemical composition of fish and seafood

The most constant value is the sum of water and fat contents of fish of different species being about 80%.

The chemical composition and energy value of fish is shown in Table 6.1.
Table 6.1.
The chemical composition and energy value of fish and seafood (per 100 g of the product)

<table>
<thead>
<tr>
<th>Product</th>
<th>Protein, g</th>
<th>Fat, g</th>
<th>Carbohydrates, g</th>
<th>Energy value, kkal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cod</td>
<td>18.3</td>
<td>0.7</td>
<td>-</td>
<td>80</td>
</tr>
<tr>
<td>Haddock</td>
<td>19.0</td>
<td>0.6</td>
<td>-</td>
<td>81</td>
</tr>
<tr>
<td>Sole</td>
<td>16.7</td>
<td>1.4</td>
<td>-</td>
<td>79</td>
</tr>
<tr>
<td>Whiting</td>
<td>18.7</td>
<td>0.7</td>
<td>-</td>
<td>81</td>
</tr>
<tr>
<td>Lemon sole</td>
<td>17.4</td>
<td>1.5</td>
<td>-</td>
<td>83</td>
</tr>
<tr>
<td>Monkfish</td>
<td>15.7</td>
<td>0.4</td>
<td>-</td>
<td>66</td>
</tr>
<tr>
<td>Herring</td>
<td>17.8</td>
<td>13.2</td>
<td>-</td>
<td>190</td>
</tr>
<tr>
<td>Mackerel</td>
<td>18.7</td>
<td>16.1</td>
<td>-</td>
<td>220</td>
</tr>
<tr>
<td>Tuna</td>
<td>23.7</td>
<td>4.6</td>
<td>-</td>
<td>136</td>
</tr>
<tr>
<td>Salmon</td>
<td>20.2</td>
<td>11.0</td>
<td>-</td>
<td>180</td>
</tr>
<tr>
<td>Rainbow trout</td>
<td>19.6</td>
<td>5.2</td>
<td>-</td>
<td>125</td>
</tr>
<tr>
<td>Oysters</td>
<td>11.0</td>
<td>2.75</td>
<td>4.5</td>
<td>120.00</td>
</tr>
<tr>
<td>Squid</td>
<td>18.0</td>
<td>4.20</td>
<td>2</td>
<td>110.00</td>
</tr>
<tr>
<td>Shrimp</td>
<td>18.90</td>
<td>2.20</td>
<td>1.52</td>
<td>95.00</td>
</tr>
<tr>
<td>Krill</td>
<td>20.60</td>
<td>1.70</td>
<td>-</td>
<td>98.00</td>
</tr>
<tr>
<td>Crab</td>
<td>16.00</td>
<td>3.60</td>
<td>-</td>
<td>96.00</td>
</tr>
<tr>
<td>Mussels</td>
<td>9.10</td>
<td>1.50</td>
<td>3.3</td>
<td>50.00</td>
</tr>
</tbody>
</table>

Fish proteins are complete (contain all essential amino acids); due to it fish is one of the most valuable sources of the high quality protein diet.

By the composition of amino acids meat of ground animals does not much differ from fish, but they differ in the content of certain amino acids (Table 6.2). For example, meat of oceanic fish contains a lot of tryptophan, lysine, methionine, which brings it closer to the ideal protein. Some types of ocean fish also have the increased level of such amino acids as glutamic acid, aspartic acid, serine, alanine, leucine, on the other hand, they have the reduced content of tyrosine and phenylalanine. In addition, proteins of fish products are more digestible than meat. If veal is digested in the body for 5 hours, the fish is digested only for 2-3 hours.

Table 6.2.
The amino acid composition of some types of fish

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Fresh, chilled, frozen fish</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>pink salmon</td>
</tr>
<tr>
<td>Valine</td>
<td>1.229</td>
</tr>
<tr>
<td>Isoleucine</td>
<td>0.937</td>
</tr>
<tr>
<td>Leucine</td>
<td>1.712</td>
</tr>
<tr>
<td>Lysine</td>
<td>2.016</td>
</tr>
<tr>
<td>Methionine</td>
<td>0.545</td>
</tr>
<tr>
<td>Threonine</td>
<td>1.13</td>
</tr>
<tr>
<td>Tryptophan</td>
<td>0.215</td>
</tr>
<tr>
<td>---------------</td>
<td>-------</td>
</tr>
<tr>
<td>Phenylalanine</td>
<td>0.959</td>
</tr>
<tr>
<td>Histidine</td>
<td>0.88</td>
</tr>
</tbody>
</table>

By the protein content fish can be classified:
1) low-protein fish (up to 10% of protein (coalfish, halibut));
2) medium-protein fish (10-15% of protein (shad, capelin, lamprey));
3) protein-containing fish (15-20% of protein (herring, sardines, sturgeon, grayling, pike));
4) high-protein fish (more than 20% of protein (mackerel, horse mackerel, tuna, chum salmon, and pink salmon)).

There are proteins of muscular tissue, connective tissue, gonads (hard roe and soft roe), bone tissue.

Proteins of the muscular tissue are myosin, actin, actomyosin, albumin, globulin, etc. The contractile proteins (myosin, actin, actomyosin) have a high water-holding capacity. It explains the low moisture loss during thermal treatment of fish.

Proteins of fish contain a special amino acid taurine (it does not exist in the protein of meat animals), which enhances the detoxification function of the liver, is involved in the metabolism of cholesterol, regulates blood pressure, reduces the amount of triglycerides in the blood, improves night vision. The richest taurine sources are oceanic fish and squid, shrimp, krill, sea bass, cod, tuna.

The presence of diamino acids of the formula RCOOH(NH₂)₂ (ornithine, arginine, lysine) of the total quantity up to 25% of proteins in fish provides the pH of fish tissues within 6.3-6.6 (only for some types of fish it is 6.0-6.1). This is a weak acidic medium that is good for putrefactive microbes. That is why chilled fish quickly undergoes damage (the maximum storage is 5 days) than chilled animal meat (the shelf life is up to 15 days or even more).

Due to the large amount of sulfur-containing amino acids, fish meat is a good source of sulfur. During storage sulfur-containing proteins are destroyed with the release of hydrogen sulfide. It is used to estimate the freshness of fish. Quantities of H₂S allowestimating the freshness of fish: fresh, questionable freshness, stale.

Deamination of amino acids forms ammonia:

$$R-(COOH)₂-NH₂ + H₂ \rightarrow RCH₂COOH + NH₃↑$$

And decarboxylation of amino acids forms amines:

$$R-CH(NH₂)₂-COOH \rightarrow CO₂↑+ R-CH₂-NH₂$$

The quantitative content of ammonia and amines is also indication of fish freshness.

Fish tissue contains also the complex proteins (proteids) nucleoproteids, phosphoroproteids, glycoproteids, lipoproteids.

Glycoproteids during hydrolysis release glucose, and it explains the slightly sweet taste of the fish meat.

The connective tissue proteins (non-complete proteins, they do not contain tryptophan) are collagen and elastin. The elastin content is low – 0.1%, and therefore,
the connective tissue of fish is represented almost only by collagen. The connective tissue includes different amount of collagen (from 1.7% in sturgeon to 10% in sharks), a denser structure of collagen is in large fishes (shark) and a softer structure is in small, especially fresh water fish. Due to the low content of the connective tissue proteins fish is widely used in dietary and baby food.

Such fish products as caviar and soft roe contain up to 90% of the complete protein of the globulin type and about 14% of the albumin type.

Ichthulin is 50-60% of fish globulins and is a phosphoproteid with the nitrogen content from 14 to 16%, the sulfur content of 0.4-1.1%, the phosphorus content of 0.2-0.6%. It has a strong allergenic properties, is extracted to the broth during cooking. Therefore, allergy to fish becomes apparent by eating of the fish soup, or by inhalation of the fumes produced when cooking fish.

Caviar also contains lipoproteids and glycoproteids, which provide its viscosity.

Proteins of the bone tissue are osseine, which is similar to collagen by the aminoacid composition.

The complete protein content in shellfish is from 5.5% (sea cucumbers) to 20% (mussels). The content of essential aminoacids reaches 38% of the general protein content. The peculiarity of the amino acid composition of proteins of the crab meat is a higher content of sulfur-containing amino acids (cystine, cysteine) and tyrosine. This fact affects the change of colour of the products during storage and canning. The meat of squids and octopus contains a lot of collagen (up to one third of the protein), and it gives a somewhat rough texture to the meat.

**Non-protein nitrogen-containing extractable substances** give a specific taste and flavour to fish and considerably affect the rate of its damage during storage because they are exposed to the microorganisms action more than proteins. The relative content of the non-protein content varies greatly even in the samples of the same species of fish.

The average content of the total nitrogen in muscles of majority of teleosts is 9-14%, in herring – 14-18%, in sharks and rays – 33-38%, sometimes it reaches 57%. The amount of non-protein nitrogen-containing compounds may change depending on the age, gender and physical state of fish. It increases during the spawning season. Brown muscles surpass white muscles by this indicator.

Non-protein nitrogen-containing extractable substances are divided in the following groups:
- volatile bases (mono-, di- and trimethylamines, ammonia);
- trimethylammonium bases (trimethylaminooxide, betaines, choline);
- guanidine derivatives (creatine, creatinine, arginine);
- purine derivatives (hypoxantine, xanthine and related nucleoside phosphates – AMPA, ADPA, ATPA);
- imidazole derivatives (histidine, carnosine, anserine);
- mixed group (urea, free amino acids).

The meat of fresh fish contains an insignificant amount of volatile bases (15-17 mg%, the greater part is ammonia). The content of trimethylamine is greater in sea fish and is 2-2.5 mg%, in fresh water fish it is less than 0.5 mg%. There are only
traces of mono- and dimethylamines (less than 0.1 mg%). During spoilage the amount of volatile bases and primarily ammonia increases causing an unpleasant smell.

Trimethylaminooxide (TMAO) is of the greatest importance among the trimethylammonium bases and it just causes the specific smell of fresh fish. Sea fish contains more of it than fresh water fish.

\[
\text{H}_3\text{C} - \text{N}=\text{O} \quad \text{H}_3\text{C}
\]

**Trimethylaminooxide (TMAO)**

Under the action of endogenic enzymes TMAO is reduced into trimethylamine during storage. The quantity of trimethylamine is an indicator of fish freshness.

\[
\begin{align*}
\text{H}_3\text{C} - \text{N}=\text{O} & \quad \overset{[\text{H}]}{\longrightarrow} \quad \text{H}_3\text{C} - \text{N} \\
\text{H}_3\text{C} & \quad \text{H}_3\text{C}
\end{align*}
\]

Scheme 6.1. Reduction of TMAO to trimethylamine

Betaine (the content in the meat of sea fish is from 70 to 270 mg%, in the meat of fresh water fish is from 10 to 54 mg%) participates in the taste formation.

Guanidine and purine derivatives play an important role *in vivo* metabolism and postmortem autolytical changes occurring in fish. They influence on formation of the taste of fish. The creatine content ranges from 0.28 to 0.74 mg%.

The only one of imidazole derivatives – histidine, anserine or carnosine is present in different types of fish. During the bacterial spoilage of fish these substances decompose with formation of substances with high toxic properties. For example, histidine is decarboxylated producing histamine. It explains the poisoning by stale fish (sardines, mackerel, tuna, snapper, etc.) containing a high amount of histidine.

\[
\begin{align*}
\text{N} & \quad \text{O} \\
\text{NH}_2 & \quad \text{CO}_2 \\
\text{Histidine} & \quad \text{Histamine}
\end{align*}
\]

Scheme 6.2. Biological decarboxylation of histidine

Amino acids from the mixed group of extractable substances in a free state in fresh fish are in a small amount, but when storing their content is increased as a result of hydrolysis of proteins.
Urea is contained in the cartilaginous sea fish (sharks, rays) in a large amount, and is found only in traces in fresh water teleost fish. When decomposing urea in fish ammonia is produced, which gives it an unpleasant odour.

\[
\begin{align*}
\text{O} & \quad \text{NH}_3 + \text{HNCO} \\
\text{H}_2\text{N} & \quad \text{C} \quad \text{NH}_2 \quad \rightarrow \\
\text{HNCO} & \quad + \text{H}_2\text{O} \quad \rightarrow \quad \text{NH}_3 \uparrow + \text{CO}_2
\end{align*}
\]

Scheme 6.3. Decomposition of urea

A lot of non-protein nitrogen-containing compounds are in such seafood as squids and octopus, and it determines their specific taste and smell as far as fast microbiological spoilage during storage in the chilled form. The squid meat contains a lot (up to 400 mg%) of trimethylaminooxide (TMAO). It is about 4-5 times more than in sea fish.

The amount of fat in fish vary widely from 0.6 to 18.5% (this is the average fat content of fish in the out-of-spawning period), and the fattiest fish (e.g. lampreys) contains up to 33% of fat. The fat content depends on the type, gender and age of fish, the place where it lives.

Depending on the ability to store fat fish is divided into:
- non-fatty – the fat content is 0.2-3.9% (cod, hake, saffron cod, pollock, halibut, zander, flounder, pike, whiting, ice fish, trout, the perch family, the cod family);
- moderately fatty – the fat content is 4-8 % (grouper, mackerel, most of the carp family, salmon, a part of the herring family, some types of flounder, catfish);
- fatty – the fat content is more than 8% (fatty herring, sturgeon family, halibut, lamprey, eel, many of the salmon family (particularly European varieties), mackerel, anchovy).

Fats are found mostly in the subcutaneous tissue and the liver. The characteristic of fish fats is the fact that they are tryglycerides of polyunsaturated acids. Fish also contains phospholipids: lecithins (are the source of lecithinic phosphorus), phosphatidylethanolamines (cephalin), phosphoserins, sterols (cholesterol), waxes (spermaceti); glycolipids (sphingolipids); hydrocarbons (squalene, pristan); lipochromes – pigments (carotene and xanthophyll), vitamins A, D, K, E (vitamin A in large quantities is found in the fish liver).

Unsaturated fatty acids are the basis of the fish oil (up to 84% of the total amount of fatty acids); it explains its fluid consistency and easy digestibility. At the same time a high concentration of polyunsaturated fatty acids causes the easy oxidation of fat. Glycerol and free fatty acids are formed after hydrolysis, in further oxidation they form peroxides and hydroperoxides, which are then transformed into the secondary products of oxidation and decay – aldehydes, ketones, low molecular weight fatty acids, alcohols, etc. (Scheme 5.4). Denatured fats significantly spoil the taste and smell of fish products, and they are not suitable for food because of the high toxicity of oxidation products.
Freshwater and sea fish are different in the composition of fatty acids. Freshwater fish fat contains up to 60% (of the total fatty acids) of polyunsaturated fatty acids such as palmitoleic, oleic, linoleic, linolenic, reaching the poultry fat at that point.

Fat of sea fish contains up to 65% of such fatty acids as arachidonic, clupanadonic or docosahexaenoic acid (DHA), and eicosapentaenoic acid (EPA).

\[
\text{CH}_3(\text{CH}_2)_4(\text{CH}=\text{CHCH}_2)_4(\text{CH}_2)_2\text{COOHCH}_3(\text{CH}_2-\text{CH}=\text{CH})_5(\text{CH}_2)_3\text{COOH}
\]

arachidonic acid

\[
\text{CH}_3(\text{CH}_2\text{CH}=\text{CH})_5(\text{CH}_2)_3\text{COOH}
\]

EPA

Particular importance of fish fat for human health is explained by the presence of polyunsaturated fatty acids of the omega-3 group – eicosapentaenoic acid and docosahexaenoic acid. These acids are a source for the synthesis of important biological regulators in the body – eicosanoids (omega-3 prostaglandin and omega-3 thromboxane). They slow down formation of atherosclerotic plaques, inhibit platelet aggregation and prevent formation of blood clots, inhibit inflammation, maintain the tone of blood vessels and bronchi, normalize blood pressure, reduce blood levels of triglycerides, improve the immune status, inhibit allergic conditions, regulate the secretion processes, improve the condition of the mucous membranes. Polyunsaturated fatty acids omega-3 are an important structural component of biological membranes of cells of the human body and are necessary for their normal functioning.

The cholesterol content in fat of different species of fish may vary within fairly wide limits: 0.1-0.2 – 8-10%. In the fatty fish species a small amount of cholesterol is found in the range of 0.2-1.9%, whereas non-fatty fish fats contain relatively much cholesterol – 6-10%. 
Seafood contains fat in minor amounts, it consists of 40-50% of triglycerides, 20-60% of phospholipids (80% in crab’s fat), up to 12% of cholesterol (crustaceans – shrimps, crabs, lobsters contain sufficiently large quantity of it, which corresponds to the level of cholesterol in red meat). Such mollusks as mussels, oysters and scallops are rich in non-cholesterol sterols (lanosterol), which inhibit absorption of cholesterol received with the products at the same meal.

In the fat composition of caviar the main components are phospholipids (lecinthin, phosphatidylethanolamine, phosphatidyglycerol, phosphatidylinositol, cardiolipin, lysophosphatidylcholine), mono-, di- and triglycerides, sterols, free fatty acids and sterol esters. It contains more than 45 fatty acids, the most is represented by monounsaturated fatty acids – oleic and palmitoleic, about 0.002 -0.06% of saturated acids – palmitic acid, stearic acid and myristic acid, and about 30% of polyunsaturated fatty acids of the omega-3 group.

The content of fat, unsaturated fat and fatty acids in fish and seafood is shown in Table. 6.3.

Table 6.3.

<table>
<thead>
<tr>
<th>Product</th>
<th>Lipids, g</th>
<th>Polyunsaturated fats, g</th>
<th>Fatty acids of the omega-3 group, g</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>EPA</td>
</tr>
<tr>
<td>Oysters (boiled)</td>
<td>1.6</td>
<td>0.6</td>
<td>-</td>
</tr>
<tr>
<td>Crabs (boiled)</td>
<td>5.5</td>
<td>1.6</td>
<td>0.47</td>
</tr>
<tr>
<td>Mussels</td>
<td>1.8</td>
<td>0.6</td>
<td>0.3</td>
</tr>
<tr>
<td>Herring</td>
<td>13.2</td>
<td>2.7</td>
<td>0.51</td>
</tr>
<tr>
<td>Mackerel</td>
<td>16.1</td>
<td>3.3</td>
<td>0.7</td>
</tr>
<tr>
<td>Tuna (canned)</td>
<td>4.6</td>
<td>1.6</td>
<td>0.02</td>
</tr>
<tr>
<td>Salmon</td>
<td>11.0</td>
<td>3.1</td>
<td>0.5</td>
</tr>
<tr>
<td>Rainbow trout</td>
<td>5.2</td>
<td>1.7</td>
<td>0.2</td>
</tr>
<tr>
<td>Cod liver oil</td>
<td>99.9</td>
<td>30.5</td>
<td>10.8</td>
</tr>
</tbody>
</table>

The carbohydrate content in fish is not large – about 0.01-1.5% in muscles and up to 20% in the liver, and it is mainly glycogen and the products of its breakdown – glucose (0.03%), ribose (0.007%). The glycogen content depends on the type of fish, fatness, the type of muscles.

Despite the small amount of carbohydrates in fish, they play an important role in autolytic changes of fish, and are involved in formation of taste, odour and colour of fish products. During storage, glycogen breakdown takes place (hydrolysis or phosphorolysis) forming glucose, pyruvic acid and lactic acid. During phosphorolysis, which occurs in the early hours of storage, up to 90% of glycogen is decomposed:

\[
\text{Glycogen} \rightarrow \text{glucose-1-phosphate} + \text{H}_3\text{PO}_4 \rightarrow \text{pyruvic acid} \rightarrow \text{lactic acid.}
\]

During longer storage the amylolythic decay of remaining glycogen takes place:

\[
\text{Glycogen} \rightarrow \text{polysaccharides} + \text{H}_2\text{O} \rightarrow \text{maltose} \rightarrow \text{glucose.}
\]
Glucose forming during the heat treatment of fish can react with amino acids to form melanoidins. Melanoidins give a darkish colour to the surface of the product (on contact with oxygen), a pleasant aroma and a sweet taste to the fish broth.

**Vitamins** in fish are distributed unevenly. Much of the fat-soluble vitamins are in the liver, the rest is in other internal organs. The muscles of fish contain a small amount of fat-soluble vitamins - A, D, E and K. The quantitative content can vary even within the same species, and depends on the physiological characteristics of fish, environment, gender, age. For example, vitamin A is completely absent in non-fatty fish, and fatty fish meat contains only from 0.1 to 0.9 mg% of it. The liver of sea fish (cod, sea bass, red salmon, mackerel, sharks, etc.) is the most richest in vitamin A (up to 160-490 mg%). The content of cholecalciferol (vitamin D3) ranges between 60-1900 µg%.

The fish oil contains 0.5-7% of essential fatty acids (linoleic, linolenic, arachidonic), which together form vitamin F. The largest quantity of it is found in muscles (about 7%) and the liver (about 5.1%) of Atlantic cod.

Of the water soluble vitamins fish contains vitamins of group B – B1, B2, B6, Bc, B12 and BT (carnitine), as well as vitamins H, C, PP, pantothenic acid, inositol. In general, fish meat contains more vitamins than beef, milk and eggs.

During storage of fish products vitamins are involved in a variety of chemical reactions. This is accompanied by not only by the change of taste, colour and smell of fish products, but also by decreasing of the content of vitamins themselves, thereby deteriorating of bioavailability of the food product.

Caviar is particularly rich in vitamins A (0.2-4.6 mg) and D (0.1-0.6 mg).

The content of the vitamins is given in Table 6.4.

**Table 6.4. Vitamins in fish and seafood (per 100g of the crude product)**

<table>
<thead>
<tr>
<th>Product</th>
<th>Vitamin A (retinol), µg</th>
<th>Vitamin E, µg</th>
<th>Vitamin D, µg</th>
<th>Vitamin B12, µg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oysters</td>
<td>85</td>
<td>0.9</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Lobsters (boiled)</td>
<td>25</td>
<td>1.5</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Crabs (boiled)</td>
<td>10</td>
<td>1.3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mussels</td>
<td>60</td>
<td>0.9</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Herring</td>
<td>30</td>
<td>1.2</td>
<td>30</td>
<td>10</td>
</tr>
<tr>
<td>Mackerel</td>
<td>10</td>
<td>1.6</td>
<td>-</td>
<td>12</td>
</tr>
<tr>
<td>Tuna (canned)</td>
<td>20</td>
<td>0.2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Salmon</td>
<td>30</td>
<td>2.5</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Rainbow trout</td>
<td>84</td>
<td>2.34</td>
<td>15.9</td>
<td>4.3</td>
</tr>
<tr>
<td>Cod liver</td>
<td>4400</td>
<td>8.8</td>
<td>100</td>
<td>-</td>
</tr>
</tbody>
</table>

**Minerals** of fish are very diverse in composition, but their amount is only 1.2-1.5%. The bulk of minerals is in the bone tissue (about 80% of their total amount) and consists of the main elements: salts of sodium, potassium, calcium, phosphorus, magnesium. Therefore it is important that fish that can be eaten with bones should be included in the diet. In the muscular tissue of fish the microelements – iodine, copper, zinc, iron, manganese, cobalt – are concentrated. Sea and ocean fish is especially rich
in minerals: it contains more of B, Fe, Li, Cu, K, Ca, Co, Mg, Mn, Br, P, F, I than freshwater fish.

Seafood by its food value is not inferior to milk and eggs, and sometimes exceeds the nutritional value of fish and meat of terrestrial animals. The mineral composition of fish and seafood is presented in Table 6.5.

### Table 6.5. The mineral composition of fish and seafood (per 100g of the crude product)

<table>
<thead>
<tr>
<th>Product</th>
<th>Na, mg</th>
<th>K, mg</th>
<th>Ca, mg</th>
<th>Fe, mg</th>
<th>Zn, mg</th>
<th>I, µg</th>
<th>Se, µg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cod</td>
<td>60</td>
<td>340</td>
<td>9</td>
<td>0.1</td>
<td>0.4</td>
<td>110</td>
<td>28</td>
</tr>
<tr>
<td>Haddock</td>
<td>67</td>
<td>360</td>
<td>14</td>
<td>0.1</td>
<td>0.4</td>
<td>250</td>
<td>27</td>
</tr>
<tr>
<td>Sole</td>
<td>120</td>
<td>280</td>
<td>45</td>
<td>0.3</td>
<td>0.5</td>
<td>33</td>
<td>37</td>
</tr>
<tr>
<td>Herring</td>
<td>120</td>
<td>320</td>
<td>60</td>
<td>1.2</td>
<td>0.9</td>
<td>29</td>
<td>35</td>
</tr>
<tr>
<td>Mackerel</td>
<td>63</td>
<td>290</td>
<td>11</td>
<td>0.8</td>
<td>0.6</td>
<td>140</td>
<td>30</td>
</tr>
<tr>
<td>Tuna</td>
<td>47</td>
<td>400</td>
<td>16</td>
<td>1.3</td>
<td>0.7</td>
<td>30</td>
<td>57</td>
</tr>
<tr>
<td>Salmon</td>
<td>45</td>
<td>360</td>
<td>21</td>
<td>0.4</td>
<td>0.6</td>
<td>37</td>
<td>26</td>
</tr>
<tr>
<td>Rainbow trout</td>
<td>45</td>
<td>420</td>
<td>18</td>
<td>0.3</td>
<td>0.7</td>
<td>13</td>
<td>18</td>
</tr>
<tr>
<td>Oysters</td>
<td>510</td>
<td>260</td>
<td>140</td>
<td>5.7</td>
<td>0.6</td>
<td>60</td>
<td>23</td>
</tr>
<tr>
<td>Mussels</td>
<td>290</td>
<td>320</td>
<td>38</td>
<td>5.8</td>
<td>0.5</td>
<td>140</td>
<td>51</td>
</tr>
<tr>
<td>Crabs (boiled)</td>
<td>420</td>
<td>250</td>
<td>91</td>
<td>1.6</td>
<td>5.5</td>
<td>-</td>
<td>84</td>
</tr>
<tr>
<td>Shrimps</td>
<td>190</td>
<td>330</td>
<td>79</td>
<td>1.6</td>
<td>1.5</td>
<td>21</td>
<td>16</td>
</tr>
</tbody>
</table>

**Water** in the tissues and organs of fish is found in the free and bound state. The ratio of free and bound water in the muscular tissue of fish of different species is not equal. The total moisture content is from 52 to 85%, from which free water is up to 75.5%, and bound water is up to 9.5%.

**Adulteration of fish and fish products**

*Adulteration of fresh fish* is possible in the following ways:

1. valuable fish species is replaced by another, less valuable. Most often, this is done with the fish, which is sold as a frozen fillet. To determine the type of fish, which fillet belongs to, is hard enough. Instead of the first-class products the consumer may be offered a second-class product;
2. the use of the low-quality raw material. Stale fish is sold as fresh;
3. a great quantity of water (ice) in frozen fish;
4. introduction of additives, antibiotics, preservatives, colorants.

*Adulteration of sliced fish*

The fish used for slicing is very often fed by special food with various additives such as fats, amino acids, vitamins and minerals. Such fish should not be eaten very often as these supplements can have a negative impact on health. Instead of salted salmon a coloured herring can be sold. If the sliced fish is cheaper by 20-30%, probably it is made of the pre-frozen fish, it has an unpleasant appearance and is more slippery and greasy.
Adulteration of canned fish is possible in the following ways:
1. the high water content (water or a thick layer of jelly);
2. replacement of fresh fish with stale;
3. the improper stacking of fish. This happens more often to the sprats in oil: some tins have only partial stacking, and the part of sprats are located randomly;
4. the introduction of foreign agents. Canned fish can be diluted with oil, tomato filling, fish fins, cartilage, tails, entrails, and cereals;
5. violation of technological processes and storage modes;
6. valuable fish species can be replaced by cheaper;
7. tins can have defects, such as rust, deformation, or leakage;
The upper side of a tin should have a stamping in the form of raised letters or a stamping indelibly applied. Concave letters indicate a fake.

The quality control of fish and seafood.
Assessment of the quality of fish products is carried out in accordance with GOST 7636-85 "The fish, marine mammals, marine invertebrates and derived products. Methods of analysis".

Indicators of the quality of fish products are:
1. Organoleptic characteristics (appearance, colour, texture, taste).
3. Physical parameters (length, weight).
4. Microbiological purity and the content of toxic compounds: histamine, N-nitrosamines, etc.

Organoleptic characteristics of fish

Fresh fish. Good quality fish: bulging eyes, the cornea is transparent, bright red gills, shiny scales, the muscular tissue is dense; it is difficult to separate the meat from the bone, after cooking the broth is clear and fragrant.
Poor quality fish: gills are brown, greyish-red, eyes are sunken, bloodshot, flabby muscles are separated from the bones, when pressed with your finger on the fish the pit does not become level, a putrid smell is determined by the breakdown "on the knife", after boiling the broth is opaque, with an unpleasant odour.

Frozen fish. After thawing the meat is dense, is not separated from the bones. Deep frozen fish when tapped produces a clear ringing sound. It is hard to thrust a knife into a frozen fish.

Salted fish. The brine in barrels of fish should not have an unpleasant odour. The fish should be clean and free of dirt, not rumpled. While examining one should pay a particular attention to whether the fish is not damaged by pests.

Air-dried and dried fish. It must be dry (the excessive moisture is characteristic for tarnished or damp fish, which is often the result of improper storage of the product and can lead to its rapid deterioration). It should not have mold and musty odours.

Smoked fish. Hot smoked fish should be thoroughly baked, the meat should be easy to separate from the spine, and its colour, density and texture should resemble
the meat of fried or boiled fish. Determining the quality of cold smoked fish: the surface of cold-smoked fish is quite dry, the skin is of a golden-brownish colour. Cold smoked fish must have the meat that is well adjacent to the bones, quite dense and firm, without unpleasant smell.

_Canned fish._ The fish carcasses when carefully taking out of canshould not break into fragments. The skin condition is without scales, the integrity is intact, except for the places of contact between fish. The taste and smell are pleasant. Oil and gel should be transparent, the broth is light.

**Physicochemical quality indicators**

_Determination of volatile nitrogenous bases_

1. **Titrimetric method.** Free and bound volatile bases (amines) are distilled with steam after interaction with magnesium oxide (the alkaline medium) and collected in a receiver with sulphuric acid solution. The excess of sulphuric acid is titrated with sodium hydroxide solution.

\[
2R-NH_3^+ + MgO \rightarrow 2R-NH_2↑ + Mg^{2+} + H_2O
\]

\[
2R-NH_2↑ + H_2SO_4 \rightarrow (R-NH_3)^+_2SO_4
\]

\[
H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O
\]

2. **Colorimetric method.** Ammonia and volatile bases (amines) are distilled with steam, and then in the reaction with alkaline potassium tetraiodomercurate solution (_Nessler_ reagent) they give a yellow or orange coloration.

\[
NH_3 + 2K_2[HgI_4] + KOH → \begin{array}{c} \text{Hg} \text{I} \text{H} \\ \text{NH}_2 \text{I} \end{array}^{-} + 5Kl + H_2O
\]

_Determination of hydrogen sulphide_

Hydrogen sulphide that forms during fish spoiling reacts with lead acetate with a dark coloration of lead sulphide.

\[
H_2S + Pb(CH_3COO)_2 \rightarrow PbS↓ + 2CH_3COOH
\]

_Determination of ammonia_

The method is based on the reaction of ammonia forming in stale fish as a result of enzymatic or microbiological processes with Eber’s reagent. In Eber’s reaction ammonia in the presence of hydrochloric acid gives a white cloud of ammonium chloride.

\[
NH_3 + HCl \rightarrow NH_4Cl
\]

_Determination of amino nitrogen_

1. The method is based on the protein precipitation by copper phosphate with subsequent addition of potassium iodide and titration of iodine with sodium thiosulphate solution.

2. **Sørensen formol titration.** The method is based on the reaction of amino acids with formaldehyde (amino groups blocking takes place) and quantitative determination by the results of carboxylic groups titration with sodium hydroxide.
The sodium chloride content is a general indicator of quality for all kinds of fish products (excluding fresh, chilled and frozen fish). Determination of the mass fraction of NaCl is conducted by argentometric, mercurimetric methods.
1. Argentometry (Mohr's method), the indicator is potassium chromate.
2. Mercurimetry, the indicator is diphenylcarbazone.

For smoked and dried fish in addition to the basic parameters the moisture content, the fat content, and the histamine content (only for smoked fish) are determined.

For canned fish the percentage of the constituents, dry residue, acidity, tin salts (not more than 0.02%), copper salts (in fish with tomato sauce and pastes not more than 0.0008%), lead salts (should not be present) are determined.

The fat content is one of the most important indicators of the quality of fish products. During storage, the fat contained in the tissues of fish under the influence of tissue enzymes is gradually hydrolyzed to glycerol and free fatty acids and oxidized because of high unsaturation with formation of the substances, which significantly deteriorate fish. For example, hydroperoxides are precursors of compounds with a rancid odour.

**Determination of the mass fraction of fat**
1. The extraction method in a Soxhlet apparatus. The method is based on extraction of fat with an organic solvent from a dry sample and determining its mass by weighing.
2. The refractometric method is based on measurement of the refraction indexes of the pure solvent and the miscelle.

**Histamine** is formed by biological decarboxylation of histidine (Scheme 6.2.) catalysed by histidine decarboxylase and is an indicator of fish freshness. The maximum limit should not exceed 10 mg%.

**Organoleptic characteristics of seafood**
The quality of shrimps is usually determined by the following parameters: the amount of ice in frosting, "black heads", the percentage of waste in a package, the amount of snow.

Shrimps are frozen by the technology of fast freezing at the temperature of -25-35°C. In order to protect them from damage and from drying out, they need to be glazed. Frosting is creation of an ice layer on each shrimp by pouring water on and freezing. For the quality product the percentage of frosting in the final product is not more than 8-12%.
The presence of the so-called "black heads" in a pack also suggests that the product is not of very good quality. A "Black head" can be only in a shrimp, which has not been frozen for a long time after fishing. It has a flabby meat, does not have useful properties, and is unsuitable for food. Shrimps with dark greenish heads are safe, their colour only indicates that they ate a lot of plankton.

The lower the percentage of whiskers, tails, heads in the package is, the better is the product.

As cooked-frozen shrimp is to be bent as a hook; it says that it has been boiled live immediately after catching. The stronger a shrimp is straighten, the longer it had laid before it was boiled.

The presence of large amounts of snow in the pack indicates violations of the storage conditions during transport and sale. In order the product not to be spoilt before sale, the certain temperature regimen of storage is needed: at least -18 ° C. At higher temperatures, shrimps deteriorate and become non-edible for human.

Crude chilled shrimps must not have a dry shell or the one with the yellow spots and bumps clearly seen, it indicates a spoiled shrimp. Black specks on the shell show that a crustacean is old. Meat should not be yellowish and soft to the touch. There should not be an unpleasant smell.

Bivalves. The freshness of oysters before opening is difficult to determine. The main thing is that the half shells should be tightly closed. The edges of peeled fresh oysters are always black. If they are white, and the clam meat is less elastic, the product is not good.

Mussels can be blue (with a bluish-black shells) and green (larger, in bright green shells). Their taste is practically identical. The live mollusks should have their half shells tightly closed and undamaged. You need to throw out all mussels that have not opened during cooking.

Cephalopods. Squids should be frozen (defrosted that is already have been thawed and frozen again will taste bitter and disintegrate during cooking). Squids should not be sticky, and let easily to be separated from each other (this confirms that after packaging a briquette was not thawed). The film covering the carcass may be of different colours, from grey-pink to purple. The colour, as well as the size of the squid, depends on the age and environment. Meat under the film should be only white.

Drug-food interaction

A big quantity of fish in a diet makes urine more acidic, and therefore, changes elimination of medicines with an acidic or basic character.

Fish contains large quantities of vitamin B₆, which accelerates transformation of such drug as levodopa into dopamine (Scheme 6.5) penetrating the blood-brain barrier poorly. That is why the therapeutic effect can diminish. If patients take levodopa, they should decrease the consumption of fish.
Scheme 6.5. Transformation of levodopa into dopamine

Smoked, salted, dried, pickled fish, canned fish, red and black caviar contain large amounts of tyramine. Tyramine has a vasoconstrictor effect, increases blood pressure, affects the processes of stimulation and inhibition in the nervous system.

Deactivation of the excessive tyramine in a living organism is a result of its oxidation by the enzyme monoamine oxidase (MAO). While taking the groups of MAO inhibitors, as far as physic stimulants and vasoconstrictors (the effect of which is associated with increased levels of catecholamines) patients should avoid food containing tyramine. High levels of tyramine taken together with these drugs can cause a sudden, dangerous increase in blood pressure, tachycardia, intense headache, or cerebral hemorrhage.

Different side effects of isoniazide can be developed when it is combined with fish products rich in histamine. Food products with histamine include cod, tuna, skipjack tuna and other tropical fish. Headache, shortness of breath, nausea, and tachycardia can be observed since isoniazide inhibits the activity of diamine oxidase, which catalyzes oxidation of free histamine (Scheme 6.6).

Scheme 6.6. Oxidation of histamine

Fatty fish increases the risk of hemorrhages taken together with aspirin.

For the prophylaxis of side effects of such medicines as paracetamol, corticotropine, methylandrostendiol (and other anabolic drugs) fish food is recommended.

Anticonvulsants affect the ability of the organism to assimilate vitamin D and pholates, and that is why fatty fish is essential in this situation.
QUESTIONS FOR SELF-CHECKING

1. What are the main group of fish products do you know?
2. How can fish and seafood be classified?
3. Give a description of the chemical composition of fish and seafood.
4. Describe the composition of the fish fat. What is the biological role of polyunsaturated fatty acids of omega-3?
5. What vitamins and minerals are found in fish and seafood?
6. What is the nutritional and biological role of fish and seafood?
7. Describe the main types of fish and seafood adulteration and methods of their determination.
8. Describe the main types of adulteration of fish products.
9. What organoleptic parameters of seafood do you know?
10. What methods of volatile nitrogenous bases are determined by?
11. What is the method of determining peroxidase in fish?
12. Which indicators are the parts of the medicobiological requirements (MBR) for the quality control of fish products?
13. How is ammonia determined in fish according to the State Standard of Ukraine? Explain the causes for its occurrence and write the chemical reaction.
14. Describe the methods of determining amino nitrogen.
15. Describe the methods for determination of sodium chloride in fish and fish products. Give chemical reactions.
16. What recommendation can you give for the rational combination of drugs, fish and seafood?
TASKS FOR SELF-CHECKING

1. The proteins of the fish osseous tissue are:
   A. elastin
   B. collagen
   B. ossein
   C. myoglobin
   D. myosin

2. The reaction of glucose and amino acids when thermal by treating forms:
   A. glucose-3-phosphate
   B. glycogen
   C. collagen
   D. elastin
   E. melanoidin

3. Which phosphoprotein is found in caviar?
   A. ossein
   B. ihtulin
   C. collagen
   D. elastin
   E. myoglobin

4. What polyunsaturated fatty acid in fish belongs to the group of omega-3 fatty acids:
   A. linolenic
   B. arachidonic
   C. linoleic
   D. butyric
   E. eicosapentaenoic

5. Fish meat has a sweet taste due to the content of:
   A. cholesterol
   B. glicoproteids
   C. myoglobin
   D. ichthulin
   E. ossein

6. With the help of what reagent can nitrogen be determined by the colorimetric method?
   A. solution of sodium hydroxide
   B. Fehling reagent
   C. Erdman reagent
   D. concentrated sulfuric acid
   E. Nessler reagent
7. Determination the mass fraction of common salt (sodium chloride) is carried out by:
   A. acidimetry in the non-aqueous medium
   B. indirect alkalimetry
   C. acidimetry
   D. argentometry
   E. spectrophotometry

8. When taking MAO inhibitors, stimulants, vasoconstrictor one should limit the use of smoked and pickled herring, canned fish due to their content of:
   A. collagen
   B. glycogen
   C. tyramine
   D. tryptophan
   E. oxyproline

9. With what drug should the use of fish products be limited due to the large amount of pyridoxine?
   A. paracetamol
   B. levodopa
   C. aspirin
   D. corticosteroids
   E. phenobarbital

10. What substance causes development of side effects during the co-administration of isoniazid and certain kinds of fish products?
    A. collagen
    B. histamine
    C. tyramine
    D. tryptophan
    E. oxyproline
CHAPTER 7

FRUITS

Fruit (*fructus* in Latin) is edible fruits of cultivated and wild plants.

**Classification**

- pomaceous fruits: apples, pears, quince, black chokeberries, wild rose, viburnum;
- stone fruits: apricots, plums, cherries, peaches, cornel, almond, sweet cherries;
- citrus fruits: oranges, grapefruit, lemons, tangerines;
- berries: currants, gooseberries, grapes, cranberries, lingonberries.

Exotic fruits are popular nowadays in Ukraine, they can be divided according to the place of growth:

- tropical fruits: pineapples, bananas, avocados;
- subtropical fruits: pomegranates, persimmons, figs, mangoes, oranges, grapefruit, lemons, tangerines.

According to acidity fruits and berries are divided into:

- sour fruits – oranges, grapefruit, pomegranate, lemon, sour grape, sour plum, sour apples, pineapple. They are characterized by the fact that they are rich in acids and in the components that contribute to reducing the cholesterol level, excretion of uric acid, and saturated fat decomposition.
- semi-sour fruits – fresh figs, sweet cherries, sweet apples, pears, peaches, apricots, blueberries, currants, strawberries, mandarin. They are softer and have a lower acid content, are rich in proteins.
- sweet fruits – dried fruits such as dates, figs, raisins, dried apricots, dried pears and apples (sweet varieties), sweet grapes, plums, persimmons, bananas, watermelon. They contain a small amount of acids and are rich in vitamins A, C, E, group B.
- neutral fruit – cocoa. They contain proteins, vitamins, minerals and trace elements.

It is important to know which group one or the other fruit belongs to, as not all fruits can be combined with each other. Between their components the chemical reactions are possible that are harmful to the body. Furthermore, their pH can affect the absorption of drugs.

Sweet fruits are retained in the stomach longer than the sour ones. Sweet fruits can be eaten at any time of day, but it is harmful to eat them as a dessert after meal, in this case they can cause fermentation. Sweet fruits can be combined with cream, sour cream, herbs, fermented milk products.

Sweet and sour fruits are not recommended to be eaten together since acid slows down the decomposition of sugar to glucose; such cocktails are to be consumed in small amounts.

Semi-acid fruits combine well with each other, with sweet and sour fruit, with fermented milk products, as well as with protein foods containing a lot of fat –
cheese, nuts, fat cottage cheese. Combinations with other protein foods (meat, eggs, fish, mushrooms, legumes) are harmful, mainly because of the difference in the rate of digestion. Peaches, blueberries, bog bilberries, grapes, melons are well digested when being eaten separately, but are not compatible with any other product (except for some semi-acid fruit), it is better to use them as a self-eating.

Sour fruits combine well with each other and with fermented milk products. It is possible to combine them with nuts, cheese, herbs. They are incompatible with the animal protein products and with legumes. You should not drink too much of sour fruit juices as a high content of acid in them can destroy the enamel of the teeth. Besides, very sour juices bind calcium and remove it from the body, so the use of such juices must be very careful in osteoporosis.

Citrus fruits are recommended to use before two p.m.
Neutral fruits can be mixed together.
You should not be mix neutral and sweet fruits very often. This may cause a malfunction of the liver and the digestive system because the composition of oils from neutral fruits and sugars from sweet fruits produces toxic enzymes dangerous for the life of the cells.

**Chemical composition**

The main role of this group of products in nutrition is determined by the content of carbohydrates, vitamins and minerals. The chemical composition of fruits and berries changes during ripening and depends on the variety, nature of soil, on which they were grown, use of agrochemicals, storage and processing.

The high **water** content – 75-95% – is typical of the chemical composition of fresh fruits and berries. The cell sap is the medium where the majority of nutrients are dissolved in, so they are well absorbed by the body. The loss of about 5-7% of moisture causes withering, the loss of appearance, flavour, juiciness, resistance to storage. In dried fruits the water content does not exceed 18-25%.

Fruits and berries contain relatively small amounts of **nitrogen-containing substances** (in fruits – 0.5-1% and in berries approximately 0.5%). The main part consists of free amino acids and polypeptides, and **proteins** among them are less than half. Bioavailability of vegetable proteins is lower than animal ones due to the lower content of essential amino acids – 32-45%, as well as deficiency of lysine, sulfur-containing amino acids, threonine and tryptophan. Plant proteins are poorly absorbed by the body – only 25-30% as they are contained in the cell membranes and are poorly affected by digestive enzymes. Therefore, the value of fruits and berries as a source of protein in the diet is not significant.

Biogenic amines (tyramine, dopamine, histamine, serotonin) in great quantities are found in oranges, bananas, plums. They are the precursors of catecholamines and exhibit the pressor effect. In a healthy body they are inactivated by monoamine oxidase enzymes.

The **fat** content in fruits and berries is not significant – at an average of 0.1-0.2%, exception for some berries – sea buckthorn (1.5%), lingonberries, blueberries.

The lipid complex is represented by biologically active substances – essential oils, terpenes, sitosterols, etc. Essential oils give a particular flavour to the fruit; stimulate the appetite and secretion of digestive juices. Citrus fruits contain the
greatest quantity of essential oils (from 1.2 to 2.5%). Other fruits contain a small quantity of them. Sitosterols are not digested by the body, but play an important role in prevention of atherosclerosis due to the fact that they form insoluble complexes with cholesterol in the digestive tract, thereby inhibiting absorption and facilitates its removal from the body. The main source is avocado. They are also contained in apples, apricots, bananas, cantaloupe, cherries, figs, grapefruit, lemons, oranges, peaches, pears, pineapples, plums, pomegranates. The fat-like substances are found in the upper layer of the peel of fruits: wax and cutin, they cover fruit by a thin layer increasing their resistance during storage and the environment factors.

The bulk of the organic matter of fruits and berries are carbohydrates. They both contain digestible sugars – glucose, fructose, sucrose, starch, and fibre – cellulose, pectin.

Grapes, cherries, raspberry, sea buckthorn contain the greatest quantity of glucose.

Fruits are also the source of fructose. Fructose is sweeter than glucose, is slowly absorbed, does not affect the blood sugar levels, and its metabolism occurs without insulin (it is used in human nutrition in obesity and diabetes). Grapes, pears, cherries, watermelon, black currant, dates, raisins, dried figs contain a lot of fructose.

Sucrose in fruits is of the greatest importance among disaccharides. The large amounts of sucrose are found in peaches, apricots, melons, plums. It is almost not present in berries.

The sweet taste of fruits and berries is caused not only by the content of mono- and disaccharides, but also is enhanced by polyols: sorbitol (Cornelian cherries, rowan, thorn, grapes, pears, apples, plums, apricots, peaches) and xylitol (white plum, strawberry). Oranges, grapefruit, peaches are the source of inositol. Polyols are slowly absorbed, metabolized without insulin, they are used as a sweetener in the diet of diabetic patients.

Fruits are the source of dietary fibre (cellulose, hemicellulose, pectin). They play an important role in the detoxification from endogenous and exogenous toxins, absorption and excretion of cholesterol and bile acids, radionuclides, carcinogens and other substances due to the adsorbent action. The daily need of dietary fibre is at least 20-25 g, pectin is not less than 10 g. The high content of pectin is in processed fruits: in juices – especially juices with pulp (apple – 1.2%, raspberry – 1.22%, wild strawberry – 1.63%, strawberry – 1.48-1.72%, cherry – 0.48%, grape, orange, apricot, quince – about 0.2-0.4%), in canned fruit and fruit puree.

The carbohydrate content is shown in Table. 7.1.

Table 7.1

<table>
<thead>
<tr>
<th>Product</th>
<th>Carbohydrate content</th>
<th>Mono- and disaccharides</th>
<th>Starch</th>
<th>Fibre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Glucose</td>
<td>Fructose</td>
<td>Sucrose</td>
<td>Cellulose</td>
</tr>
<tr>
<td>Banana</td>
<td>21</td>
<td>7.7</td>
<td>7.5</td>
<td>3.7</td>
</tr>
</tbody>
</table>
Fresh fruits and berries are the most important sources of vitamins (Table 7.2). *Ascorbic acid* is unevenly distributed in the mass of the fruit: in the epithelial tissues its quantity is 2-3 times more than in the pulp. It is easily oxidized by oxygen of the air and is destructed by ultraviolet radiation, as far as during the heat treatment. Boiling destroys 50-70% of the vitamin, the long-term storage – up to 40-50%. The sources of vitamin C are citrus fruits in addition to berries, especially strawberries (60 mg%), black currant, sea buckthorn (200 mg%) and wild rose (up to 2000 mg%).

**Table 7.2**

<table>
<thead>
<tr>
<th>Product</th>
<th>Carotene (µg)</th>
<th>Vit. C (mg)</th>
<th>Vit. B6 (µg)</th>
<th>Biotin (µg)</th>
<th>Niacin (mg)</th>
<th>Pantothenic acid (mg)</th>
<th>Vit. B2 (mg)</th>
<th>Folate (µg)</th>
<th>Vit. B1 (mg)</th>
<th>Vit. E (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Banana</td>
<td>0.12</td>
<td>10</td>
<td>0.38</td>
<td>-</td>
<td>0.6</td>
<td>0.25</td>
<td>0.05</td>
<td>10</td>
<td>0.04</td>
<td>0.4</td>
</tr>
<tr>
<td>Watermelon</td>
<td>0.1</td>
<td>7</td>
<td>0.09</td>
<td>-</td>
<td>0.24</td>
<td>-</td>
<td>-</td>
<td>8</td>
<td>0.04</td>
<td>-</td>
</tr>
<tr>
<td>Melon</td>
<td>0.4</td>
<td>20</td>
<td>0.06</td>
<td>-</td>
<td>0.4</td>
<td>0.23</td>
<td>0.04</td>
<td>6</td>
<td>0.04</td>
<td>0.1</td>
</tr>
<tr>
<td>Apricot</td>
<td>1.6</td>
<td>10</td>
<td>0.05</td>
<td>0.27</td>
<td>0.7</td>
<td>0.3</td>
<td>0.06</td>
<td>3</td>
<td>0.03</td>
<td>0.95</td>
</tr>
<tr>
<td>Cherry</td>
<td>0.1</td>
<td>15</td>
<td>0.05</td>
<td>0.4</td>
<td>0.4</td>
<td>0.08</td>
<td>0.01</td>
<td>6</td>
<td>0.03</td>
<td>0.32</td>
</tr>
<tr>
<td>Pear</td>
<td>0.01</td>
<td>5</td>
<td>0.03</td>
<td>0.1</td>
<td>0.1</td>
<td>0.05</td>
<td>0.03</td>
<td>2</td>
<td>0.02</td>
<td>0.36</td>
</tr>
<tr>
<td>Peach</td>
<td>0.5</td>
<td>10</td>
<td>0.06</td>
<td>0.4</td>
<td>0.7</td>
<td>0.15</td>
<td>0.08</td>
<td>8</td>
<td>0.04</td>
<td>1.5</td>
</tr>
<tr>
<td>Plum</td>
<td>0.1</td>
<td>10</td>
<td>0.08</td>
<td>traces</td>
<td>traces</td>
<td>0.6</td>
<td>0.15</td>
<td>1.5</td>
<td>0.06</td>
<td>0.63</td>
</tr>
<tr>
<td>Sweet cherry</td>
<td>0.15</td>
<td>15</td>
<td>-</td>
<td>traces</td>
<td>traces</td>
<td>0.4</td>
<td>-</td>
<td>0.01</td>
<td>-</td>
<td>0.01</td>
</tr>
<tr>
<td>Summer apple</td>
<td>0.02</td>
<td>10</td>
<td>0.08</td>
<td>-</td>
<td>0.23</td>
<td>-</td>
<td>0.03</td>
<td>1.6</td>
<td>0.01</td>
<td>-</td>
</tr>
<tr>
<td>Winter apple</td>
<td>0.03</td>
<td>10</td>
<td>0.08</td>
<td>0.3</td>
<td>0.3</td>
<td>0.07</td>
<td>0.02</td>
<td>2</td>
<td>0.03</td>
<td>0.63</td>
</tr>
<tr>
<td>Orange</td>
<td>0.05</td>
<td>60</td>
<td>0.06</td>
<td>1</td>
<td>0.2</td>
<td>0.25</td>
<td>0.03</td>
<td>5</td>
<td>0.04</td>
<td>0.22</td>
</tr>
<tr>
<td>Lemon</td>
<td>0.01</td>
<td>45</td>
<td>0.06</td>
<td>-</td>
<td>0.1</td>
<td>0.2</td>
<td>0.02</td>
<td>9</td>
<td>0.04</td>
<td>-</td>
</tr>
</tbody>
</table>
Fruits and berries are an important source of carotene, the most active of these is \( \beta \)-carotene. Carotene is absorbed and assimilated better in the case of taking together with fats. It is thermostable and is destroyed during sterilization of juices only by 10%. It occurs in all the fruits and berries of orange-red colours: apricot, persimmon (1.2 mg%), sea buckthorn (up to 10 mg%).

**Folic acid** in plants is contained in a bound, inactive form and is activated by enzymes of the duodenum. It is sufficiently stable to storage and processing. It is found in apples, apricots.

Fruits and berries contain small amounts of other vitamins of B group: thiamine – 0.01-0.06 mg/200g, riboflavin – 0.01-0.06mg/100g, the loss during the thermal treatment is 10-20%. Pyridoxine (vit. B\(_6\)) is found in almost all fruits and berries, with an average of 0.1-0.3 mg/100 g. Biotin is present in small quantities – an average of 0.1-2 \( \mu \)g/100g. Such fruits and berries as sea buckthorn, peaches, and apricots contain additionally the fat-soluble vitamins A and E - 0.1-0.6 mg/100 g.

Many fruits and berries contain the important "vitamin-like" substances – conditionally essential dietary factors resembling the physiological effect of vitamins, but deficiency of them does not cause development of pathological changes. They include \( p \)-aminobenzoic acid (PABA), vitamin U, lipoic acid. Small amounts of these "vitamin-like" substances are found in many fruits.

**PABA** is involved in the synthesis of folic acid, in formation of red blood cells preventing anemia, helps absorption of fats and proteins, has lactogogues properties, and improves the skin tone. It is used in almost all sunscreens, because PABA is UVB absorber. Its content is not big in fruits – 0.1-5 \( \mu \)g/100g.

**Vitamin U** exhibits the antihistaminic, cholesterol lowering and lipotropic effects, due to the presence of methionine in its structure it promotes healing of ulcers of the stomach and duodenum, it is found in small amounts in bananas.

**Lipoic acid** is a regulator of the lipid and cholesterol metabolism, normalizes the function of the liver and kidneys, forms stable complexes with salts of heavy metals, and thus helps to detoxify the body. Lipoic acid in very small amounts was found in almost all plant products.

The substances being naphthoquinone derivatives that have the properties of vitamin K have been found in chokeberry and wild rose.

**Bioflavonoids** are the organic compounds of the polyphenolicnature, and plants are the only sources of them. They include anthocyanins, leucoanthocyanos, catechins, glycosides, flavonols and flavones. Bioflavonoids are involved in redox processes in
the cellular respiration, in regulation of penetrability of the walls of blood vessels due to stabilization of collagen in them and inhibition of the hyaluronidase activity. P-active substances reduce the blood pressure, promote the bile formation, improve the functional state of adrenal glands, and prevent degradation of ascorbic acid in the product. The human need for P-active substances is 25-30 mg per day. The content of bioflavonoids is given in Table 7.3.

Table 7.3. 
**The content of bioflavonoids in fruits and berries (mg/100 g)**

<table>
<thead>
<tr>
<th>Product</th>
<th>Content of bioflavonoids</th>
<th>Product</th>
<th>Content of bioflavonoids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apricot</td>
<td>20-200</td>
<td>Grape</td>
<td>7-300</td>
</tr>
<tr>
<td>Quince</td>
<td>200-825</td>
<td>Strawberry</td>
<td>500-750</td>
</tr>
<tr>
<td>Cherry</td>
<td>250-1500</td>
<td>Viburnum</td>
<td>300-500</td>
</tr>
<tr>
<td>Plum</td>
<td>100-250</td>
<td>Raspberry</td>
<td>125-300</td>
</tr>
<tr>
<td>Sweet cherry</td>
<td>1600-3200</td>
<td>Rowanberry</td>
<td>400-2280</td>
</tr>
<tr>
<td>Apple</td>
<td>60-200</td>
<td>Chokeberry</td>
<td>2000-5000</td>
</tr>
<tr>
<td>Orange</td>
<td>500</td>
<td>Black currant</td>
<td>300-800</td>
</tr>
<tr>
<td>Lemon</td>
<td>500</td>
<td>Blueberry</td>
<td>800-1300</td>
</tr>
<tr>
<td>Haw</td>
<td>100-250</td>
<td>Wild rose</td>
<td>1000-2500</td>
</tr>
</tbody>
</table>

*Anthocyanins* determine the red, blue or violet colour of the fruit, most of them are presented in intensely coloured fruits (black and red currants, grapes, raspberries, strawberries, apricots, cherries, plums, etc.). Leucoanthocyanins by their properties are similar to anthocyanins, but do not have colour. In large quantities they are found in Altai sea buckthorn (240-260 mg/100 g), haw (400-1200 mg/100 g), gooseberries, currants and other berries.

*Flavones and flavonols* – quercetin, rutin – protect ascorbic acid in food from destruction, increase the shelf life due to inhibition of ascorbate oxidase by blocking copper in its structure. Therefore, black currants, which contain a lot of ascorbic acid and flavonoids, retain its vitamin activity for a long time. Flavones and flavonols are also present in apricots, black grapes, bog bilberries, pears, strawberries, nectarines, peaches, apples, oranges, grapefruit, lemons, lingonberries, cherries, blackberries, plums, blueberries. The loss of bioflavonoids during processing and storage of fruits is not more than 10-20%.

Fruits and berries are a good sources of *minerals* providing the human body by salts of potassium, calcium, magnesium, phosphorus and such trace elements as Fe, Mn, Cu, Zn, I, F (Table 7.4).

Table 7.4

**The mineral content in fruits and berries (in 100 g of the edible part)**

<table>
<thead>
<tr>
<th>Product</th>
<th>Main elements, mg</th>
<th>Trace elements, µg</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>K</td>
<td>Ca</td>
</tr>
<tr>
<td>Banana</td>
<td>358</td>
<td>5</td>
</tr>
<tr>
<td>Melon</td>
<td>118</td>
<td>16</td>
</tr>
<tr>
<td>Apricot</td>
<td>305</td>
<td>28</td>
</tr>
</tbody>
</table>
Cherry | 256 | 37 | 26 | 500 | 80 | 100 | 150  
Pear | 155 | 19 | 12 | 450 | 65 | 120 | 190  
Peach | 363 | 20 | 16 | 610 | 140 | 50 | 100  
Plum | 214 | 28 | 17 | 150 | 110 | 87 | 100  
Apple | 248 | 16 | 9 | 630 | 47 | 110 | 150  
Orange | 297 | 34 | 13 | 300 | 30 | 67 | 210  
Lemon | 163 | 40 | 12 | 600 | 40 | 240 | 125  
Grapes | 255 | 30 | 17 | 600 | 90 | 80 | 91  
Garden strawberry | 161 | 40 | 18 | 1200 | 200 | 125 | 97  
Gooseberry | 260 | 22 | 9 | 850 | 45 | 130 | 90  
Raspberry | 224 | 40 | 22 | 1200 | 210 | 170 | 200  
Black currant | 350 | 36 | 31 | 1300 | 180 | 130 | 130  

Potassium is almost 50% of the total mineral content of fruits and berries. The high potassium content is found in cherries, black currant, apricots, peaches, bananas, grapes, as far as in dried fruit (prunes, raisins, apricots).

Calcium is contained in all fruits (30-100 mg/100 g), but absorption from these products is considerably more complicated because of the unfavourable presence of phosphorus and magnesium, as well as because of the presence of inositol phosphoric and oxalic acids in them, which form insoluble compounds with calcium blocking its absorption in the intestine.

The magnesium content in fruits is small (10-15 mg/100 g), it is 4-6 times more in some berries (blueberries), cherries, plums, the highest amount is in watermelons – 224 mg/100 g.

Iron is mainly in the form of ferric salts, which in the acidic medium of the stomach is reduced to ferrous salts and is absorbed in this form. The presence of ascorbic acid and other organic acids in fruits promotes the reduction of iron, greatly improving its absorption. Iron is found in many fruits – apples, black currants, melons, wild strawberries, strawberries, gooseberries, raspberries, blueberries, Cornelian cherries, quince, etc.

Copper is synergistic with iron and accelerates its absorption in the intestine, is a part of fruits and berries in small amounts (0.1-0.2 mg/100 g), a little more of it is in lemons (0.24 mg/100 g).

Manganese is found in fruits in quantity of 0.2-0.42 mg/100 g. The daily requirement (5-10 mg) is almost completely replenished by fruits and vegetables.

The zinc content is low – 0.1-0.4 mg/100 g, it is in such foods as avocados, dried prunes, dried apricots.

The content of iodine and fluorine depends on the geochemical characteristics of soil in crop-growing regions.

Mineral substances of fruits and berries are stable during storage, and during the heat treatment 2-25% of them is decomposed: the most when boiling and frying – 10-25%, significantly lower (2-5%) at stewing and blanching.
**Organic acids** (malic, tartaric, oxalic, citric) are also part of fruits and berries. When combined with sugars and tannins, they give the product a specific taste, stimulate the activity of the digestive system, promote better digestion and absorption of certain nutrients (e.g., iron) or, conversely, inhibit these processes (oxalic and phytic acids). Great quantities of organic acids are presented in lemons – 5.75g/100g, cranberries – 3.15g/100 g, black currants, sea buckthorn, gooseberries, cherries, plums, raspberries, strawberries, apples.

During fermentation of fruits under the influence of lactic acid bacteria, lactic acid is produced from monosaccharides. It has bacteriostatic properties.

The composition of most berries (cranberries, lingonberry) includes appreciable amounts of benzoic acid. This acid acts as a preservative so that these berries can be stored for a long time even when fresh.

**Phytocides** are biologically active substances formed by plants with a bacteriostatic and bactericidal activity, effects against microscopic fungi, protozoa. They are found in some fruits and berries – currants, citrus fruits, Cornelian cherries, apples of variety “Antonovka”.

The presence of **anti-nutritional substances** in fruits and berries has a significant impact on their nutritional value. These substances are the food ingredients worsening the absorption of some components and minerals or inactivating vitamins. These include specific protease inhibitors.

Ascorbate oxidase is the most common among the substances having antivitamin properties. It is the copper-containing enzyme that catalyzes oxidation of ascorbic acid to dehydroascorbic acid and diketogulonic acid that are highly thermolabile and quickly destroyed during heating, especially in alkaline medium. Ascorbate oxidase is present in watermelons, melons, grapes, apples; absent in citrus fruits, black currants, wild rose, so these fruits retain their vitamin activity for a long time. Ascorbate oxidase is sensitive to the effects of temperature – it is inactivated by boiling, even after brief boiling (2-3 minutes).

Anti-mineral substances are also anti-nutritional substances, namely phytin and oxalic acid. Phytin forms insoluble complexes (phytates) with metallic ions-calcium, magnesium, iron, copper, disturbing their absorption in the intestine. A small amount of phytin is found in wild strawberries. Oxalic acid forms precipitates practically insoluble in water with calcium salts. It may substantially reduce the calcium intake with milk, cheese, and other products. Small amounts of oxalic acid are found in sour apples, strawberries, black and red currants, gooseberries.

**Glycosides** are contained in fruits and berries; give them a specific aroma and a distinctive bitter taste (hesperidin in citrus fruits, punitsin in pomegranate, idein in cranberry). Some glycosides have toxic properties. For example, amygdalin as a component of bitter almonds (2.5-3%), kernels of apricots (2-3%), peaches (2-3%), cherries (0.82%), and plums (0.96%) after hydrolysis under the influence of glycosidase enzyme gradually hydrocyanic acid forms, it is accumulated and is a potent poison. Amygdalin is a thermostable substance, at the same time destroying it glycosidase enzyme is thermolabile (is destroyed within 20 minutes). Therefore, the thermal treatment leads to degradation of the enzyme that prevents the formation of hydrocyanic acid.
Adulteration and the defects of fruit
Upon the sale of apples, pears, bananas, pineapple, kiwi and other fruits ripening in the process of storage the following assortment fake may occur:
- a product in the harvest stage, which has to be stored for a long time till its consumption under certain conditions, is offered as ripe fruits;
- adding water. To increase the mass of fruits they are placed in cold water for some time, sometimes water with addition of antibiotics, the fruit weight can be increased up to 10-15%. To identify such fake by appearance is almost impossible. The shelf life of such products without antibiotics is dramatically reduced, and on the contrary with the use of antibiotics it is increased significantly;
- selling of low-quality products – rotten, crushed, broken, with signs of disease, wormy, sour, etc.;
- introduction of antibiotics and preservatives, addition of nitrates, ethylene and other compounds to accelerate the ripening;
- for a better safety a fruit before transporting is coated with a thin layer of wax, which is difficult to wash off.

Adulteration of dried fruits
- adding the water. To increase the weight of the dried fruits and vegetables they are placed in the storage area with a high humidity and are stored there for a certain time. Depending on the type and size of fruit their weight can be increased by 5-10%, while the fruits will look wetter. As a result of the fruit storage in wet areas they begin to soak, mold begins to appear on the surface of the products. To remove all traces of mold is almost impossible. Therefore, either such products are packaged in an opaque package for selling or used for recycling. The result is a lower-quality product;
- use of low-quality raw material – rotten, crushed, broken, with signs of mold, wormy, sour, etc.;
- violation of a formulation; introduction of preservatives and antibiotics to prolong the shelf life. During the production of dried fruits and berries sulfur dioxide in large quantities can be added to the raw material produced in Central Asia. It reacts with sugars, and bisulfite sugar derivatives form. As a result, sugars are not decomposed, and fruits and berries do not have a light brown colour but the colour of natural fruits and berries.

Pesticides treatment of fruits
Pesticides, which have a negative effect on the human health, are often used to preserve harvest. The negative impact of chemicals, above all, is in provoking hormonal changes, as well as reducing the body’s resistance to disease. To remove the pesticide coating you can add the juice of half a lemon and a teaspoon of sea salt to a basin of water and use the solution to wash fruits.

Fruit juices
In accordance to the technical regulations, a juice is a liquid food product, which is unfermented, fermentable, prepared from edible parts of good quality, ripe, fresh or stored fresh or dried fruits and (or) vegetables by physical impact on these
edible parts and, in which, in accordance to the peculiarities of the method of preparation, the nutritional value, physicochemical and organoleptic properties characteristic for the juice from the same fruit and (or) vegetable are preserved.

Juices are obtained from fruits and berries by squeezing or diffusion, they retain all the nutrients present in fresh fruits and berries, and are easily absorbed by the body. The nutritional value of juices is the high content of digestible carbohydrates (glucose, fructose, sucrose, etc.), a complex of water-soluble vitamins, mineral salts, pectin substances, organic acids, aromatic compounds.

Types of juices: natural, juices with sugar, blended, baby food, juices with pulp, citrus, concentrated, preserved with alcohol, sulfur dioxide or sodium benzoate.

Natural juices are produced from one type of healthy ripe fruits without addition of other components. They can be clarified (transparent) or unclarified (opaque) of the highest and high quality. In accordance to the European standards, natural fruit juices are drinks, which contain from 80% to 100% of juice. Additionally, they may contain sugar (not more than 150 g of sugar per 1 litre of juice) and citric acid.

Natural fruit juices are produced in different ways – either by squeezing or by recovery. Squeezing is suitable for juices from fruits available in the place of production. And for the production of tropical fruits juices in the regions where these fruits do not grow recovery of concentrated juices is used.

Natural clarified juices are nutritionally inferior to juices with pulp but have a more pronounced refreshing and thirst-quenching effect as far as an increased C-vitamin activity because it is not mixed with a sugar syrup.

Clarification of juice is a technological process, which is carried out by the following physical or biochemical methods:
• clarification by heating to 80-90 °C for 1-3 min (for coagulation of colloidal substances), followed by rapid cooling to 35-40 °C, and separation of suspended particles by centrifugation;
• clarification by tannin – its solution is thoroughly mixed with the juice, waiting until settling and compacting the resulting flakes, decantation of the juice (the process step of separation of the liquid phase of the juice by draining it from the sediment);
• clarification by activated clay (usually bentonite being the clay of volcanic origin) – they are able to neutralize the electrical charges of colloids in the juice and make them precipitate, etc.

Juices with sugar are produced from fruits with high acidity, clarified and unclarified.

Blended juices are prepared by adding up to 33% of another juice to the main juice. They are produced with sugar, without sugar, as well as with the pulp and sugar.

Juices for baby food are produced from high-quality fruits and berries, only the highest grade. They may be natural, with sugar, pulp, and are recommended for children from 6 months of age.
Juices with the pulp (nectars) are prepared from the pureed and homogenized fruit pulp with addition of a sugar syrup (from 16 to 50%) or without it. To improve the taste and colour in some juices with pulp citric acid and ascorbic acid are added. It is not allowed to add preservatives, artificial flavourings, sweeteners, and colorants. The juice content in these beverages is lower than in natural juices – from 25% to 50%. Because some fruits and berries contain very little natural moisture, it is inappropriate to prepare natural juices from them. Therefore, such fruit pulp is diluted to obtain nectar. Water or other fruit juices are used to dilute them; "mixed" nectars are obtained. For example, the peach pulp can be diluted with apple juice, and the banana pulp with orange juice.

Fruit waters should contain not less than 15% of the natural juice. It can be made of puree, concentrated fruit juice and frozen berries. According to the norms a fruit water should not contain any artificial colorants and flavorings – only natural components should give the taste of a fruit water.

Citrus juices (multivitamin) – tangerine, orange, lemon, grapefruit – contain vitamins C, B₁, rutin and carotenoids. They are produced unclarified, natural and with sugar.

Juices for diet food are produced from vegetables and fruits with the low sucrose content, sweetened with xylitol or sorbitol, are recommended for patients with diabetes.

Concentrated juices are juices, which moisture is partially removed by the physical method. They contain 4.5-6.5 times more of a dry residue than the original juice (from 43.8 to 70%). They can be clarified and unclarified, and are not divided into grades.

In the manufacture of fruit juices natural flavourings, L-ascorbic acid (antioxidant), citric acid (acidifier), and sugar (sucrose, glucose, fructose) may be added to them.

Juice drinks have the content of 10-40% of juice. The remaining amount is water and various additives. According to the standards they may contain taste improvers, artificial colorants and flavourings.

The use of the most popular juices with the medical and preventive purposes:
1. orange – strengthens the immune system, helps to lose weight, promotes excretion of cholesterol from the organism, normalizes the intestinal function, reduces the risk of birth defects in the fetus, and protects against some forms of cancer;
2. pineapple – is useful for chills and stress, promotes the weight loss;
3. grape – normalizes metabolism, is effective for gastritis, anemia and high blood pressure, helps to retain a healthy complexion, to cope with the neuroses;
4. apricot – strengthens the heart muscle and helps to eliminate the excessive liquid;
5. apple – is useful in dysfunction of the intestine, liver and kidney diseases, lack of iron;
6. pear – has antibacterial and diuretic properties, is recommended for diseases of the circulatory system and kidneys;
7. *plum* – regulates the activity of the gastrointestinal tract, is useful for gastritis;
8. *grapefruit* – normalizes sleep, helps for kidney stones, fatigue;
9. *cherry* – is useful for anemia, strengthens the walls of blood vessels, has the anti-inflammatory effect;
10. *cranberry* – is useful for prevention and treatment of infections of the genitourinary system.

**Adulteration of juices**
• diluting juice with water to the minimum allowable dry substances content or replacement of the natural soluble solids of juice by sugar or a mixture of sugar and organic acids (malic, citric, etc.);
• addition of invert sugar;
• blending of juice and fruit extracts or hydrolysates (adding an extract of the pulp, etc.);
• use of the cheaper raw material (nectarines in the production of a peach nectar);
• use of non-standard raw material;
• use of artificial colorants and flavourings.

It is possible to identify the following methods of adulteration by laboratory tests according to physical and chemical parameters: titrated acidity, citric and malic acid content, by the quantity of main elements, ash, nitrates, sulphates, sugars, hesperidin, proline.

The recommended temperature for storing of most of the juices varies from 0 to 15 °C at a relative humidity below 75%. Juices bottled in consumer package under aseptic conditions with the specified mode can be stored for up to two years. At higher storage temperature the taste and smell of juices are deteriorated, and the colour is changed in the reaction of melanoidine formation. Orange, tangerine, wild strawberry, raspberry juices are the most susceptible to such changes, so it is desirable to keep them at a low temperature from 0 to 2 °C.

**Indicators of the quality of fruits and berries**
Assessment of the quality of fresh fruits is conducted by the parameters of safety and commercial quality regulated by the standards or other normative documents.

Safety of fresh fruits is ascertained by such indicators as the permissible content of toxic elements, pesticides, mycotoxins and radionuclides.

According to the requirements of the standard for fresh fruits the limit content of such toxic elements as lead, arsenic, cadmium, mercury, copper, pesticides, and isomers of hexachlorocyclohexane is fixed. Patulin is the main mycotoxin determined in fresh fruits.

The radiation safety of fresh fruits is confirmed by the allowable level of specific activity of radionuclides of cesium-137, strontium-90.

The main general indicators of the commercial quality of fresh fruits include appearance, size, smell, taste and permissible deviations.
The quality of tropical fruits supplied and sold in this country is estimated mainly in accordance with the special requirements of contracts.

**Organoleptic characteristics:**

- **Appearance** (freshness, consistency, colour, shape, surface condition, ripeness).
- **Freshness** (density of peel and the pulp tissue, the degree of ripeness). Fresh fruits should not be faded.
- **The size** of fresh fruits is determined by the greatest transverse diameter. The size is not specified for plums, cherry plums and small-fruited varieties of apples, apricots and cherries of the 2nd commercial varieties, as well as for most berries (exception is strawberries of the 1st commercial grade).
- **Smell and taste** are characteristic to the botanical variety, free of foreign smell and taste.

The possible deviations are regulated by the standards for each type of fruits in terms of freshness, consistency, shape, surface condition and size. Common damage is the damage caused by pests and mechanical damage (minor – scrapes, scratches; significant – pushes, damage caused by hail, punctures, cracks; critical – crushing).

**Organoleptic parameters of the quality of fruits and berries:**

- the form of the fruit should be characteristic to the pomologic variety,
- the fruit should be fresh, intact, robust, clean,
- free of foreign smell and taste,
- of a certain size,
- of a certain degree of ripeness.

Fruits may have healed injuries or with minor mechanical damage without damaging the integrity of the skin (pushes, scrapes, scratches, etc., may occur), without a pedicel, the presence of thick, black mesh on the surface of fruits (for persimmon), admixture of edible berries of other species, for some fruits a slight greenish cast is allowed. There should not be rotting, green, crushed, damaged by diseases and pests fruits.

**Physicochemical parameters**

Determination of the mass fraction of soluble dry substances in the fruit juice (carried out refractometrically).

**Quality parameters of juices**

The quality of juices, nectars and juice drinks, except for baby food, dietary and special juices must comply with the requirements of GOST 659-79, GOST 657-79, GOST 13366-79, GOST 51433-99, etc., and technical documentation.

*Organoleptical control* – taste, aroma and appearance of the drink are estimated.

In addition to the organoleptical parameters, the main quality parameters of juices, which are often taken into account in commercial operations, are density (the ratio of weight to volume), the content of soluble dry substances expressed by the Brix degrees (°Brix), and the Ratio index.

The Brix index characterizes the total content of soluble dry substances, by this indicator one can judge the degree of the juice concentration.
A specific content of soluble dry substances corresponds to the specific density value. Concentrated juices have the highest density, and therefore, the high content of soluble dry substances.

The Ratio indicator is used to assess the taste of juices, concentrated juices, nectars and juice drinks. It characterizes the ratio between the total sugar content expressed in the Brix degrees and the acids content expressed as % of the total titrated acidity of the product. Products with the balanced content of sugars and acids have a Ratio indicator in the range from 12 to 15. Products with the Ratio indicator more than 15 have the predominant sweet taste, with the Ratio indicator of less than 12 – the predominant acid taste.

In sour juices the taste is corrected by sugar. Therefore, a very high content of carbohydrates in the drink may be indicative of serious violations of the technology of its recovery.

Fresh juices are often "corrected" by addition of such organic acids as citric, succinic and some others. In its pure form these additives are more expensive than sugar, but are cheaper than a dry natural juice. If the concentration of organic acids in the drink is above normal, it is not entirely correct to speak about the "restored" natural juice.

The concentration of amino acids is the most adequate indicator of quality among common biochemical parameters. Firstly, addition of amino acids is not practical for producers due to their high cost. Secondly, the higher the concentration of amino acids is, the more correctly is the juice restored, and the higher is its quality. The concentration of amino acids is sufficiently low in plants, but they are always present, as well as vitamins. Unlike the latter, amino acids are more resistant to storage, oxidation, heat treatment. If they are not present in a beverage, it is not a juice.

The composition of physicochemical parameters used to analyze the quality of different groups of juice drinks has differences. The general indicators are the mass fraction of soluble dry substances, the mass fraction of hydroxymethylfurfural content.

1. Directly squeezed fruit juices:
   - titrated acids content;
   - ethyl alcohol content.
2. Fruit juices prepared by recovery:
   - pH;
   - ethyl alcohol content.
   - pulp content (for juices with the pulp).
3. Concentrated fruit juices:
   - recommended general content of titrated acids;
   - sediment content.
   - sulfur dioxide content (for grape juice).
4. Fruit nectars:
   - pH;
   - sediment and pulp content;
- vitamin C content (for fortified ones).
5. Fruit drinks:
- sediment content;
- carbon dioxide content (for carbonated juices);
- vitamin C content (for fortified).

**Dry residue content** is determined either by the *refractometric method* or *gravimetrically*. The dry residue consists of the actual dry matter of the original juice plus commercial additives.

**General titrated acidity** determines the content of all free acids and their acidic salts in the juice. It is determined by alkaliometry.

**Recommendations for the use of drugs and fruit juices**
The use of citrus juices, which are histamine liberators, can lead to development of pseudoallergic reaction. It may interpreted by mistake as a side effect of a medicine.

Grapefruit juice can affect the pharmacokinetics of some drugs to a large extent. The biologically active substances in its composition inhibit the metabolism of antihypertensive and other drugs in the liver significantly increasing their toxicity. It exhibits by severe headache, development of the cardiac rhythm disorders, depression, and other adverse effects, including death. Seville (sour) oranges and pomelos (a type of grapefruit) have a similar effect. Oranges, tangerines and lemons and derived juices does not possess such action.

Table 7.5 presents the data of the main drugs, which metabolism is affected by grapefruit juice.

**Table 7.5**

<table>
<thead>
<tr>
<th>Drug</th>
<th>Effect</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albendazole</td>
<td>Possible potentiation</td>
<td></td>
</tr>
<tr>
<td>Amiodarone</td>
<td>Possible toxicity</td>
<td>Avoid combination</td>
</tr>
<tr>
<td>Benzodiazepines</td>
<td>Potentiation of triazolam, oral</td>
<td>Avoid combination</td>
</tr>
<tr>
<td></td>
<td>midazolam, alprazolam</td>
<td></td>
</tr>
<tr>
<td></td>
<td>theoretically, diazepam</td>
<td></td>
</tr>
<tr>
<td>Budesonide</td>
<td>Possible toxicity</td>
<td>Doubling the systemic effect</td>
</tr>
<tr>
<td>Buspirone</td>
<td>Possible toxicity</td>
<td>Avoid combination</td>
</tr>
<tr>
<td>Carbamazepine</td>
<td>Possible toxicity</td>
<td>Concentration monitoring</td>
</tr>
<tr>
<td>Cyclosporine</td>
<td>Possible toxicity</td>
<td>Concentration monitoring</td>
</tr>
<tr>
<td>Dextromethorphan</td>
<td>Increased risk of toxicity</td>
<td>Moderate effect</td>
</tr>
<tr>
<td>Diltiazem</td>
<td>Possible toxicity</td>
<td>Moderate effect</td>
</tr>
<tr>
<td>Erythromycin</td>
<td>Possible increase in toxicity</td>
<td>Moderate effect</td>
</tr>
<tr>
<td>Estrogens</td>
<td>Potentiation of ethinyl estradiol and</td>
<td></td>
</tr>
<tr>
<td></td>
<td>17β-estradiol</td>
<td></td>
</tr>
<tr>
<td>Etoposide</td>
<td>Possible weakening of the action</td>
<td>Avoid combination</td>
</tr>
<tr>
<td>Felodipine</td>
<td>Possible toxicity</td>
<td>Potentiation when increasing</td>
</tr>
<tr>
<td>Drug</td>
<td>Interaction Description</td>
<td>Notes</td>
</tr>
<tr>
<td>----------------------</td>
<td>-----------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>Fexofenadine</td>
<td>Possible weakening of the action</td>
<td>It is important, apple and orange juice produce a similar effect</td>
</tr>
<tr>
<td>Fluoxetine</td>
<td>Development of the serotonin syndrome is possible</td>
<td>A case was recorded when the patient also received trazodone, which could be involved in interactions</td>
</tr>
<tr>
<td>Fluvoxamine</td>
<td>Possible increase in toxicity</td>
<td>Data from studies in healthy volunteers</td>
</tr>
<tr>
<td>HMG-CoA reductase inhibitors</td>
<td>Possible increase in toxicity of lovastatin, simvastatin or atorvastatin (less likely). The action may last for more than 24 h; usually does not interact with pravastatin, fluvastatin and rosuvastin</td>
<td></td>
</tr>
<tr>
<td>Indinavir</td>
<td>Possible weakening of the action</td>
<td>The data are inconsistent, the clinical significance has not been found</td>
</tr>
<tr>
<td>Intraconazole</td>
<td>Possible weakening of the action</td>
<td>Avoid combination</td>
</tr>
<tr>
<td>Lovastatine</td>
<td>Possible increase in toxicity</td>
<td></td>
</tr>
<tr>
<td>Methylprednisolone</td>
<td>Possible weakening of the action</td>
<td></td>
</tr>
<tr>
<td>Nicardipine</td>
<td>Possible increase in toxicity</td>
<td>Minor changes in the hemodynamic effect</td>
</tr>
<tr>
<td>Nifedipine</td>
<td>Possible toxicity</td>
<td>Avoid combination</td>
</tr>
<tr>
<td>Nimodipine</td>
<td>Possible toxicity</td>
<td>Avoid combination</td>
</tr>
<tr>
<td>Nisoldipine</td>
<td>Possible increase in toxicity</td>
<td>Avoid combination</td>
</tr>
<tr>
<td>Praziquantel</td>
<td>Possible toxicity</td>
<td></td>
</tr>
<tr>
<td>Quinidine</td>
<td>Possible toxicity</td>
<td>Moderate effect</td>
</tr>
<tr>
<td>Saquinavir</td>
<td>Increase in bioavailability</td>
<td>Moderate effect, the clinical significance is not known</td>
</tr>
<tr>
<td>Sertaline</td>
<td>Possible toxicity</td>
<td>The clinical significance is not clear</td>
</tr>
<tr>
<td>Sildenafil</td>
<td>Possible toxicity of sildenafil; vardenafil and tadalafil may also interact</td>
<td>Avoid combination</td>
</tr>
<tr>
<td>Simvastatine</td>
<td>Possible increase in toxicity</td>
<td></td>
</tr>
<tr>
<td>Sirolimus</td>
<td>Possible toxicity</td>
<td>Avoid combination</td>
</tr>
<tr>
<td>Tacrolimus</td>
<td>Possible toxicity</td>
<td>A case is recorded of a sharp increase in concentration after eating one grapefruit; avoid combination</td>
</tr>
<tr>
<td>Drug</td>
<td>Effect</td>
<td>Notes</td>
</tr>
<tr>
<td>------------</td>
<td>------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>Theophylline</td>
<td>Possible weakening of the action</td>
<td>Moderate effect</td>
</tr>
<tr>
<td>Verapamil</td>
<td>Possible increase of toxicity</td>
<td>A moderate increase in the concentration of verapamil in plasma</td>
</tr>
<tr>
<td>Varfarin</td>
<td>Potential increase in the anticoagulant effect</td>
<td>One case was recorded (1999), in the previous study in 10 patients the effect was not detected</td>
</tr>
</tbody>
</table>

Tyramine and serotonin contained in bananas, pineapples, figs, red and white currants can significantly affect the pharmacodynamics of antidepressants, psychostimulants, isoniazid, reducing their therapeutic efficacy and causing increased side effects in the form of a rise in blood pressure.

The sour juices reduce absorption of macrolides, ampicillin. Also, certain fruit juices contain iron and calcium ions, which can form insoluble complexes with these drugs.

Currant and cherry juice slow down absorption of furosemide, calcium chloride, ibuprofen, isoniazid, and metamizole sodium.

Tyramine contained in pineapple, lemon, orange, tangerine, grape, currant juices may cause a hypertensive crisis when combined with stimulants and MAO inhibitors.

Cherry, apple, pear juices are incompatible with drugs metabolized in the intestine. Quercetin contained in these juices slows down the enzymatic reactions in the liver and intensifies the action of a drug.
QUESTIONS FOR SELF-CHECKING

1. Define the term of fruits. Give the classification of types of fruits.
2. What is the nutritional value of fruits?
3. Give recommendations on the simultaneous use of types of fruits to at are different in their acidity.
4. List the main vitamins that make up the fruits composition. What fruits do they contain in?
5. Define the term of bioflavonoids and their main function.
6. Describe the anti-nutritional substances found in fruits.
7. What are the main methods of adulteration of fruits and dried fruits?
8. Describe the main types of fruit juices.
9. Give the main ways of adultering juice products.
10. Describe the organoleptic parameters of fruits.
11. List the groups of drugs, which cannot be combined with grapefruit juice.
12. Give recommendations for the rational use of fruit juices and pharmaceuticals.
TASKS FOR SELF-CHECKING

1. Choose the stone fruits:
   A. cherry
   B. apple
   C. peach
   D. orange
   E. quince

2. What are the components of fruits having the enterosorbic action and playing a role in detoxification of the body?
   A. nitrogenous substances
   B. essential oils
   C. dietary fibre
   D. vitamin D
   E. disaccharides

3. A group of organic compounds involved in oxidation-reduction processes and having P-vitamin action is:
   A. nitrogenous substances
   B. essential oils
   C. dietary fibre
   D. vitamin D
   E. bioflavonoids

4. What substances block the action of the enzyme ascorbate oxidase protecting ascorbic acid against decomposition:
   A. flavonols and flavones
   B. essential oils
   C. dietary fibre
   D. leucoanthocyanins
   E. anthocyanins

5. What kind of acid is found in some berries providing a preservative effect:
   A. malic
   B. tartaric
   C. oxalic
   D. citric
   E. benzoic

6. What antinutrient shows the antivitamins properties:
   A. ascorbate oxidase
   B. phytin
   C. oxalic acid
   D. benzoic acid
   E. glycosidase
7. What glycoside contained in fruits has a toxic effect?
   A. hesperidin
   B. amigdalin
   C. idein
   D. phytin
   E. puntisan

8. What substance is used for dried fruits treatment to achieve a preservative effect, as well as to improve their consumer properties?
   A. sulfur dioxide
   B. essential oil
   C. vitamin A
   D. malic acid
   E. bioflavonoids

9. By what parameter one can determine the quality of fruit juices:
   A. water content
   B. vitamin content
   C. dietary fibre content
   D. concentration of amino acids
   E. concentration of juice

10. Which fruit juice affect the pharmacokinetics of antihypertensive drugs, significantly increasing their toxicity?
    A. apple
    B. orange
    C. grapefruit
    D. lemon
    E. pineapple

11. Which groups of drugs should not be taken with fruit juices with a high content of minerals, especially iron and calcium salts?
    A. steroid hormones
    B. antibiotics
    C. anticoagulants
    D. antiprotozoal
    E. antidiabetics
CHAPTER 8

VEGETABLES

*Vegetables* is a culinary term for the edible portion (e.g., a fruit or tuber) of plants, as well as any solid plant food, with the exception of fruits, cereals and nuts. From the point of view of botany, vegetables are edible parts of herbaceous plants.

The culinary term "vegetable" can be applied to the edible fruits, which from the point of view of botany are berries and fruits.

**Classification of vegetables:**
- tubers – potato, Jerusalem artichoke (artichoke), sweet potatoes;
- root vegetables – carrots, beets, turnips, rutabaga, radish;
- cabbage – cabbage, red, savoy, Brussels sprouts, cauliflower, kohlrabi, broccoli;
- leafy greens – lettuce, spinach, sorrel, rhubarb;
- onion – onion, leek, Welsh onion, garlic;
- white roots – parsley, parsnips, celery, horseradish;
- spicy vegetable seasonings – dill, tarragon, savory, basil, marjoram;
- solanaceae – tomatoes, peppers, eggplant;
- cucurbits – cucumbers, pumpkin, squash, zucchini;
- legumes – peas, beans, kidney beans;
- crops – sweet corn;
- gourmet – artichoke, asparagus, rhubarb.

Depending on the keeping quality (persistence), vegetables are divided into:
- those that are able to transfer to the state of rest (potatoes, onions, cabbage, carrots, beets, garlic);
- those that are not capable to transfer to the state of rest (fruited vegetables, sorrel, lettuce, dill).

By the life expectancy vegetables are:
- annual (watermelons, melons, cucumbers, tomatoes, radishes, dill, lettuce);
- biennial (during the first year the reproductive organs are formed, and during the second year seeds are formed carrots, beets, onions, cabbage, red, savoy);
- perennial (garlic, horseradish, asparagus, rhubarb, sorrel, artichokes, Welsh onion).

**Chemical composition**

It depends on many factors, such as the type and variety of vegetables, growth conditions, the nature of the soil, how it is grown using farming techniques, processing and storage conditions, etc.

By the *water* content different kinds of vegetables are markedly different: 75% of water of potatoes, 97% – in cucumbers. The ability to maintain the shape with a high water content is due to the presence of protein and pectin that are capable of restraining plenty of water. Water containing in vegetables is unevenly distributed: the pulp contains more water and the epithelial tissues contain less.
Most of the water is in a free state, and only a small part – in a bound one. For this reason, it is easy to dry vegetables to 10-12% of humidity. Further removal of each percent is difficult and may be achieved by using special methods of drying.

When the average moisture content in various fruits and vegetables varies from 75 to 95% of water, the proportion of solids is between 5 to 25%, most of them is represented by carbohydrates. The content of dry substances depends on the variety of climatic conditions (in a hot summer their amount is more than in a rainy summer), maturity (immature fruits contain less than mature ones). The content of dry substances is considered in vegetable processing; thereon the yield of the final product is calculated.

Carbohydrates - are the main energy material. Their content in vegetables calculated by the wet weight is low (Table 8.1), and therefore, the caloric value does not exceed 25-40 kcal per 100 g.

Of carbohydrates in vegetables there are mono- and di-saccharides, starch, dietary fibre (cellulose), fibre cell (hemicellulose), pectin.

Monosaccharaides in vegetables are glucose, fructose (in small amounts). The highest content of glucose is found in the eggplant, white cabbage, carrots, pumpkin.

Of a great importance is disaccharide sucrose, the highest number of it in sugar and red beets, onions. In mushrooms there is trehalose.

All sugars with amino acids and proteins form melanoidins, causing browning of vegetables during storage.

Starch is the primary storage material in potato tubers, is also contained in legumes and cereals. The starch content in carrots, onions, cabbage is less than 10 percent and in other vegetables it is even less. The starch content of some vegetables characterizes technological properties, the degree of maturity. For example, in green peas by the content of starch the early harvest period is determined, to yield a high quality product. The potatoes are conditioned by the starch content. The more starch is the more is mealliness of boiled potatoes. It has been found that the starch granules during storage are reduced in size, as a result a cooking property and mealliness boiled potatoes change.

Dietary fibre (cellulose) and cell fibre (hemicellulose) are the bulk of the cell walls. The polysaccharide content varies considerably from 2.5 to 5% in horseradish, dill, less than 0.5 to 8% in cucumbers, zucchini, squash, and lettuce. Inulin is found in garlic from 15 to 20%, Jerusalem artichoke – from 13 to 20%, replacing starch. In hydrolysis of inulin a small amount of fructose and glucose is formed.

Pectin is found in vegetables as protopectin (mostly in unripen fruits), pectin and pectinic acids. The pectin content in vegetables is less than in fruit: in carrots, pumpkin it is about 1%, in cabbage – 0.4% Potato – 0.2%.

The main feature of pectins is formation of gel in the presence of sugar and acid; pectin of vegetables is gelling weaker than pectin in fruits.

Certain changes in pectin are observed during ripening of the fruit. Protopectin while maturing transfers into soluble pectin in the cell sap, as a result the consistency of the fruit is changes. When storing, pectin also decomposes. Various types of darkening of the peel and pulp of the fruit are related to this.
Table 8.1

<table>
<thead>
<tr>
<th>Product</th>
<th>The total carbohydrate content</th>
<th>Mono- and disaccharides</th>
<th>Starch</th>
<th>Dietary Fibre</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Glucose</td>
<td>Fructose</td>
<td>Sucrose</td>
</tr>
<tr>
<td>Eggplant</td>
<td>6.9</td>
<td>3</td>
<td>0.8</td>
<td>0.4</td>
</tr>
<tr>
<td>Cabbage</td>
<td>7.9</td>
<td>2.6</td>
<td>1.6</td>
<td>0.4</td>
</tr>
<tr>
<td>Potato</td>
<td>19.1</td>
<td>0.6</td>
<td>0.1</td>
<td>0.6</td>
</tr>
<tr>
<td>Onion</td>
<td>10.2</td>
<td>1.3</td>
<td>1.2</td>
<td>6.5</td>
</tr>
<tr>
<td>Carrot</td>
<td>9.2</td>
<td>2.5</td>
<td>1</td>
<td>3.5</td>
</tr>
<tr>
<td>Ground cucumber</td>
<td>3.8</td>
<td>1.3</td>
<td>1.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Red bell pepper</td>
<td>7.2</td>
<td>2.1</td>
<td>2.4</td>
<td>0.7</td>
</tr>
<tr>
<td>Beet</td>
<td>11.8</td>
<td>0.3</td>
<td>0.1</td>
<td>8.6</td>
</tr>
<tr>
<td>Tomatoes</td>
<td>5</td>
<td>1.6</td>
<td>1.2</td>
<td>0.7</td>
</tr>
</tbody>
</table>

**Nitrogenous substances** include proteins and non-protein nitrogen compounds – amides, amino acids and other compounds. The total amount of nitrogenous substances in vegetables is more than in fruits – an average of 1-2%, and in such vegetables as green peas – 6.6%, brussel sprouts – 5.3%, cauliflower – 2.5%.

The total protein content in vegetables is small on the average 1-2%. Their biological value is significantly lower than in animal proteins, vegetables have partial proteins, except potato protein – tuberin (the ratio of amino acids in it approaches the egg white), as well as proteins of legumes, spinach, lettuce, cabbage vegetables. Besides, plant proteins are much worse absorbed by only 25-30%. The important thing is that the combined use of vegetables with meat products significantly improves the amino acid composition of food and improves absorption of both plant and meat proteins.

Some vegetables contain high amounts of purine bases that affect the taste of the products themselves, but also stimulate the secretory activity of the digestive glands. However, the final breakdown product of purine is uric acid, which adversely affects the metabolism, the mucous membrane of the stomach and liver. The highest content of purine bases is in spinach, sorrel, cauliflower and beans.

The **fat** content in vegetables is low; much more of it is in the seeds (up to 23-60%).

The greatest fat content is in olives fruits (up 55%). Such fatty acids as oleic, linoleic, linolenic, palmitic and stearic as parts of vegetable fat are found.

**Organic acids** in the ratio with sugars largely determine the taste of vegetables. The most common acids are malic, citric and tartaric acids; oxalic, salicylic, benzoic, succinic, pyruvic, chlorogenic, acetic acids, etc., are less common. In fruits there are more acids than in vegetables. There are acids in such vegetables as tomatoes, sorrel, rhubarb.

Acids have a strong effect on the secretion of digestive juices in the human body. Therefore, they contribute to a better absorption of food components, which contain a small amount of acids (fish, meat, flour, cereals, etc.).

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Together with fruits vegetables are important sources of vitamins C, E, K, carotene, PP, group B and others (Table 8.2).

The most common in vegetables is vitamin C, it is found in three forms: ascorbic acid – restored; dehydroascorbic acid – oxidized; ascorbigen – the bound form of ascorbic acid with proteins, nucleic acids.

By the content of vitamin C fruits and vegetables are divided into the following groups:
- with a high content – 100-2500 mg % (-150-200 horseradish, parsley (green) – 100-190);
- with a moderate content – 30-90 mg % (cruciferous vegetables, onions – green onion);
- with a low content – up to 25 mg % (carrot, beetroot).

When storing and processing (drying, canning), the vitamin C content decreases.

*Vitamin C* is relatively well preserved in pickling, rapid freezing.

*Vitamin B₁* (thiamine) is contained in peas, spinach, cauliflower, *vitamin B₂* (riboflavin) – in green vegetables, cauliflower, *vitamin B₃* (pantothenic acid) – in spicy vegetables, *vitamin B₅* (nicotinic acid) – in significant amount in potatoes, *vitamin B₉* (folic acid) – in carrots, cabbage; in green vegetables contain such vitamins as *vitamin B₁₂*, vitamin *E*, vitamin *K*.

---

**Table 8.2**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Eggplant</td>
<td>0.2</td>
<td>5</td>
<td>0.15</td>
<td>-</td>
<td>0.6</td>
<td>-</td>
<td>0.05</td>
<td>18.5</td>
<td>0.04</td>
<td>-</td>
</tr>
<tr>
<td>Green Peas</td>
<td>0.4</td>
<td>25</td>
<td>0.17</td>
<td>5.3</td>
<td>2</td>
<td>0.8</td>
<td>0.19</td>
<td>20</td>
<td>0.34</td>
<td>2.6</td>
</tr>
<tr>
<td>Courgettes</td>
<td>0.03</td>
<td>15</td>
<td>0.11</td>
<td>0.4</td>
<td>0.6</td>
<td>0.1</td>
<td>0.03</td>
<td>14</td>
<td>0.03</td>
<td>-</td>
</tr>
<tr>
<td>White cabbage</td>
<td>0.02</td>
<td>70</td>
<td>0.16</td>
<td>1.5</td>
<td>0.6</td>
<td>0.9</td>
<td>0.1</td>
<td>23</td>
<td>0.1</td>
<td>0.15</td>
</tr>
<tr>
<td>Cauliflower</td>
<td>0.02</td>
<td>20</td>
<td>0.3</td>
<td>0.1</td>
<td>1.3</td>
<td>0.3</td>
<td>0.07</td>
<td>8</td>
<td>0.12</td>
<td>0.1</td>
</tr>
<tr>
<td>Potato</td>
<td>Traces</td>
<td></td>
<td></td>
<td>10</td>
<td>0.12</td>
<td>0.9</td>
<td>0.2</td>
<td>0.1</td>
<td>0.02</td>
<td>9</td>
</tr>
<tr>
<td>Onion</td>
<td>9</td>
<td>5</td>
<td>0.13</td>
<td>0.6</td>
<td>1</td>
<td>0.26</td>
<td>0.07</td>
<td>9</td>
<td>0.06</td>
<td>0.63</td>
</tr>
<tr>
<td>Carrot</td>
<td>0.06</td>
<td>10</td>
<td>0.04</td>
<td>0.9</td>
<td>0.2</td>
<td>0.27</td>
<td>0.08</td>
<td>4</td>
<td>0.03</td>
<td>0.1</td>
</tr>
<tr>
<td>Cucumbers</td>
<td>2</td>
<td>250</td>
<td>0.5</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>0.08</td>
<td>17</td>
<td>0.1</td>
<td>0.67</td>
</tr>
<tr>
<td>Parsley</td>
<td>5.7</td>
<td>150</td>
<td>0.18</td>
<td>0.4</td>
<td>0.7</td>
<td>0.05</td>
<td>0.05</td>
<td>110</td>
<td>0.05</td>
<td>1.8</td>
</tr>
<tr>
<td>Radish</td>
<td>Traces</td>
<td>25</td>
<td>0.1</td>
<td>-</td>
<td>0.1</td>
<td>0.18</td>
<td>0.04</td>
<td>6</td>
<td>0.01</td>
<td>-</td>
</tr>
<tr>
<td>Salad</td>
<td>1.75</td>
<td>15</td>
<td>0.18</td>
<td>0.7</td>
<td>0.65</td>
<td>0.1</td>
<td>0.08</td>
<td>48</td>
<td>0.03</td>
<td>0.66</td>
</tr>
<tr>
<td>Beet</td>
<td>0.01</td>
<td>10</td>
<td>0.07</td>
<td>traces</td>
<td>0.1</td>
<td>0.12</td>
<td>0.04</td>
<td>13</td>
<td>0.02</td>
<td>0.14</td>
</tr>
<tr>
<td>Tomatoes</td>
<td>1.2</td>
<td>25</td>
<td>0.1</td>
<td>1.2</td>
<td>0.53</td>
<td>0.25</td>
<td>0.04</td>
<td>11</td>
<td>0.06</td>
<td>0.39</td>
</tr>
<tr>
<td>Dill</td>
<td>1</td>
<td>100</td>
<td>0.15</td>
<td>-</td>
<td>0.6</td>
<td>0.25</td>
<td>0.1</td>
<td>27</td>
<td>0.03</td>
<td>-</td>
</tr>
<tr>
<td>Horseradish</td>
<td>Traces</td>
<td>55</td>
<td>0.7</td>
<td>-</td>
<td>0.4</td>
<td>-</td>
<td>0.1</td>
<td>37</td>
<td>0.08</td>
<td>-</td>
</tr>
</tbody>
</table>

*Bioflavonoids* (anthocyanins – in beetroot malvidin is in; flavonols – quercetin is the most common, which gives a golden colour to dry onion scales, carotenoids,
tannins) have P-vitamin activity. The bioflavonoids content in vegetables (Table 8.3) is significantly less than in fruits, the exception is sorrel (500 mg/100 g).

### Table 8.3

<table>
<thead>
<tr>
<th>Product</th>
<th>Content of flavonoids</th>
<th>Product</th>
<th>Content of flavonoids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potato</td>
<td>15-35</td>
<td>Parsley</td>
<td>157</td>
</tr>
<tr>
<td>White cabbage</td>
<td>10-69</td>
<td>Celery</td>
<td>139</td>
</tr>
<tr>
<td>Carrot</td>
<td>50-100</td>
<td>Dill</td>
<td>170</td>
</tr>
<tr>
<td>Beet</td>
<td>37-75</td>
<td>Sorrel</td>
<td>500</td>
</tr>
<tr>
<td>Spinach</td>
<td>63</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Chlorophylls paint fruits and vegetables in green. Chlorophylls are in chloroplasts of leaves. The highest content of chlorophyll is in leaves of spinach, nettle. Chlorophylls are formed only in the light, so the vegetables with the underground reproductive part are devoid of chlorophyll. When ripening of vegetables chlorophylls in most cases are destroyed or transformed into chromoplasts, and it changes the colour of the fruit. When heating at boiling, under preserving the change in discoloration to a dark brown colour occurs.

In vegetables *vitamin-like substances* are also found: vitamin U, inositol, lipoic and paraaminobenzoic (PABA) acid. Vitamin U is an anti-ulcer factor, the leaves of cabbage (16.4-20.7 mg/100 g), cabbage, kohlrabi (12.9 mg/100 g), cauliflower (4-6.1 mg/100 g), green parsley (6.4 mg/100 g), celery (3.8 mg/100 g), tomatoes (1.1-2.9 mg/100 g) are the richest in it. Inositol normalizes the lipid and cholesterol metabolism; it is used to improve the function of the gastrointestinal tract. The sources of inositol are green peas and potatoes. Lipoic acid (a regulator of the lipid and cholesterol metabolism) is contained in the green parts of plants, the highest concentration is in cabbage – 11.5 mcg/100g. PABA is contained in vegetables in small amounts, a bit more of its content is in potatoes – 40-50 mcg, carrots 10-20 mcg, and spinach 60-130 mcg/100 g. The *mineral content* in vegetables is within 0.25-3.0%. Minerals are in an assimilable form, contain a number of trace elements, which are rare in other products: I, Br, B, Zn, Co, Cu, Pb, etc. Of all elements the highest content is K, followed by a gradual decrease in Ca, P, Na, Mg, Fe, in smaller quantities there is Mn, Al, S, Si.

The richest in Ca, P and Fe are carrots, green onions, lettuce, cruciferous vegetables; Mg is in green vegetables, legumes (Table 8.4).

### Table 8.4

<table>
<thead>
<tr>
<th>Product</th>
<th>Macroelements, mg</th>
<th>Microelements, mkg</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>K</td>
<td>Ca</td>
</tr>
<tr>
<td>Eggplant</td>
<td>238</td>
<td>15</td>
</tr>
<tr>
<td>White Cabbage</td>
<td>185</td>
<td>48</td>
</tr>
<tr>
<td>Potato</td>
<td>568</td>
<td>10</td>
</tr>
<tr>
<td>Onion</td>
<td>175</td>
<td>31</td>
</tr>
<tr>
<td>Green Onion</td>
<td>259</td>
<td>100</td>
</tr>
<tr>
<td>Carrot</td>
<td>200</td>
<td>51</td>
</tr>
<tr>
<td>Ground</td>
<td>141</td>
<td>23</td>
</tr>
</tbody>
</table>

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Essential oils give flavor to vegetables; they are a mixture of substances of different nature: hydrocarbons, aldehydes, ketones, aromatic alcohols, terpenes, phenols and other compounds.

The composition of essential oils of some vegetables varies: parsley contains apnol, onion – allyl propyl disulfide, aldehydes can be acetic and butyric, ketones are butanone and propanone.

Essential oils of garlic and onion have the phytoncide action. Such a substance is allicin, which gives garlic a characteristic pungent odour. Essential oils are concentrated mainly in the peel, but in the pulp they are few. They are in hundredths or thousandths of a percent, with the exception of spicy vegetables where their content reaches from 1.2% to 2.5%.

The maximum accumulation of essential oils occurs when ripening. Weather conditions affect their accumulation – on a bright day they are formed more than in a cloudy rainy weather.

Phytoncides by the chemical nature are a set of different compounds such as essential oils, acids, glycosides, aldehydes, ketones, hydrocarbons of ethyl series. The most active phytoncides are found in onions, garlic, horseradish, as well as in radish, red pepper, tomatoes, carrots and beets. Inhibiting or killing microorganisms or pests they increase the resistance of plants against bacterial and fungal diseases. However, many of the microorganisms in the process of evolution have adapted to live in the phytoncidic environment, so they can overcome the phytoncidic barrier and hit plants, including vegetables rich in phytoncides.

Antinutrients are natural components containing in vegetables, they inactivate vitamins and disturb absorption of individual food components. Specific protease inhibitors are low molecular weight proteins that form stable complexes with proteolytic enzymes of the digestive system, thereby inhibiting the digestion of proteins. They are found in large amounts in legumes, in fewer amounts in other vegetables, when heating protease inhibitors are destroyed, so the biological role of these compounds is insignificant.

Ascorbate (catalyzes the oxidation of ascorbic acid, it leads to its rapid degradation) is in large amounts in vegetables such as cucumbers, zucchini, cabbage, Brussels sprouts and cauliflower, parsley, horseradish, celery greens, it is less in eggplant, white cabbage, potatoes, carrots, green onions, tomatoes.

Legumes are rich in antinutrients phytin (with the demineralization effect), its insignificant amounts are found in carrots, cabbage, potatoes. Oxalic acid, also having the effect of demineralization, found in spinach (100 mg/100 g), sorrel (500 mg/100 g), rhubarb (800 mg/100 g), beet root (275 mg/100 g), purslane (1300
mg/100 g). Eating products rich in oxalic acid is undesirable for people suffering from gout or kidney disease. Besides, the lethal dose of oxalic acid for an adult is 5-15 g.

**Glycosides** are widely distributed in plants and often cause their specific taste and aroma, as well as resistance to pathogens of the microflora. The most common of them are solanine, sinigrin, gluconasturcin.

Solanine occurs in eggplants in unripe tomatoes, in the peel of potatoes. Tubers resistance to microorganisms is related with solanine. Greening of tubers (the extract in the light) leads to a significant increase of solanine in the core, due to it potatoes are well preserved. However, this method is only applicable to seed, potato increase of solanine in potatoes for food is undesirable. The normal content of solanine does not exceed 0.002-0.01%, with increase up to 0.02% and higher the presence of solanine significantly affects the taste (bitterness appears), and at the higher level it can cause poisoning, which is accompanied by nausea, vomiting, dysfunction of the large intestine, neurological disorders.

Sinigrin is found in horseradish. Its aglycone contains sulfur. Under the action of enzymes the essential oil gets burning taste.

Gluconasturcin is contained in turnips.

**Adulteration and the defects of vegetables**

The assortment quality adulteration of vegetables can be similar as in fruits by the following methods:

- substitution of one type, class, other vegetables, substitution of high quality products with low-grade products, substitution of vegetables at the consumer stage to the fruits being at the yielding stage of maturity;
- addition of water;
- the sale of low-quality products (rotten, depressed, broken, with signs of disease, wormy, sour, etc.);
- introduction of preservatives or antibiotics;
- addition of nitrates, ethylene, and other compounds to accelerate the ripening of vegetables;
- the sale of genetically modified vegetables.

**Indicators of quality of vegetables**

The quality of vegetables is regulated by State standards, Republican standards, Industry standards, Technical Specifications, as well as the contractual terms if the products have no standards or specifications.

Indicators of quality of vegetables are divided into general and specific. The common indicators of quality include appearance, size and tolerances in size and quality. Specific indicators of quality of vegetables are considered to be the maturity or ripeness, the internal structure, taste, density, maturity or immaturity of seeds and some others parameters.

**Organoleptic characteristics:**

- **Appearance** (shape, colour, maturity, freshness, integrity, dirtiness, mechanical damage and pest control);
- **Freshness** (tissue thickness of the peel and pulm, the degree of maturity). Fresh vegetables should not be faded.
- **Form** (must be typical of every household and botanical varieties). Vegetables with ugly forms are not allowed;
- **Smell and taste** are inherent to the botanical variety, without the presence of foreign odour and taste.
- **Size** is determined in the majority of vegetables by the largest transverse diameter, in brassica vegetables – by weight of a cabbage head in kilograms, in green onion, salads, horseradish, it depends on the length.

  The indicators of safety are the content of toxic elements (lead, arsenic, cadmium, mercury, copper, zinc), mycotoxin patulin, pesticides, nitrates, radionuclides, and microbiological indicators (mesophilic aerobic and facultative anaerobic microorganisms, coliform bacteria, yeast).

**Physical and chemical parameters**

Determination of the mass fraction of soluble dry substances in the juice of the fruit (carried out refractometrically).

**Recommendations for the use of drugs with vegetables**

Sour vegetable juices can neutralize the pharmacological effect of some antibiotics (erythromycin, ampicillin, cycloserine), intensity the pharmacological effect of salicylates, barbiturates, nitrofurans, slow down absorption of ibuprofen, furosemide.

Legumes and other products containing phytin limit absorption of iron, forming poorly soluble complexes with them.

Thyramine-containing products (avocado) affect the pharmacodynamics of antidepressants, psychostimulants, isoniazid, reducing their therapeutic efficacy and may cause increased side effects in the form of a rise in blood pressure (the so-called "cheese" syndrome).

Patients receiving anticoagulants of indirect action should exclude broccoli and brussels sprouts, spinach, lettuce, zucchini, watercress, cauliflower and soybeans from the diet since as leafy vegetables contain vitamin K, which is an antagonist of indirect anticoagulants.

The concomitant use of antithyroid drugs and cabbage, lettuce, radishes intensities their pharmacological effect and reduces the effect of thyroid hormones.

Antihypertensive medicines with plenty of beet can lead to hypotension as beets are vasodilating agents.

Because of formation of insoluble compounds and decrease of the therapeutic efficacy food rich in oxalic acid (spinach, purslane, rhubarb, sorrel) is contraindicated with calcium administration. Introduction to the diet of large amounts of fibre-containing food (green leafy vegetables, legumes) helps to eliminate constipation.

During the treatment with digitalis drugs a patient should avoid food rich in fibre, because these drugs bind to both soluble and an insoluble fibre and it reduces the treatment efficacy. But a patient should enrich the diet with potassium (potatoes).

Diuretics (especially thiazide and loop diuretics) that promote to reduce the level of potassium in the blood in patients with chronic heart failure can cause arrhythmias. These complications can be avoided by eating food with high potassium content, and low sodium content, e.g., carrot juice. However, drinking tomato juice
should be avoided because along with a high content of potassium it contains high concentrations of sodium. And when taking potassium-sparing diuretics, on the contrary, it is necessary to limit the consumption of food rich in potassium to avoid hyperkalemia.

Acetylsalicylic acid, pyrimethamine, and methotrexate worsen absorption of folate; to prevent it one should eat plenty of food rich in folate, such as beans and greens. After discontinuation of oral contraceptives, planning pregnancy, to reduce the risk of malformations in the fetus, as well as it is necessary to enrich the diet with food rich in folate.

Beans, table green, can reduce the activity of anticonvulsant drugs.

When taking carbamazepine and amidopyrine it is recommended to eat green vegetables because these drugs disturb utilization of biotin (vitamin H), and it can lead to serious neurological disorders.

Cucumbers, zucchini, parsley reduce the effectiveness of ascorbic acid. The use of corticotropin and deoxycorticosterone is rationally to combine with the use of a diet rich in potassium, i.e. vegetables.
QUESTIONS FOR SELF-CHECKING

1. Define the concept of vegetables, give their classification.
2. Describe the chemical composition of vegetables.
3. What are the main vitamin-like substances found in vegetables?
4. What are phytoncides and in which vegetables are they contained in the greatest amounts?
5. Antinutrients in vegetables, describe their basic properties.
6. The main methods of adulteration of vegetables.
7. Give recommendations for the rational consumption of vegetables and medicines.
TASKS FOR SELF-CHECKING

1. What vegetables can go into state of rest during storage?
   A. tomatoes
   B. potatoes
   B. onions
   G. cucumbers
   D. lettuce

2. What substances cause a green colour of the fruit?
   A. anthocyanins
   B. chlorophylls
   B. flavonols
   G. carotenoids
   D. xanthophylls

3. What vitamin-like substance contained in cabbage regulates the lipid and cholesterol metabolism?
   A. lipoic acid
   B. chlorophyll
   B. p-aminobenzoic acid
   G. vitamine U
   D. benzoic acid

4. Substances contained in some vegetables increase the resistance of plants against bacterial and fungal diseases. What are they?
   A. antinutritional substances
   B. volatile
   B. organic acids
   D. vitamins
   E. glycosides

5. Which substance contained in vegetables is not desirable for people suffering from gout?
   A. lipoic acid
   B. chlorophyll
   C. p-aminobenzoic acid
   D. vitamine U
   E. benzoic acid
CHAPTER 9

BREAD AND BAKERY PRODUCTS

Bread is the most important food product, which occupies a special place in human nutrition. Scientists believe that the precursor of bread was a soggy slur of whole grains thus, which accidentally got on the hot stones of the cave fire more than 15 thousand years ago – the first cake appeared. On with time the preparation of bread turned into art. Millstones grinding grain into flour appeared. Bread became softer and finer by taste. The ancient Egyptians gave the world the bread of the sour dough about 5,000 years ago. Even at the time, in Egypt knew how to brew beer. Apparently, brewer's yeast by mistake got into the pan with the dough, and it started to bubble and breathe. The bread obtained appeared to be gentle and easy. The secret of making of the "air" bread was taken over by the ancient Hebrews and Phoenicians, after them by the Romans and Greeks. The Romans also organized the first city bakeries, and to the present day in Rome there is a 13-metre monument – a monument to the baker. And the Greeks were the authors of the word "bread": it was derived from the name of a pot for baking bread called "klibanos."

Bread is a food product produced from different types of flour with addition of salt, water and various baking products.

Bakery products are a wide range of products of sweet dough made of flour, fat, eggs and sugar. With a large amount of sugar and fat the bakery products turn into confectionery products – cakes and pastries.

Classification of grain products

Bread products are classified by several parameters.
1. By the type of flour:
   - rye;
   - rye-wheat;
   - wheat and rye;
   - wheat.
2. By the sort of flour:
   - rye bread can be of wholemeal, peeled and seeded flour
   - wheat bread is of wholemeal of the 1-st, 2-nd and higher grades.

Bread products include all varieties of rye, rye-wheat and wheat flour products weighing more than 500 g (production of breads weighing 300 g is permitted) and the mass of baked goods of less than 500 g

3. By to the formula:
   - simple – products made of the main raw material: flour, water, salt and yeast;
   - improved – products, which include the additional raw material: sugar, corn syrup, fats, etc.;
   - sweet dough – products containing increased amount of sugar and fat (in the total amount of 14%) and, moreover, nuts, raisins, candied fruits, eggs, sugar, etc., can be added. By name they can be grouped into the
following main groups: bread, rolls, buns, puffs, small-size products, pies, cakes.

Each group may include several types and varieties.

There is no any single principle in giving names of bread types. Part of types of bread are named by the type and grade of flour – bread of wheat flour, the first or second grade, while in the name of the bread of the flour mixture the predominant type of flour with the share of 50% is in the first place. In other grades the name of flour is omitted, but the certain features of formulations (bread Mustard, Milk, Sitnya, with raisins, flavoured, etc.) are specified. The name of some types was formed long time ago, has become a tradition and emphasizes the local features (bread Borodino, Ukrainian, Minsk, Riga, etc.).

Together with basic types of bread there are also national breads: in Ukraine – palyanytsa, Kiev arnaut, kalach, Darnytsa buns, Transcarpathian bagels, in Russia – kalach, in the Baltic States – the bread, which is composed of natural or dried milk, whey: Lithuanian and Kaunas bread, roll with poppy seeds aukstaychu, Latvian homemade bread, Riga buns road, etc.; in Middle Asia – all sorts of cakes, Churek, boursaks, in Uzbekistan – gidzha cakes, pulat, obinon, katyr, sutlinon, kulcha, in Tajikistan – cakes chabot, noniragvani, pita bread, dzhuybori, Turkmen kulche, Kyrgyz chuynan, kolyuchnan and others; in Armenia – pita, in Georgia – madauli, shoti, trakhtinuli, saodzhakho, mrgvali, kutkhiani.

Dietary bakery products depending on the purpose are divided into seven groups:
  • salt-free;
  • with a low acidity;
  • a low carbohydrate content;
  • a reduced protein content;
  • a high content of dietary fibres;
  • with addition of lecithin or oat flour;
  • with a high content of iodine.

The raw material used in baking is divided into main and auxiliary.

The main raw material is:

1. Flour is the leading component in the process of making bread. The nutritional qualities of flour depend on its type and variety. The main types of flour are wheat and rye. The type of flour is determined by the nature of grinding grain. Grain, from which the flour is obtained, is covered with several shells that contain many essential nutrients – vitamins, iron and other minerals. During the preparation of flour the grain is milled, separated from the most of membranes and the embryo, which form a bran fraction (they contain fats oxidizing during storage and promoting deterioration of flour).

By the degree of grinding the flour can be of fine and crude grinding. The less the bran is separated of the flour while processing, the coarse are grains, the darker in colour is the flour. This flour is called the flour of lower grades (wholemeal flour and Class II). The flour of the first and the premium grade is substantially free of bran, so it is white. Wholemeal flour is made by grinding whole grains together with the shell. Other names are whole, grain, wholegrain.

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Types of wheat flour are:
• Wheat flour, baking premium. Refined (purified) flour consists only of the inner portion of the grain. It contains the maximum amount of gluten that promotes the best pore formation, the volume structure of the dough.
• Wheat flour for general use.
• Baking flour class I, contains a small amount of grain shells.
• Baking wheat flour, class II, contains more grain shells.
• Wholemeal wheat flour, unrefined.

Types of rye flour are:
• Baking rye flour seeded contains a small amount of grain shells.
• Baking peeled rye flour contains more grain shells.
• Wholemeal bread baking rye flour, unrefined.
2. Water can be substituted or combined with other liquids.
3. Salt enhances the flavour of the bread and promotes formation of a stable porous structure of the dough, slows down the process of fermentation.
4. Baker's yeast is of *Saccharomyces* microorganisms family, the basic form used is *Saccharomyces cerevisiae* making alcoholic fermentation, i.e. conversion of simple sugars (monosaccharides) into ethyl alcohol and carbon dioxide:
   \[
   C_6H_{12}O_6 + H_2O \rightarrow 2 CH_3CH_2OH + 2 CO_2
   \]
   It is used with wheat flour and a mixture of wheat and rye flour for production of a yeast dough.
5. Bread sourdough or rye sourdough is a portion of the ripe dough cooked without salt, which contains the active lactic acid bacteria and a small amount of yeast. It is used for bread made from rye flour as the usual baker's yeast are unable to make such a fairly porous structure dough. Sourdough can be prepared either by using cultures of lactic acid bacteria, or by the natural fermentation of rye flour in warm water with access to air (which is always a certain amount of lactic acid bacteria). As a result, fermentation in the dough accumulates lactic acid and other volatile acids, some amount of carbon dioxide, ethanol and other compounds.
6. Chemical baking powders are used for baking of quick bread, cakes and other confectionery products. The excess of baking powder in the dough can give an unpleasant taste. Some of the main types of chemical baking powders are:
   - **Sodium bicarbonate** - baking soda (E500). Soda when heated emits a small amount of carbon dioxide, but it is not enough to raise the dough. Besides, soda that has not decomposed gives the dough a yellow-brown or greenish colour and an unpleasant taste.
   \[
   2NaHCO_3 \xrightarrow{t} Na_2CO_3 + CO_2 + H_2O
   \]
   Therefore, soda needs to be slacken with acid:
   \[
   NaHCO_3 + H^+ \rightarrow Na^+ + CO_2 + H_2O
   \]
   - Sodium carbonate (E500):
   \[
   Na_2CO_3 + H^+ \rightarrow 2 Na^+ + CO_2 + H_2O
   \]
   - Potassium carbonate (E501):
\[
K_2CO_3 + H^+ \rightarrow 2 K^+ + CO_2 + H_2O
\]
- Ammonium carbonate — a food additive (E503);
- Ammonium bicarbonate — a food additive (E503);
- Sodium pyrophosphate and other phosphates (E450-E452) — are part of the disintegrating mixtures (baking powder), which act as acidifiers:

\[
Na_2H_2P_2O_7 \rightarrow 2Na^+ + P_2O_7^{2-} + 2H^+
\]

In addition, in the yeast dough, phosphates and polyphosphates are consumed in the synthesis of proteins and RNA during the growth and reproduction of yeast cells, they have such properties as emulsifiers, baking powders, stabilizers and activators of enzymatic systems of flour and yeast presented in the dough as enzymatic drugs; which increase water absorption capacity of flour and dimensional stability of the product, help to preserve the freshness of products as they delay the retrogradation of starch.

**Auxiliary raw material:**

1. **Fats** – vegetable and animal fats, margarine or butter spread, hydrofat. Fats give a delicate texture to a breadcrumb. In the manufacture of cakes and other sweet pastry, solid fats can act as disintegrative products if whipped alongside with sugar.
2. **Sugar** gives a sweet taste, is a nutritional component for the yeast. Its amount in the recipe affects the colour of a bread crust. One can also use honey and other sugar containing substances.
3. **Milk** – natural milk, skim, dry, condensed, and serum;
4. **Eggs** – egg powder or egg products (flour products). Egg white is a disintegrative agent when whipping, therefore, eggs and egg products give the dough stand-up;
5. **Malt** – this is flour from a dried and germinated barley (malt white) or rye (red malt);
6. **Molasses** – a starch syrup, obtained by starch saccharification by enzymes or dilute acids followed by filtration and boiling of the syrup;
7. **Spices** (cumin, coriander, vanilla, etc.) give the bread a distinct taste and aroma.
8. **Additives** – jam, raisins, nuts, dried fruit, etc.

**Preparation of bread** begins with mixing, which results in a uniform mass. The leading role in adhesion of particles belongs to proteins as they bind water, swell, individual molecules bind together to form a three-dimensional structure (gluten). This is the framework of the dough that determines its elasticity and extensibility. In this framework there are starch grains, soluble flour, residues grain shells. The framework is affected by salt, air, carbon dioxide, enzymes. During fermentation the frame is stretched. Starch also binds some amount of water.

Besides the solid phase in the dough the liquid phase is presented (mineral and organic water-soluble substances, some of which bind with insoluble proteins when swelling). When mixing, air bubbles get attached to the dough. Fermentation starts with mixing the dough and continues until it is baked. The set of all processes in the dough is called "dough maturation." During maturation of the
dough, the process of lactic acid and or alcoholic fermentation occurs. Carbon dioxide forming during alcoholic fermentation loosens the dough, and ethyl alcohol participates in formation of the bread flavour. The intensity depends on the quality of fermentation of the yeast and their activity, sugar, temperature and the acidity of the medium. In wheat dough alcoholic fermentation prevails, and in the rye dough there is lactic fermentation. Simultaneously hydrolysis of starch, maltose and sucrose occurs. The optimum fermentation temperature is 26-32 °C. To intensify the process of maturation of the dough such processes as: repeated doughing, rise of temperature, the use of food additives, food surfactants and enzyme substances are using. Then to obtain a certain mass and shape of the dough it is divided into pieces and baked.

Baking of the dough is a complicated process. At the beginning fermentation is intensifies (at 35 °C) and stopped at the temperature of 50-60 °C. Intensive gas formation leads to increase in volume. When the temperature increases proteins partially lose moisture, the partial proteolysis takes place, and at 70 °C and above. There is the partial denaturation of proteins and their recovery. Starch partially absorbs water, isolated by proteins gelatinized and hydrolyzed to form dextrins and a some amount of sugars. Especially vigorous hydrolysis of starch is when baking rye bread.

During the baking process the processes of formation of taste and aroma of bread are rapid, the leading role belongs to aldehydes (isovalerianol, furfural, hydroxymethylfurfural). The crucial reaction in forming the aroma and taste of bread belongs melanoidins.

Baked bread during storage is gradually losing 2-4% of moisture. As a result of aging of gelatinized starch it hardens, compacted in the structure and loses moisture. To slow staling additives are used (serum, milk, fat) and good packaging material.

**The chemical composition** of bakery products (Table 9.1) depends mainly on the type and grade of flour, from which they are made and the formulation (additives used for its production).

**Carbohydrates** are the main component of bread (from 40% in rye bread with whole meal flour, up to 70% in breadcrumbs). They are represented mainly by starch (amylose and amyllopectin) and its hydrolysis products - dextrin, glucose, fructose, arabinose, sucrose, maltose, lactose.

Bread, mainly whole meal, is a source of dietary fibres, in particular cellulose, hemicellulose and cellulose. Dietary fibres are concentrated in the shells of grains and to a large extent lost in production of flour. Therefore, the content of fibre in whole grain bread reaches 1.1-1.2%, and in the higher grades of wheat bread it is no more than 0.2-0.1%.

**Table 9.1**

<table>
<thead>
<tr>
<th>Products</th>
<th>Protein (g)</th>
<th>Fats (g)</th>
<th>Carbohydrate (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat flour, highest grade</td>
<td>10.30</td>
<td>1.08</td>
<td>69.00</td>
</tr>
<tr>
<td>Wheat flour, 1st grade</td>
<td>10.60</td>
<td>1.30</td>
<td>67.40</td>
</tr>
<tr>
<td>Seeded rye flour</td>
<td>6.90</td>
<td>1.39</td>
<td>64.30</td>
</tr>
<tr>
<td>Wholemeal rye flour</td>
<td>10.70</td>
<td>1.94</td>
<td>56.80</td>
</tr>
<tr>
<td>Molded white bread, 1st grade</td>
<td>7.63</td>
<td>0.86</td>
<td>50.15</td>
</tr>
<tr>
<td>Product</td>
<td>Protein</td>
<td>Fat</td>
<td>Ash</td>
</tr>
<tr>
<td>-----------------------</td>
<td>---------</td>
<td>-------</td>
<td>--------</td>
</tr>
<tr>
<td>White bread, highest grade</td>
<td>7.59</td>
<td>0.81</td>
<td>50.15</td>
</tr>
<tr>
<td>Wheat bread grain</td>
<td>8.13</td>
<td>1.38</td>
<td>45.62</td>
</tr>
<tr>
<td>Molded rye bread</td>
<td>6.62</td>
<td>1.20</td>
<td>41.82</td>
</tr>
<tr>
<td>Cream crackers</td>
<td>8.50</td>
<td>10.80</td>
<td>69.63</td>
</tr>
<tr>
<td>Sweet bun</td>
<td>7.61</td>
<td>5.28</td>
<td>56.80</td>
</tr>
<tr>
<td>Long loaf</td>
<td>7.70</td>
<td>3.02</td>
<td>53.33</td>
</tr>
<tr>
<td>Yeast</td>
<td>12.70</td>
<td>2.73</td>
<td>00</td>
</tr>
</tbody>
</table>

**Protein substances** in bread are 6.5% in rye bread and 11% in wheat bread. They are proteins and protein hydrolysis products – polypeptides, peptides, amides, amino acids. Among all amino acids there are essential acids, but like any other vegetable proteins, they are not complete proteins – they have a little quantity of lysine and threonine, but white bread has more quantity of them more than rye bread.

In bread of rye and wheat flour of a rough grinding the amino acid composition is better than in high-grade flour bread. The number and ratio of individual amino acids in bread does not correspond to the optimal number, and there is a sharp imbalance of essential amino acids. Thus, if in wheat flour the quantity of valine reaches 141.5%, phenylalanine – 221% relative to the optimum amount, and the content of leucine, isoleucine and threonine is close to the norm, the amount of tryptophan, lysine and methionine is only 54, 56.5 and 65% of the norm. To increase the proportion of amino acids, the skimmed milk, whey, molasses, which contain protein substances with the optimal amino acid composition, as well as calcium and phosphorus, are added to some varieties.

Wheat flour differs from the rye flour by the presence of two water-insoluble protein groups: glutenin and gliadin. When mixed with water soluble proteins are dissolved, the remaining glutenin and gliadin form the dough structure. When mixing the dough, glutenin develops in long thin chain molecules, while the shorter gliadin forms bridges between the chains of glutenin. The mesh of these two proteins is called gluten.

Bread products made of flour contain about 0.6-1.2% of fat. It is triglycerides of saturated and unsaturated fatty acids. When separation of the grain from shells, the embryo containing fat is removed. More fat is in bread prepared from the wheat flour. The rye flour generally contains less fat. Some types of bread, as well as buns, sweet bread and rusk products contain significantly more fat (from 3 to 15%, sometimes even more) because of their introduction into the process of making the dough.

**Organic acids in bread** are lactic acid, malic acid, acetic acid, tartaric acid, formic acid, oxalic acid. In the rye bread among free organic acids phytic acid prevails. The overall composition of organic acids is 0.3-1.3%.

**The vitamin composition** of bread displays the features of the vitamin content in flour of different grades (Table 9.2). Bread contains such vitamins as Thiamin (B₁), riboflavin (B₂) and nicotinic acid (PP), tocopherol (E) and others, but virtually devoid of vitamins A, C and D. When grinding grain into flour 65% of its vitamins are lost, and the more finely it is ground, the higher is the grade of flour. Bread of the wholemeal flour is characterized by a high content of vitamins providing for the optimal vitamin composition and a balance of microelements such as iron, copper and manganese involved in hematopoiesis.
Table 9.2

<table>
<thead>
<tr>
<th>Bread</th>
<th>B&lt;sub&gt;1&lt;/sub&gt;</th>
<th>B&lt;sub&gt;2&lt;/sub&gt;</th>
<th>PP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wholemeal rye flour</td>
<td>0.15</td>
<td>0.13</td>
<td>0.45</td>
</tr>
<tr>
<td>Wholemeal wheat flour</td>
<td>0.26</td>
<td>0.12</td>
<td>3.10</td>
</tr>
<tr>
<td>Wheat flour, the 2&lt;sup&gt;nd&lt;/sup&gt; grade</td>
<td>0.20</td>
<td>0.08</td>
<td>1.60</td>
</tr>
<tr>
<td>Loaves of wheat flour, the 1&lt;sup&gt;st&lt;/sup&gt; grade</td>
<td>0.10</td>
<td>0.07</td>
<td>0.67</td>
</tr>
<tr>
<td>Urban wheat bread, the 1&lt;sup&gt;st&lt;/sup&gt; grade</td>
<td>0.12</td>
<td>0.10</td>
<td>0.70</td>
</tr>
</tbody>
</table>

**Minerals** in bread are varied and their content depends on the type of flour: the lower it is, the richer is the content of mineral salts in the bread. Bread is a source of K, Ca, Mg, Na (because of introduction of common salt), P, S, Fe, Cu, I, F, Mn. Table 3 presents the data describing the human daily requirements in the individual minerals in the consumption of 500 g of bread. A low content of calcium, along with a high content of phosphorus causes their unfavourable balance. In bread products, which are made with milk, calcium and phosphorus, balance is much better.

Table 9.3

<table>
<thead>
<tr>
<th>Bread</th>
<th>Coverage requirements (in %) for</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ca</td>
</tr>
<tr>
<td>Wholemeal rye flour</td>
<td>20.0</td>
</tr>
<tr>
<td>Wholemeal wheat flour</td>
<td>16.9</td>
</tr>
<tr>
<td>Wheat flour, the 2&lt;sup&gt;nd&lt;/sup&gt; grade</td>
<td>15.0</td>
</tr>
<tr>
<td>Wheat flour, the 1&lt;sup&gt;st&lt;/sup&gt; grade</td>
<td>12.5</td>
</tr>
<tr>
<td>Loaves of wheat flour, the 1&lt;sup&gt;st&lt;/sup&gt; grade</td>
<td>13.1</td>
</tr>
<tr>
<td>Urban wheat bread, the 1&lt;sup&gt;st&lt;/sup&gt; grade</td>
<td>13.1</td>
</tr>
</tbody>
</table>

Bread contains **flavouring substances** that are represented by hydrocarbons, alcohols, phenols, esters and sulfur compounds formed during fermentation of the dough and during baking of bread.

In the grain there are different **enzymes** that are mainly concentrated in the kernel and peripheral parts of the grain. Therefore, more enzymes are contained in the lower grades of flour than in the white flour. Enzymes are only active in solution, so when storing dry grain and flour their effect is almost not observed. After doughing many enzymes catalyze the decomposition reactions in the starting complex of substances in flour. The activity of the complex insoluble substances decomposition in flour into simpler soluble substances under the influence of its own enzymes is called **autolytic activity**.

**Amylolytic enzymes** act on starch forming maltose. The technological significant of amylases varies: β-amylase, saccharifying starch containing in the dough contributes to the accumulation of sugars required for alcoholic fermentation in the dough; α-amylase converting starch into dextrins worsens the quality of bakery
products. In comparison with starch dextrins swell poorly in water. A crumb with a high content of dextrins is wet and sticky even with normal humidity. The rye flour always contains α-amylase, which significantly affects its baking properties.

The increased activity of protease worsens the quality of gluten, deprives it elasticity and ability to swell. A moderate influence of proteinase on proteins is necessary for "maturation" of the dough. Gluten becomes softer, and it improves porosity of the structure and increases the bread volume. The proteinase activity reduces by introduction of oxidizing agents, such as potassium iodate, which is used to improve the quality of bread.

Lipases catalyze the breakdown of fats into glycerol and fatty acids, it is important for storage of flour because increase in acidity of the flour during storage is mainly due to the action of this enzyme.

O-diphenoloxidase (polyphenol oxidase) oxidizes phenols to quinones, which condense and convert into melanin. The colour of melanins formed depends upon their molecular weight – the larger the molecule is, the darker is the colour. Melanins cause darkening of the dough and the bread crumb when processing certain batches of flour.

The nutritional value of bread is due to its chemical composition, flour milling, manufacturing technology of the dough, the nature of the substances added and the method of baking.

Bread is digested by a person not by 100% because it contains indigestible substances such as cellulose, hemicellulose, etc. However, the high absorption of substances in bread is due to the fact that it has a porous, elastic crumb, wherein there are proteins in the optimum degree of denaturation, gelatinized starch, dissolved sugar, emulsified fats, shell particles of grain are greatly swollen and softened, making them easily accessible to the action of enzymes of the human digestive tract. Therefore, the larger the volume of bread is, the more it is porous, the better it is impregnated with digestive juices, the better it is absorbed by the body.

The average daily consumption of bread by man in various countries ranges from 150 to 600 g and depends on national traditions, gustatory habits, and the climatic and economic conditions.

Consuming 350 g of bread a day a person provides more than a third of the need in proteins and carbohydrates, 25-60% – in vitamins, to a large extent – in minerals.

The biological value of bread is characterized by the amino acid composition, the content of mineral elements, vitamins and polyunsaturated fatty acids. The finer grinding and the higher grade flour is, the less are proteins and especially minerals, vitamins, fibre, but more starch, and therefore, digestibility of its products is better.

Due to the content of starch and simple sugars, bread is a high-caloric food. The lowest energy capacity of bread is of wholemeal flour. The caloric content and digestibility of grain mill products from high-grade flour are higher. The energy value of wheat bread is higher than that of the corresponding sort of rye bread. Breads where the formulation provides additives of various nutrients have a higher energy value (Table 9.4).
### Table 9.4

<table>
<thead>
<tr>
<th>Bread</th>
<th>Energy value per 100 g, kJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wholemeal wheat flour</td>
<td>849</td>
</tr>
<tr>
<td>Wholemeal wheat flour, the highest grade</td>
<td>975</td>
</tr>
<tr>
<td>Seeded rye flour</td>
<td>895</td>
</tr>
<tr>
<td>Improved bread</td>
<td>Up to 1100</td>
</tr>
<tr>
<td>Rich products</td>
<td>Up to 1450</td>
</tr>
</tbody>
</table>

A pleasant aroma that is typical for bread has a physiological importance. It stimulates production of digestive juices and thus improves digestion and absorption of nutrients in the product. In addition, bread gives the absorbed food a favourable consistency and the structure conducive to the most efficient operation of the digestive tract and the most complete wetting of the food with the digestive juices.

In addition to the usual bread, the food industry produces dietary and further enriched grain products that can increase their flavour and the nutritional value, improve metabolism and digestion. In the formulation of bread products fats are introduced, mainly unsaturated fatty acids, materials containing lipotropic substances (such as soy flour, phosphatidic preservatives, etc.), sorbitol and xylitol, some trace elements (e.g., iodine).

Among the various natural products soy flour, yeast, milk powder, embryos of cereals and sunflower food pomaces are of special attention because of the high content of lysine.

Soy flour contains 50% of proteins having the valuable amino acid composition and 5-6% of such minerals as Ca, K, P, etc.

Beer and food yeasts have the high protein content (50-60% by dry weight) and vitamin B.

The protein content of bread is increased due to milk and dairy products. The nutritional value of wheat germ is extremely high: they contain 33-39% of protein, 21-30% of sugars, 13-19% of lipids, 4,6-6,7% of minerals and significant amounts of vitamins B₁, B₂, B₆, PP and E. Wheat germ proteins are superior milk proteins in biological value.

A rich source of protein is the millcake: sunflower and cotton (from 78% to 81% of pure protein).

Sometimes bread is prepared limiting some components: salt-free bakery products, with low acidity, with the low protein content.

Bread and bakery products are used in dietary nutrition.

For people with diseases of the kidneys, cardiovascular system and endocrine hypertension there are salt-free baked products. The content of whey (milk serum) in these breads masks the absence of salt, and allows to eat it with an appetite.

For people with gastritis and peptic ulcer disease with increased acidity of the gastric juice bread products are designed with a low acidity value. The acidity of bread is one of the criteria for the dietary value. Using this parameter, bread is divided into sweet (1-2˚), slightly sour (2-4˚), sour (4-7˚) and highly sour (7-10˚ - titratable acidity). Organoleptic acidity of bread is due to the presence of organic acids, the combined term of "acidic phosphatides." Most of the free organic acids are
volatile compounds and a significant part of them is lost because of bread staling is lost. That’s why in diets yesterday's bread and crackers are used.

For patients with diabetes mellitus, burn injuries, obesity and rheumatism there are baked products with a low content of carbohydrates, especially starch.

For nutrition of patients with chronic renal failure and other diseases associated with disorder of protein metabolism bakery with a low content of protein (protein-free product) is used.

Bakery products with a high content of dietary fibre are intended for people suffering from intestinal atony, obesity, elderly, atherosclerosis, hypertension, intestinal constipation.

For people suffering from atherosclerosis, obesity, liver disease, nervous exhaustion, decreased bowel function, cardiovascular diseases and the elderly products with addition of lecithin or oat flour are recommended.

Bakery products with a high content of iodine are recommended for people with diseases of the thyroid gland, cardiovascular system, as well as those for living in areas of iodine deficiency. The high level of iodine is achieved by introduction of the powder of oarweed (laminaria). Oarweed powder has a positive effect on the kinetics of exchange of radioisotopes, reduce their absorption in the metabolism due to the content of alginic acid.

In diets wheat crackers are widely used. They are more amenable to the action of the gastric juice, more quickly digested and absorbed by the body more easily than the soft bread. For this reason, non-sweet wheat crackers are recommended by doctors for diseases of the stomach and intestines, such as exacerbation of chronic gastritis, colitis and peptic ulcer disease. In need of a nourishing diet, sweet crackers that contain a lot of carbohydrate are prescribed.

Taking into account the lower energy content of the rye bread, it should be used more often than wheat bread by older people and those who are prone to being overweight; bread of the crude flour is particularly useful. In clinical nutrition rye bread is often included in case of overweight and constipation.

Rye bread is not recommended in acute gastric ulcer and duodenal ulcer, chronic gastritis with high acidity, exacerbation of chronic colitis. In these cases it is recommended to use wheat bread made a day before, or non-sweet crackers and cookies.

The consumption of bread by children requires special attention. From 7 months you can give your baby rusks and biscuits for babies enriched with vitamins. Bread is recommended to introduce to the diet with 8 up months of age, starting with 3 g per day, increasing its volume by up to 15. Up to 3 years of age children are not recommended to give fresh rye and white bread. The rye bread contains oligosaccharides (trisaccharide raffinose and tetrasaccharide stachyose). In infants and about 10% of the adult population, the gastro-intestinal tract has no enzymes capable of disposing these carbohydrates. The enzyme system at an early age of the child is not also able to break down gluten. Their entry into the body leads to problems of the gastrointestinal tract, such as increased gas formation in the intestines (flatulence). It is not recommended without medical recommendations to give to a child bread with bran cereal. Bread with bran cereal is recommended to improve
bowel movement in the case of intestinal constipation, as well as for children of over the age of 3-5 years old that are overweight, but each case must be considered individually by professionals. Crackers, fresh pastries, dried, bagels, etc., are possible to give children older than 1.5 in the amount of up to 50-60 g. But many of these products may contain additives that can cause allergic reactions, such as peanuts, hazelnuts, and more. From 1 year to three years the number of white bread and bakery products in the diet of a child increases to 60-80 g, with good tolerability closer to 3 years old it is possible to introduce rye bread in the amount of 15-20 g per day. Children of 3 to up to 6 years old can get bread in the amount of 100-120 g per day, including cakes, and rye bread – 50 g.

Quality indicators. For each type of bread and bakery products there are individual state standards that establish a method of baking, shape, and a need to comply with the formulation standards and specifications. In normative documents there are requirements for food safety: the content of toxic elements, mycotoxins, pesticides, and microbiological parameters. Previously there was no control of microbiological elements in grain products.

Quality indicators of bread and bakery products are as follows:
1. Organoleptic parameters (Table 5): appearance, colour, odour, taste, crumb condition, porosity, etc.
2. The main physical and chemical parameters: humidity, porosity, acidity, content of salt, sugar, fat, and the insoluble material.
3. Medical and biological requirements (Table 9.5): toxic elements, mycotoxins, pesticides, radionuclides.

Table 9.5

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appearance</td>
<td>The appropriate form of bread, in which it was baked, with a bit convex upper crust, with no swirly sides</td>
</tr>
<tr>
<td>Shape Heart</td>
<td>Round, oval or oblong-oval, unstructured without holes. When making in tunnel kilns with mechanized transfer 1 - 2 small slips are permitted</td>
</tr>
<tr>
<td>Surface</td>
<td>No large cracks and holes, with dimples or cuts, or without them, in accordance with the technical description. The presence of a seam from the divider is permitted</td>
</tr>
<tr>
<td>Colour State</td>
<td>From light - yellow to dark - brown (top crust)</td>
</tr>
<tr>
<td>of the crumb</td>
<td>When baked not wet to the touch. Elastic, after a light finger pressure, the crumb should take the initial shape</td>
</tr>
<tr>
<td>degree of baking</td>
<td>No lumps and traces of mixing</td>
</tr>
<tr>
<td>mixing</td>
<td>Developed without holes and firming</td>
</tr>
<tr>
<td>porosity</td>
<td>Characteristic of this type of product, without foreign taste</td>
</tr>
<tr>
<td>taste</td>
<td>Characteristic of this type of product, free from foreign smell</td>
</tr>
<tr>
<td>odour</td>
<td></td>
</tr>
</tbody>
</table>

**Determination of the moisture content of grain:**
Gravimetric method — based on weighing the sample before and after drying. A high humidity reduces the nutritional value of bread, affects the taste and reduces the shelf life. Typically, the higher the grade of flour is, the less humidity rate of bread.

**Determination of bread acidity:**

- **Alkalimetric method** — based on calculation of the acidity degree, which means the amount of 1 M sodium hydroxide or potassium hydroxide required to neutralize acids contained in 100 g of the bread crumb. At end of titration a slightly pink coloration appears, which does not disappear within 1 minute.
- **Potentiometric method** — based on determination of the pH of bread products with a potentiometer.

Acidity affects the flavor properties of the bread. Bread that is insufficiently or too sour has an unpleasant taste. By this parameter the correctness of the technological process is estimated.

**Determination of bread porosity:** The higher the porosity of the product is, the longer it stays fresh and is better absorbed by the body. Well-aerated bread with a uniform fine thin-wall porosity is better digested.

**Determination of fat in baked products:**

- **Extraction method** with pre-hydrolysis of the sample;
- **Extraction method by weight** — based on the effect of anhydrous Na₂CO₃ on the test sample, extraction of fats during grinding with an organic solvent in a mortar, it is filtered and weighed after the removal of the solvent;
- **Refractometric method** — based on extraction of fats from the weighed sample with an appropriate solvent and further determination of difference between the refraction indexes of the solvent and the solution of fat in the solvent.

### Table 9.6

**Safety indexes of bread and bakery products**

<table>
<thead>
<tr>
<th>Toxic elements</th>
<th>Allowable standards, mg/kg, not more</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead</td>
<td>0,35</td>
</tr>
<tr>
<td>Arsenic</td>
<td>0,15</td>
</tr>
<tr>
<td>Cadmium</td>
<td>0,07</td>
</tr>
<tr>
<td>Mercury</td>
<td>0,015</td>
</tr>
<tr>
<td>Microtoxins:</td>
<td></td>
</tr>
<tr>
<td>Aflatoxin B</td>
<td>0,005</td>
</tr>
<tr>
<td>Vomitoxin (Deoxynivalenol)</td>
<td>0,7</td>
</tr>
<tr>
<td>T – 2 toxin</td>
<td>0,1</td>
</tr>
<tr>
<td>Zearalenone</td>
<td>0,2</td>
</tr>
<tr>
<td>Pesticides:</td>
<td></td>
</tr>
<tr>
<td>Hexachlorocyclohexane</td>
<td>0,5</td>
</tr>
<tr>
<td>Mercury-organic pesticides</td>
<td>0,01</td>
</tr>
<tr>
<td>Radionuclides:</td>
<td></td>
</tr>
<tr>
<td>Cesium – 137</td>
<td>Bq - Becquerel</td>
</tr>
<tr>
<td>Strontium - 90</td>
<td>40 Bq/kg</td>
</tr>
<tr>
<td>Contamination by grain pests (insects, mites).</td>
<td>Not allowed!</td>
</tr>
</tbody>
</table>
**Bread defects** are caused by various reasons: the quality of the primary and secondary raw material, violation of its dosing and disturbance of technical process of bread after baking. There are defects in appearance, crumb, taste and smell.

1. **Defects in appearance** include:
   - irregular shape – occurs if the bread is baked from badly fermented dough or if the dough during baking is unevenly heated;
   - defects of the surface – there is no crust, large cracks, dark crust appear when the dough is not matured or at too high temperature, or in the absence of steam in the oven.

2. **Defects in the crumb** include:
   - bad mixing is areas of crumb that contain flour, slices of salt occurred as a result of disturbance of doughing;
   - sad bread is a non-porous layer of the moist crumb located near the lower crust; as a result of bread formation on a cold surface, when placing in the preheated oven;
   - sticky crumb is when using flour from sprouted or frosted grains short time of baking.

3. **Defects of taste and smell** — the presence of crunch when chewing, the presence of impurities, the use of fermented dough.

**Bread diseases** arise as a result of certain microorganisms. All kinds of diseases make bread uneatable.

**Potato disease** is caused by development of spore-forming bacteria— potato or hay coli (Bac. mesentericus). These bacteria are on the grain surface and when grinding they get into the flour. Heat resistant spores retain their vitality when baking bread. During the storage of grain under favourable conditions, spores form bacterial cells, which break down the bread crumb by their enzymes, and thus, an unpleasant odour appears making it turn into a dark viscous mass. The first signs of the disease (spots in the crumb, foreign odours) appear within 10-20 hours after baking the bread. The variety of the flour, bread of which appeared to be infected in 24 hours are used for baking bagels, crackers, cookies and other products that do not suffer from the potato disease because of low humidity. Manufacturers prevent development of the disease by increasing the acidity of the dough, using mesophilic lactic ferments or chemical acidifiers.

**Bread diseases caused by "miraculous coli" bacterium.** It is non-sporous bacterium that forms red pigments. When the bacterium gets into the bread from the external environment, it colours the crumb in red, it sugars the starch and breaks down proteins in the bread. This bacterium does not form anything harmful substances to the human body, but the affected bread loses its market quality and it is unfit for consumption.

**Chalk's disease** is caused by special yeast-like fungi, which get bread with flour. As a result of their development, dry white spots resembling chalk on the crust and on the crumb of the bread are formed for the human health. **Chalk’s disease** is not dangerous, but the bread is unfit for consumption.

The **bread mold** is caused by long or improper storage of bread. It occurs due to the impact of mold spores from the environment on the bread. Molds first affect the
bread crust, and then the crumb lead to deterioration of taste and smell. Some types of mold forms toxic substances. Moldy bread is unfit for food. To prevent the growth of molds the surface of bread can be treated with ethyl alcohol or sorbic acid, and then the bread is packed in a soft packaging. Sorbic acid or calcium acetate are also added to the dough to prevent molds. Bread with a long storage period, preservative-treated, is stored without deterioration for several months.

**Adulteration of bread and bakery products.**

1. **Assortment adulteration** of the bread and bakery products is done by: replacement of true bread and bakery products into fake ones produced from different flours, one type of bakery products to others. Such fraud can be distinguished by colour, but a more accurate conclusion can be made on the basis of physical and chemical parameters, and it can done only by an expert. The sale of wheat-rye bread instead of the species of bread made of flour of the first grade – is recognized by the high acidity of the product.

2. **Qualitative adulteration** of the bread and bakery products can be achieved by the following methods:

- increased water content – occurs in winter, because production of such bread in summer leads to the rapid development of the potato disease and the growth of molds;
- adding up to 15-25% of other types of flour;
- introduction of nutritional supplements – flour improvers:
  a) bleaching of flour due to oxidation or reduction processes – in the first grade flour an oxidizing agent is added, the resulting flour is bleached and is identical by its colour to white flour (high grade flours have white snow colour). Then from that flour bakery products are made as products from white flour. Flour bleachers are sodium pyrosulfite, calcium peroxide, benzoyl peroxide, carbamide (urea), azodicarbonamid, sodium and potassium salts of cystine and cysteine, potassium bromate, calcium bromate. Many of these compounds are harmful to the human health and may cause cancer;
  b) complexing agents (they increase binding of gluten) such as calcium lactate, ammonium lactate, magnesium lactate, calcium phosphate, ammonium phosphate, steryl tartrate, ammonium chloride, sulphates of calcium, ammonium, calcium oxide, iron, ferric chloride are introduced in in the flour with a low quality and quantity of gluten. These compounds are less harmful to the human health;
  c) various chemical disintegrants, which intensify the liberation of carbon dioxide such as pyrophosphates, sodium carbonates, ammonium carbonates, gluconic acid are introduced.
- replacement of the yeast with chemical disintegrants that enhance the liberation of carbon dioxide. The bread made by such technology has no aroma and flavour characteristic of bakery products, the crumb is not grey, it is white. With complete replacement of the fermentation process bread can have a granary smell;
• failure to add a required amount of valuable ingredients (butter, eggs, sugar, poppy, raisins, nuts, etc.) provided by the recipe;
• non-observance of the technological parameters of the bread production;
• addition of preservatives, antibiotics to lengthen the storage period of baked goods. If the storage period of the bakery products is more than 48 hours, then they have preservatives and/or antibiotics, and if there is no information about them on the label of the bread, then this bread is falsified.

3. Quantitative adulteration of bread and bakery products (underweight) – it is deviation of the product parameters (mass) exceeding the maximum permissible limits of deviations.

4. Information adulteration of bread and bakery products – this is the consumer’s fraud by inaccurate or distorted information about the product.

Flour may have such defects as the presence of various pests (beetles and their larvae, caterpillars), spoilage as mold, rancidity, etc. Unpleasant odours and properties of flour may be received as a result of dampness, and for selling this flour it is dried.

In the flour foreign non-food additives such as chalk, lime, gypsum and other non-food alternatives to the alkaline reaction medium can be added. These additives can be identified by adding cold water and an acid (acetic, hydrochloric, citric, etc.) to a small amount of the product, as a result, carbon dioxide is liberated and the mass starts to increase rapidly in volume:

\[ \text{CaCO}_3 + \text{H}^+ \rightarrow \text{Ca}^{2+} + \text{CO}_2 \uparrow + \text{H}_2\text{O} \]

The pH of the aqueous solution is determined by the litmus test: in the alkaline medium it turns blue.

In wheat flour bran, rye flour or pea flour can be mixed. The product can be made of immature grain and weed seeds: if you mix 1 part of flour and 1 part of water and allow this mixture to stand for 3 hours, the gluten settles (a sticky cake, which is washed with water). If it is non-uniform, grey and doesn’t stretch, then the flour is spoiled and contains impurities. The dark colour indicates impurities of non-wheat flour. If during compression the flour crumbles, then it has the excess of minerals or bran. When adding large amounts of water into the flour the bran will float on the surface of the solution. Furthermore, when using a silk screening sieve these particles will remain in it and will pass through the sieve.

In order to choose good quality bread, the attention should be paid to its appearance, the state of the crumb and crust, smell and taste. The crumb should also be cross, with no lumps. Stringy and sticky bread is hazardous to health. You cannot eat bread with blue, yellow, red, orange spots. If a loaf of bread is not ribbed, and pimply or smooth pattern on the bottom, the bread is made in a private bakery, and possibly using chemical disintegrants. The crumb colour should not be too white, or vice versa, dark. If you have a lumpy loaf, the dough has impurities. Do not buy bread that is flat, it could be acidic. The excessive fluidity of bread and large voids inside the bread indicate disturbance of technology or other foreign supplements. The storage period of bread in a polymer film is not more than 3 days. In the open form it is 16 – 24 hours.
Recommendations for the use of drugs and bakery products. Flour products are not indifferent to drugs; as a rule, assimilation of drugs worsens.

It is not recommended to mix flour products with:
- sulphanilamides and antibiotics (macrolides, cephalosporins, tetracyclines). Carbohydrates slow emptying of the stomach, which can disturb their absorption. The tetracycline concentration in the human blood serum decreases by 50% when using the food rich in carbon. In addition, fresh rye bread contains a significant amount of organic acids, which are capable of destroying antibiotics. Yeast contains a lot of protein and folic acid, which prevent absorption of sulphanilamide drugs;
- iron-containing drugs – phytin containing in bread limits absorption of ferrous ions forming poorly soluble complexes;
- paracetamol, furosemide;
- cardiac glycosides – they bind to cellulose, and it reduces the efficiency of treatment, i.e. the drug concentration in the blood decreases. Digoxin and other slowly absorbed drugs should not be combined with warm flour confectionery and desserts as they accelerate the peristalsis of the gastrointestinal tract;
- acetylsalicylic acid – absorption of the substance reduces twice, resulting in decrease of its therapeutic effectiveness;
- corticosteroids and steroid hormones – they cause metabolic changes, including carbohydrates, and therefore, the amount of easily digestible carbohydrates consumed should be reduced;
- pancreatin, bisacodyl, drugs of potassium salts – they reduce the concentration in the blood by 50%;
- levodopa reduces the therapeutic effect since under the action of vitamin B₆, containing in whole grain bread and yeast the conversion to dopamine, which penetrates the blood-brain barrier, accelerates;
- tricyclic antidepressants - a high level of fibre food can reduce their serum level;
- antidepressants – when combining with yeast they can cause hypertensive crises.

It is recommended to eat:
- bread from wheat flour when using laxatives;
- whole grain bread and bran in the treatment with nystatin that can block the action of vitamin B₂ (riboflavin) and B₆ (pyridoxine).
QUESTIONS FOR SELF-CHECKING

1. Define the concept of bread and bakery products.
2. How can the bakery be classified?
3. Describe the main raw material used in baking.
4. What auxiliary materials are used in baking?
5. Describe the process of making bread.
6. Give a description of the chemical composition of bread and bakery products.
7. What enzymes are parts of the grain?
8. What is the nutritional and energy value of bread?
9. How can bread be used in dietary nutrition?
10. What main types of adulteration of flour do you know?
11. Describe the main types of adulteration of bread and bakery products and methods for their determination.
12. Describe the organoleptic properties of bread.
13. What is the method of acidity determination for bread? What does it influence on?
14. Give the characteristics for the defects of bread, the causes for their occurrence.
15. What diseases of bread do you know?
16. What recommendations for the rational combination of bread, bakery products and medicines can you give?
1. Dietary bakery products include:
   A. salt-free products
   B. products with a high content of carbohydrates
   C. products with a high-protein content
   D. products with a high salt concentration
   E. flour-free products

2. Rye flour in comparison with wheat flour contains more:
   A. essential amino acids
   B. amino acids
   C. collagen
   D. carbohydrates
   E. proteins

3. The chemical disintegrant of baking is:
   A. calcium hydrogen carbonate
   B. sodium hydrogen carbonate
   C. ammonium oxalate
   D. calcium carbonate
   E. sodium citrate

4. The optimum fermentation temperature for doughing is:
   A. 50-55 ºC
   B. 10-15 ºC
   C. 0-5 ºC
   D. 37-40 ºC
   E. 26-32 ºC

5. Baking yeast is microorganisms that provide alcoholic fermentation:
   A. Streptomyces venezuelae
   B. Penicillium notatum
   C. Cephalosporium salmosynematum
   D. Saccharomyces cerivisiae
   E. Lactobacilus lactis

6. What drugs are not recommended to be combined with flour products:
   A. iron medicines
   B. laxatives
   C. vitamins
   D. sulphanilamides
   E. alkaloids
CHAPTER 10

GROATS

Groats are the second food product (after flour) by significance among the most important food products and have a high nutritional value. The Technical Regulation defines cereals as a product obtained by peeling the grain and separating floral, seed and fruit shells (husk) and the germ from it, and it is intended for food purposes. In the human diet groats are up to 8-13% of the total consumption of cereals and give the human diet for more than 50% of the total daily calories.

Classification of groats

Depending on the grain of cereal groats are divided into the following types:
- wheat,
- buckwheat,
- oats,
- barley,
- rice,
- millet, etc.

According to the method of grain processing they are:
- whole,
- crushed ground,
- crushed unpolished,
- flattened.

By the content of impurities and quality of grain kernels:
- uncrushed ones are divided by grade (oat, whole-grain buckwheat, rice, millet).
- crushed ones are divided:
  • by the size of the numbers of grains, rolled grain (wheat, barley, corn) are divided into five numbers, and unpolished (barley) – into three numbers;
  • depending on the type of wheat farina (manna groats) is divided into brands.

Names and the groats range is presented in Table 10.1.

Table 10.1.

<table>
<thead>
<tr>
<th>Grain</th>
<th>Name and range</th>
<th>Grade, number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice</td>
<td>Polished rice</td>
<td>The supreme, the first, second, third grade</td>
</tr>
<tr>
<td></td>
<td>Crushed polished rice</td>
<td>Not divided into grades</td>
</tr>
<tr>
<td></td>
<td>Polished rice for baby food</td>
<td>The supreme and the first grade</td>
</tr>
<tr>
<td>Buckwheat</td>
<td>Whole-grain</td>
<td>The first, second, third grade</td>
</tr>
<tr>
<td></td>
<td>Crushed grain</td>
<td>Not divided into grades</td>
</tr>
<tr>
<td></td>
<td>Whole-grain quick-cooking</td>
<td>The first, second, third grade</td>
</tr>
<tr>
<td></td>
<td>Crushed quick-cooking grain</td>
<td>Not divided into grades</td>
</tr>
<tr>
<td></td>
<td>Whole-grain quick-cooking</td>
<td>The first grade</td>
</tr>
<tr>
<td>Groats</td>
<td>Description</td>
<td>Grades</td>
</tr>
<tr>
<td>------------------</td>
<td>--------------------------------------------------</td>
<td>---------------------------------------</td>
</tr>
<tr>
<td>Buckwheat</td>
<td>For baby food</td>
<td>Instant, Not divided into grades</td>
</tr>
<tr>
<td>Oat</td>
<td>Whole oats</td>
<td>The supreme, the first, second grade</td>
</tr>
<tr>
<td>Rolled oats</td>
<td></td>
<td>The supreme, the first, second grade</td>
</tr>
<tr>
<td>Oats for baby food</td>
<td></td>
<td>The supreme grade</td>
</tr>
<tr>
<td>Oat flakes</td>
<td>Hercules</td>
<td>Not divided into grades</td>
</tr>
<tr>
<td>Oat flakes Extra</td>
<td></td>
<td>1, 2, 3</td>
</tr>
<tr>
<td>Oatmeal</td>
<td></td>
<td>Not divided into grades</td>
</tr>
<tr>
<td>Oatmeal for baby food</td>
<td></td>
<td>Not divided into grades</td>
</tr>
<tr>
<td>Millet</td>
<td>Polished millet</td>
<td>The supreme, the first, second, third grade</td>
</tr>
<tr>
<td>Quick-cooking</td>
<td></td>
<td>The supreme, the first, second, third grade</td>
</tr>
<tr>
<td>Barley</td>
<td>Pearl barley</td>
<td>1, 2, 3, 4, 5</td>
</tr>
<tr>
<td>Peeled barley groats</td>
<td></td>
<td>1, 2, 3</td>
</tr>
<tr>
<td>Quick-cooking peeled barley groats</td>
<td></td>
<td>1, 2, 3</td>
</tr>
<tr>
<td>Barley groats with short cooking time</td>
<td></td>
<td>1, 2, 3, 4, 5</td>
</tr>
<tr>
<td>Instant barley groats</td>
<td></td>
<td>Not divided into grades</td>
</tr>
<tr>
<td>Wheat</td>
<td>Wheat groats Poltavskaya</td>
<td>1, 2, 3, 4</td>
</tr>
<tr>
<td>Wheat groats Artek</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Wheat groats quick-cooking</td>
<td></td>
<td>1, 2, 3</td>
</tr>
<tr>
<td>Wheat farina</td>
<td></td>
<td>M, MT, T</td>
</tr>
</tbody>
</table>

**Chemical composition of groats.**

By the ratio of essential nutrients buckwheat and oat groats have the most favorable chemical composition (Table 10.2).

*Proteins* (from 7% in rice and 23% in peas) of groats are not complete, as they contain little amount of essential amino acids. The most favourable composition of proteins is in buckwheat containing 18 amino acids, by the biological value of proteins it is equal to meat, fish and eggs. By the content of valine, phenylalanine and tryptophan it is not inferior to animal products. Oatmeal, as well as buckwheat, contains the most favourable ratio of essential amino acids, the protein of groats have the hypolipidemic effect (useful in diseases of the liver). By the number of protein rice is not inferior other groats, but the amino acid composition of its protein resembles animal proteins. Most groats are relatively poor in essential amino acids such as lysine (rice, millet, oats, barley, corn), threonine (rice, oats, barley, corn),
leucine (whole-grain buckwheat). However, the combination of groats with other products such as milk, meat, eggs, improves their nutritional value.

The fat content in groats varies from 0.2% (sago) and 0.7% (rice) to 6% (oatmeal). Fats of all types of groats by 70-80% are unsaturated fatty acids, mainly linoleic, linolenic, oleic and palmitic.

The content of a large amount of unsaturated fatty acids affects negatively the quality of groats. The consequence of the fact that these acids are easily oxidized, is the ability to fast rancidity, especially oat groats and millet get quickly rancid. Rice groats is stored well as it is low in lipids (0.7%).

In buckwheat there are small amounts of the fat-like substances – lecithin, β-sitosterol.

**Carbohydrates** in the grains are presented mainly by starch, and to a much lesser extent by vegetable fibre containing in the shells. The most important is starch (48-70%); the increase of the groats volume when cooking and porridge consistency depend on its quantity and properties. The greatest amount of starch contains in rice (up to 85% of a dry substance), starch granules are small, easily digested, so rice is a dietary product. The amount of fibre in groats varies depending on the degree of grinding of the cereal. Fibre complicates digestion and absorption of starch (buckwheat and oat groats), carbohydrates of wheat farina and rice, which are poor in fibre and have a soft texture are easily digestible. In addition to starch and fibre, groats contain small amounts of glucose, fructose, raffinose and sucrose.

<table>
<thead>
<tr>
<th>Groat</th>
<th>Water</th>
<th>Protein</th>
<th>Fat</th>
<th>Carbohydrates</th>
<th>Ash</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat farina</td>
<td>14.0</td>
<td>10.3</td>
<td>1.0</td>
<td>0.3</td>
<td>0.2</td>
</tr>
<tr>
<td>Buckwheat</td>
<td>14.0</td>
<td>12.6</td>
<td>3.3</td>
<td>1.4</td>
<td>60.7</td>
</tr>
<tr>
<td>Rice</td>
<td>14.0</td>
<td>7.0</td>
<td>1.0</td>
<td>0.7</td>
<td>70.7</td>
</tr>
<tr>
<td>Millet</td>
<td>14.0</td>
<td>11.5</td>
<td>3.3</td>
<td>1.7</td>
<td>64.8</td>
</tr>
<tr>
<td>Oatmeal</td>
<td>14.0</td>
<td>11.5</td>
<td>6.0</td>
<td>1.5</td>
<td>48.7</td>
</tr>
<tr>
<td>Porridge oat</td>
<td>12.0</td>
<td>11.0</td>
<td>6.1</td>
<td>0.9</td>
<td>48.8</td>
</tr>
<tr>
<td>Pearl barley</td>
<td>14.0</td>
<td>9.3</td>
<td>1.1</td>
<td>0.9</td>
<td>65.6</td>
</tr>
<tr>
<td>Barley</td>
<td>14.0</td>
<td>10.0</td>
<td>1.3</td>
<td>1.1</td>
<td>65.2</td>
</tr>
</tbody>
</table>

Many groats contain derivatives of carbohydrates – mucigenic substances (e.g., lichenin in oatmeal). The consumption of these products improves the digestion of proteins, mucigenic substances are also gentle stimulants of alimentary tract walls.

Groats are a major source of **B vitamins**, most of these vitamins are in cereals, the manufacture of which remains external shell grains (buckwheat, oats, barley). The leader among cereals is buckwheat. Deficiency of B vitamins in polished rice is explained by removing the shells and additional grinding of grains. Raw buckwheat contains vitamin E, a great number of routine.
Wheat groats has quite a lot of niacin. Due to the content of tocopherols corn groats is well kept, it contains very little vitamins, but a lot of carotenoids (predominant is carotene) and niacin. The vitamin content in groats is presented in Table 10.3.

<table>
<thead>
<tr>
<th>Groat</th>
<th>β-carotene. mg</th>
<th>Vit E. mg</th>
<th>Vit B6. mg</th>
<th>Biotin. mg</th>
<th>Niacin. mg</th>
<th>Pantothenic acid. mg</th>
<th>Riboflavin. mg</th>
<th>Thiamin. mg</th>
<th>Folic. mg</th>
<th>Choline. mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat farina</td>
<td>-</td>
<td>2.55</td>
<td>0.17</td>
<td>-</td>
<td>1.20</td>
<td>-</td>
<td>0.04</td>
<td>0.14</td>
<td>23.0</td>
<td>-</td>
</tr>
<tr>
<td>Buckwheat</td>
<td>0.006</td>
<td>6.65</td>
<td>0.40</td>
<td>-</td>
<td>4.19</td>
<td>-</td>
<td>0.20</td>
<td>0.43</td>
<td>32.0</td>
<td>-</td>
</tr>
<tr>
<td>Rice</td>
<td>-</td>
<td>0.45</td>
<td>0.18</td>
<td>3.50</td>
<td>1.60</td>
<td>0.40</td>
<td>0.04</td>
<td>0.08</td>
<td>19.0</td>
<td>78.0</td>
</tr>
<tr>
<td>Millet</td>
<td>0.015</td>
<td>2.60</td>
<td>0.52</td>
<td>-</td>
<td>1.55</td>
<td>-</td>
<td>0.04</td>
<td>0.42</td>
<td>40.0</td>
<td>-</td>
</tr>
<tr>
<td>Oatmeal</td>
<td>-</td>
<td>-</td>
<td>0.20</td>
<td>-</td>
<td>0.70</td>
<td>-</td>
<td>0.06</td>
<td>0.22</td>
<td>20.0</td>
<td>-</td>
</tr>
<tr>
<td>Porridge oat</td>
<td>traces</td>
<td>3.40</td>
<td>0.27</td>
<td>20.00</td>
<td>1.10</td>
<td>0.90</td>
<td>0.11</td>
<td>0.49</td>
<td>29.0</td>
<td>98.0</td>
</tr>
<tr>
<td>Pearl barley</td>
<td>-</td>
<td>3.70</td>
<td>0.36</td>
<td>-</td>
<td>2.00</td>
<td>0.50</td>
<td>0.06</td>
<td>0.12</td>
<td>24.0</td>
<td>-</td>
</tr>
<tr>
<td>Barley</td>
<td>-</td>
<td>-</td>
<td>0.5</td>
<td>-</td>
<td>2.74</td>
<td>-</td>
<td>0.08</td>
<td>0.27</td>
<td>32.0</td>
<td>-</td>
</tr>
</tbody>
</table>

Table 10.3

The mineral composition of groats is quite diverse. They supply the body with such macroelements as K, Ca, Si, Mg, Na, S, P, Cl, and are the major source of trace elements such as Mn, Zn, F, Cu, I. Cereals are rich in iron, but it is poorly absorbed because of phytin. The least amount of minerals are in wheat-farina and rice. The mineral composition of groats is presented in Table 10.4.

Citric acid and malic acid, with which buckwheat is very rich, are catalysts of digestion.

![citric acid](image)

![malic acid](image)

Table 10.4

The content of macro- and microelements in groats (per 100g)

<table>
<thead>
<tr>
<th>Groat</th>
<th>K. mg</th>
<th>Ca. mg</th>
<th>Mg mg</th>
<th>P. mg</th>
<th>Al. mg</th>
<th>Fe. mg</th>
<th>I. mg</th>
<th>Mn. mg</th>
<th>Cu. mg</th>
<th>Mo. mg</th>
<th>Ni. mg</th>
<th>Zn. mg</th>
<th>F. mg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat farina</td>
<td>130</td>
<td>20</td>
<td>18</td>
<td>85</td>
<td>570</td>
<td>960</td>
<td>-</td>
<td>440</td>
<td>70</td>
<td>11.3</td>
<td>11.5</td>
<td>590</td>
<td>20</td>
</tr>
<tr>
<td>Buckwheat</td>
<td>380</td>
<td>20</td>
<td>200</td>
<td>298</td>
<td>-</td>
<td>6650</td>
<td>3.3</td>
<td>1560</td>
<td>640</td>
<td>34.4</td>
<td>10.1</td>
<td>2050</td>
<td>23</td>
</tr>
<tr>
<td>Rice</td>
<td>100</td>
<td>8</td>
<td>50</td>
<td>150</td>
<td>-</td>
<td>1020</td>
<td>1.4</td>
<td>1250</td>
<td>250</td>
<td>3.4</td>
<td>2.7</td>
<td>1420</td>
<td>50</td>
</tr>
<tr>
<td>Millet</td>
<td>211</td>
<td>27</td>
<td>83</td>
<td>233</td>
<td>100</td>
<td>2700</td>
<td>4.5</td>
<td>930</td>
<td>370</td>
<td>18.5</td>
<td>8.8</td>
<td>1680</td>
<td>28</td>
</tr>
<tr>
<td>Oatmeal</td>
<td>351</td>
<td>58</td>
<td>111</td>
<td>325</td>
<td>510</td>
<td>3000</td>
<td>-</td>
<td>3130</td>
<td>500</td>
<td>38.7</td>
<td>48.3</td>
<td>2680</td>
<td>84</td>
</tr>
<tr>
<td>Porridge oat</td>
<td>362</td>
<td>64</td>
<td>116</td>
<td>349</td>
<td>700</td>
<td>3920</td>
<td>4.5</td>
<td>5050</td>
<td>500</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Pearl barley</td>
<td>172</td>
<td>38</td>
<td>40</td>
<td>323</td>
<td>-</td>
<td>1810</td>
<td>-</td>
<td>650</td>
<td>280</td>
<td>12.7</td>
<td>20.0</td>
<td>920</td>
<td>60</td>
</tr>
<tr>
<td>Barley</td>
<td>205</td>
<td>80</td>
<td>50</td>
<td>343</td>
<td>8</td>
<td>1810</td>
<td>-</td>
<td>760</td>
<td>370</td>
<td>13.0</td>
<td>-</td>
<td>1090</td>
<td>20</td>
</tr>
</tbody>
</table>
**Glycemic Index of porridge.**


With a high GI (over 70): semolina – 81.

Note. * The GI (glycemic index) is lower, the less a porridge mess contributes to obesity and diabetes.

**Adulteration of groats.**

1. Assortment adulteration of groats occurs due to substitution: one grade by other groats, grains of one number by another, one kind of other groats; grains, obtained from one type of grain by others. The most common fraud is to sell low-quality rice (for example, third grade) under the type of the premium rice cereals. A substitution of quality polished rice by the crushed one or whole-grain buckwheat by the crushed grain one also occurs.

2. For buckwheat such a type of fraud is used: steamed whole-grain buckwheat manufactured by specially equipped enterprises can be sold. It can be identified by the following indicators: good peeled groat, with smooth edges having whiter colour than the kernel due to leaching of dyes by a condensed water steam. However, private producers when growing buckwheat in small areas, instead of steaming the cereal, roast it. This groat is easily identified by the following characteristics. It has a brown colour, and the lateral edges are not lighter, but rather darker than the ground grain. As a result of roasting, particularly wet grain buckwheat, the glue-like layer is formed, which does not yield when cooking a fluffy porridge. Sometimes, instead of steamed groat the raw buckwheat is sold; it has a greenish tint and a specific odour.

3. Qualitative adulteration of groats can be achieved by the following methods: insufficient separation of impurities (weed, mineral, organic, etc.); adding foreign agents (bran, ash, sand, mineral powders); selling moldy, fermented groats.

The most common high-quality adulteration of groats is the high content of regulated admixtures. When processing these groats on the mini-mills in the farm, as a rule, the grain undergoes accelerated cleaning of earth, stones, and the process of peeling and crushing is accelerated technology with a high yield of cracked or crushed kernels when manufacturing high-quality groats.

When producing the number groats under the same conditions particles are obtained with sharp edges, not polished enough. Therefore, an experienced specialist can easily distinguish the number groat, produced at the factory by traditional technology, and groats obtained in mini-mills.

To increase the quantitative values of groats various foreign agents can be introduced to them. For example, wheat bran, crushed grain can be added to groat Poltavskaya and Artek and grated yellow brick can be in polished millet.

To determine such adulterations is possible by organoleptic methods – by appearance, colour, content of a good quality kernels.

4. During storage of groats at the high humidity they can become moldy and can even undergo fermentation.
5. Quantitative adulteration of groats (underweight) – it is a fraud of a consumer by significant deviations of the product parameters (weight), exceeding the maximum permissible standard deviation. For example, the net weight of a bag of rice, or millet is understated, or the weight of the package with groats weighs exactly 1,000 g or 500 g, but it should be more taking the weight of packing, etc. To detect such fraud is simple by measuring the mass with calibrated standards of weight.

6. Information adulteration of groats – is a fraud of a consumer with inaccurate or distorted information about the product. This type of adulteration occurs by the distortion of information in accompanying documents for goods, the product labeling. When falsifying the information about the groat the following data are often distorted or inaccurately indicated:
   - the name of a product;
   - groat processing;
   - quantity of a product.

   It may also be a substitution of certificates, conclusions of laboratories, etc.

**Indicators of quality groats.**
- organoleptic characteristics (colour, taste, odour);
- physical and chemical characteristics (humidity, the content of a good quality kernels, the content of ash);
- microbiological parameters (the number of *Escherichia coli*, salmonella, mold, *B. Cereus*, mesophilic aerobic and facultative anaerobic microorganisms).
  - safety indices:
    - toxic elements (lead, arsenic, cadmium, mercury);
    - mycotoxins;
    - pesticides;
    - radionuclides (cesium-137, strontium-90).

**Determination of colour, odour, taste and crunch of the product.** Colour of groats is determined by considering the average of the sample scattering by a thin layer on a sheet of paper. Detection is conducted by natural diffused light.

   Groats of any kind must be of typical colouring: millet is light yellow, rice – white; whole-grain buckwheat and crushed quick-cooking buckwheat – light brown, oatmeal and Hercules – white with a grayish tinge; barley – yellow-gray; Poltavskaya, Artek, corn – amber, etc. The taste and odour must be characteristic for the groat, without foreign flavours and odours, a little bitter taste in oatmeal is allowed.

**Determination of the moisture content of groats.** Dry the sample of milled grains in the oven at 130 °C for 40 minutes. After that, weigh it and calculate the moisture loss.

**Determination of the ash content.** It characterizes the mineral content in groats and is standardized only for oat flakes, wheat farina and corn groats. Research is carried out in a muffle oven.

**Determination of acidity.** It is based on potentiometric titration of the total amount of free fatty acids with sodium hydroxide.

\[
\text{R(CH}_2\text{)}_n\text{-CH=CH-(CH}_2\text{)}_m\text{COOH + NaOH} \rightarrow \text{R(CH}_2\text{)}_n\text{-CH=CH-(CH}_2\text{)}_m\text{COONa + H}_2\text{O}
\]
For oat flakes standards regulate acidity, which should be no more than 5 degrees. Accumulation of acids during storage is due to disintegration of fats.

Contamination of grain stocks with pests is not allowed.

The presence of impurities and defective kernels reduce the consumer properties of groats. Groats contain minerals and organic substances, seeds of weeds, harmful impurities (smut, ergot, etc.), damaged kernels, peeled grain, broken kernels, etc.

Mineral impurities in wheat farina are not allowed. The content for each type of groat is standardized in percent. The grade of groat and the product compliance with the state regulation depend on the content of impurities.

The most important indicator of the quality of groat is its *content of kernels quality*. In various groats it should be at least 98-99%. Depending on this parameter and the presence of impurities the commercial grade of groats is set.

The culinary advantages of groats are also determined. This estimate includes the colour, taste and texture of the cooked porridge, the cooking time and the cooking property coefficient, which is the ratio of the volume of porridge to the volume of groats taken for cooking.

Depending on the variety of the raw material, methods of processing and the assortment of groats this ratio usually varies within the following limits: 4-5.2 for millet; buckwheat groats – from 3.2-4; 4.3-5.2; for rice, barley for 5.5-6.6; and 3.3-4.1 for oat.

**Interaction with drugs**

Eating food products containing phytin (groats) reduces absorption of calcium, so You should not take medicines of calcium within 2 hours after the intake of groats. Uncooked cereals reduce the absorption of iron when used during the treatment with antibiotics from tetracycline group and penicillamine because they form complexes that reduce iron absorption and decrease the antimicrobial activity of antibiotics.

Food rich in vitamin B₆ reduces the therapeutic effect of drugs containing levodopa as under the effect of vitamin B₆ the conversion to dopamine, which poorly permeates through the blood-brain barrier, accelerates. Therefore, the diet of a patient receiving the drugs of levodopa must limit – the consumption of cereals that are the sources of vitamin B₆.

Oat flakes, buckwheat and barley groats because of the large content of fibre block absorption of such drugs as tricyclic antidepressants, and digitalis medicines since these drugs bind both soluble and insoluble fibre, reducing the efficiency of treatment.

In the treatment with nistatine, which can block the action of vitamin B₂ (riboflavin) and B₆ (pyridoxine) it is necessary eat food rich in B vitamins, such as whole grains. To eliminate constipation is possible by introduction of a large amount of food containing fibre, including whole grains, into a diet.

A protein diet affects absorption of isoniazid, and a protein-free diet, on the contrary, improves it. Isoniazid intake may lead to pellagra – a disease associated with deficiency of nicotinic acid. Therefore, treatment with isoniazid should include food rich in pyridoxine (cereals).
QUESTIONS FOR SELF-CHECKING

1. Define the concept of groat. Give their classification.
2. Describe the chemical composition of various groats.
3. What is the glycemic index, its value?
4. What nutritional and energy values of groats?
5. Describe the main types of adulteration of groats and methods of their determination.
6. What organoleptic quality values of groats do you know?
7. What recommendations for the rational combination of groats and medicines can you give?
TASKS FOR SELF-CHECKING

1. Which groat is divided into grade M, MT, T?
   A. buckwheat
   B. rice
   C. millet
   D. oat
   E. barley

2. The main carbohydrate in groats is:
   A. starch
   B. glucose
   C. cellulose
   D. fructose
   E. sucrose

3. Which groat has the most favourable composition of proteins?
   A. buckwheat
   B. rice
   C. millet
   D. oat
   E. barley

4. What carbohydrate derivative, which belongs relating to mucigenic substances, is contained in oatmeal?
   A. starch
   B. lihenin
   C. cellulose
   D. tannin
   E. sucrose

5. Which groat has the highest amount of fats:
   A. buckwheat
   B. rice
   C. millet
   D. oat
   E. barley

6. What substance contained in cereals, prevents the absorption of calcium and iron:
   A. starch
   B. phytin
   C. cellulose
   D. fructose
   E. sucrose
CHAPTER 11

CHOCOLATE

Chocolate is a processed food produced from the seed of the tropical Theobroma cacao tree. The word “theobroma” in Latin means “Food of the Gods”. Chocolate was also called Devil’s food.

History. More than 3000 years ago the chocolate drink was first prepared in the Gulf of Mexico by the first major Mexican civilization – The Olmecs. Many scientists suggest an even earlier date of production of chocolate. The Olmecs were not the only ones who made a chocolate drink; at some time it was prepared by the Maya. They called it "chocolatl." The Aztecs used cacao beans to make a hot, foamy beverage with stimulant and restorative properties. Chocolate got its name due to the fact that in ancient times it existed only as a liquid, and the word "chocolatl" could mean "water and foam" or "bitter water." At the time, chocolate was prepared from roasted cocoa beans, water, corn flour, and various spices - from cloves to pepper.

In 1502 Christopher Columbus was the first European to taste the chocolate drink in Nicaragua. In 1519 Hernán Cortés came to Mexico and the Aztec Emperor Montezuma II gave him the chocolate drink. In 1528 Cortés returned to Spain from Mexico with galleon ships fully loaded with cocoa beans. Later, the Spanish established a supply and an improved the recipe for preparation of the chocolate drink.

The first chocolate bar was made in Switzerland in 1819, and in 1875 Swiss milk chocolate appears. In 1912 Belgium was made the first hand-made candy chocolates with a praline filling, cream and nut pastes. Today chocolate is accepted in any form – liquid, solid, soft, powdery. It is used not only in the confectionery, but also in other industries, even in medicine.

The raw materials and ingredients. The main raw material for production of chocolate is cacao beans.

Cacao beans are special by processed and dried seeds from the cacao tree. The cacao tree is well-cultivated in tropical America, Africa, and some islands of Asia (Java, Ceylon, New Guinea, etc.). On average, a tree produces 1 kg of dry cacao beans per year.

The numerous species of cacao tree are divided into two main groups:

Criollo – the main culture, the tree requires specific climatic conditions, but gives the best quality beans (varieties from Maracaibo, Puerto Cabello, Java, Ceylon, Arriba, Grenada, etc.);

Forastero – it includes other species and hybrids, less demanding of climatic conditions and having higher crop yields, but giving lower quality beans (varieties from Accra, Bahia, Cameroon, Nigeria, Surani, etc.)

The quality and taste of the chocolate depends primarily on the type of cacao beans. Cacao beans are divided into two groups on this basis:

- noble (high-quality), which have a delicate taste and a pleasant aroma with a variety of subtle colours (Java, Trinidad and Tobago);
• consumer (ordinary) having a bitter or sour taste and strong aroma (Bahia, Accra, etc.).

Cacao beans are extracted from the fruit seeds, pulp particles and sweet juices still remaining to their surface. They are then placed in large boxes and subject to ferment action. Under the influence of fungal microorganisms – yeast – cacao beans ferment for several days. The temperature of the beans gradually increases and reaches 50°C. During fermentation, sugars are converted into alcohol and carbon dioxide. Some of the alcohol is oxidized to form acetic acid and other acids, which react with the cacao beans. Complex chemical and biochemical processes involving enzymes alter the composition and improve the taste of the beans, lower their tannin content, reduce their bitterness and astringency, and change their colour. After fermentation the beans are slowly dried in the sun or in special kilns at 45 - 75°C.

In processing of cacao beans three major semi-finished products are obtained: **cacao mass, cacao butter, and press cake**. Cacao mass and cacao butter are used to prepare chocolate, while press cake is used to prepare cacao powder.

**Cacao mass** is the main component of the chocolate mass and the initial material obtained from the production of cacao butter and cacao powder. Cacao mass is obtained by grinding cacao beans. The kernel of a cacao bean consists of individual cells in dense walls that contain cacao butter, starch, and proteins. The main purpose of grinding is to break down the cellular tissue and cell walls and release the cacao butter from these cells.

**Cacao butter** is one of the basic ingredients for chocolate production. Cacao butter is a fat of the vegetable origin, light-yellow or creamy in colour and solid with a brittle consistency at room temperature. It has the characteristic odour of roasted cocoa beans and melts in the mouth quickly and completely, without a greasy taste. Cacao butter has a pleasant taste similar to the melted chocolate, as its melting point (33-34°C) is below the human body temperature. There is natural cocoa butter and the deodorized variety that is further process.

Cacao butter is the most expensive ingredient in chocolate. To simplify and cheapen the manufacture of chocolate, manufacturers sometimes use cacao butter substitutes like palm oil, soybean oil, rapeseed oil, and cottonseed oil.

Cacao beans are cleaned, roasted, ground, and separated from the husk to make the cacao mass. It is then pressed to obtain cacao butter. The remaining product after pressing is the cacao press cake. It is milled to manufacture cacao powder, which is used as an intermediate for production of some types of confectionery products (for dusting sweets, candies, cakes, pastries, in the manufacture of fat coating, etc.) and the beverage cacao. The finer the powder particles are and the longer they are suspended, the higher is the quality of the beverage.

The chocolate mass itself is a mixture of grated cacao mass, cacao butter, and powdered sugar. Besides these basic components, flavouring additives are also included in the chocolate. The most widely used are milk, cream, grated hazelnut or almond, etc. Aroma additives include vanilla or vanilla essence.

Chocolate recipes can also include the soy phosphatide concentrate, also known as lecithin (emulsifier E322). It reduces viscosity of the chocolate when molding and glazing chocolate products. For high-quality chocolate only natural,
non-GMO lecithin is used. It is obtained from the precipitate, which is formed during hydration of vegetable oils. The mass fraction of the phosphatide concentrate is 0.4%.

A mandatory component of chocolate is granulated sugar (sucrose). For production of diabetic chocolate other sweeteners are used, such as fructose, saccharin, sorbitol, and xylitol. For production of milk chocolate milk is used.

Classification
Currently, chocolate production is classified according to the standard DSTU 3924-2000. Standards for many familiar varieties are missing, including such term as dark chocolate. According to these standards there is plain chocolate, dessert chocolate, and porous chocolate. It also defines the standards for white chocolate and milk chocolate.

Chocolates are classified according to the recipe, the method of, the chocolate mass processing, size, and shape.

1. Depending upon the formula and the method of processing, chocolate is subdivided into dessert, ordinary and porous varieties.

Dessert chocolate has high taste and aromatic qualities and fine dispersion of the solid phase. These properties are acquired using noble cacao varieties and particularly thorough continuous processing while manufacturing. The sugar content should not exceed 55%, while cocoa butter should be between 33 and 36%.

Ordinary chocolate has low taste and aromatic qualities and lesser dispersion. The sugar content should not exceed 63%, and cocoa butter should be between 30 and 33%.

Porous chocolate is obtained mainly from the dessert chocolate mass left under vacuum for up to 4 hours. After this, large cavities appear in the chocolate due to expansion of air pockets within it.

2. Depending on the composition ordinary chocolate and dessert chocolate are divided into plain chocolate, with additives, filled, diabetic and white.

Plain chocolate is made of the cacao mass, sugar powder and cacao butter. This chocolate has pronounced specific inherent characteristics of cacao beans. By changing the ratio between sugar powder and cocoa, you can change the taste characteristics of the resulting chocolate from bitter to sweet. Dark chocolate contains cacao (cacao mass or cacao butter) not less than 45%, bitter chocolate – from 45 up to 87%.

Chocolate with additives made of cacao, cacao butter, sugar powder, and various nutrients, spices, flavours and additives to enhance flavour and nutritional diversity of chocolate (milk, cream, kernels, coffee wafers, candied fruit, alcohol, cognac, vanillin/vanilla, food seasonings, etc.).

Milk chocolate always contains milk powder, and the content of cacao products varies from 25 to 31%.

Chocolate with fillings is prepared from the chocolate mass without and with addition of milk, in the form of tiles, sticks, shells and other shapes with different fillings: nuts, fondant, fruit jelly, cream, milk, butter. Quantity of filling can be from 25 to 50%.

3. White chocolate is made of cacao butter, sugar, milk powder and vanillin/vanilla, without addition of the cacao mass, so it has a cream colour. The
content of cocoa butter should be about 40%. The coefficient of sweetness for white chocolate is infinite.

4. Powder chocolate is produced from cacao and sugar powder and with or without addition of milk products. It is intended for preparing a drink by diluting it with hot water or milk.

5. Diabetic chocolate is produced using sugar substitutes such as sorbitol, xylitol, mannitol.

Confectionery industry also produces confectionery bars (they are also called sweet chocolate bars), in their recipes cocoa butter is replaced with a solid confectionery fat. These products are not actually chocolate since according to the current standard for chocolate it is not allowed to use the chocolate mass with addition of solid confectionery fat or cocoa butter substitutes. At the same time, in many European countries, not more than 5% substitutes or cacao butter equivalents can be added to the chocolate mass.

Currently, there are the following classification of analogues for cacao butter:
- equivalents and improvers of cacao butter – non-hydrogenated vegetable fats, that don’t contain lauric acid are obtained by fractionation. These fats contain the same triglycerides as cacao butter and, therefore, are mixed with them in an arbitrary ratio, up to full substitution;
- cacao butter substitutes – hydrogenated and refined vegetable fats containing no lauric acid. They are produced by fractionation of soybean, cottonseed, rapeseed and palm oils. These fats are different from cacao butter by the triglyceride composition;
- cacao butter surrogates are prepared from refined palm or coconut oils by fractionation, hydrogenation, if necessary in combination with transesterification. Their triglyceride composition is completely different from that of cacao butter, but hardness, smell and taste are almost the same. Cacao butter surrogates are high in lauric acid, and therefore, they are sometimes called lauric substitutes. Due to a great difference in the triglyceride composition of surrogates and cacao butter, their miscibility is very limited. In practice, they can only be used together with the cacao powder with a low fat content.

**Chemical composition of chocolate**

The composition of chocolate depends primarily on the chemical composition of cacao beans. Cacao beans contain 20-25% of carbohydrates, 15-20% of proteins, 3.5% of ash components, including calcium, iron, magnesium, potassium, sodium, copper, manganese, zinc, etc., 5% water, vitamin PP, group B and 50% of solid oil, tannins, organic acids and flavouring substances (linalool terpene alcohol, amyl butyrate, etc.) giving a specific chocolate aroma.

The chemical composition of chocolate is as follows (in%): the mass fraction of carbohydrates is 5-55; fat – 30-38, proteins – 5-8, theobromine and caffeine – about 0.5, minerals about 1. The energy value of chocolate is 2200-2300 kJ per 100g (Table 3.1).

The fat in chocolate consist of cacao butter, which includes 35% of oleic acid, 35% of stearic acid, 25% of palmitic acid and 5% of other types of fats. One third of
the fat containing in chocolate is accounted for stearic acid. The other third is monounsaturated oleic acid, which reduces cholesterol.

In chocolate 380 different substances were identified. The chocolate action on the central nervous system and appearance of chocolate effects are due to a number of components that it contains.

**Energy stimulants**

- Sugar. Chocolate bars (unlike cacao) contain large amounts of sugar, which is a readily available energy source.

- Theobromine or 2,6-dihydroxy-3,7-dimethylpurine alkaloid:

![Theobromine structure](image)

It increases the mood, has a mild stimulating effect. Theobromine is the cause of the outflow of the acid from the stomach since it loses the sphincter of the stomach, allowing the gastric juice to enter easily into the esophagus. The content in beans is <1.3 - 2%.

- Caffeine – 1,3,7-trimethylxanthine - alkaloid:

![Caffeine structure](image)

In chocolate, caffeine is present in small amounts. In 30 g of dark chocolate the content of caffeine varies from 5 to 10 mg, in milk chocolate it is about 5 mg, and a 170 ml cup with cacao contains about 10 mg. The content in beans is 0.2 - 0.4%.

**Neuromediators**

- Anandamide – ethanolamide of arachidonic acid:

![Anandamide structure](image)

Chocolate contains a small amount of this endogenous cannabinoid. Its name means "blessed" or "perfect happiness." Neurotransmitters and neuromediators play a role in the mechanisms of the pain origin, depression, appetite, memory, reproductive function.
- Chocolate also contains small amounts of structurally similar to anandamide compounds, N-oleylethanolamine and N-linolenolethanolamine with possesses anxiolytic and antidepressant properties. The substances mentioned above do not exclude the synergistic effect.

- Dopamine 2 - (3,4-dihydroxyphenyl)-ethalamine:

It is a neuromediator, as well as a hormone that is produced by the adrenal medulla and other tissues (e.g., kidney). In the extrapyramidal system this is a stimulating neuromediator that promotes the physical activity, reduction of motor inhibition and stiffness, decrease of the muscle hypertonicity. According to the chemical structure, dopamine is related to biogenic amines – catecholamines. Dopamine is a precursor of norepinephrine and epinephrine in its biosynthesis.

- Serotonin:

It has a general stimulatory action, stimulates the higher nervous activity, improves mood, brings mental relaxation and creates a sense of emotional well-being. The concentration in beans is 0.62 - 5.82%.

- Histamine:

Histamine ingestion is poorly absorbed in the body, and therefore, has no effect. The concentration in beans is 0.04 - 0.13%.

- Phenethylamine – 2-phenyl-1-aminoethane (PEA):

It is a neuromediator and neuromodulator of the interpersonal relationships energy. Isolation of PEA improves the emotional warmth, affection, sexuality, and its impact on the human behaviour is usually explained on the basis of the hypothesis by M. Liebowitz ("psychochemical hypothesis") about being in love: if we find someone who we like, the brain begins to produce PEA. Its biosynthesis in the brain and distribution throughout the nervous system play a role with excitation embracing us when looking at a person we loved one. But during consumption PEA is destroyed.

*Tetrahydroisoquinoline*

- Salsolinol – 1-methyl-6,7-dihydroxy-1,2,3,4-(tetrahydroisoquinoline)*
It has the opiate action. The psychoemotional impact of salsolinol is expressed in the feeling of "being loved" – a very comfortable and life-affirming state.

- Tetrahydro-β-carbolines causes a pleasant sensation in the brain:

**Amino acids**

- Tryptophan – α-indolylaminopropionic or 2-amino-3-(1H-indol-3-yl) propionic acid:

It is essential amino acid, which is directly converted into serotonin in the human organism. The low content of tryptophan and serotonin in the body causes depression, anxiety, insomnia, attention disorders, hyperactivity, migraine, headaches, tension. The high content of tryptophan can cause fatigue and shortness of breath in patients with asthma.

- Arginine – aliphatic amino acid, which is nonessential for adults, for children it is essential:

It stimulates production of insulin and synthesis of the growth hormone, promotes the tissue regeneration, enhances the synthesis of protein for the muscle growth, reduces the level of urea in the blood and urine, is involved in the process of burning fat, making people more active, initiative and strong, has a positive psychotropic effects. The lack of arginine in the diet leads to retardation in the growth of children. Arginine intensifies the growth of adolescents, it is not recommended for children because it may cause gigantism. Arginine is not recommended for pregnant or lactating women.

**Amines**

- Methylhistamine – 1-methyl-4-(2-aminoethyl) imidazole:
After histamine release from the presynaptic membrane it is inactivated by histamine-N-methyltransferase, which breaks down histamine into the metabolite – of methyl histamine, which, in turn, is converted by MAO-B in acetaldehyde. The concentration in beans is 0.01 - 1.54%.

- Spermidine, spermine, putrescine (0.05 - 1.15%):

```
\[ \text{putrescine} \]
\[ \text{spermidine} \]
\[ \text{spermine} \]
```

The specific functions of these amines are not known, however, their concentration in the body may rise sharply during the growth of many tissues, for example in the liver regeneration.

- Tyramine – (n-hydroxyphenyl)-ethylamine:

```
\[ \text{tyramine} \]
```

Due to the vasoconstrictive effect it increases the blood pressure, affects the processes of excitation and inhibition in the nervous system, it is toxic. It is formed from the amino acid tyrosine under the action of bacterial decarboxylases, in particular in processes of putrefaction in the intestine. Neutralization of the excess of tyramine in the organism occurs as a result of its oxidation by the enzyme MAO. The concentration in beans is 0.03 - 0.18%.

**Other compounds**

- “Cocochil” promotes the growth of the skin cells, and therefore, heals the wounds, removes wrinkles and reduces the risk of gastric ulcer.

- Epicatechin

```
\[ \text{epicatechin} \]
```

It is an antioxidant that increases the elasticity of blood vessels and protects the nerve cells in the brain.
Confectionery industry also uses lecithin, which is not an essential nutrient, but it has an important value in the diet:

![Chemical structure of lecithin]

Lecithin facilitates digestion, absorption and proper metabolism of fats, increases bile secretion, in combination with protein it forms the cell membrane, normalizes metabolism of cholesterol, promotes secretion of various hormones, including sex hormones, strengthens nerves, promotes the mental activity, transports fatty acids and prevents accumulation of acids and alkalis in the blood. The daily requirement of an adult for lecithin is approximately 5 g.

**Nutritional and dietary value**

Nutrients and the energy content of chocolate are regulated by state standards (Table 11.1) due to a high content of digestible carbohydrates, fats and proteins. The source of fat in chocolate is cacao butter, which is very rapidly absorbed by the human body, and therefore, chocolate quickly gives strength to the human body.

Bioavailability is characterized by a high content of potassium, calcium and phosphorus, polyunsaturated fatty acids, etc.

The physiological value is determined by the content of alkaloids – caffeine and theobromine, as well as tannins that give the colour of the dessert types of chocolate.

<table>
<thead>
<tr>
<th>Name of the product</th>
<th>Protein, g</th>
<th>Fat, g</th>
<th>Carbohydrates, g</th>
<th>Energy value of 100 g in chocolate, kcal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plain chocolate</td>
<td>5.4</td>
<td>35.3</td>
<td>52.6</td>
<td>544</td>
</tr>
<tr>
<td>Milk chocolate</td>
<td>6.9</td>
<td>35.7</td>
<td>52.4</td>
<td>550</td>
</tr>
<tr>
<td>Chocolate with milk-nut paste</td>
<td>7.3</td>
<td>34.5</td>
<td>53.1</td>
<td>544</td>
</tr>
<tr>
<td>Porous milk chocolate</td>
<td>6.9</td>
<td>35.5</td>
<td>52.3</td>
<td>549</td>
</tr>
<tr>
<td>Chocolate with whole and crushed nuts</td>
<td>6.6</td>
<td>40.9</td>
<td>48.0</td>
<td>580</td>
</tr>
<tr>
<td>White chocolate</td>
<td>6.4</td>
<td>36.9</td>
<td>54.9</td>
<td>600</td>
</tr>
<tr>
<td>Milk chocolate with xylitol</td>
<td>7.0</td>
<td>35.5</td>
<td>51.1</td>
<td>545</td>
</tr>
</tbody>
</table>
At moderate physical and motor activity the maximum consumption of chocolate should be restricted to 100 g per day. According to the American physicians, the daily rate of consumption of chocolate without consequences for the organism is 50 - 80 g per day. If you have any health problems like obesity, liver disease, high blood pressure, it should be limited to 40 - 50 g per day. It should be noted that the most high-calorie chocolate is White chocolate; it is made on cacao butter base without addition of the cacao mass and contains about 24% of dry milk and has more than 600 kcal per 100 g.

Nutritionists say that the most useful is the dark chocolate, especially the bitter one. The more the chocolate bar has cacao products, the lower is the content of sugar and milk in it. Preference should be given to dark chocolate with a relatively low (less than 30%) content of natural sugar. The positive effect of chocolate is due to the concentration of chemical substances mentioned above. Their concentration in chocolate is greater, the greater is the content of the cacao product and the cacao mass.

It is not recommended to give chocolate to children under three years old and those kids who are prone to allergies. For other children a 25 g bar will not cause any harm. For children the best chocolate is milk chocolate: it contains less cacao powder, which has a stimulant effect on the nervous system of the child.

Modern medical research has allowed the chocolate to take its rightful place among the useful products, primarily due to the presence of natural stimulants like caffeine and theobromine having a slight stimulating effect that fights off fatigue and increases the body's resistance to stress.

Chocolate is rich in glucose, which activates the cells of the brain and promotes mental performance.

Dark chocolate helps to lower the blood cholesterol levels. Animal fat can only be detected in milk chocolate.

Cacao has a higher antioxidative activity than of tea or red wine. Dietary antioxidants (cacao flavanols) reduce the risk of cardiovascular disease by inhibiting oxidation of LDL cholesterol and reducing of the blood coagulation.

Cacao contributes to the insulin production, which is associated with a high content of arginine – an amino acid that promotes insulin release.

Chocolate stimulates the production of a neuromediator – serotonin. Together with theobromine, phenylethylamine and dopamine neuromediator, serotonin has a general stimulating action, stimulates the higher nervous activity, and improves the mood. It is assumed that one of the manifestations of chocolate action is increase of secretion of pituitary hormones – endorphins having the analgesic effect.

Phosphorus containing in chocolate improves the memory, magnesium and potassium stimulate the muscular and the nervous systems.

Contributing to the formation of immunoglobulin, chocolate strengthens systemic immunity in the body.

Tannin in chocolate regulates the digestive system, has a mild laxative effect and excretes wastes from the body, but it can also cause headache as it constricts the blood vessels of the brain.
Cacao butter has found application in the pharmaceutical industry. It contains methylxanthine, caffeine and tannin, having a healing effect, stimulating the blood circulation, and normalizing the blood flow of the blood and lymph. Cacao butter is used by manufacturers of laxative and analgesic suppositories and ointments. Cacao butter has regenerative properties due to stearic, palmitic, oleic and linoleic acids.

Basically, cacao butter is used in the confectionery industry: in production of chocolate bars, figurines, candy bars, glaze.

**Indicators of the chocolate quality.** All kinds of chocolate are controlled by the following parameters:

1. Organoleptic (appearance, shape, colour, consistency, texture, taste and odour).
2. The main physical and chemical parameters: fineness degree of the chocolate mass, moisture, mass fraction of sugar, fat, cocoa, ash (insoluble in 10% hydrochloric acid);

In the organoleptic evaluation of the chocolate quality human senses such as vision smell, taste, touch and hearing are used. In assessing the quality of chocolate, this method is of primary importance, but is subjective and does not give a complete picture of the chocolate quality, its chemical composition, the presence or absence of hazardous substances.

Unacceptable chocolate defects are dull surface (with the exception of milk varieties), the presence of stains or grey bloom, deformation, soft consistency (at the temperature 16-18 °C), unpleasant and unusual chocolate flavours and odours.

Quality of chocolate is also determined by the particles size of sugar and cacao butter. According to the standards for plain chocolate, the particles size should be in the range of 15-30 microns. If the particles are less than 5 microns, the chocolate becomes sticky.

**Moisture determination of chocolate:**

- *the arbitration method* is based on weighing the sample before and after drying.

**Determination of fat in chocolate:**

- *the refractometric method* is based on the change in the refraction index of the light depending on the content of dry substances in the product.
- *the extraction-weight method* is based on extracting fat by a solvent from the sample treated with hydrochloric acid. The method is carried out using a Soxhlet apparatus, after distillation of the solvent from the extract; the rest is dried and weighed.

**Determination of sugar:**

- *the iodometric method* is based on the ability of sugar to be oxidized by the excess of iodine in the alkaline medium:

\[
I_2 + 2NaOH \rightarrow NaI + NaOI + H_2O
\]

\[
R-C=O + NaOl + NaOH \rightarrow R-C-O-ONa + NaI + H_2O
\]

\[
NaI + NaOI + H_2SO_4 \rightarrow Na_2SO_4 + I_2 + H_2O
\]

\[
I_2 + 2Na_2S_2O_3 \rightarrow 2NaI + Na_2S_4O_6
\]
- *the ferrocyanide method* is based on the ability of sugar to be oxidized and to reduce potassium ferrocyanide \([K_4Fe(CN)_6]\) in the alkaline medium;

- *the photometric method*.

The *fluorescent method* belongs to express-methods for the determination of the quality of the chocolate. It is based on the fact that under the action of ultraviolet rays many substances in the dark give the glow of various shades. Fluorescent glow has a high sensitivity to change of the chocolate chemical composition and serves to reveal the processes of its spoilage that are not tangible by taste and smell.

Practically all types of chocolate are packed in wraps. As a rule, chocolate wraps have two layers: the foil and decorative appearance of labels (bars) or a layout of the waxed paper and the label (loafs).

Chocolate should be kept at a temperature of no higher than 18°C and with a relative humidity of the air not more than 75%. Fluctuations of the temperature should not exceed + 3°C (condensation of the surface of the chocolate can occur, it of a grey bloom, which are tiny crystals of sugar – sugar graying may appear). Chocolate should not be exposed to direct sunlight. Heating of chocolate to the temperature of 26°C and above causes melting of the cacao butter and when cooling due to appearance of crystals of fat on the surface a greyish bloom – fatty graying may form. Depending on the packaging, the presence of additives and the nature of the chocolate it is kept from 1 to 6 months.

**Adulteration of chocolate**

There are the following types of adulteration of chocolate:

*assortment* – the substitution of one type of chocolate to another (usually dessert chocolate to a plain one);

*qualitative* – a violation of the formula (in the chocolate mass the share of cacao butter and cacao mass is reduced at the expense of introduction of increased quantity of dry and condensed milk, cream, raisins, etc.), introduction of foreign additives, antioxidants, preservatives, dyes and flavourings, introduction of the increased content of sugar and water, introduction of surface-active substances allowing the increase of the water content up to 9%;

*quantitative* – a significant deviation of the chocolate mass, exceeding the maximum permissible norms of deviations specified in the current standards;

*ininformative* – inaccurate or distorted information about the goods indicated on the label, advertising or the accompanying documents. Sometimes products that have no relation to chocolate at all are called chocolate.

The quality of chocolate can be judged by information the label – a true chocolate consists of the cacao mass, cacao butter and sugar (or sugar substitutes), emulsifier lecithin, flavour (it is often vanillin) and some other natural additives. If vegetable oils are indicated in the composition, this testifies the low quality of the chocolate. The products made on their basis have specific names such as "confectionery bar" and "sweet bar". It is undesirable the presence of preservatives in chocolate, especially chemicals of benzoic series (it is allowed the presence of sorbic acid; sorbitol, calcium sorbate should be not more than 5%).
**Signs of high-quality chocolate are the following:**

- high-quality chocolate should have a uniform, smooth, shiny surface, but at the fracture of the chocolate bar the tarnish is clearly visible;
- a whitish bloom on the surface of the chocolate is not allowed;
- when breaking it should produce a characteristic dry crunch;
- a true chocolate melts in your mouth, but not smear in the hands;
- "buttery aftertaste" is the evidence of the presence equivalents or substitutes for cacao butter in the chocolate;
- when dissolving the chocolate in hot water husk (cacao vella) should not appear;
- the expiration date is not more than 6 months.

The easiest way to determine the quality of the chocolate is the method of boiling chocolate slices in water. At first, natural chocolate made of true cacao beans completely dissolves, in the chocolate with impurities sedimentation can be observed. If the mixture is boiled for a long time, then during evaporation it turns into a powdery, loose mass. If the chocolate has a great number of additives, after boiling and evaporation it turns into the mass that looks like a glue or gelatin. Then to the dry of mass the solution of iodine can be added, it will give the true chocolate a colour from green to yellow-green. Soy chocolate or a product with a large number of additives will colour iodine into blue colour and its shades.

**Interaction with other drugs.**

Doctors recommend to avoid eating chocolate when taking cardiovascular drugs.

When taking anti-inflammatory drugs the use of chocolate should be avoided, as it stimulates the release of histamine from the cells. The consumption of chocolate, which is a histamine releaser, can lead to development of pseudoallergic reactions that can become a cause of a drug withdrawal or improper prescription of anti-allergic drugs. Therefore, when treating patients who are prone to allergies, chocolate as an obligate allergen should be excluded from the diet.

The simultaneous use of chocolate and laxatives should be avoided because it contributes to the opposite effect.

As chocolate refers to tyramine-containing products, it can seriously affect the pharmacodynamics of antidepressants, psychostimulants, isoniazid, reduce their therapeutic efficiency and provoke intensification of their side effects in the form of the arterial pressure increase.
QUESTIONS FOR SELF-CHECKING

1. Define the concept of chocolate.
2. What raw material and ingredients are used in chocolate manufacture?
3. How is chocolate classified?
4. Describe the chemical composition of chocolate.
5. What energy stimulants are parts of it?
6. Describe the nutritional, biological and physiological values of chocolate.
7. What indicators of chocolate quality do you know?
8. Describe the main types of adulteration of chocolate and methods of their determination.
9. What recommendations about the rational combination of chocolate and medicines can you give?
TASKS FOR SELF-CHECKING

1. Which ingredient is introduced into the chocolate mass to reduce its viscosity?
   A. starch  
   B. lecithin  
   C. cocoa butter  
   D. palm oil  
   E. stearic acid

2. Which substances belonging to neurotransmitters are included in the chocolate composition?
   A. dopamine  
   B. theobromine  
   C. serotonin  
   D. salsolinol  
   E. caffeine

3. What is the main alkaloid in chocolate?
   A. dopamine  
   B. theobromine  
   C. serotonin  
   D. theophylline  
   E. caffeine

4. What method is used for determination of the sugar content in chocolate?
   A. argentometry  
   B. refractometry  
   C. iodometry  
   D. nitritometry  
   E. thiocyanatometry

5. What drugs can cause increase of their side effects when taking them together with chocolate?
   A. antiarrhythmic drugs  
   B. antidepressants  
   C. laxatives  
   D. antiprotozoal drugs  
   E. antibiotics
CHAPTER 12

TEA

Tea is a drink obtained by boiling, brewing or infusing the leaves of the tea bush, which is preliminarily prepared in a special way. A tea leaf itself intended to prepare the drink is also called tea.

Classification of tea
There are two main types of tea:
- Chinese tea – Thea (Camellia) sinensis, which is common in the northern parts of India, China and Japan, it is frost resistant and imprententious;
- Assamese (Indian) tea – Thea (Camellia) assamica grown in hot tropical countries: India, Ceylon, Indonesia, etc. The minimal winter temperature for this species is -3 °C.

The principal technological process, which determines the quality of tea, is fermentation. In the process of fermentation the oxidation processes occur and the tea leaf acquires a characteristic colour, flavour and aroma due to conversion of tannins and other substances.

According to the degree of fermentation (oxidation) tea is classified into:
- fermented (oxidation up to 12%) – white and green;
- poorly fermented (oxidation from 12 to 30%) - yellow, red (oolong);
- fermented (oxidation within 35 - 45%) – black.

By appearance tea is classified as follows:
White tea – composed entirely of tea tips (tender buds). The infusion is yellowish, almost colorless, has a very thin and light flavor. When making, it only passes two stages – withering and rolling.
Green tea – the infusion has a light-golden to amber colour with a delicate aroma and astringent taste. The technological process includes heat treatment (fried in China, steamed in Japan), rolling and drying, heat exposure and sorting.
Yellow tea is made only of tea tips; it is different by having an amber-yellow colour and a delicate flavour. The technological process consists of withering, heat treatment, rolling, drying, heat exposure and sorting.
Red tea (oolong) has a bright red infusion and a spicy aroma. The red tea contains the highest amount of essential oils. The technological process consists of withering, rolling, fermenting, heat treatment, repeated rolling and drying.
Black tea – the technological process of black tea consists of withering, rolling, fermenting and drying. Pu-erh tea has a special place among the types of black teas.

By the type of tea leaf and its mechanical processing (International Classification of teas) tea is divided into:
- High-grade whole leaf teas
  Tippy (T) – tea from the tips of tea buds.
  Pekoe (P) – long leaf tea. Big tea, badly stranded with open plates. Collected while matured, with large leaves. Usually the second leaves from the bud are gathered. Therefore, in this case, it has less caffeine than Orange Pekoe. It has a
pronounced bitterness in the taste. The more grown-up leaf is, the more it has tannins and related substances, and it makes the taste of the brewed tea earthy and astringent.

*Orange* (O) is the common name for high whole-leaf teas made only of whole twisted leaves, as a rule – the youngest.

*Orange Pekoe* (OP) consists of large, well-twisted leaves (the first (upper) and second leaves), contains virtually no tea tips. This variety has a relatively high content of essential oils, so the infusion of tea is very fragrant. It also has a characteristic bitter taste due to the high content of tannins.

*Flowery Orange Pekoe* (FOP) is a high-quality tea from delicate, recently blown leaves, large, well-twisted, homogeneous, with tips. The tea has a subtle and delicate taste than Orange Pekoe. Ready dry tea consists of medium-sized one-piece twisted leaves and the caffeine content is higher than in OP.

*Flowery* (F) – this tea has unblown buds, the lower part of the tea tip is covered with a light fuzz, it remains light after fermentation. Namely the tea tips are the ones that give a floral flavour.

*Golden* (G) – the tea contains a large number of the most tender and young tips, which give a golden colour after fermentation.

Teas of higher quality may contain the name of the following characteristics - Fine (F), Super-fine or Super-fancy (SF), Special (SP), or Extra Special (EXSP).

- **Medium-grade teas** are teas from broken or chopped leaves formed as a waste from whole-leaf production of the tea, or can be reduced in size (cut) on purpose. They have more higher extract content, but the worse flavour and less delicate taste.

The classification of broken-leaf teas is similar to the classification of whole-leaf teas; international labeling is formed by adding the letter B (Broken) at the beginning of the corresponding whole-leaf tea class marking.

- **Low-grade ground tea** are tea leaves specifically milled, as well as from tea production waste produced when sorting or sifting.

*Granulated tea* (CTC (cut, tear & curl)) is the tea, which leaves after oxidation are passed through rotating rollers with serrations that cut and roll them. This cutting method produces less waste than the conventional method. The raw material is not only the first two or three level leaves from the buds, but also the fourth and fifth leaves. CTC tea is brewed stronger and has more astringent flavour and a bright colour, but has less rich flavour than the leaf teas. This method is used mainly in India and Ceylon.

*Tea bags* consists primarily of tea crumbs and dust enclosed in bags of filter paper, sometimes tissue. There are black tea and green tea bags. Tea bags can be subdivided into classes, which are similar to *Broken Orange Pekoe*, in the case if they are manufactured from the corresponding raw material.

“Low-grade” teas are also *brick, tile and instant tea*.

**The chemical composition of tea**

The chemical composition of freshly picked green tea leaves and dried tea leaves obtained from the same leaf is not the same. In the dry tea it is diverse and complex. Not all chemical substances presented in the fresh leaves remain in the dry
ones after their treatment: some simply disappear, some get oxidized and others react chemically with each other.

**Protein substances** together with the free amino acids are ranged from 16 to 25% of tea – the major component of the tea leaves since all enzymes are proteins. In addition, they serve as a source of amino acids, which occur while processing into finished tea leaves. In the fresh tea leaf there are mainly proteins soluble in alkalis - glutelins, and to a lesser extent the proteins that are soluble in water – albumins. During processing of the tea leaf the albumin content is increased by 10%. The finished green tea has more albumins, and black teas are generally made up mainly of glutelins.

According to the content of proteins and their quality, by its nutrition properties the tea leaf is not inferior to bean crops. Green teas are especially rich in proteins (among them the Japanese green teas have the highest value).

The increased content of proteins does not harm the quality of the green tea, but it reduces the quality of the black tea and worsens its taste and colour due to a large number of proteins in the final infusion of the tea accompanied by decrease of the tannin content, and it can be confirmed by a dimmed colour of the tea.

With regard to amino acids, there are 17 different types, and the nature of one of them has not yet been found. Amino acids interact with sugars, tannins and catechins in the tea manufacturing process at elevated temperatures, thus forming aldehydes that participate in formation of the tea aroma.

**Tea carbohydrates** are simple sugars and complex polysaccharides. The higher the percentage of the tea carbohydrate content is, the lower is its grade. Tea mostly contains insoluble carbohydrates (starch, cellulose, hemicellulose) ranging from 10 to 12%, soluble carbohydrates (sucrose, glucose, fructose, maltose) ranging from 1 to 4%.

**Extractable substances** contain about 30-50% in tea, green teas contain more soluble substances (40-50%), and black teas have less (30-45%). Furthermore, the younger are the tea leaves, the higher is the quality and the richer is the content of the extractive substances obtained from the dried tea. And, on the contrary, the older and rougher are the leaves, much less are soluble substance in the infusion, the less tasty is the tea.

Of the soluble extractable substances the most important are: tannin, essential oils, alkaloids, amino acids, pigments and vitamins.

**Tannin substances** are one of the basic components, they constitute 15-30% of the tea and are a mixture consisting of tannin, catechin, polyphenols and their derivatives. Due to the great amount of tannins, they give the tea thirst-quenching properties, astringent taste, pleasant astringent flavour and a beautiful colour. It should be taken in mind that the tea tannin (theotannin) is not the same as the pharmaceutical tannin (gallotannin). The fresh tea leaf tannin tastes bitter, but after factory processing this bitterness disappears and the tannin in the tea has a pleasant astringency that gives the basic flavour of the tea infusion. In addition, tannic acid and tea catechins have the properties of vitamin P, and that is why tea is the main source of this vitamin.
Typically, the content of tannin in green teas is significantly higher (about 20%) than in black teas (8 to 12%) because green tea tannin is almost in a non-oxidized state, whereas black tea tannins are 40-50% oxidized. The tannin content depends on the place of growth of tea, harvest time. The higher is the grade of the tea, the more is the tannin content. The oxidation products of tea tannins – quinones formed during factory production of tea, in turn, oxidize other substances of tea leaves to form aromatic products involved in creating the flavour of the tea.

**Essential oils** are in both the green leaves and the finished tea product (about 0.02%). The quality of tea depends on their amount. While processing the tea leaf the loss of essential oils are about 70-80%, during this another process take place – new essential oils appear. The number of chemical components in the composition of essential oils in the finished tea comes up to 32. Many of them have the smell of roses, honey, vanilla, citrus, lilac and cinnamon. A mixture of so many flavours creates a unique aroma “bouquet”.

Chemically pure essential oils are aliphatic and aromatic hydrocarbons, aldehydes, ketones, phenols, esters, acids and other volatile compounds. Most of them volatilize at higher temperatures, improper storage or improper brewing. The content and composition of essential oils and their solubility in different types of tea are different. The largest amount of essential oils in the form of soluble aromatic aldehydes are contained in red teas, the most fragrant of all kinds of tea; that is why they are used as additives to some varieties of black tea. In green and yellow teas aromatic aldehydes that are part of essential oils are in a bound state, and therefore, they are less released into the infusion, do not take part in formation of the final flavour of tea. There are flavour is created mainly due to tannin.

Important components of tea are **alkaloids**, caffeine being the main one. Its content is more (from 1 to 4%) than in coffee, but caffeine tea acts softer than pure coffee caffeine since brewing takes usually a much lesser amount of tea than coffee and, consequently, creates a lower concentration of caffeine. Moreover, caffeine in tea in combination with tannin forms tannate of caffeine, which acts more smoothly on the cardiovascular and central nervous system. Besides tea caffeine does not retain, does not accumulate in the human body; and it eliminates the risk of caffeine poisoning even with the frequent intake of tea.

The content of caffeine changes slightly when processing. However, different varieties of teas contain different percentages of caffeine. This is due to the fact that caffeine is unevenly distributed in the tea plant. The first leaves of flushes contain 4-5% caffeine, the second − 3-4%, the third − 2.5%, others - from 0.5 to 1.5%. Therefore, high-quality teas made of the first leaves contain more caffeine than teas of the coarse raw material.

Besides caffeine, in tea there are small amounts of other alkaloids – soluble in water theobromine and theophylline, poorly soluble in water adenine and completely insoluble in water guanine − purine based with negative characteristics, and partly toxic with an overwhelming effect on the nervous system.
Guanine is released from the tea leaf extract only as a result of a sharp boiling action or prolonged brewing of the tea.

**The pigments** in the composition of tea also play an important role. Such pigments as chlorophyll containing primarily in green tea, as well as xanthophyll and carotene containing mainly in black teas are involved in pigmentation of the tea infusion.

In addition to these pigments, the colour of the tea infusion is provided by two other groups of dyes – thearubigins and theaflavins. The first ones giving a reddish-brown hues are 10% of the dry tea, the latter having a golden-yellow range are only 2% of the dry tea. Theaflavins consist of the theaflavin itself and theaflavin-gallate, and these substances are unstable, with little oxidation they turn into thearubigins. These properties of pigments explain many of the properties of the tea infusion. For example, a re-used and low-grade tea quickly turns brown and becomes opaque, dark if left to stand for a while. This means the oxidation of theaflavins giving not only the colour, but also the tone and brightness of the infusion.

Thus, the absence or presence of theaflavins in tea is quite precise and clear indication of the quality of tea. The constant ratio of theaflavins and thearubigins in a good tea is 1:10, and in bad – 1:20. This made it possible to develop a simple and accurate scale of tea quality expressed in precise digital indicators, and to monitor the changes by a specific scale.

According to the international rules any tea blend should have a ratio of theaflavins and thearubigins not lower than 1:16, i.e. it should have at least an average of a good quality tea, and if the ratio is higher than 1:25, the tea must be declared unfit for use and removed from sale.

Tea has a considerable amount of **vitamins**. It has pro-vitamin A – carotene, vitamins of group B (B₁, B₂, B₅, B₁₅) and vitamin K. The content of vitamin C in fresh tea leaves is 4 times more than in the juice of lemons and oranges, but during the factory processing of the tea part of this vitamin is lost, the highest concentration are in the green and yellow teas (10 times higher than in black teas).

The main vitamin in tea is vitamin P. Its content in tea is much richer than in buckwheat (85 units in tea, 61 – in buckwheat). Green tea has the highest P-vitamin activity. However, not only green, but black tea, especially with a high content of tannin contain vitamin P. Three-four cups of tea provide the daily prophylactic dose of vitamin P.

In addition to these groups of substances, minerals, inorganic, resinous substances, as well as organic acids containing in tea in smaller quantities are of a considerable importance to the consumer of tea.

**Mineral substances** containing in tea are from 4 to 7%. There are iron salts, metals, such as magnesium, manganese, sodium, silicon, potassium and calcium.
the form of microelements, there is fluorine, iodine, copper, gold, etc. All of these substances are part of complex compounds, but being in the colloidal state, they are subjected to dissolution in water passing into the tea infusion (especially fluorine and iodine). Tea contains phosphorus and its compounds. The Georgian Tea includes phytin, hexammonophosphate, hexose diphosphate, phosphoric acid serving the nervous tissue nutrition. The higher the grade of tea is, the more it has phosphorous and potassium.

The composition of tea contain a small part by the specific gravity, but diverse group of resinous substances - alcohol (resenol), resin acids, resin phenols and other organic compounds. They serve mainly as carriers and fixing of the tea aroma. Therefore, high quality tea is rich in resinous substances that hinder odour staling. Furthermore, resins give stickiness to the tea, making the possibility of its pressing (the production of brick and tile grades).

Another group of soluble organic compounds in tea is organic acids (about 1%), which include Oxalic, Citric, Malic, Succinic, Pyruvic and Fumaric acid. As a part of tea they increase the nutritional and dietary value of the tea.

\[
\text{HOOC-CH}=\text{CH-COOH} \quad \text{CH}_3\text{COCOOH}
\]
Fumaric acid
Pyruvic acid

Tea has groups of substances, which components are only partially soluble in water or completely insoluble. They are of great importance for production of tea. They include enzymes, pectic substances, glycosides.

The main chemical characteristics of finished teas are presented in Table 12.1

<table>
<thead>
<tr>
<th>The main types of chemical indicators of the finished tea</th>
<th>Various types of tea leaves</th>
<th>Fixed tea leaf (raw material)</th>
<th>White</th>
<th>Green</th>
<th>Yellow</th>
<th>Red (oolong)</th>
<th>Black</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main chemical components of the tea leaf</td>
<td></td>
<td>Extractive substances, %</td>
<td>43.36</td>
<td>44.50</td>
<td>43.81</td>
<td>45.05</td>
<td>35.86</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Caffeine, %</td>
<td>2-4</td>
<td>2.87</td>
<td>2.45</td>
<td>2.50</td>
<td>2.61</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Phenolic compounds (Tanin-catechin complex), %</td>
<td>23.37</td>
<td><strong>23.04</strong></td>
<td>22.54</td>
<td>21.21</td>
<td>12.91</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Volatile aldehydes, mg/100g of the tea</td>
<td>1.41</td>
<td>5.37</td>
<td>2.62</td>
<td>4.49</td>
<td><strong>13.82</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fatty acids, mg/g</td>
<td>13.8</td>
<td>11.32</td>
<td>10.5</td>
<td>10.5</td>
<td>18.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L-Ascorbic acid, mg %</td>
<td>204.5</td>
<td>157.50</td>
<td><strong>200.6</strong></td>
<td>62.94</td>
<td>26.22</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Chlorophyll, %</td>
<td>0.610</td>
<td>0.452</td>
<td>0.480</td>
<td><strong>0.556</strong></td>
<td>0.455</td>
</tr>
</tbody>
</table>

Ferments or enzymes containing in tea are mostly insoluble, in the bound state and act as biological catalysts. It is thanks to them all chemical reactions occur in a living tea plant during its growth, and in the process of tea manufacturing. Due to
enzymatic oxidation processes various types, varieties and qualities of teas can be obtained from the same raw material. The main enzymes of the tea are polyphenol oxidase, peroxidase, catalase and invertase.

*Pectin substances* are colloidal substances with the complex structure. A tea leaf contains three groups of pectin substances: insoluble in water (protopectin), soluble in water (hydropectin) and pectic acid. Their content in tea varies from 2 to 3%. Pectins are of great importance to preserve the quality of tea: such physical property of tea as its hygroscopicity is connected with them. Pectic acid covers every tea leaf with a thin, impermeable to moisture gelatinous film. With the lack of pectin acid in the tea, its hygroscopicity rises sharply and tea deteriorates faster. A good quality tea usually contains more water-soluble pectins than bad varieties of teas. Basic chemical indicators of brewed black tea are shown in Table 12.2

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Water</strong></td>
<td>3-7%</td>
<td></td>
</tr>
<tr>
<td><strong>Dry substance</strong></td>
<td>93-97%</td>
<td></td>
</tr>
<tr>
<td><strong>Extractable</strong></td>
<td>36-44%</td>
<td><strong>Ballast</strong></td>
</tr>
<tr>
<td><strong>substances</strong></td>
<td></td>
<td><strong>substances</strong></td>
</tr>
<tr>
<td>Phenolic compounds</td>
<td>7.5-15%</td>
<td>Proteins</td>
</tr>
<tr>
<td>(tannin-catechin</td>
<td></td>
<td>20-22%</td>
</tr>
<tr>
<td>complex)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>3-4.5%</td>
<td>Insoluble</td>
</tr>
<tr>
<td>(monosaccharaides,</td>
<td></td>
<td>carbohydrates</td>
</tr>
<tr>
<td>disaccharides)</td>
<td></td>
<td>(cellulose,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>starch,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>hemicellulose)</td>
</tr>
<tr>
<td>Caffeine</td>
<td>1.5-3.5%</td>
<td>Pectin</td>
</tr>
<tr>
<td></td>
<td></td>
<td>substances</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(protopectin)</td>
</tr>
<tr>
<td>Hydroascorbic acid</td>
<td>0.2-0.3%</td>
<td>Lignin</td>
</tr>
<tr>
<td>Pectin substances</td>
<td>1.5-1.7%</td>
<td>Resins</td>
</tr>
<tr>
<td>(hydropectin)</td>
<td></td>
<td>2-3%</td>
</tr>
<tr>
<td>Mineral substances</td>
<td>3.2-4.2%</td>
<td></td>
</tr>
<tr>
<td>Amino acids</td>
<td>1.7-2%</td>
<td></td>
</tr>
<tr>
<td>Organic acids</td>
<td>0.4-1%</td>
<td></td>
</tr>
<tr>
<td>(malic acid,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>succinic acid,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>citric acid, etc.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other soluble</td>
<td>1.5-2%</td>
<td></td>
</tr>
<tr>
<td>substances</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(water soluble</td>
<td></td>
<td></td>
</tr>
<tr>
<td>vitamins, nitrogenous substances,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>enzymes, flavourings,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>alcohols)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Theaflavins</td>
<td>1-2%</td>
<td></td>
</tr>
<tr>
<td>Thearubigins</td>
<td>7-8%</td>
<td></td>
</tr>
</tbody>
</table>

**Adulteration of tea**

There is the quality and assortment adulteration of tea.

1. Qualitative adulteration of tea is made by misdescription, full or partial replacement of good quality tea to low-grade or re-used one, or replacement of high-quality tea of the popular titles (Indian, Ceylon, Chinese) to low quality tea. Such adulterations can be revealed by the organoleptic methods estimation of taste, aroma and colour of the infusion, paying attention to the presence of a coarse taste and a weak flavour, a poor colour of the infusion, opacity and turbidity. Tea leaves are uneven, badly twisted.
2. Assortment adulteration occurs much less frequently and is achieved by replacing the tea plant raw material to other ones with similar appearance. Organoleptic estimation is used to determine taste and odour, visual inspection of the soaked leaves.

Adulteration of tea in catering establishments:

3. Re-used tea is used the most frequently as imitators of tea products. The mass of re-used tea is dried to appropriate moisture and then mixed with some good quality tea leaves. Identification of such counterfeits can be made only by laboratory methods: estimating the number of tannins, caffeine, shape and appearance of boiled tea leaves, etc.

4. To increase the extractability of tea soda is added into water, it softens and improves isolation of tannins from the tea leaf. To identify the presence of soda the test litmus paper is used, which colour changes in the presence of alkali or by addition of any acid (e.g. acetic acid), and the release of carbon dioxide can be observed.

5. Preparation of the solution of burnt sugar. In appearance, it completely mimics the real tea, but if you add lemon, its colour does not change, while natural tea lightens. It is because of the nature of tea – the colloidal system of tannins and when adding acid or alkali coagulation processes begin, and dispersion of the particles changes. Thus, addition of lemon in tea is a test for its naturality.

6. Tinting dry tea with dyes and other colouring substances. Detection of this kind of fraud can be achieved by mixing dry tea with cold water; tinted dry tea will colour cold water with the dyes.

**Quality indicators of tea**

*Organoleptic characteristics*: appearance, intensity of the infusion, aroma, taste, colour of boiled leaf.

*Physical and chemical properties*: mass fraction of moisture, water-soluble extractives, caffeine, tannin, crude fibre, metallic-magnetic impurities, water soluble and insoluble ash.

*Microbiological analysis*: the content of aflatoxins, pesticides and mold.

*Safety indicators*: the content of toxic elements (lead, arsenic, mercury, cadmium, copper), radionuclides (cesium-137, strontium-90)

* Determination of appearance of dry tea leaves.* During the estimation of the appearance of tea main attention is paid to homogeneity of the mass, the colour of tea leaves, tea twist, and the presence of coarse stems, wood hairs, dust and other impurities.

  Good quality teas consist of uniform, well-twisted tea leaves, tea leaves without a mixture of different sizes and have the appropriate type of tea colour, indicating the correct sorting.

  The presence of tea stems (red stems) or wood threads indicate that the tea produced from the coarse raw material (raw material of the late harvest) and it is poorly sorted. The more stalks or wood hairs the tea contains, the lower is its quality.

  Admixtures of untwisted leaves adversely affect the quality of tea. When processing the coarse raw material the third tea leaf is badly twisted, important
substances escape from it while squeezed, so untwisted leaves contain less extractive substances, which adversely affects the flavour and taste of tea.

**Determination of colour of the tea infusion.** It is determined by the intensity and the nature of colour. The tea infusion prepared from tea leaves, processed under normal conditions should be clear and bright, and its characteristics cannot be lesser than the declared category of tea. The intensity of the brewed tea is characterized by the definitions: "very strong", "strong", "above average," "average," "below average," "rather weak", "weak".

Particularly high demands are to the colour of the infusion of black tea, the more intense the colour is, the higher the quality of tea:
- teas that have a bright (intense) infusion and a red colour are defined as the best compared to the ones that are dull brown teas or those that have a greenish colour;
- the dark (grey-black) or muddy colour presents a defect of the black tea. When the tea extract has a brownish colour, it means that the leaf was re-fermented. Greyish infusion shows that the process of fermentation was taken excessively long period of time;
- extremly bright infusion of tea with a greenish tinge indicates the lack of fermentation and the fact that the raw material is processed very late.

Black tea of high quality is rich in tannins, has the property to precipitate extractives – "cream tea", which is obtained when cooling the infusion of tea. "Cream" represents a mixture of catechins and caffeine containing in a hot tea solution. When cooling, they are extracted from the solution in suspension. With longer cooling they settle to the bottom. The bright colour of the "cream" is indicative of good quality tea, dull colour is considered to be a negative phenomenon. Usually, the "cream" forms high concentrative teas. Assam tea has the "cream" of the colour as if milk is added. Ordinary teas have a dull, heavy "cream". Characteristically, in the light and aromatic infusions, "cream" is not formed, but it does not reduce the value of tea.

When comparing the intensity of the infusion the type of tea is taken into account: whether it belongs to the whole-leaf or small leaf. Small tea leaves have a more intense infusion than the whole-leaf one.

**Determination of tea flavour.** To assess the flavour of tea infusion a tea specialist drains out the infusion out of the kettle, giving it to cool down a little, he removes the lid from the pot and determines the nature and strength of flavour. Good quality teas have the following characteristics of flavour, "pleasant", "strong", "gentle", "rosy", "honey", "flower", "lemon", "bread", "almond". Aroma is especially pronounced in the leafy teas. Defects of the tea bouquet, its flavour and taste are considered to be "smoky", "fried", "acidic" and or green grass smell, especially with shades of dampness and of mustiness.

**Determination of the tea taste.** Of all the indicators that determine the quality of tea, the most important role is played by is the **taste**, the properties of which have specific requirements. The taste of tea is determined by tea specialists that take a sip without swallowing, only rinsing it in their mouths, paying major attention to its astringent properties and completeness. Depending on the astringent action of tea to
the mucous membranes of the mouth and gums they judge about astringency of tea. A bitter taste and no astringency indicate the poor quality of the tea due to excessive fermentation. In good teas along with astringency the extract content must be felt, or "body" of the infusion; tea specialists assess it by the word "complete", i.e. quite intense, strong and with a pleasant astringent taste. As a rule, bad teas have greater astringency and full flavour than the leaf teas.

**Determination of the colour of a boiled leaf.** Appearance of a boiled leaf (boiled tea) is sufficiently objective measure of the quality of fermentation. It is in direct proportion to the intensity of the infusion, aroma and flavour of tea.

Boiled tea is determined after the infusion is poured off and boiled tea leaves are turned over on the lid and squeezed. The best black tea has the colour of new copper coins, other shades of the boiled leaf (brown, green, dull, dark, and others) indicate the violation of fermentation technology and is characteristic for low-quality teas. For example, the brownish colour indicates that the tea leaf is re-fermented, it negatively affects the flavour of the tea, and the dark (blackish) colour, which is usually obtained by the excessive fermentation, is considered to be a defect. Boiled low-fermented leaf tea is always characterized by a greenish colour. If boiled leaf tea leaves contain a light brown and greenish colour, this is due to processing of the non-uniform raw material since the same process conditions with react differently different materials when withering, rolling and fermentation. If the greater part of the tea leaves is well fermented, it has a light brown colour, but if it still contains small amounts of dark colour tea leaves, it must be attributed to improper preparation of the blend.

**Determination of moisture.** Dry tea is weighed at a definite temperature and the weight loss is calculated relative to the weight of the sample before drying.

**Determination of soluble extractives** is based on extraction of extractive substances, quantitative determination of the dried extract by gravimetric and refractometric methods.

**Determination of caffeine** in tea is carried out by the following methods:

1. Spectrophotometric method. Determination is carried out by the method of standard after extracting caffeine from the tea.
2. Iodometric method. Back titration, the indicator is starch.

\[
\begin{align*}
\text{H}_3\text{C} & \quad \text{N} & \quad \text{N} - \text{CH}_3 \\
\text{O} & \quad \text{O} & \quad \text{CH}_3 \quad + 2 \text{I}_2 + \text{HI} \quad \rightarrow \quad \text{H}_3\text{C} & \quad \text{N} & \quad \text{N} - \text{CH}_3 \\
& \quad \text{O} & \quad \text{O} & \quad \text{CH}_3 & \quad * \text{I}_4 * \text{HI} \\
\end{align*}
\]

\[\text{I}_2 + 2\text{Na}_2\text{S}_2\text{O}_3 \rightarrow 2\text{NaI} + \text{Na}_2\text{S}_4\text{O}_6\]

**Determination of tannin.** The method is based on oxidation of tea tannin with potassium permanganate; indigo carmine is used as an indicator.
**Determination of crude fibre** (the total amount of insoluble substances) is based on the ability of these substances to ashing, after acidic and alkaline treatment.

**Determination of water-soluble ash** is performed after ashing in a muffle furnace by weighing the dry residue.

**Interaction with drugs**

Tea contains caffeine, which changes absorption and the pharmacological action of many medicines. Caffeine increases permeability of the blood-brain barrier, and potentiates the effect of analgesics, antipyretics (paracetamol metamizole, acetylsalicylic acid), intensifies and prolongs the effect of theophylline.

- It can intensify the action of insulin causing overdose with normal doses.
- It reduces the effect of haloperidol and other antipsychotics drugs.
- It prevents absorption of iron from the drugs.
- MAO inhibitors slow the metabolism of caffeine, it can contribute to mutual intensification of their toxicity.

Caffeine stimulates the nervous system, that is why it is undesirable to use tea with various stimulants and drugs used to treat depression. The combination results in a very intense stimulation of the nervous system and can cause side effects such as increased heart rate, increased blood pressure and nervousness. Antibiotics such as ciprofloxacin, enoxacin, norfloxacin, sparfloxacin, trovafloxacin and grepafloxacin slow down degradation of caffeine. It increases the risk of side effects, including feeling of anxiety, heart palpitations and headaches.

- Caffeine reduces the effect of erythromycin and penicillin antibiotics.
- Clozapine, dipyridamole, disulfiram in combination with tea can cause increased excitability and nervousness, headaches, palpitations, hyperactivity, irritability.

Contraceptives due to the content of hormonal substances (ethinyl estradiol, norethindrone, levonorgestrel) slow down the process of degradation of caffeine in the body; the side effects observed in this case are headache, heart palpitations, irritability and nervousness.

The combination of tea with drugs having an additional impact on the liver increases the risk of the liver damage, therefore use of tea (especially green) when taking acetaminophen, amiodarone, carbamazepine, isoniazid, methotrexate, erythromycin, phenytoin, lovastatin is not recommended.

- Green tea can accelerate coagulation, thus, its use with drugs, which reduce blood clotting (aspirin, ibuprofen, heparin, warfarin, diclofenac, naproxen, etc.) may lead to increase of bleeding.
- Tannin containing in tea reduces absorption of codeine, atropine, morphine, papaverine, platyphylline and other drugs containing alkaloids.
QUESTIONS FOR SELF-CHECKING

1. Define the concept of tea; name the main types of tea classification.
2. In what types tea is divided by types of tea leaves?
3. What is fermentation? What types of tea are distinguished depending on the degree of fermentation?
4. What tannins are part of tea?
5. Name the main alkaloids of tea, describe their properties.
6. Give basic methods of tea adulteration.
7. Describe the organoleptic properties of the tea quality.
8. Give recommendations on simultaneous use of tea and medicines.
TASKS FOR SELF-CHECKING

1. What substances in tea are responsible for its astringent taste?
   A. organic acids
   B. caffeine
   C. tannins
   D. essential oils
   E. pigments

2. What substances in tea act as carriers and fixing agents of tea flavour?
   A. organic acids
   B. caffeine
   C. tannins
   D. resinous substances
   E. pigments

3. Which vitamin is basic in tea?
   A. vitamin C
   B. vitamin P
   C. vitamin A
   D. vitamin D
   E. vitamin B₁

4. What substances provide hygroscopicity of the tea leaf?
   A. organic acids
   B. caffeine
   C. tannins
   D. resinous substances
   E. pectin substances

5. Caffeine of tea increases permeability of the blood-brain barrier, and potentiate the effect of:
   A. paracetamol
   B. morphine
   C. haloperidol
   D. MAO inhibitors
   E. atropine

6. What medicines slow down digestion of caffeine?
   A. NSAIDs
   B. laxatives
   C. psychostimulants
   D. contraceptives
   E. antiarrhythmic drugs

7. What medicines are antagonists of green tea?
A. heparin
B. paracetamol
C. psychostimulants
D. aspirin
E. antiarrhythmic drugs

8. Which substances in tea lead to decrease of absorption of alkaloid-containing drugs?
   A. organic acids
   B. caffeine
   C. tannins
   D. essential oils
   E. pigments
CHAPTER 13

COFFEE

Coffee (Arabic Qahwa – "stimulating drink") - a drink (usually hot) made of roasted coffee tree beans. Due to the content of caffeine it has a stimulating effect. The name coffee comes from Kaffa – an area in the south-west of Ethiopia where, according to the legend, the first tonic properties of this plant were discovered.

Classification of coffee

Species and varieties. More than 200 species of coffee tree are known. But only three types of trees are of interest:
- Arabian Coffee (C. arabica);
- Congolese Coffee (C. robusta);
- Liberica Coffee – occurs in many countries as a mix of arabica or robusta coffee.

These are the types that the main varieties of coffee are created. Thousands of varieties of coffee are known, they are divided into blended and unblended coffees.
- Blended varieties of coffee are mixtures of ground coffee beans. These coffee beans may belong to different types of coffee trees. They can be gathered in different plantations in different continents, at different times of the year.
- Unblended varieties of coffee are coffee beans taken from one species of coffee trees. They may be known as a country or locality, in which this type of coffee is grown, for example, Colombian coffee as well as the name of the port, through which they are delivered to the whole world, for example, coffee Santos named after the famous port of Santos in Brazil.

International Classification of coffee:
- The category of Mild (Mild - "soft", "rather weak", "light") includes all the best varieties of Arabica coffee – from rare to common.
- The category of "Brazilian coffee" is lower-quality, sharp and coarse by taste, cheap beans. This name does not accurately reflect the reality since Brazil produces also soft varieties under the category Mild.
- The category that includes all varieties of Robusta coffee. They are inferior in taste and aroma of Arabica coffee varieties, they contain more caffeine (about 30-40%).

Coffee is also divided by the degree of roasting:

Easy "Scandinavian" roasting – the colour of grains is light brown. In this mode of roasting a small amount of oil comes out, and the process of caramelization begins.

The average degree of roasting – "Vienna" – a darker colour of beans (chocolate brown), and there is a more active isolation of essential oils, filling the coffee with luxurious flavours.

A strong degree of roasting – "French" – the beans become dark brown and begin to shine abundantly because of the released oils. When brewing the beverage obtained has a pronounced bitter taste.
The darkest roast – "Italian". Beans have a dark brown colour, turning into black and brown, the surface of the bean is oily. The taste is bitter, a little "moonshine".

There is also a special way of roasting coffee for espresso – the strongest degree of roasting. Beans are of black colour on the verge of charring, the surface is shiny, oily.

In the industrial production coffee roasted is by three different methods: thermal (contact and convective), dielectric and radiation.

Coffee also varies by the degree of grinding:

Coarse grind: rough or coarse, grind with particles as small as 0.8 mm. The time of coffee extraction is 6-8 min. It is suitable for brewing in the coffee machine in the piston coffee machine or in any vessel-pot.

Medium grind: can be used in many ways of brewing. The time of coffee extraction is 4-6 min.

Fine grind: used for coffee drinks made with filters. The time of its extraction is 1-4 min.

Fine espresso grind: it is necessary for espresso coffee machines, in which the jet of hot water is passed through the ground bean.

Pulverized grind: used exclusively for brewing Turkish coffee with ibriq (turkish coffee brewing pot, cezve).

Instant coffee is the extract of natural coffee. Depending on the manufacturing technology there are three kinds of it:

- Powder (spray)
- Granular (agglomerate)
- Sublimated ("freeze-dried")

Coffee powder
The cheapest way of producing instant coffee is production of powder. The raw coffee is purified, after that it is fried. Then beans are crushed into particles with the size of 1.5-2 mm.

The next process stage is extraction of soluble substances with hot water under pressure. This finely ground coffee is treated with hot water for 3-4 hours under the pressure of 15 atmospheres. After cooling the extract is filtered to remove insoluble and resinous substances and then dried with hot air. The resulting powder mass is cooled.

Agglomerate instant coffee – coffee in granules
The production cycle is not very different from the production of powder. The difference is only in the last stage when the powder is made into pellets by steam. It should be noted that the intense pressure alters the molecular structure of the bean and has an adverse effect on the flavour and taste of coffee.

Freeze-dried instant coffee
Sublimation (from the Latin sublimatio - "exaltation, rapture") is dehydration, drying of frozen products under vacuum at low pressure. Freeze drying retains the basic biological properties of the material since oxygen of the air does not oxidize and change the volume of the product. High quality products are obtained, approaching by their organoleptic characteristics to fresh products maximally keeping
all the original properties of natural coffee. The essence of the production lies in the
fact that coffee infusion is frozen at very low temperatures. As a result ice crystals are
formed. These crystals are dehydrated under vacuum, and then the dehydrated mass
is broken crystals of uneven form are obtained.

The advantages of instant coffee are the speed of brewing and extended storage
life (due to evaporation of organic coffee oils the natural coffee quickly loses flavour).

The main disadvantage is much weaker flavor than in the natural coffee.

The chemical composition of coffee

Coffee beans contain a great number of complex organic substances. Each
variety of coffee is characterized by its own special combination of substances.

The taste and aroma of coffee depend on the method of roasting and the
preparation technology, in which organic substances are subjected to chemical
transformations (Table 13.1).

<table>
<thead>
<tr>
<th>Components</th>
<th>Content in coffee. %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Raw</td>
</tr>
<tr>
<td>Water</td>
<td>11.3</td>
</tr>
<tr>
<td>Soluble substances (total)</td>
<td>29.5</td>
</tr>
<tr>
<td>Nitrogenous substances</td>
<td>12.6</td>
</tr>
<tr>
<td>Fats</td>
<td>11.7</td>
</tr>
<tr>
<td>Sugars</td>
<td>7.8</td>
</tr>
<tr>
<td>Dextrin</td>
<td>0.4</td>
</tr>
<tr>
<td>Cellulose</td>
<td>23.9</td>
</tr>
<tr>
<td>Hemicellulose</td>
<td>5.0</td>
</tr>
<tr>
<td>Ash elements</td>
<td>3.8</td>
</tr>
<tr>
<td>Caffeine</td>
<td>1.18</td>
</tr>
<tr>
<td>Caffetannic acid</td>
<td>8.4</td>
</tr>
<tr>
<td>Chlorogenic acid (the total of the free and bound acids)</td>
<td>9.6</td>
</tr>
</tbody>
</table>

By the chemical composition calculated with reference to dried substance in
raw coffee beans there are 32-36% extractive substances, and under normal storage
conditions their stability is within 7 years.

In raw coffee of three major species (Arabica, Robusta and Liberica) the
protein substances are practically in the same amount (amino nitrogen – 1.55-1.63%,
the total protein content – 9.69-10.19%). In the structure of coffee proteins there are
20 amino acids, including glutamine, asparagine, glycine and leucine. In coffee beans
γ-aminobutyric acid has been also foung, in raw coffee beans of Arabica and Liberica
pipecolic acid has been found.

\[
\text{Pipecolic acid}
\]

193
In the process of coffee roasting the composition of amino acids in proteins substantially remains unchanged, but many of them are significantly reduced (serine – trice, glycine – twice, etc.). The total protein content is reduced by about 15%.

Raw coffee beans have a high content of free amino acids. There is more than 1% of phenylalanine, more than 0.6% of glutamic acid. However, when roasting free amino acids vaporize almost completely leaving only traces of threonine, serine, valine, aspartic acid and glutamic acid. This is due to the fact that free amino acids enter into sugar amine and quinoneimine reactions, involve in formation of colour and coffee aroma.

The content of free fatty acids (mainly linoleic, palmitic and oleic) in raw coffee beans, is in higher grades about 0.5-3%, of lower quality beans – up to 20%.

The share of carbohydrates is 50-60% of the total mass of raw coffee beans. Carbohydrates in coffee are sucrose (6-10%), cellulose (5-12%), pectins (2-3%) and high molecular weight polysaccharides (cellulose, lignin, etc.). The main water-soluble component of macromolecular polysaccharides of raw coffee is arabinogalactan (2-5%).

Furthermore, glucogalactomannan, galactose, mannose and arabinose have been isolated from coffee beans.

When roasting deep changes occur in the carbohydrate complex of coffee. For example, sucrose is almost completely disappears (it is 0.56%) and the heat turns it into caramel that together with other soluble products of caramelization gives a brown colour to coffee. The start of roasting also decreases sharply the monosaccharide content, but at the end of the process it significantly increases: 1.25% of glucose, 1.1% of fructose, 0.15% of arabinose and 0.1% of galactose. This is explained by the fact that part of them is consumed for caramelization and melanoidin formation (primary and secondary stages of roasting), and then at a temperature of 205-220 ° C their concentration increases due to hydrolysis of cellulose, pentosans and other polysaccharides.

The water content in raw coffee beans by the rate adopted by the International Coffee Organization (ICO) should be 12 ± 1%. The moisture index of green coffee is essential to estimate its quality. The moisture content in raw coffee plays an important role in its exports and imports since all transactions between suppliers and buyers of coffee made on the basis of the moisture index expressed as percentage. Depending on the conditions of storage and transportation the moisture index of raw coffee can vary between 9-14%.

Most organic acids in coffee are in the form of salts, and only 1/3 in the free state. They include such acids as malic, citric, oxalic, acetic, caffeic, quinic, chlorogenic. Chlorogenic acid is the most valuable because it gives coffee a little astringent taste. Acidity of the raw coffee of different types and sorts is in the range from 2.4 to 4 T. With long-term (3-5 years) storage of raw coffee its acidity increases slightly.
Chlorogenic acids are mono- and diesters, caffeic and quinic acid are the major part of phenolic compounds and contain in raw coffee in the quantity of 7-10%. Robusta coffee species have a higher concentration (9-11%) than the species of Arabica coffee (5.5-8%).

The major part of chlorogenic acids is coffeoylquinic acids (in Arabica – 5.5-7% and in Robusta – 8-9%). Then there are dicoffeoylquinic acids (isochlorogenic acids) (in Arabica – 0.5-0.6%, in Robusta – 1.4-1.7%). Coffee contains feruloylquinic acid in less amount (in Arabica – 0.2-0.25%, in Robusta – 0.6-1.2%).

During roasting of coffee beans the content of chlorogenic acid dramatically reduces by 65-67%, of cryptochlorogenic acid by 2 times, of isochlorogenic acid – by 2.5-3 times. Decrease in the amount of chlorogenic acids occurs due to thermal destruction (increase of the proportion of caffeic and quinic acids) and their participation in reactions with amino acids and proteins formine dark-coloured products.

Phenolic acids in coffee beans also are represented by o-coumaric, 3,4-dimethoxycinnamic, 3,4,5-trimethoxy, sinapic, 4-methoxy cinnamic, ferulic and n-coumaric acid.

The mineral substance content in raw coffee beans is 3-4.5% depending on the sort of coffee, growing region, method of processing, the type of fertilizers introduced into the soil and products used for plant protection. With the help of atomic absorption spectrophotometry the quantitative mineral composition has been determined in coffee beans. The predominant element is potassium (about half), followed by magnesium and calcium (about 10 times less), sodium, iron, manganese, rubidium, zinc, copper, strontium, and traces of chromium, vanadium, barium, nickel, cobalt, lead, molybdenum, titanium and cadmium. A certain relationship between the amount of minerals and the quality of coffee beverage does not exist, but it is believed that the content of zinc, manganese, rubidium in raw beans determines the best properties of the finished coffee.

In addition, coffee contains vitamins – thiamin (B<sub>1</sub>), riboflavin (B<sub>2</sub>), pantothenic acid (B<sub>5</sub>), niacin (B<sub>3</sub>, PP), pyridoxine (B<sub>6</sub>) and tocopherol (E). When roasting of coffee beans a significant amount of nicotinic acid is formed, one cup of coffee can contain up to one third of the daily requirement of the vitamin. That is why coffee is one of prophylactic agent for avitaminosis of vitamin PP.
The content of water-soluble extractive substances in different types and varieties of raw coffee is not the same and is about 20-29%. The least amount is found in Arabica variety – 19-20%, and Robusta contains 24-27%. In raw coffee the content of extractive substances includes alkaloids, proteins, phenolic compounds, mono- and disaccharides, lipids, organic acids, amino acids, mineral elements and other substances in small quantities.

Trigonelline (methyl-betaine-nicotinic acid) in plants is formed by methylation of nicotinic acid. Its content in coffee varieties is: Arabica – 1-1.2% Robusta species – 0.6-0.74%, and in Liberica sort – only 0.2-0.3%. Trigonelline is readily soluble in water, but is thermally unstable. When processing coffee beans it is easily converted into nicotinic acid (vitamin PP), so it is considered to be a major precursor in formation of nicotinic acid in coffee beans. Trigonelline participates in formation of flavour and taste of coffee.

The major alkaloid in coffee is caffeine; it has absolutely no changes after the process of roasting coffee beans.

Caffeine is slightly bitter, but it does little for the taste of coffee. Caffeine is extracted well and is uniformly distributed in solution.

Different types of coffee are characterized by the following caffeine content (% of a dry substance): Arabica – 0.6-1.2, Robusta – 1.8-3, Liberica – 1.2-1.5. The amount of caffeine in beans varies greatly and depends on the sort of coffee. The caffeine content in beans plays a very important role when assessing the quality of the raw material and setting technical requirements for it.

Coffee beans have also such alkaloids as theobromine and theophylline.

The content of theobromine and theophylline in raw coffee beans is minor – 1.5-2.5 mg% and 4.1 mg%, respectively.

In beans of wild coffee plant pentacyclic diterpene glycoside – mascaroside (C_{12}H_{26}O_{11}) isolated from cultivated plants of coffee beans has been found.

Raw coffee beans contain polyamines (putrescine, spermine, spermidine), which form in deamination or oxidation of a variety of heterocyclic alkaloids.

\[
\begin{align*}
\text{Putrescine} & \quad \text{Spermine} \\
\begin{array}{c}
\text{C}_{2}\text{H}_{4}\text{N} \quad \text{C}_{3}\text{H}_{7}\text{N} \\
\uparrow \quad \uparrow \\
\text{N} \quad \text{N} \\
\text{C}_{2}\text{H}_{5} & \quad \text{C}_{3}\text{H}_{7}
\end{array}
\end{align*}
\]
The tannin content of raw coffee beans ranges from 3.6 to 7.7%, they give coffee its bitterness. In the roasting process (especially at a temperature of 175-205 °C) their amount drastically reduces and the final product has about 0.5-1.0% of tannins. They are very labile coffee component that are intensively oxidized under the action of polyphenoloxidase, at a temperature of 80-125 °C for 5-8 minutes of treatment. Further non-enzymatic conversion of tannins takes place, resulting in formation of products of secondary transformation – dark-coloured pigments.

Decrease of the amount of tannin during roasting is not considered to be a negative factor as it promotes the formation of flavour and colour of coffee. However, when overheating, tannin is fully decomposed. Blank or flat taste of roasted coffee can sometimes be partially explained by disappearance of tannin. Therefore, considering decomposition of both tannin and chlorogenic acid in the final product it is important to preserve at least part of phenolic compounds.

When roasting of coffee beans new *flavor substances*, which not existing before accumulate in them. The main one is coffeol – a complex mixture of volatile aromatic compounds that provide the characteristic aroma of coffee. Its composition, according to one source, includes 70 different substances, while different sources say that it includes even up to 220 different substances, including methyl alcohol, acetaldehyde, methylfurfurol, acetate, pyridine, etc., many of them are products of decomposition of proteins, fats, sugars, and other substances.

The resulting substances are very volatile and rapidly oxidized by atmospheric oxygen, and that is why it is recommended to roast coffee just before brewing.

**Adulteration of coffee**

Adulteration of coffee may be assortment and qualitative.
1. Costly components are replaced with cheaper products. For example, instead using natural coffee beans one can use other artificial substitutes or counterfeits painted in a coffee colour.
2. Coffee beans – beans surface are treated with oil to give a gloss.
3. Ground coffee: natural (no additives), with addition of chicory – partial or complete replacement with chicory, grain-containing coffee substitutes, acorns.
5. Sale of re-used coffee (waste from catering), which is again dried and packaged.

**Indicators of coffee quality**

*Organoleptic characteristics:* appearance, odour, flavour and aroma of the drink.

*Physicochemical:* moisture, pH, content of extractive substances, caffeine, total ash, organic and mineral impurities.

*Microbiological analysis:* the content of aflatoxins and pesticides.

**Determination of appearance.** It is determined visually, subject to the same conditions and the state of the surface layer of the same light. The smell of coffee beans is set organoleptically. It should not have moldy, medicinal, putrid and other foreign odours.

**Determination of flavour and aroma.** It is determined organoleptically in the beverage prepared from the sample of the roasted coffee. Drinks from the premium coffee should have a pleasant taste with distinctive hues (bitter, sour, with a slight taste of bread), a thin and delicate flavour and a strong infusion. Coffee drinks from
the first class should have a pleasant bitter, astringent flavour with a touch of sour, faintly aroma and a nice strong infusion. Coffee drinks from the second grade have abrupt and rude taste, poor flavour and a strong infusion.

_Determination of moisture._ High humidity of raw coffee (over 14%) leads to the growth of molds and spoilage. The optimum moisture content of raw coffee is considered to be 10-12%. Thus, the respiratory processes are slow, which, in turn, contributes to reducing the rates of biochemical processes in the tissue cells and prevents the loss of water-soluble solids by beans.

_Determination of pH_ is carried out by the potentiometric method.

_Determination of extractive substances_ is based on extraction of extractive substances and quantitative determination of the dried extract by the gravimetric method.

_Determination of the caffeine content_ in natural instant coffee is done by:
1. _Spectrophotometric method._ Determination is carried out by the standard method after pre-extraction of caffeine from coffee beans by the column chromatography.
2. _Photocolorimetry method._ By formation of murexide.

3. _Iodometric method._ Back titration, the indicator is starch.
Interaction with drugs  
Due to the caffeine content coffee changes the pharmacological effect of certain medicines. You should avoid drinking coffee while taking drugs that regulate the heart rhythm. Caffeine is an antagonist of sedative, hypnotic drugs. Medicines for treating of osteoporosis, thyroid diseases, antidepressants and hormonal agents should not be taken together with coffee.

Caffeine potentiates the effect of analgetics (citramon, citrapar, etc.). Some drugs increase the effect of caffeine on the human body (antidepressants, oral contraceptives and antibiotics); they block the enzyme in the liver CYP1A2, which promotes the absorption of caffeine in the body. Finally, caffeine retains in the body for longer period. The pharmacological effects of coffee can be weakened if diluted with milk that binds caffeine.

Caffeine dilates blood vessels of the brain, and it may sometimes substitute the use of drugs to relieve headaches, such as hypotension, meteopatia, sharp fluctuations in atmospheric pressure. However, with migraine headaches, vascular spasm in arteriosclerosis or high blood pressure, drinking coffee should be avoided.

Coffee stimulates the gastric juice, and it can promote gastritis and ulcers, therefore, in these diseases it is necessary to reduce or discontinue the use of coffee.

In the treatment with homeopathic medicines coffee should be completely avoided or limited by 1-2 cups per day, with an interval of 2-3 hours after taking the drugs.

Coffee reduces the effect of certain vitamins, such as vitamin A, $\beta$-carotene, vitamins of group B and selenium, so while taking them the use of, coffee should be limited.
QUESTIONS FOR SELF-CHECKING

1. Define the concept of coffee. What main types of coffee do you know?
2. Give the classification of coffee by the degree of roasting.
3. What is the instant coffee? What is the technology of its production? Name the main advantages and disadvantages of instant coffee.
4. Describe carbohydrates which are part of coffee, what happens with them in the process of roasting coffee beans?
5. What organic acids are there in coffee?
6. What alkaloids are found in coffee? Describe their properties.
7. Describe aromatic substances containing in roasted coffee.
8. What methods can the caffeine content in coffee be determined by?
9. Describe the possible interactions of coffee with drugs.
TASKS FOR SELF-CHECKING

1. What acid is the main organic acid in coffee?
   A. chlorogenic
   B. perchloric
   C. hydrochloric
   D. malic
   E. citric

2. What substance is formed in coffee from carbohydrates during the roasting of coffee beans?
   A. acetaldehyde
   B. caramelen
   C. glucose
   D. coffeol
   E. citric acid

3. The main mineral substance containing in coffee beans is:
   A. potassium
   B. magnesium
   C. calcium
   D. iron
   E. sodium

4. What new aromatic substances are accumulated in roasting of coffee beans?
   A. colophony
   B. coffeol
   C. acetaldehyde
   D. malic acid
   E. citric acid

5. Determination of the caffeine content in coffee is carried out by:
   A. acidimetry in the non-aqueous media
   B. indirect alkalimetry
   C. acidimetry
   D. argentometry
   E. iodometry

6. Caffein is the antagonist of:
   A sedatives
   B. laxatives
   C. analgesics
   D. iron preparations
   E. antacids
CHAPTER 14

SUGARS, HONEY AND ARTIFICIAL HONEY

Carbohydrates are the most widely distributed and abundant organic compounds on earth. They have a central role in the metabolism of animals and plants. Carbohydrate biosynthesis in plants starting from carbon dioxide and water with the help of light energy, i.e., photosynthesis, is the basis for the existence of all other organisms, which depend on the intake of organic substances with food.

Carbohydrates represent one of the basic nutrients and are quantitatively the most important source of energy. Even the nondigestible carbohydrates, acting as a bulk material, are of importance in a balance of daily nutrition.

The term carbohydrates goes back to times when it was thought that all compounds of this class were hydrates of carbon, on the basis of their empirical formula, e.g. glucose, C\(_6\)H\(_{12}\)O\(_6\) (6C+6H\(_2\)O).

Carbohydrates are commonly divided into monosaccharides, oligosaccharides and polysaccharides.

Sugar is the generalized name for sweet, short-chain, soluble carbohydrates.

Only a few of the sugars occurring in nature are used extensively as sweeteners. Besides, sucrose (saccharose), other important sugars are glucose (starch sugar or starch syrup); invert sugar (equimolar mixture of glucose and fructose); maltose; lactose; and fructose. In addition, some other sugars and sugar alcohols (polyhydric alcohols) are used in diets or for some technical purposes. These include sorbitol, xylitol, mannitol, maltulose, isomaltulose, maltitol, isomaltitol, lactulose and lactitol. Some are used commonly in food and pharmaceutical industries, while applications for others are being developed.

Nutritional and physiological properties

The role of carbohydrates in metabolism is primarily determined by the ability of disaccharides to be hydrolyzed in the gastrointestinal tract and by the mechanisms of monosaccharide absorption. The human organism hydrolyzes sucrose, lactose and oligosaccharides of the maltose and isomaltose type. The enzyme lactase, which is responsible for lactose hydrolysis, is absent in some adults.

Glucose and galactose are actively transported, while all other monosaccharides are transported only by diffusion. Sugar phosphorylation occurs preferentially in the liver. All monosaccharides, which are metabolized, can be interconverted. Sugar alcohols are oxidized: sorbitol —> fructose, xylitol —> xylulose. However, only glucose can enter the insulin-regulated and -dependent energy metabolism and be utilized by all tissues.

Galactose is rapidly transformed into glucose and is therefore nutritionally equal to glucose. Oral intake of glucose and galactose causes a rapid increase in blood sugar levels and, as a consequence, insulin secretion. All other monosaccharides are primarily metabolized by the liver and do not directly affect the glucose status or insulin release. After fructose intake, insulin secretion is only 50% of that after glucose intake.
Sugars to be avoided by diabetics are, therefore, glucose, galactose, lactose and maltose.

Fructose, xylitol, sorbitol and mannitol can be well tolerated by diabetics and sucrose, invert sugar and a hydrogenated glucose syrup are only moderately well tolerated. Some oligosaccharides are bifidogenic because they enter the large intestine and promote the growth of Bifidobacteria there. This is desirable because potential pathogenic microorganisms (Enterobacteriaceae, Clostridia), which cannot metabolize these oligosaccharides, are simultaneously suppressed. Apart from vitamins, natural substances with an antioxidative effect, minerals and trace elements, n-3 and n-6 polyunsaturated fatty acids, bifidogenic oligosaccharides belong to the components of nutraceuticals or functional foods.

These are products, which not only have a pure nutritional value, but also offer a physiological advantage, which promotes health. They contain, e.g., substances, which inhibit cancer or reduce cholesterol, protect against infections of the gastrointestinal tract, reduce blood pressure, etc. Bifidogenic oligosaccharides and inulin belong to the group of prebiotics. These are indigestible substances, which promote the growth of bifidobacteria in the intestine or possibly other microorganisms. In this way, they should have positive effects on health.

### Table 14.1

<table>
<thead>
<tr>
<th>Substance</th>
<th>Resorption</th>
<th>Utilization in metabolism</th>
<th>Effect on the blood sugar level and insulin secretion</th>
<th>Other properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sucrose</td>
<td>Effective after being</td>
<td>Hydrolysis to fructose and</td>
<td>Moderately high</td>
<td>Cariogenic</td>
</tr>
</tbody>
</table>

D-glucose

b-D-glucopyranose

D-galactose

b-D-galactopyranose

D-fructose

b-D-fructopyranose
<table>
<thead>
<tr>
<th>Hydrolyzed Glucose</th>
<th>Effective Insulin-dependent in all tissues</th>
<th>High</th>
<th>Less cariogenic than sucrose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glucose</td>
<td>Effective</td>
<td>High</td>
<td>Less cariogenic than sucrose</td>
</tr>
<tr>
<td>Fructose</td>
<td>Faster than by diffusion process</td>
<td>Low</td>
<td>Accelerates alcohol conversion in the liver</td>
</tr>
<tr>
<td>Lactose</td>
<td>Effective after being hydrolyzed</td>
<td>High</td>
<td>Intolerance by humans lacking the lactase enzyme; laxative effect</td>
</tr>
<tr>
<td>Sorbitol</td>
<td>Diffusion</td>
<td>Low</td>
<td>Slightly cariogenic and laxative</td>
</tr>
<tr>
<td>Mannitol</td>
<td>Diffusion</td>
<td>Low</td>
<td>Slightly cariogenic and laxative</td>
</tr>
<tr>
<td>Xylitol</td>
<td>Diffusion</td>
<td>Low</td>
<td>Not cariogenic, available data indicate an anticariogenic effect; mildly laxative</td>
</tr>
</tbody>
</table>

**Sucrose (beet sugar, cane sugar)**

Sucrose is widely distributed in nature, particularly in green plants, leaves and stalks (sugar cane – 12-26%; sweet corn – 12-17%; sugar millet – 7-15%; palm sap – 3-6%); in fruits and seeds (stone fruits, such as peaches; core fruits, such as sweet apples; pumpkins; carobs or St. John's bread; pineapples, coconuts; walnuts; chestnuts); and in roots and rhizomes (sweet potatoes – 2-3%; peanuts – 4-12%; onions – 10-11%; beet roots and selected breeding forms – 3-20%). The two most important sources for sucrose production are sugar cane (*Saccharum officinarum*) and sugar beet (*Beta vulgaris ssp. vulgaris var. altissima*). Cane sugar and beet sugar are distinguished by the spectrum of accompanying substances and by the ratio of isotopes. Sucrose is the most economically significant sugar and is produced
industrially in the largest quantity.

Honey is the oldest known sweetener and has relatively recently been displaced by cane sugar. Cane sugar was brought to Europe from Persia by the Arabs. After the Crusades, it was imported by Cyprus and Venice and, later, primarily by Holland, from Cuba, Mexico, Peru and Brazil.

In 1747 Marggraf discovered sucrose in beets, and in 1802 Achard was the first to produce sucrose commercially from sugar beets. The new sugar source had a great economic impact; sucrose accumulation in the beets was increased by selection and breeding.

**Production of beet sugar**

The isolation of beet sugar will be described first because the processes used in material preparation and sugar separation have been developed to perfection. These processes were later transferred to the production of cane sugar from the clear juice concentration stage onwards. In fact, cane sugar was processed fairly primitively for a long time. Prolonged selection efforts have led to sugar beets, which reach their maximum sucrose content of 15-20% in the middle of October. Currently, beet varieties have high sugar content and small amounts of non-sugar substances. Anatomically they have a favourable shape, i.e. are small and slim with a smooth surface, and have a firm texture. Since the sugar accumulation in beets peaks in October and since the sugar decomposition due to respiration occurs during subsequent storage of beets, they are rapidly processed from the end of September to the middle of December.

The beet sugar extract contains about 17% of sucrose, 0.5% of inorganic and 1.4% of organic nonsucrose matter. The invert sugar and raffinose content is 0.1% (in molasses this may be as high as 2%). Trisaccharide kestose, which is present in the extract, is an artifact generated in the course of beet processing.

**Other sources for sucrose production:**
- *Date sugar* is obtained from date palm (Algeria, Iraq);
- *Palm sugar* is from various palm species, e.g. palmyra, saga or Toddy palm, coconut and Nipa palm (India, Sri Lanka, Malaysia and the Philippines);
- *Maple sugar* is obtained from the maple tree (*Acer saccharum*) found solely in North America (the USA and Canada) and Japan.
- *Sorghum sugar*. Sugar sorghum (*Sorghum dochna*) stalks contain 12% of sucrose. This source was important earlier in the USA. Sugar sorghum is processed into sorghum syrup on a small scale on individual farms in the Midwestern United States.

**Packaging and storage**

Sucrose is packaged in paper, jute or linen sacks, in cardboard boxes, paper bags or cones, in glass containers and in polyethylene foils; the latter serving as lining in paper, jute or wooden containers.

Sugar is stored at a relative humidity of 65-70% in a loose form in bins or by stacking the paper or jute sacks. The unbagged, loose or bulk sugar is distributed to industry and wholesalers in bins on trucks or rail freight cars.
Types of sugar

Sucrose is known under many trade and popular names. These may be related to its purity grade (raffinade, white, consumer's berry, raw or yellow sugar), to its extent of granulation or crystal size (icing, crystal, berry and candy sugar, and cube and cone sugar) and to its use (canning, confectionery or soft drink sugar). Liquid sugar is a sucrose solution in water with at least 62% solids (of which a maximum of 3% is invert sugar). The invert sugar content is high in liquid invert sugars and invert sugar syrups. Such solutions are easily stored, handled and transported. They are dosed by pumps and are widely used by the beverage industry (soft drinks and spirits), the canning industry and ice cream makers, confectionery and baking industries, and in production of jams, jellies and marmalades. Use of liquid sugar avoids the additional crystallization steps of sugar processing and problems associated with packaging of sugar. Criteria for the analytical determination of sugars are: (a) colour; (b) colour extinction coefficient (absorbance) of 50% sugar solution expressed in ICUMSA-units; (c) the ash content determined from conductivity measurements of 28% aqueous sugar solutions; (d) the moisture content; (e) optical rotation; and (f) criteria based on the content of invert sugar.

Composition of some sugar types

The chemical composition of the given type of sugar depends on the extent of sugar raffination. A raffinade, as mentioned above, consists of practically 100% of sucrose. Washed raw beet sugar has about 96% of sucrose, < 1.4% of moisture, 0.9% of ash and 1.5% of nonsugar organic substances. Berry sugar consists of 98.8% of sucrose, 0.70% of moisture, 0.20% of ash and 0.29% of nonsugar organic substances. The presence of raffinose, a trisaccharide, is detected by high optical rotation readings or by the presence of needle- or spearlike crystals.

Molasses

Molasses obtained after sugar beet processing contain about 60% of sucrose and 40% of other components (both on the dry basis). The nonsucrose substances expressed as percent weight of molasses include: 10% of inorganic salts, especially those of potassium; raffinose (about 1.2%); trisaccharide kestose, an artifact of processing; organic acids (formic, acetic, propionic, butyric and valeric); and N-containing compounds (amino acids, betaine, etc.). The main amino acids are glutamic acid and its derivative, pyrrolidone carboxylic acid. Molasses are used in production of baker's yeast; in the fermentation technology for production of ethanol and citric, lactic and gluconic acids, as well as glycerol, butanol and acetone; as an ingredient of mixed feeds; or in production of amino acids.

Effervescent lemonade powders

The powder or compressed tablets (effervescent bonbons) are used for preparation of artificial sparkling lemonades. They contain sodium bicarbonate and an acid component (lactic, tartaric or citric acid). When dissolved in water, they generate carbon dioxide. Other constituents of the product are sucrose or another sweetener, and natural or artificial flavouring substances. Sodium bicarbonate and acids are often packaged and marketed separately in individual capsules or in two separate containers.
Honey

Bees produce honey by mixing nectar, which is a sweet substance secreted by flowers, with bee enzymes. Honey is made up of 35% of protein and contains half of all the amino acids, and is a highly concentrated source of many essential nutrients, including large amounts of carbohydrates (sugars), some minerals, B-complex vitamins, and vitamins C, D, and E.

Honey is used to promote energy and healing. It is a natural antiseptic and makes a good salve for burns and wounds. Honey is also used for sweetening other foods and beverages. It varies somewhat in colour and taste depending on the origin of the flower and nectar, but, in general, it is approximately twice as sweet as sugar, so not as much is needed for sweetening purposes. People who have diabetes or hypoglycemia should be careful when consuming honey and its by-products. These substances affect blood sugar levels in the same way that refined sugars do. Tupelo honey contains more fructose than other types of honey and it is absorbed at a slower rate, so some people with hypoglycemia can use this type sparingly without ill effects.

Buy only unfiltered, unheated, unprocessed honey, and never give honey to an infant under one year of age. In its natural form, honey can contain spores of the bacteria that cause botulism. This poses no problem for adults and older children, but in infants, the spores can colonize the digestive tract and produce the deadly botulin toxin there. Honey is safe for babies after age one.

Honey is produced by honeybees. They suck up nectar from flowers or other sweet saps found in living plants, store the nectar in their honey sac, and enrich it with some of their own substances to induce changes. When the bees return to the hive, they deposit the nectar in honeycombs for storage and ripening. Honey production starts immediately after the flower pollen, nectar and honeydew are collected and deposited in the bee's pouch (honey sac). The mixture of the raw material is then given to worker bees in the hive to deposit it in the six-sided individual cells of the honeycomb. The changing of nectar into honey proceeds in the cell in the following stages: water evaporates from the nectar, which then thickens; the content of invert sugar increases through sucrose hydrolysis by acids and enzymes derived from bees, while an additional isomerization of glucose to fructose occurs in the honey sac; absorption of proteins from plant and bees, and acids from the bee's body; assimilation of forage minerals, vitamins and aroma substances; and absorption of enzymes from the bees' salivary glands and honey sacs. When the water content of the honey drops to 16-19%, the cells are closed with a wax lid and ripening continues, as reflected by a continued hydrolysis of sucrose by the enzyme invertase and by the synthesis of new sugars.

Production and types

In the production and processing of honey, it is important to preserve the original composition, particularly the content of aroma substances, and to avoid contamination. The following kinds of honey are differentiated according to recovery techniques:

Comb Honey (honey with waxy cells), i.e. honey present in freshly-built, closed combs devoid of brood combs (young virgin combs). Such honey is produced in high
amounts. In some countries, primarily in the USA, Canada and Mexico, it is widely available. A darker coloured honey is obtained from covered virgin combs not more than one year old and from combs, which include those used as brood combs.

Extracted honey is obtained with a honey extractor, i.e. by centrifugation at somewhat elevated temperatures of brood-free comb cells. This recovery technique provides the bulk of the honey found at the market. Gentle warming up to 40 °C facilitates the release of honey from the combs.

Pressed honey is collected by compressing the brood-free honey combs in a hydraulic press at the room temperature.

Strained honey is collected from brood-free, pulped or unpulped honey combs by gentle heating followed by pressing.

Beetle honey is recovered by pulping honey combs, which include brood combs. This type of honey is used only for feeding bees. Based on its use, honey is distinguished as:

Honey for Domestic use. This is the highest quality product, and is consumed and enjoyed in a pure form.

Baking honey. This type of honey is not of high quality and is used in place of sugar in the baking industry. Such honey has spontaneously fermented, to a certain degree has absorbed or acquired other foreign odours and flavours, or was overheated. This category includes caramelized honey.

According to the recovery (harvest) time, honey is characterized as: early (collected until the end of May); main (June and July); and late (August and September). Honey can be classified according to the geographical origin, e.g., German (Black Forest or Allgau honey), Hungarian, Californian, Canadian, Chilean, Havanian, etc. The flavour and colour of honey are influenced by the kinds of flowers from which the nectar originates. The following kinds of honey are classified on the basis of the type of plant from which they are obtained.

Flower honey, e.g., from heather; linden; acacia; alsike, sweet and white clovers; alfalfa; rape; buckwheat and fruit tree blossoms. When freshly manufactured, these are thick, transparent liquids, which gradually granulate by developing sugar crystals. Flower honey is white, light-to-dark, greenish-yellow or brownish. Maple tree honey is light amber; alfalfa honey, dark-red; clover honey, light amber-to-reddish; and meadow flower honey, amber-to-brown. Flower honey has a typical sweet and highly aromatic flavour that is dependent on the flavour substances, which together with the nectar are collected by the bees; it sometimes has a flavour reminiscent of molasses. This is especially true of honey derived from heather (alfalfa and buckwheat honeys).

Honeydew honey (pine, spruce or leaf honey-dew). This type of honey solidifies with difficulty. It is less sweet, dark coloured, and may often have a resinous terpene-like odour and flavour.

Processing
Honey is marketed as a liquid or semi-solid product. It is usually oversaturated with glucose, which granulates, i.e. crystallizes, within the thick syrup in the form of glucose hydrate. To stabilize liquid honey, it has to be filtered under pressure to remove the sugar crystals and other crystallization seeds. Heating of honey decreases its viscosity during processing and filling, and provides
complete glucose solubilization and pasteurization. Heating must be gentle since the low pH of honey and its high fructose content make it sensitive to heat treatment. As with other foods, continuous, high temperature-short time processing (e.g., 65°C for 30 s followed by rapid cooling) is advantageous. Processing of honey into a semi-solid product involves seeding of liquid honey with fine crystalline honey to 10 % and storing for one week at 14 °C to allow full crystallization. This product is marketed as creamed honey.

**Physical properties**

Honey density (at 20 °C) depends on the water content and may range from 1.4404 (14% water) to 1.3550 (21% water). Honey is hygroscopic and hence is kept in airtight containers. Most honeys behave like Newtonian fluids. Some, however, such as alfalfa honey, show thixotropic properties, which are traceable to the presence of proteins, or dilating properties (as with opuntia cactus honey) due to the presence of trace amounts of dextran.

**Composition**

Honey is essentially a concentrated aqueous solution of invert sugar, but it also contains a very complex mixture of other carbohydrates, several enzymes, amino and organic acids, minerals, aroma substances, pigments, waxes, pollen grains, etc. The following table presents data on its composition.

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Average value</th>
<th>Variation range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>17.2</td>
<td>13.4-22.9</td>
</tr>
<tr>
<td>Fructose</td>
<td>38.2</td>
<td>27.3-44.3</td>
</tr>
<tr>
<td>Glucose</td>
<td>31.3</td>
<td>22.0-40.8</td>
</tr>
<tr>
<td>Saccharose</td>
<td>2.4</td>
<td>1.7-3.0</td>
</tr>
<tr>
<td>Maltose</td>
<td>7.3</td>
<td>2.7-16.0</td>
</tr>
<tr>
<td>Higher sugars</td>
<td>1.5</td>
<td>0.1-8.5</td>
</tr>
<tr>
<td>Others</td>
<td>3.1</td>
<td>0-13.2</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>0.06</td>
<td>0.05-0.08</td>
</tr>
<tr>
<td>Minerals (ash)</td>
<td>0.22</td>
<td>0.20-0.24</td>
</tr>
<tr>
<td>Free acids³</td>
<td>22</td>
<td>6.8-47.2</td>
</tr>
<tr>
<td>Lactones</td>
<td>7.1</td>
<td>0-18.8</td>
</tr>
<tr>
<td>Total acids</td>
<td>29.1</td>
<td>8.7-59.5</td>
</tr>
<tr>
<td>pH value</td>
<td>3.9</td>
<td>3.4-6.1</td>
</tr>
<tr>
<td>Diastase value</td>
<td>20.8</td>
<td>2.1-61.2</td>
</tr>
</tbody>
</table>

**Water**

The water content of honey should be less than 20%. Honey with a higher water content is readily susceptible to fermentation by osmophilic yeasts. Yeast fermentation is negligible when the water content is less than 17.1%, while between 17.1 and 20% of fermentation depends on the count of osmophilic yeast buds.
Carbohydrates

Fructose (on average 38\%) and glucose (on average 31\%) are the predominant sugars in honey. Other monosaccharides have not been found. However, more than 20 di- and oligosaccharides have been identified, with maltose predominating, followed by kojibiose. The composition of disaccharides depends largely on the plants from which the honey is derived, while geographical and seasonal effects are negligible. The content of sucrose varies appreciably with the honey ripening stage.

During the long-term storage and in inappropriate conditions glucose of honey forms 5-hydroxymethyl furfural (5-HMF):

\[
\text{H}_2\text{C} = \text{C} - \text{H} + \text{H}^+ , t^0 \rightarrow \text{HOH}_2\text{C} - \text{CH} = \text{C} - \text{OH} + 3\text{H}_2\text{O}
\]

5-HMF is a volatile compound; it interacts with aniline or procaine inflicted on a filtration paper, which covers a test tube. The result is a yellow colour. Then the furan cycle opens up with formation of a polymethine dye (a raspberry-violet colour). The supposed mechanism of this reaction is:

\[
\text{HOH}_2\text{C}_\text{-O}_{\text{H}} \text{C} = \text{O} \xrightarrow{\text{H}_2\text{N-R}_1} \text{HOH}_2\text{C}_\text{-O}_{\text{H}} = \text{CH} - \text{N= R}_1 \xrightarrow{\text{H}_2\text{N-R}_1} \text{HOH}_2\text{C}_\text{-C} = \text{CH} = \text{N= R}_1
\]

5-HMF can be determined with resorcinol in the presence of concentrated sulphuric acid:

\[
\text{HOH}_2\text{C}_\text{-O}_{\text{H}} = \text{C} = \text{O} + \text{HO} - \text{C}_{\text{H}} = \text{OH} \xrightarrow{\text{H}_2\text{SO}_4 ; t^0} \text{HOH}_2\text{C}_\text{-C} = \text{CH} = \text{N= R}_1
\]

Raspberry (red-violet) colouring

Enzymes

The most prominent enzymes in honey are \(\alpha\)-glucosidase (invertase or saccharase), \(\alpha\)- and \(\beta\)-amylases (diastase), glucose oxidase, catalase and acid phosphatase. Invertase and diastase activities, together with the hydroxymethyl furfural content, are of significance for assessing whether or not the honey was heated. After hydrolysis processes most of oligosaccharides are cleaved into monosaccharides. Thermal inactivation of invertase in honey and its half-life values at various temperatures have been thoroughly investigated. Practically all invertase
activity is derived from bees.

The enzymatic oxidation by-product, hydrogen peroxide, is partly responsible for a bacteriostatic effect of nonheated honey. The enzymatic oxidation yeilds gluconic acid, the main acid in honey.

**Pigments**

Relatively little is known about honey colour pigments. The amber colour appears to originate from phenolic compounds and from products of the nonenzymic browning reactions between amino acids and fructose.

**Toxic Constituents**

Poisonous honey (pontius or insane honey) has been known since the time of the Greek historian and general, Xenophon, and the Roman writer, Plinius. It comes mostly from bees collecting their nectar from rhododendron species (Asia Minor, Caucasus Mountains); some plants of Ericaceae family; insane ("mad") berries; Kalmia evergreen shrubs; Eurphorbiaceae; and honey collected from other sweet substances, e.g., honeydew exudates of grasshoppers. Rhododendrons contain the poisonous compounds, andromedotoxin (an acetylandromedol) and grey anotoxins I, II and III (a tetracyclic diterpene) used in medicine as a muscle relaxant (I: \( R^1 = OH, \ R^2 = CH_3, \ R^3 = COCH_3 \); II: \( R^1, R^2 = CH_2, \ R^3 = H \); III : \( R^1 = OH, \ R^2 = CH_3, \ R^3 = H \)) (see Formula).

![Formula](image)

The poisonous nature of New Zealand honey is a result of tutin and hyenanchin (mellitoxin) toxins from the tutu shrub (tanner shrub plant, Coriaria arbora). Poisonous flowers of tobacco, oleander, jasmine, henbane (Datura metel) and of hemlock (Conium maculatum) provide nonpoisonous honeys. The production of these honeys is negligible in Europe.

**Storage**

Honey colour generally darkens on storage, the aroma intensity decreases and the content of hydroxymethyl furfural increases depending on pH, the storage time and temperature. The enzymatic inversion of sucrose also continues at a low level even when honey has reached its final density. Honey should be protected from the air moisture and kept at temperatures lower than 10°C when stored. The desired temperature range for use is 18-24°C.

**Utilization**

Honey use goes back to prehistoric times. Beeswax and honey played an important role in ancient civilizations. They were placed into tombs as food for deceased spirits, while the Old Testament describes the Promised Land as "a land flowing with milk and honey". In the Middle Ages honey was used as an excellent
energy food and, up to the introduction of cane sugar, served as the only food sweetener. Besides being enjoyed as honey, it is used in baking (honey cookies, etc.) or in the manufacturing of alcoholic beverages by mixing with alcohol (honey liqueur, "beartrag") or by fermentation into honey flavoured wine (Met). Medicines containing honey, in combination with milk and cereals, are processed for children. Tobacco products are occasionally flavoured with honey. In medicine, honey is used in pure form or prescribed in medications such as honey milk, fennel honey and ointments for wounds. It is incorporated into cosmetics in glycerol-honey gels and tanning cream products. The importance of honey as a food and as a nutrient is based primarily on its aroma constituents and the high content and fast absorption of its carbohydrates.

**Artificial Honey**

Artificial honey is mostly inverted sucrose from beet or cane sugar and is produced with or without starch sugar or starch syrup. It is adjusted in appearance, odour and flavour to imitate true honey. Depending on the production method such creams contain nonsugar constituents, minerals, sucrose and hydroxymethyl furfural.

**Production**

Sucrose (75% solution) is cleaved into glucose and fructose by acidic hydrolysis using hydrochloric, sulfuric, phosphoric, carbonic, formic, lactic, tartaric or citric acid or, less frequently, enzymatically using invertase. The acid used for inversion is then neutralized with sodium carbonate or bicarbonate, calcium carbonate, etc. The inverted sugar is then aromatized, occasionally with strongly flavoured natural honey. To facilitate crystallization, it is seeded with an invert sugar mixture that has already solidified, then packaged with automated machines. During inversion, an oligosaccharide (a "reversion dextrin") is also formed, mostly from fructose. Over inversion by prolonged heating results in a dark colouring of the product and in some bitter flavour. Moreover, glucose and fructose degradation forms a noticeable level of hydroxymethyl furfural – this could be used for identification of artificial honey.

Liquid artificial honey is made of inverted and neutralized sucrose syrup. To prevent crystallization, up to 20% of a mildly degraded, dextrin-enriched starch syrup is added (the amount added is proportional to the end-product weight).

**Composition**

Artificial honey contains invert sugar (>50%), sucrose (<38.5%) water < 22%), ash (<0.5%) and, when necessary, saccharified starch products (<38.5%). The pH of the mixture should be >2.5. The aroma carrier is primarily phenylacetic acid ethyl ester and, occasionally, diacetyl, etc. The hydroxymethyl furfural content is 0.08-0.14%. The product is often coloured with certified food colours.

**Utilization**

Artificial honey is used as a sweet spread for bread and for making Printen (honey cookies covered with almonds), gingerbread and other baked products.
QUESTIONS FOR SELF-CHECKING

1. Define the concept of sugar. Give the classification of carbohydrates.
2. Chemical composition, nutritional and dietary values of sugars.
3. What advice can you give on the use of sugar-containing products for people suffering from diabetes?
4. Define the concept of honey.
5. Describe the chemical composition of honey.
6. Provide basic methods of honey adulteration.
7. Name the main types of honey.
8. Define the concept of artificial honey.
9. What substance can appear in honey during its long term storage and wrong conditions of storage? How can it be determined?
TASKS FOR SELF-CHECKING

1. Which carbohydrates is sucrose composed of?
   A. Fructose and galactose
   B. Glucose and fructose
   C. From two molecules of glucose
   D. Glucose and galactose
   E. Xylose and arabinose

2. What hormone regulates the blood glucose level?
   A. Insulin
   B. Glucagon
   C. Adrenaline
   D. Hydrocortisone
   E. Testosterone

3. What is the main enzyme of honey?
   A. Inulase
   B. Reductase
   C. Lipase
   D. Amylase
   E. Invertase

4. Which substance is produced during the long-term storage of honey?
   A. Insuline
   B. Reductase
   C. 5-HMF
   D. Acraldehyde
   E. Invertase
CHAPTER 15

ALCOHOLIC BEVERAGES

Alcoholic beverages are produced from sugar-containing liquids by alcoholic fermentation. Sugars fermentable by yeasts are either present as such or are generated from the raw material by processing, i.e. by hydrolytic cleavage of starches and dextrins, yielding simple sugars. The most important alcoholic beverages are beer, wine and brandy. Beer and wine were known to early civilizations and were produced by a well-developed industry.

The distillation process for liquor production was introduced much later. The nutritional energy value of ethanol is high (29 kJ/g or 7 kcal/g).

Among alcoholic beverages there are:
• products with the low alcohol content made by fermentation of sugar- or starch-containing materials;
• products with the high alcohol content are prepared by distillation of products with the low alcohol content.

Sometimes the amount of alcohol in the product with its low content is increased by adding distillates, especially in the case of wine.

In accordance with the technical regulations the drinking alcohol is rectified ethyl alcohol with the ethyl alcohol content not more than 95% of the finished products produced from the food raw material and diluted with the demineralized water.

The main types of alcoholic beverages are:

**Vodka** is an alcoholic beverage that is made on the basis of ethanol produced from the food raw material and water, with the ethanol content from 38 to 56% of the final product.

**Wine** is an alcoholic beverage, which is produced from wine materials, with the content of ethyl alcohol produced from the food raw material not more than 22% of the final product.

**Natural wine** (including sparkling and champagne) is an alcoholic product with the content of ethyl alcohol not more than 15% of the final product, which is produced without the addition of ethyl alcohol, aromatic agents and flavours of the wine materials produced without addition of ethyl alcohol, aromatic agents and flavourings. If an organization produces wine without addition of ethyl alcohol, i.e. obtained by natural fermentation of grape or fruit raw material, but it adds sugar or flavour additives to this wine, such a wine can not be considered natural.

**Beer**

Beer making or brewing involves the use of germinated barley (malt), hops, yeast and water. In addition to malt from barley, other starch- and/or sugar-containing raw material is important, e.g., other kinds of malt such as wheat, unmalted cereals called adjuncts (barley, wheat, corn, rice), starch flour, starch degradation products and fermentable sugars. The use of the additional raw material may necessitate in part the use of microbial enzyme preparations.
Beer owes its invigorating and intoxicating properties to ethanol; its aroma, and flavour are due to a bitter taste of hops, kiln-dried products and aroma constituents formed during fermentation; its nutritional value is due to the content of unfermented solubilized extracts (carbohydrates, protein); and, finally, its refreshing effect is due mainly to carbon dioxide.

**Raw material**

**Barley**

Barley is the most important of the raw material used for beer production. Different cultivars of the spring barley (*Hordeum vulgare convar. distichon*) with exceptionally suitable properties are used for brewing and malting barley in Germany. In addition, six-row winter barley has an increasing role. Barley of high brewing value provides sufficient quantities of the extract from the resultant malt, and has a high starch, but moderate protein (9-10%) content, a high degree of germination (at least 95% of kernels), high germination vigor and good swelling ability. Sensory assay (hand appraisal) should also be included in the evaluation of barley.

**Foam formers**

The foam-forming properties of beer are due to proteins, polysaccharides and bitter constituents. Three-glucans stabilize the foam through their ability to increase viscosity. Addition of semi-synthetic polysaccharides, e.g., propylene glycol alginate (4 g/hectoliter) to beer provides a very stable foam although the addition is judged as unfavourable. Lysophosphatidyl cholines (LPC), which occur in cereal as amylose inclusion compounds, reduce the foam stability. The temperature conditions during the fermentation process regulates the LPC concentration because it determines the activity ratio of α-amylase, which contributes to the release of LPC from amylose, to phospholipase B, which catalyzes degradation of LPC. Temperatures above 65 °C favour the more stable α-amylase, increasing the LPC concentration.

**Beer brands**

**Top fermented beers**

Selected examples of top fermented beers from Germany are: Berlin weiss beer is, brewed from a wort having 7-8% of solids from barley and wheat malts and inoculated in fermentation with yeast and lactic acid bacteria; Bavarian weiss beer is brewed from weakly-smoked barley malt with a little wheat malt and fermented only with yeast; Graetzer beer is made of wheat malt with a smoky flavour and with a stemwort content of 7-8%; malt beer (caramel beer) is a dark, sweet and slightly hop-flavoured full beer.

*Pale ale* is a beer, which uses a top-fermenting yeast and predominantly pale malt. It is one of the world's major beer brands.

*Stout and porter* are dark beers made using roasted malts or roast barley, and typically brewed with slow fermenting yeast.

*Mild* has predominantly a malty taste. It is usually dark coloured with the alcohol content of 3% to 3.6%; although there are lighter hued Milds, as well as stronger examples reaching 6% and higher.
Wheat beer is brewed with a large proportion of wheat although it often also contains a significant proportion of malted barley.

Lager is the English name for cool fermenting beers of the Central European origin. Pale lagers are the most commonly consumed beers in the world.

Lambic, a beer of Belgium, is naturally fermented using wild yeasts, rather than cultivated. Many of these are not strains of brewer's yeast (*Saccharomyces cerevisiae*) and may have significant differences in aroma and sourness.

**Diet beers**

Diet beers exhibit a high degree of fermentation and contain almost no carbohydrates, which are undesirable for diabetics. They are produced by special fermentation processes and contain a relatively high alcohol content. Subsequently, the alcohol level is frequently reduced to values typical of normal beer.

**Low-alcohol or alcohol-free beers**

Production of low-alcohol and alcohol-free beers is possible by application of suitable technological procedures, e.g., decrease of fermentation and use of special yeasts, reduction of the stemwort content, and elimination of the alcohol formed (distillation, ultracentrifugation).

**Export beers**

They originate from widely different brands of beer. They are mostly pasteurized and additionally treated with flocculating or adsorption agents (tannin, bentonite) or with proteolytic enzyme preparations to remove most of the proteins. The proteolytic enzymes split the large protein molecules into soluble products. Such beers are free of cloudiness or turbidity (chill-proofed beers) even after prolonged transport and cold storage.

**Beer flavour and beer defects**

Apart from a great variety of terms for odour notes, the terms bitter, salty, metallic, and alkaline are used only for taste and the terms sour, sweet, "body", etc. are applied to both taste and odour.

Foaming is an important criterion of the taste of beer. A distinction is made between the foam volume (produced by the content of carbon dioxide), foam density, and especially foam stability (caused by protein degradation products, bitter hop compounds, and pentosans). The lower content of fatty acids that are present in beer bouquet act as defoamers.

Beer defects affect the odour and taste and are caused by improper production and storage. An example of a taste defect is the harsh, hard, bitter taste caused by oxidation of polyphenols and some hop constituents. A flat taste, as already mentioned, comes from the low content of carbon dioxide. Diacetyl and ethanal in concentrations greater than 0.13 mg/l and 25 mg/l, respectively, produce a taste defect. Acceleration of fermentation caused, e.g., by intensive stirring of the wort, raises the content of diacetyl and higher alcohols in beer and lowers the content of esters and acids, on the whole, negatively influencing on the aroma. Higher concentrations of
ethanal can be, e.g., at higher fermentation temperatures and higher yeast concentrations.

The main substance for defects is (E)-2-nonenal. However, experiments have shown that its concentration does not reach the odour threshold value (0.11 ug/l beer) during longer storage of beer.

**Wine**

Wine is an alcoholic beverage made of fermented grapes or other fruits. Wine is a beverage obtained by full or partial alcoholic fermentation of fresh, crushed grapes or grape juice (a must). The woody vine grape has thrived in the Mediterranean region since ancient times and Italy, France and Spain are still among the leading wine-producing countries in the world. Other major producers are USA, Argentina, Chile, Germany and South Africa.

**Grape cultivars**

Among the cultivated species of *Vitis*, the most important is the grapevine *Vitis vinifera*, L. ssp. *vinifera* in its many forms; more than 8,000 cultivars are known. The size, shape and colour of the grapes vary: there are round, elongated, large or small grape clusters. Grapes are either wine-type grapes, for white or red wine making, or table grapes, which are even grown in greenhouses in some northern countries. The cultivars are different in the sugar content and aroma. The European *V. vinifera* and the American vines (*V. labrusca*) were hybridized in order to produce pest-resistant forms (hybrids, "direct producers"), giving plants with pest resistance and good quality must production, although the hybrids still leave much to be desired. The wines are considered rather ordinary, with less character and a more obtrusive flavour than the parent plants.

Sucrose (dry sweetening) or grape must concentrates are added. To improve the quality, the **sweetness reserves** of the wine can be raised by addition of grape must. The fermentation of this must is prevented by cold sterile storage, short-time heating (87 °C) or saturation with CO₂ (15 g/1, pressure tank). The bouquet (aroma) is not improved. Poor or inferior wine is not improved by amelioration. Deacidification is achieved primarily by adding calcium carbonate, which may give either a precipitate of calcium tartrate or a mixture of calcium tartrate and calcium malate.

In addition, the residual sugar, aldehydes and pyruvate are degraded so that less SO₂ is required in a subsequent sulfur treatment step. Growth of the lactic acid bacteria is promoted by increasing the temperature to 20 °C and stirring up the yeast settling.

Wine blending is a suitable way of eliminating defects, refreshing old wines, deepening the colour of red wines (table wines) and enhancing the bouquet or readjusting the low acid content, thus producing a uniform quality wine for the market.

Tartaric or citric acid can be added to low-acid wines from southern European countries. The addition of gypsum or phosphate treatment to enhance the color of red wines used in the case of certain southern wines (e.g., Malaga, Marsala) is based on increase in the colour yield caused by lowering the pH with CaSO₄ or CaHPO₄.
Composition

The chemical composition of wine varies over a wide range. It is influenced by environmental factors, such as climate, weather and soil, as well as by cultivar and by storage and treatment of grapes, must and wine.

Within the scope of wine analysis, the analysis of wine extract, alcohol, sugar, acids, ash, tannins, colour pigments, nitrogen compounds and bouquet-forming substances is important. Hence, the value and quality of a wine is assessed by the content of ethanol, extract, sugar, glycerol, acids and bouquet substances. With the large number of quality-determining constituents, the evaluation and classification of wine are possible only by combination of chemical analysis and sensory testing.

Carbohydrates

Carbohydrates (0.03-0.5%) present in fully fermented wines are small amounts of hexoses glucose and fructose and of nonfermentable pentoses. Incompletely fermented wines contain higher concentrations of both hexoses, but substantially more of the slower fermenting fructose. The average ratio of glucose to fructose in the residual sugar of wine is 0.58:1, but it varies to a great extent. The pentose sugars, which are present in fermented wines, consist of 0.05-0.13% arabinose, 0.02-0.04% rhamnose, and xylose in trace amounts.

Ethanol

The ethanol content of wine varies over a wide range. Normal grape wines, according to vintage and cultivar, have the ethanol content of 55-110 g/l. Light wines contain 55-75 g/l; average wines – 75-90 g/l; and stronger wines – 90-110 g/l or more. The ethanol content of strong wines is 110-130 g/l. The alcohol level above 144 g/l indicates addition of ethanol.

Other alcohols

Methanol occurs in wines at a very low level (38-200 mg/l), but much more it is present in fermentation of pomace as a product of pectin hydrolysis. Brandy distilled from pomace often contains 1-2% methanol. Higher alcohols in wine are propyl, butyl and amyl alcohols, which constitute 99% of the wine fusel oil. Hexyl, heptyl and nonyl alcohol and other alcohols, including 2-phenylethanol (up to 150 mg/l), are present in small amounts. D-Mannitol is not present in healthy wines, but is present in spoiled, bacteria-infected wines at levels up to 35 g/l.

Acids

The pH of grape wine is between 2.8 and 3.8. The titratable acidity in wines is between 4 and 9 g/l (expressed as tartaric acid). Acid degradation and cream of tartar precipitation decrease the acid content of ripe wines. Red wines generally contain less of acids than white wines.

Wine acids from grapes are tartaric, malic and citric acids and acids from fermentation and acid degradation are succinic, carbonic (carbon dioxide) and lactic acids, as well as some amounts of some volatile acids. The presence of acetic and propionic acids, as well as an anomalous amount of lactic acid, is an indication of
diseased wine.

*Botrytis cinerea* can form gluconic acid in concentrations up to 2 g/1 of the must. Therefore, this acid is found in the corresponding wines.

**Phenolic compounds**

Red wines contain phenols in considerably higher concentrations than white wines. Exceptions are gentisic and ferulic acid, but relatively high concentrations of the last mentioned compound are characteristic of Riesling. In the process of red wine maturation tannins are subjected to polymerization.

**Spoilage**

As with beer, defects in wine are in its appearance, odour and taste and, if not controlled, they result in complete spoilage. Of importance is browning due to oxidative reactions of phenolic compounds, which in red wine may result in complete flocculation of the colour pigments. This oxidative darkening process is as much chemical as enzymatic (polyphenoloxidases). Sulfurous acid is the preferred agent to prevent browning. Once the wine is affected by browning, it may be lightened by treatment with activated charcoal. The charcoal treatment can also remove other defects, such as the taste of mash or rotten grapes. Proteins, tannins or pectins can cause cloudiness (black casse). The so-called copper casse or turbidity is based on formation of Cu$_2$S and other compounds with monovalent copper. Cu$^{2+}$ ions present in wine reduce in the presence of SO$_2$ excess.

**Dessert wines**

Dessert wines are those with a high alcohol content, which can not be derived directly from fermentation of a fresh grape must, and/or are wines with a high sugar content. They are made principally by two processes, which can be combined to a certain extent:

- Fermentation of grape juice of an exceptionally high sugar concentration, or blending of concentrated grape juices with normal wines (the concentrated dessert wine).
- When the must is sufficiently fermented, alcohol or concentrated must mixed with alcohol is added (spirit-enriched dessert wine), stopping further fermentation.

Among a great number of dessert wines coming from southern European countries, several are worthy of mention: Hungarian dessert wines, Szamorodny, fortified Tokay and Tokay essence; and the French Haute Sauternes – they are concentrated dessert wines.

**Wine-like beverages**

*Fruit liquor (Fruit brandy)*

Whole fruits of the various sweet cherry cultivars are partly crushed together with the seeds and a pulp. The fruits are left to ferment for several weeks using a pure yeast culture. The fermented mash is then distilled in a copper still on an open fire or is heated with steam. During distillation the first and last fractions are separated. The
main distillate contains 60 % by volume or more alcohol. It is usually diluted with water to about 40-50 of alcohol by volume, and clear, colourless brandy is obtained. Plum brandy is produced from fully-ripe plums in a similar way to Kirschwasser, though mostly no seed crushing is involved. Besides Germany and Switzerland (Pfluemli water), major producers are the Balkan states, Czech Republic and France.

Fruit spirits are obtained from a fresh or frozen fruit pulp or juice to which alcohol has been added prior to distillation. Fruits and berries used for this purpose are apricot, peach, bilberry, raspberry, strawberry, red currant, etc. Pome fruit liquor is obtained from freshly fermented apple or other pome fruits, either whole or crushed, or their juices, without prior addition of sugar-containing materials, sucrose or alcohol of some other origin. The alcohol content of liquor from pome fruits is at least 38% by volume. Hydrogen cyanide plays an important role in the chemical composition of fruit liquors of either stone or pome fruit. The cherry liquor sold at the market contains about 0.3-60 mg of hydrogen cyanide per litre of alcohol. In the same range there are the concentrations of benzaldehyde (at least 20 mg/l) and the bouquet substances (about 7-15 mg/100 ml). Plum brandy contains less hydrogen cyanide (0.6-21.3 mg/l).

**Gentian liquor ("Enzian")**

Gentian brandy is a product obtained by distilling the fermented mash of gentian roots, or in which a gentian distillate is used. The raw material is the roots of many plants of the gentian family, which in the fresh state contain substantial amounts of sugars (6-13%) in addition to the bitter glycoside-type compounds, such as gentiopicrin, amarogentin and others. The major production regions are the Alps (Tyrol, Bavaria, Switzerland), as well as the French and Swiss Jura mountains.

**Juniper liquor (Brandy) and gin**

Juniper brandy is obtained from pure alcohol and/or a grain distillate by addition of a juniper distillate or its harsh, raw brandy. The use of juniper oil is uncommon. Juniper spirit is made exclusively of the distillate of whole juniper berries or from a fermented aqueous extract of juniper. The berries of *Juniper communis* are processed into brandy in Germany, Hungary, Austria, France and Switzerland. Pure juniper brandy is also used as an intermediate product for production of alcoholic beverages with a juniper flavour as, for example, in Geneva gin. Common gin is made from juniper distillates and spices, and contains at least 38% of alcohol by volume. Dry gin has an alcohol content of at least 40% by volume.

**Rum**

Major rum-producing countries are Jamaica, Cuba, Barbados, Puerto Rico, Guyana and Martinique, as well as Brazil and Mauritius.

Rum production in sugar cane-cultivating regions uses the sugar syrup or the freshly pressed extract, often with addition of such by-products as foam skimmings, molasses, press-skimmings and their extracts, the residue leftover from the previous distillation. The sugar-containing solutions are diluted and allowed to ferment spontaneously at the maximum temperature of 36°C and then are usually distilled in simple pot stills. Parts of aromatic plants are occasionally added to increase the
aroma of the fermenting mash. This results in rum brands with different aromas. The quality of individual products fluctuates greatly. Jamaican rum is especially highly appreciated; it is marketed in various quality grades. A general classification divides them into drinking and blending types. Export rums have an alcohol content of about 76-80% by volume ("original rum"). Rum has the most intense aroma of all the distilled spirits enjoyed as drinks. This is acquired only after long aerobic aging in casks, by absorption of extracted substances from oakwood, and by formation of esters and other aroma constituents during aging. Original rum contains about 80-150 mg acids per 100 ml calculated as acetic acid. A large part occurs in a free form as acetic and formic acids, the rest, along with other low molecular weight fatty acids, is esterified. The ester content and composition are of utmost importance for assessment of the aroma quality.

**Arrack**

Arrack is made of rice, sugar cane molasses, or sugar-containing plant juices (primarily from the sweet coconut palm extract or its bloomy spadix) by fermentation and subsequent distillation. Dates are used for the same purpose in the Middle East. Countries, which produce arrack, are Indonesia (Java), Sri Lanka, India (Malabar coast) and Thailand. In comparison to rum, arrack is not available in very many varieties. It is imported as the "original arrack" with an alcohol content of 56-60% by volume, from which "true arrack" is obtained by dilution with water to 38-50% of alcohol by volume. At least a tenth of the alcohol in arrack blends must be from genuine arrack.

**Liquors from cereals**

Typical products are grain alcohol and whiskey (American and Irish brands are usually spelled with an "e", while Scottish and Canadian brands tend to use "whisky"). Different cereals (rye, wheat, buckwheat, oats, barley, corn, millet) are used. The cereals are first ground, mixed with acidified water, and made into an uniform mash by starch gelatinization. The enzymes are inactivated by heating the mash to 62 °C. The sweet mash is fermented by a special yeast and is then distilled.

The main volatile compounds are:
- higher alcohols;
- carbonyl compounds (acetaldehyde, propanal, isobutanal, pentanal, hexanal etc.);
- organic acids (valeric, caproic, caprylic, capric).

The total acid content in mg/l is 200 for cognac, 100 for Scotch whisky, 400 for bourbon whiskey and 600 for a rum with a good aroma.

- esters, especially those derived from short chain acids and from aliphatic alcohols ("fruit" esters), play an important role in forming odour and taste of distilled spirits. Ethyl acetate predominates, followed by the ethyl, isobutyl and 3-methylbutyl esters of lower fatty acids.
- other compounds. This group includes various phenols (p-methyl and p-ethylguaiacol, guaiacol, etc.), terpenes derived from essential oils, the bitter glycosidic compounds of gentian brandy (gentianarin, etc.) and, finally, the nitrogen compounds (e.g., pyridines, picolines and pyrazines) found in rum and whiskey.
Miscellaneous alcoholic beverages

Many liquors are made "cold" by simply mixing the purified alcohols of various brands with water and are named according to the place of origin: Klarer, Weisser, East-German, etc. Such mixes often contain flavourings (seasonings, spices), e.g., freshly distilled or aged grain liquor, extracts of caraway, anise, fennel, etc., as well as sugar, essence, essential oils or other flavouring substances. These products are designated as aromatized liquors. Some examples are:

*Vodka* (in Russian = diminutive of water) is made of alcohol and/or a grain distillate by a special process. In all cases the characteristic smoothness and flavour must be achieved. The flavour should be neutral. The extract content is 0.3 g/100 ml and the alcohol content is at least 40% by volume.

*Aquavit* is a liquor flavoured primarily with caraway. It is made of a distillate of herbs, spices and contains at least 35% of alcohol by volume (potato alcohol or grain distillate). It is a favourite type of liquor in the Scandinavian countries.

*Bitters* are made of alcohol and bitter and aromatic plant or fruit extracts and/or their distillates, fruit saps and natural essential oils, with or without sugar, i.e. starch syrup. This group of products includes Boonekamp, bitter drops, English and Spanish bitters, and Angostura. The so-called "Aufgesetzter" is made of black currants and spirit or grain alcohol.

*Absinthe* is a liqueur flavoured with aromatic constituents of wormwood and other aromatic plants. It becomes turbid after dilution with water.

*Other Products.* Some special liquors of the regional importance should be mentioned, such as tequila and mescal from Mexico and South America made of fermented sap of the agave cactus; and liquors from the Middle East made of sultana raisins, figs or dates.

Liqueurs (Cordials)

Liqueurs are alcoholic beverages with 20-35% by volume alcohol and 220-500 g/1 of sucrose or starch syrup, and flavoured with fruit, spices, extracts or essences.

**Fruit Sap liqueurs**

Fruit liqueurs contain the sap of fruits, which give the liqueur its name. Examples of fruit liqueurs are pineapple, strawberry, cherry, blackberry liqueurs, etc. Cherry brandy, a special type of a cherry liqueur, consists of a cherry sap, cherry-water, sucrose or starch syrup, wine essence and water.

**Other liqueurs**

Other liqueurs include:

Crystal liqueur, which contains sugar crystals (e.g., "crystal caraway").

Allasch, a special aromatic alcohol- and sugar-rich caraway liqueur with at least 40% of alcohol by volume.

Ice liqueur, which is mixed and drunk with ice (e.g., lemon ice liqueur), and has an extract content of at least 30 g/100 ml and a minimum alcohol content of 35% by volume.
**Mixed drinks**

Mixed drinks or cocktails are mixtures of liquors, liqueurs, wines, essences, fruit and plant extracts, etc. They are prepared immediately before drinking in restaurants or bars, or are marketed as ready-made cocktail mixes or as their separate constituents.

There are common and specific methods of adulteration for alcoholic beverages given in Table 15.1.

<table>
<thead>
<tr>
<th>Name</th>
<th>Method of adulteration</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Common</strong></td>
<td></td>
</tr>
<tr>
<td>Alcoholic beverages</td>
<td>Industrial alcohol: partial or total replacement</td>
</tr>
<tr>
<td></td>
<td>Water: dilution, complete replacement</td>
</tr>
<tr>
<td><strong>Specific</strong></td>
<td></td>
</tr>
<tr>
<td>Liquors</td>
<td>The use of synthetic dyes</td>
</tr>
<tr>
<td></td>
<td>The use of synthetic flavourings</td>
</tr>
<tr>
<td>Wines</td>
<td>Dilution with the cheaper wine</td>
</tr>
<tr>
<td></td>
<td>Bad, sour wine &quot;improved&quot; by adding water to a known volume, and then adjusting the acidity of the strength to a certain extent regulated by the current standard</td>
</tr>
<tr>
<td></td>
<td>Treatment of a sour wort with alkaline agents, as well as addition of sugar either before or during fermentation</td>
</tr>
<tr>
<td></td>
<td>Maceration and fermentation of a sugar syrup in the pomace (pulp) remaining after separation of the grape juice Adding glycerol to reduce acidity, bitterness, to increase sweetness and to stop the fermentation process</td>
</tr>
<tr>
<td></td>
<td>Use of preservatives (salicylic acid and other antiseptics) in order to accelerate the technological process. For example, salicylic acid is used for preservation of cheap, wines easily turned sour and wines that have not passed the stage of maturation and storage</td>
</tr>
<tr>
<td></td>
<td>Fake of bouquet (mixtures of various esters and ethers – entanic, valerianic, amyl valerianic, butyric etc., as well as dried grape flowers)</td>
</tr>
<tr>
<td></td>
<td>Technological adulteration</td>
</tr>
<tr>
<td></td>
<td>Preparation of artificial wines</td>
</tr>
<tr>
<td>Cognac</td>
<td>Substitution by a product with a little age</td>
</tr>
</tbody>
</table>
Substitution by the alcoholic solution of tea infusion
Tinting cognac by alcoholic infusion of tea
Substitution of an alcohol tincture based on the plant raw material with a high content of tannins (oak chips, walnut shells, etc.)

There are three methods to detect adulteration by industrial alcohol:
- organoleptic;
- physical;
- chemical.

Organoleptic method determines the taste and smell of alcoholic beverages. The presence of foreign odours and flavours can be determined only at high concentrations of contaminants. It is difficult to detect small but dangerous doses of contaminants, it requires a high level of professionalism.

There are simple and affordable ways to conduct qualitative analysis:
1. The method for determining the presence of fusel oil based on its proper peculiar smell. A sample of a few drops should be rubbed by hands, the appearance of a specific smell indicates the presence of fusel oil. A pure sample of the alcohol or vodka has no odour.

2. The method of detection of synthetic dyes in alcoholic beverages is based on changing the pH by addition of any alkali solution (ammonia, soda and even a soap solution) in the volume excesses the volume of a beverage. When changing the pH natural dyes of red, blue, purple colours (anthocyanins) change their colour: red – to a dirty blue, blue and violet – to red and brown. The colour of synthetic dyes in the alkaline medium is not change. Drinks of yellow, orange and green colour after addition of the alkaline solution should be boiled. Natural dyes (carotene, carotenoids, chlorophyll) are destroyed, and the colour of the drink varies: yellow and orange colours fade, green colour becomes brownish-green or dark green.

3. Synthetic flavours prepared on the oil base can be detected by rubbing a few drops of beverage by hands. Thus, at the end of rubbing when alcohol and water evaporate the feeling of oiliness should appear. However, this method is unsuitable if flavours prepared on the alcoholic base.

When buying alcoholic beverages the attention should be paid to the following things:
- The stopper on the bottle must not be scrolled.
- If the bottle turn over, the content should not leak.
- The label must be attached exactly: the back or the front of the label on the bottle itself, or the stopper must be marked by the date of manufacture.
- Vodka, liquors, wines must be transparent, without any foreign inclusions.
- It is necessary to pay attention to the completeness of filling: factory bottling involves filling the bottle to the middle of the neck – no more, no less.

**Indicators of the quality of alcoholic beverages**

*Organoleptic parameters* (colour, transparency, aroma, taste);

*Physical and chemical indicators*:
- The total one for alcoholic beverages – determination of the volume fraction
of ethanol (strength), which is normalized in%.

- For potable ethyl alcohol and vodka – the mass concentration of aldehydes, fusel oils, esters, alkalinity (for vodka), the furfural (for alcohol), the test on methyl alcohol is performed.
- For alcoholic beverages – the mass concentration of the total extract, sugar and acids calculated to citric acid.
- For wines and brandies – the mass concentration of sugars (g/dm³), iron, and copper (dm³), for cognac the mass concentration of methyl alcohol is also determined, and for wine – the mass concentration of titratable and volatile acids, the given extract, total and free sulfuric acid, and for sparkling wines – carbon dioxide pressure in the bottle at 20°C.
- For beer – the mass fraction of solids in the initial wort (%), the mass fraction of alcohol (%), acidity, colour, the mass fraction of CO₂ (%), resistance and fermentation time (in days).

**Organoleptic analysis**

The results of the organoleptic study is expressed in standard units – points. A 10-point system, in which the maximum score of the beverage examined can not be more than 10, is used. Each indicator is set depending on its importance, the next highest score is colour and transparency – 2, flavour – 4, taste – 4. Those drinks that have more than 8.5 points are recognized to be of high-quality.

**Determination of odour and taste**

Approximately 50 ml of the sample is put into a tasting glass, and after premixing with rotational movements aroma and flavour of the product are estimated.

**Determination of transparency**

The method is based on visual determination of the product transparency in transmitted light or on the light screen. The test product in the amount of 10 ml is placed in a colourless glass test tube and transparency is determined in transmitted light or on the light screen. In the absence of turbidity the product is considered to be transparent. Turbidity determination is also carried out photoelectrocolorimetrically.

**Determination of colour**

Colour is determined visually in transmitted light or by the colorimetric method using the optical density value that is characteristic for each product.

To determining the colour by the visual method take 10 ml of the test product and place into a test tube of a transparent glass, and then determine the colour in transmitted light. Assess the colour and intensity of the colour of the product.

**Determination the completeness of filling**

The method is based on determining the amount of the sample in a bottle with the help of glassware for measuring.

To determine the completeness of filling take the content of a bottle and transfer into a graduated volumetric flask. Check the volume in 30 sec after transferring to verify the amount of the product.

Underfill is determined quantitatively by introduction of the additional volume of the sample in a volumetric flask with a 0.05 cm³ pipette.

Overfill is determined quantitatively by subtraction of the excess volume of the
sample in a volumetric flask with a 0.05 cm³ pipette.

**Determination of strength**

The method is based on measuring the concentration of ethyl alcohol in the distillate obtained after the preliminary distillation of ethanol from the test sample.

**Determination of the mass concentration of the total extract**

The total mass concentration of the extract is determined by a refractometer with alcohol remaining after distillation from the test sample. Reading is made by the sucrose scale.

**Determination of the mass concentration of sugar**

1. The mass concentration of sugar is determined by the chemical method of direct titration. It is based on reduction of Fehling's reagent with invert sugar. A certain volume of Fehling's solution with a fixed concentration is titrated with the solution to be analyzed containing the sugar to complete recovery of copper oxide (II) to copper oxide (I). The end of titration is determined by methylene blue.

\[
\text{R-COOH} + \text{NaOH} \rightarrow \text{R-COONa} + \text{H}_2\text{O}
\]

2. The sugar content is determined refractometrically, similar to the determination of the mass concentration of the total extract.

**Determination of acidity**

The total acidity is determined by titration of a sample with 0.1 M sodium hydroxide solution. The end of titration is set by changing the colour of the indicator (bromothymol blue) or potentiometrically (in a dark-coloured product).
### Table 15.2

<table>
<thead>
<tr>
<th>Medicine</th>
<th>Result of interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNS depressants (sedatives, tranquillizers, antihistamines, antipsychotics, analgesics, antipyretics, NSAIDs)</td>
<td>Potentiation of the inhibitory action on the central nervous system</td>
</tr>
<tr>
<td>Hypnotics and benzodiazepine tranquilizers</td>
<td>Potentiation of the inhibitory action on the central nervous system</td>
</tr>
<tr>
<td></td>
<td>Stimulate development of addiction and ethanol abuse</td>
</tr>
<tr>
<td>Antidepressants, MAO inhibitors</td>
<td>Development of a hypertensive crisis</td>
</tr>
<tr>
<td>Diphenine</td>
<td>Blockade of biotransformation, increasing its toxicity</td>
</tr>
<tr>
<td>Antihypertensives</td>
<td>Development of orthostatic collapse</td>
</tr>
<tr>
<td>Vasodilators</td>
<td>Potentiation of the vasodilator effect, collaptoid state</td>
</tr>
<tr>
<td>Glycerol trinitrate, antispasmodics</td>
<td>Acute circulatory insufficiency, collapse</td>
</tr>
<tr>
<td>Diuretics</td>
<td>Manifestations of hypokalemia (vomiting, diarrhea, decreasing of the blood pressure)</td>
</tr>
<tr>
<td>Indirect anticoagulants</td>
<td>Bleeding, hemorrhage in the internal organs (including the brain)</td>
</tr>
<tr>
<td>Oral contraceptives</td>
<td>Decrease the effectiveness of contraceptives</td>
</tr>
<tr>
<td>Paracetamol</td>
<td>A significant increase in toxicity of paracetamol, manifestation of its hepatotoxic action</td>
</tr>
<tr>
<td>Aspirin</td>
<td>The acute increase in the ability of aspirin antiplatelet, increased bleeding Ulceration of the gastric mucosa</td>
</tr>
<tr>
<td>Vitamin B3, tryptophan, zinc medicines</td>
<td>Potentiation of the toxic effects of ethanol on the liver</td>
</tr>
<tr>
<td>Thiamine, ascorbic acid, antioxidants</td>
<td>Decrease of toxic effects of ethanol on the liver</td>
</tr>
<tr>
<td>Metronidazole, furazolidone, cephalosporins, antidiabetic agents, sulfonlurea derivatives, medicines of arsenic and mercury, thiol poisons</td>
<td>Significant strengthening of the toxic effect of ethanol (by blocking alcohol dehydrogenase)</td>
</tr>
<tr>
<td>Unitherol, acetyl cysteine, methionine</td>
<td>Reducing toxic effects of ethanol (by increasing the activity of alcohol dehydrogenase)</td>
</tr>
<tr>
<td>Inducers of microsomal liver enzymes (barbiturates, phenytoin, steroids, etc.)</td>
<td>Development of cross-tolerance</td>
</tr>
</tbody>
</table>
QUESTIONS FOR SELF-CHECKING

1. Define the concept of drinking alcohol.
2. Give the main types of alcoholic beverages.
3. Describe the process of beer production, the raw material used in it.
4. What are the indicators of quality and possible defects of beer?
5. Describe the types of wine, its production and the chemical composition.
6. What are the defects of wine?
7. Enumerate the types of hard alcoholic beverages, describe their composition.
8. Name the methods of adulteration of alcoholic beverages.
9. Describe the main indicators of quality of alcoholic beverages.
10. Describe the possible interactions between alcohol and medicines.
TASKS FOR SELF-CHECKING

1. Alcoholic beverage containing ethyl alcohol not more than 15% of the final product, which is produced without addition of ethyl alcohol is:
   A. vodka
   B. wine
   C. beer
   D. natural wine
   E. liquor

2. The most important raw material used in production of beer is:
   A. barley
   B. foaming agents
   C. wheat
   D. enzyme preparations
   E. millet

3. What is the specific material for gin production?
   A. barley
   B. juniper
   C. wheat
   D. grapes
   E. millet

4. What is the method of determination of total acidity in alcoholic beverages?
   A. acidimetry
   B. alkalimetry
   C. nitritometry
   D. argentometry
   E. refractometry

5. What drug causes hepatotoxicity due to use of ethanol?
   A. glycerol trinitrate
   B. metronidazole
   C. metamizole sodium
   D. hydrocortisone
   E. paracetamol
CHAPTER 16

FOOD ADDITIVES

Food additives are natural, identical to natural or synthetic (artificial) substances that are deliberately introduced into the food with the purpose of giving certain properties (Law of Ukraine "On the quality and safety of food products and food raw material").

Food additives have been known for thousands of years. People in prehistoric times received and used some chemicals for food. It is known that 400 years BC Egyptians stained wine and sweets with flowers, leaves and fruits of various plants, used salt and smoke for smoking. Meanwhile, in Asia, saffron was used not only as a spice, but also as a colouring agent for food products. Vinegar, honey, spices, pepper, etc. were also used as food. Later, the Romans began to use natural dyes such as turmeric and saffron, spices – nutmeg, cinnamon, and for the wine stabilization – sulfur dioxide, etc. However, their widespread use began in the late XIXth century and was associated with the growth of population and its concentration in urban areas, causing a need to increase food production, improvement of traditional technologies of their production with the use of the achievements of chemistry and biotechnology, advanced trading techniques. Today we can identify several reasons for wide use of food additives by food producers. They are:

• modern methods of trading under conditions of transportation of food products (including perishable) at long distances; it determined the use of additives extending the preservation of their quality;
• rapidly changing individual ideas of the modern consumer about food, including its taste and attractive appearance, low cost, easy to use; – satisfaction these needs causes the use of fragrances and dyes;
• creation of new types of food corresponding to the modern standards of nutrition science: functional products (analogues of meat, dairy and fish products, products with low or high content of sugar and fat, low-calorie foods); it is associated with the use of food additives regulating food consistency;
• reduction of the areas for agricultural production;
• obtaining of extra-profits.

The main goals of food additives introduction (Fig. 16.1.) include:

1. Improvement of the technology of food preparation and processing of the raw material, production, packaging, transportation and storage of food (without masking effects of the use of low-quality or damaged material, or technological operations in unsanitary conditions).
2. Conservation of the natural qualities of the food.
3. Improvement of organoleptic characteristics or the structure of food and increase of their stability.
By the Commission of FAO/WHO according to the Codex Alimentarius food additives are any substances, which are not used as food or food ingredients, regardless of their nutritional value, and specially added for technological purposes or to improve the organoleptic properties of food and other products in their production, processing, transportation and storage. Thus, the primary function of the marketing of food additives is to improve the market quality of the products.

There are 23 main classes of food additives. Their list, subclasses and the corresponding technological function are as follows:

1. Antioxidants (synergists antioxidants, complexing agents) – increase the shelf life of foods by protecting against deterioration caused by oxidation, such as fat rancidity and colour changes;
2. Flour treatment agents (bleaching agents, dough improvers, flour improvers) – improve the baking properties of flour or its colour.
3. Substances that prevent caking and clumping (additives, which prevent hardening, reduce stickiness, drying agents, powders and separating substances) – reduce the ability of particles of food for sticking.
4. Substances which contribute the preservation of colour (colour fixatives and stabilizers) – stabilize, maintain or intensity the colour of the product.
5. Humectants (retain moisture / water, wetting agents) – prevent foods from drying out by neutralizing the influence of the air with low humidity.
7. Coating agents (film–forming agents, polishing agents) – when lubricating of the outer surface of the product give a brilliant view or form a protective layer.
8. Thickeners – increase the viscosity of food products.
9. Acids – increase the acidity and / or impart a sour taste.
10. Preservatives (antimicrobial, antifungal additives, supplements for fighting with bacteriophages, chemical sterilizing agents in the maturation of wines, disinfectants) – increase the shelf life of food, protect against damage caused by microorganisms.
11. Colourants – intensity and restore the colour of the product.
12. Fillers – substances other than water and air, which increase the volume of the product, without affecting significantly its energy value.
13. Defoamers – prevent or reduce formation of foam.
14. Foaming agents (frothing, aerating agents) – create the conditions for a uniform diffusion of the gaseous phase into liquid or solid foods.
15. Sweeteners (artificial sweeteners) – substances of the non-sugar nature that give the sweet taste of foods.
16. Propellant gases – gases other than air, ejecting the product from the container.
17. Disintegrants (baking powder, substances that promote the yeast action) – a substance or mixture of substances that release gas and increase the volume of the dough.
18. Acidity regulators (acids, bases, buffers, pH adjusters) – modify or regulate the acidity or alkalinity of the food product.
19. Stabilizers (binders, firming agents, moisture-and water-retaining agents, foam stabilizers) – allow to save a homogeneous mixture of two or more not miscible substances in food.
20. Plant tissue firming agents – make or keep tissues of fruits and vegetables fresh and dense, interact with gelling agents to form or strengthen a gel.
21. Flavour enhancers (enhancers, taste modifiers, additives that facilitate cooking) – enhance the natural flavour and (or) the smell of food.
22. Emulsifiers (emulsifiers, emollients, dispersing additives, surfactants, additives, wetting agents) – form or maintain a homogenous mixture of not miscible phases in food.
23. Emulsifying salts (salt-melters, complexing agents) – interact with proteins of cheeses to prevent separation of fats when manufacturing cheese.

Recently a great number of complex food additives have appeared. Under this name the industrially manufactured mixtures of food additives of the same or of various technological purpose, which composition may include also biologically active additives, flavourings and certain food ingredients, such as flour, sugar, starch, proteins, etc., are understood.

Such mixtures are not food additives, but technological additives of the complex action.

They have got a wide distribution in baking technology, production of confectionery and meat industry. Examples of these are extractive substances and fats hydrogenation catalysts – they do not improve the technological process, but implement it making it possible. Substances that increase the nutritional value of food products and substances referred to the group of biologically active substances such as vitamins, minerals, amino acids, etc., do not belong to food additives.

The number of food additives used in food production in most countries of the world now reaches 500 names without their combined mixtures: in the USA more than 1500, in the EU – 1200, in Russia – 415, in Germany – 350, in Ukraine – 221.

In the EU countries more than 400 fragrances and flavourings are allowed the use in the food industry. Until the early 90-ies of the XX-th century the use of food additives in Ukraine was limited in comparison with Europe and the United States.
In recent decades, the use of food additives has increased considerably: in 1994, according to the Decree of the Cabinet of Ministers, the use of 194 additives was allowed, and in 1990 they were already 221 ("About approval of the list of food additives authorized for use in foodstuffs "from 1999). Food additives can be referred to as individual substances (vanillin, benzoic acid, sodium ascorbate) or by the group name (dyes, antioxidants, stabilizers, etc.). Countries of the European Union has developed a rational system of the numerical codification of food additives known as "E-codes" (valid from 1953). It is included in the code for the food products (Codex Alimentarius, Ed.2, V.1) FAO/WHO as the international digital codification system of additives food (International Numbering System - INS).

To the each food additive a digital three-or four-digit number is assigned (in Europe, preceded by the letter E). Experts index E identify either as the word Europe or the abbreviation EG / EV, which in Russian also begins from the letter E, and also with the words ebsbar / (from German) – "edible ".

After some E-numbers there are small letters (a, b, c, etc.), which designate the classification section of additives. In some cases, after the E-code are small Roman numerals (I, II etc.), which specify the difference in the specification of a group of food additives and are not obligatory.

According to the proposed system, of digital coding of food additives their classification in accordance with the purpose is as follows:

- E 100 - E 182 – dyes;
- E 200 - E 299 – preservatives;
- E300 - E 399 – antioxidants;
- E 400 - E 449 – stabilizers of consistency;
- E 450 - E 499 – emulsifiers;
- E 500 - E 599 – acidity regulators, disintegrating agents;
- E 600 - E 699 – flavour enhancers;
- E 700 - E 899 – spare indexes for other possible information;
- E 900 - E 999 – glazed agents, flame dampers;
- E 1000 E 1521 – various technological functions.

Many food additives have complex technological functions that reveal depending on the features of the food system. For example, the additive E339 (sodium phosphate) can exhibit the properties of an acidity regulator, emulsifier, stabilizer, complexing agent and humectant; sorbitol E420 is a sweetener, but may be complexing agent, humectant, exhibit surface-active properties; edible tannins E181 are food dyes, emulsifier and stabilizer.

The World Food and Agriculture Organization, the World Health Organisation;

Safety of food additives. The use of food additives raises the question of their safety. It should be understood that the effect of any chemical substance on the human body depends on individual specific features of the organism and on the amount of a substance.

To protect public health and to limit the intake of food additives by a person the following factors are taken into account:
- MPC (mg / kg) – the maximum permissible concentration of foreign substances (including additives) in food;
- ADI (mg / kg) – acceptable daily intake;
- ADC (mg / day) – acceptable daily consumption – the value, calculated as a derivative of ADI by the mean of the body weight – 60 kg;
- TDI (mg / day) – tolerable daily intake – the value, calculated as the derivative of ADI by the mean of body weight – 60 kg;

Acceptable Daily Consumption (ADI) is a central issue to ensure safety of food additives in the last 30 years. For some food additives such a dose is a few mg / kg (e.g., sodium nitrite), for others it is tenths of g / kg (e.g., citric acid, aspartame).

The list of food products, in which it is appropriate to add food additives, has been regulated, as well as it is restricted or prohibited to use food additives in baby food products.

Adding food additives should not increase the risk, the potential adverse effect of the product on the consumer's health and reduce its nutritional value (except for certain products for special purpose and dietary products). Introduction of new food additives must be preceded by experimental studies in animals with the study of general toxicity, kinetics in the body, metabolism, study of long-term effects of food additives on 2-3 generations of animals (embryonic and gonadotoxicity, carcinogenicity, mutagenicity, allergenicity), clinical observations on human volunteers, and research concerning their identification and specification.

The study of food additives, determination of ADI, TDI, MPC is a complex process, which is time-consuming, very expensive, but extremely necessary and important for the health. It requires continuous attention and improvement.

When introducing food additives in the products it is necessary to keep the following requirements:
- add in the minimum required amounts to achieve the technological goals and do not exceed the amounts of MPC set by law;
- add only if the aim can not be achieved by other means;
- food additives should be non-toxic and do not increase the risk of morbidity of the population;
- food additives must have a high degree of purity (set by technical specifications).

Depending on the origin all the food additives are divided into three groups: natural, analogues of natural and synthetic substances.

For a long time food additives of the natural origin were considered to be harmless for human, and when using in food production they were preferred over synthetic analogues or natural substances. From a toxicological point of view, food additives, even of the natural origin, can not be completely harmless for the human health because the majority of toxic substances are of the natural origin.

The rapid development of chemistry at the end of the XX th century changed the opinion about the low toxicity of natural products. At the present moment more attention is paid to the study of their toxicity. However, food additives of the synthetic origin are now considered to be the most dangerous because they are...
xenobiotics, with which the human body during its evolution does not encounter and, therefore, there are no enzymes that convert them into non-toxic metabolites. The main aspects of the toxic effect of food additives are changes in the structure and function of the intestine, disorder of the oxidation-reduction reactions in the mitochondria, carcinogenicity, mutagenicity, neuro-, immuno-, embryotoxicity, allergenicity and pyrogenicity, the effect on reproduction.

In Ukraine it is possible to use only those food additives that are in the list of Cabinet of Ministers of Ukraine from 01.04.1999 "On approval of the list of food additives authorized for use in foodstuffs" and in the list with the amendments provided by the Resolutions of Cabinet of Ministers of Ukraine No.342 from 17.02.2000, No.1140 from 21.07.2000, No.1656 from 08.11.2000, No.674 from 21.06.2001, No.143 from 11.02.2004.

Food additives that are prohibited for use in Ukraine in food production are presented in Table 1.

<table>
<thead>
<tr>
<th>Code</th>
<th>Food additive</th>
<th>Technological function</th>
</tr>
</thead>
<tbody>
<tr>
<td>E121</td>
<td>citrus red</td>
<td>Colourant</td>
</tr>
<tr>
<td>E123</td>
<td>amaranth</td>
<td>Colourant</td>
</tr>
<tr>
<td>E128</td>
<td>red 2G</td>
<td>Colourant</td>
</tr>
<tr>
<td>E216</td>
<td>Propyl ester of n-hydroxy benzoic acid</td>
<td>Preservative</td>
</tr>
<tr>
<td>E217</td>
<td>Sodium salt of propyl ester of n-hydroxy benzoic acid</td>
<td>Preservative</td>
</tr>
<tr>
<td>E240</td>
<td>Formaldehyde</td>
<td>Preservative</td>
</tr>
<tr>
<td>E924a</td>
<td>Potassium bromate</td>
<td>Flour and bread improver</td>
</tr>
<tr>
<td>E924b</td>
<td>Calcium bromate</td>
<td>Flour and bread improver</td>
</tr>
</tbody>
</table>

In addition, there is a list of unauthorized food additives, which have not been tested or are being tested, but there is no final conclusion about their safety (see appendix).

Food colourants

The main group of substances that determine the appearance of food are food dyes.
Food in the process of thermal treatment and storage can change its original, coloration that is familiar to consumers, and sometimes have an unnatural appearance, which makes them less attractive, affects negatively the appetite and digestion.

The colour changes very much in canning fruits and vegetables; it is associated with conversion of chlorophylls into pheophytin or with the colour change of anthocyanin pigments because of changes in pH or formation of complexes with metals.

That is why manufacturers use food colorants for colouring foods and beverages, in order to improve their appearance.

In addition, the colorants can sometimes be used to adulterate the foods, such as colouring them, which is not provided by formulation and technology – to give the product the properties imitating its high quality.
Colourants are added to food products in order to:
• restore the colour that has been lost during processing / storage;
• increase the intensity of the natural colour;
• for colour colourless products (soft drinks, ice cream and confectionery).
For colouring the food products natural or synthetic (organic and inorganic) dyes are used.

Natural colouring agents are isolated from natural sources in the form of a mixture of compounds that are different by their chemical nature, the composition of which depends on the source and technology (carotenoids, anthocyanins, flavonoids, chlorophyll).

The raw material for natural colorants are different parts of plants (flowers, leaves, roots, fruits, berries, etc.), waste of their processing at wineries, canneries; and in addition, some of them can be obtained by chemical and microbiological synthesis.

As a rule, they are not toxic, but for some of them the acceptable daily intakes are set.

Do not confuse the food dyes and existing natural products that are also able to give colour to food. For example, to make the product red you can use cranberry juice, red currant, cherry, barberry; for obtaining a yellow colour – saffron, turmeric, carrot juice, pumpkin are used; a brown colour can be achieved by carnation, and a green colour by spinach juice and apples.

Synthetic dyes give bright, repeatable colours and less sensitive to different types of exposure during the manufacturing process.
They are represented by several classes of organic compounds, azo dyes (tartrazine, crimson) triaryl methane colourants (green S), quinoline (quinoline yellow), indigoid (indigo carmine). Most often, they are sodium salts, which cause their water solubility and the ability to be added in almost all foods.
Currently in Ukraine about 60 names of natural and synthetic dyes, including additives marked by E-codes, are permitted for use in food products.
The list of colorants permitted in Ukraine is presented in Appendix and those prohibited in the country are given in Table 1.

In addition, Ukraine has allowed colorants without E-codes – methyl violet, rhodamine C, acidic fuchsin, ultramarine, red rice, red for caramel 1.2, and red 3.

Some dyes (calcium carbonate E170 and food tannins E181) are food additives of the complex action.
Food colorants are the most commonly used in the manufacture of confectionery, beverages, margarine, canned food, cereals, processed cheese, ice cream, mayonnaise and ketchup.

In the EU, from June 20, 2010 the rule of labeling 6 colours, which are dangerous for children, is valid, i.e. manufacturers are obliged to give warning labels, "colorants (or dye)", "the name or number", "may have an adverse effect on activity and attention of children."

Colorants, which are dangerous for children, include:
E102 tartrazine – causes asthma attacks, mental disorder (hyperactivity);
E104 quinoline yellow – allergen;
E110 Sunset Yellow – allergen, causes nausea;
E122 Azorubine, (Carmoisine) – causes renal disease;
E124 Ponceau 4 R – causes a stomach ulcer, a carcinogen;
E129 charming red – carcinogen.
These colourants are prohibited in Norway, Austria, Sweden, Canada and some other countries, in Ukraine they are allowed.

Preservatives
The need to preserve the harvest, products obtained from hunting or fishing, gathered berries and mushrooms appeared in humans since ancient times.

People have learned how to extend the shelf life of foods due to drying, salting and preservatives (sugar, honey, wine, alcohol, carbon dioxide, sulfuric acid to stabilize the wine).

With development of chemistry in the late XIX\textsuperscript{th} - early XX\textsuperscript{th} century the use of chemical preservatives: benzoic and salicylic acids began. Widespread preservatives found a wide application at the end of the twentieth century. 

Preservatives are substances that extend the shelf life of products protecting them from damage caused by microorganisms (bacteria, fungi, yeast). Preservatives are used in cases when other methods of food preservation are impossible.

The spectrum of the antibacterial action of a particular preservative is different, in some cases it determines the expediency of using a mixture of several preservatives. Besides, it is necessary to take into account the peculiarities of food products into which they are introduced. The efficiency of a preservative is closely related to its concentration.

It is recommended to use a preservative at the initial stage of growth of microorganisms; it can reduce the dose of the preservative and does not mask the unfresh condition of the product.

It is not allowed to use preservatives in violation of industrial hygiene, or obtaining the product in unsanitary conditions. Preservatives are often used in combination with physical methods of conservation (heating, drying, low temperature, radiation, etc.).

Besides, preventing the access of oxygen to food products the hermetically sealed packing and preservatives inhibit development of aerobes. After opening the package, the growth of microorganisms re-starts and food spoilage occurs. That is why juices in hermetic package are stored for several months and after opening – only 36-48 hours.

Preservatives can be natural and synthetic. By their chemical nature they are divided into organic and inorganic. For example, acetic and lactic acids belong to natural preservatives.

Pickling cabbage, salting vegetables are based on fermentation of sugar and, as a result of it, the products accumulate lactic acid. Antibiotics nisin E234 – produce strains of \textit{Lactococcus lactis} bacteria and pimaricin E235 – produce strains of \textit{Streptomycyes natalensis} bacteria belong to natural preservatives. Natural preservatives are considered to be the safest for humans. The list of permitted preservatives in Ukraine is presented in Appendix (see Table), and of prohibited ones – in Table 16.1.
Preservatives anyway affect the human body. For a long time such preservatives as formaldehyde, propyl ester of p-hydroxybenzoic acid and its sodium salt have been used in the food industry. At the moment, the carcinogenic effect of these substances has been proven, and it has that led to prohibition of their use. At the same time, the use of sodium benzoate E211 is allowed since the information about its influence on development of malignancies is not sufficient for its prohibition. Hexamethylenetetramine E 239 is a cellular toxin due to formaldehyde, which slowly forms from it in the acidic medium, so it is permitted to use in a strictly defined concentrations. Most often this preservative is used in production of red caviar.

Special attention should be paid to nitrates and nitrites E250-252. Nitrites are potentially dangerous to the human body; entering the body they interact with hemoglobin and prevent absorption of oxygen by cells leading to tissue hypoxia. Besides, because of their high reactivity, at a temperature above 120°C, nitrites form nitrosamines, which cause cancer, and decrease the resistance to infection. Nitrites have a similar effect after biochemical reduction to nitrites.

Sorbic acid destroys vitamin B_{12}; sulfur dioxide – Vitamin B_{1} and, in addition, it has a negative effect on the renal function. Too many artificial preservatives can cause allergies, even asthma attacks, headache and nausea.

It is not easy to refuse using preservatives despite the negative influence on the body. They are used in various sectors of the food industry – dairy products, bread, cheese, sweets, dried fruits, wine, oil, fish, canned vegetables, mayonnaise, ketchup, sausages, soft drinks, juices, chocolate.

**Antioxidants**

Oxidation is the main problem when preserving products containing animal fats, in particular unsaturated fatty acids.

Fat oxidation is a complex process that occurs by a radical-chain type: the initial oxidation products are peroxides and hydroperoxides, the secondary ones are alcohols, aldehydes, ketones, acids, etc. The oxidation process changes the colour, taste and smell, destroys nutrients and forms toxic compounds. The principle of action of most antioxidants is based on their ability to form low-active radicals, thereby interrupting the auto-oxidation reaction. Consequently, the use of antioxidants gives the opportunity to extend the shelf life of the food raw material, intermediates and final products, protecting them from damage caused by oxygen.

The most common natural antioxidants are ascorbic acid and mixtures of tocopherols, the artificial ones are derivatives of phenol. Phenolic antioxidants are being tested for toxicity. The food industry uses additives E320-321 although the final conclusions about their safety are still absent. Effective manifestation of the antioxidant activity is observed when using a mixture of different compounds with the properties of inhibitors of radical oxidation and synergistic antioxidants that are substances by themselves without the antioxidant effect or they are weak antioxidants that intensity the effect of antioxidants (acids or complexing agents). For better antioxidant action, it must be completely dissolved in the product. Foods such as nuts are treated with an antioxidant spray solution in water or oil, or the product is immersed in a concentrated solution of an antioxidant. In addition, antioxidants can be introduced with a syringe.
The list of antioxidants permitted in Ukraine is presented in Appendix (see Table).

**Food stabilizers**

This group of food additives includes substances that are used to create the desired consistency or change the existing properties of food products, i.e. additives, regulating or forming their consistency: thickeners, gelling agents, stabilizers of physical condition, surface-active substances, such as emulsifiers and foaming agents.

They can be both of natural and synthetic origin and are used either individually or in a variety of blends. Natural stabilizers can be of animal (gelatin), and vegetable (pectins, carrageenans, gum) origin. Stabilizers improve the appearance and taste of the product, increase the shelf life of products, maintain the necessary consistency and shape of the food. In addition, stabilizers contribute to the yield of the final product. Food stabilizers are powders used for preparing aqueous solutions and are injected into food. The list of permitted stabilizers in Ukraine is presented in Appendix.

Carrageenan E407 is a natural thickener, which is obtained by processing red algae. It is also a gelling agent, stabilizer, clarifier.

Carrageenan is a dietary fibre; it is not absorbed in the human body, but is able to reduce the extent and rate of absorption of other food ingredients. It can cause an allergic reaction. It is noted that the splitted carrageenans contribute to formation of abscesses.

Gums can be: Locust Bean or Gum Carob Gum E 410, Oat gum E411, Guar gum E412, Xanthan gum E415, Karaya gum E416, Gellan gum E 418. Gums are thickeners, stabilizers, gelling agents and the agent for encapsulation. Gums are widely used in production of processed cheese, ice cream and dairy products, raw sausages, sauces, baked goods, canned fish, margarine and spreads. Gums are not dangerous for human health. They are not digested by enzymes of the digestive tract. Protein found in guar gum is an allergen. Guar gum effectively reduces the level of cholesterol and saturated fats. Karaya gum has a laxative effect. Gellan gum is a dietary fibre and also increases the amount of fecal and improves intestinal permeability.

Pectins E440 are natural substances that are obtained by extraction from fruits and vegetables. Pectin is a gelling agent, stabilizer, thickener, clarifier. It is harmless for human consumption. In addition, pectin is a dietary fibre, can absorb and excrete biogenic toxins, xenobiotics, products of metabolism, cholesterol, bile acids, urea, etc. Pectic acid can form complex salts with heavy metals, including radionuclides, and thus remove them from the body.

**Emulsifiers** are food additives, which, when added to a food product, provide the possibility of forming and preserving a uniform dispersion of two or more immiscible substances. They are widely used in production of mayonnaise, butter, margarine, ketchup, sauces, ice cream, soft and hard drinks and confectionery.

As the first food emulsifiers natural substances, such as gums, saponins, lecithin, etc., were used. Some of them have retained their popularity, however, in the industry today, synthetic emulsifiers or products of the chemical modification of
natural substances are the most widely used. The main types of food emulsifiers are nonionic surface active agents.

The exceptions are lecithin and anionic lactylates. By the chemical nature the main types of food emulsifiers are derivatives of mono- and polyhydric alcohols, mono- and disaccharides, which are structural components of acid residues of various structures: glycerides of fatty acids E471, glycerol esters, fatty and organic acids E472, E442 gums, ammonium salts of phosphatidic acid E442, polysorbates E 432, 436, sodium and potassium stearyl lactates E481-482, etc.

The list of the emulsifiers permitted in Ukraine is presented in Appendix. The common property that unites emulsifiers and distinguishes them from other classes of food additives is the surface activity. In some cases the use of these food additives may be associated not only with emulsification, but with their interaction with food ingredients such as protein, starch, etc. For example, emulsifiers are often used in production of bakery products because they interact with the proteins of flour strengthening the gluten, leading to increase in the dough density; improve porosity and increase the shelf life.

The most dangerous emulsifiers are considered to be phosphates E450 since they cause gastrointestinal and hepatic diseases. They are used in production of bread, cheese, soft drinks.

Flavour enhancer is a substance, which being introduced into the food product intensifies or modifies its taste and / or odour. Its addition into food restores the natural taste of the product, which can be lost during storage and processing. Industrial production of flavour enhancers started from 1909. These substances can not have their own smell and taste, but perfectly restore, "animating", "refreshing" the lost ones during industrial production of the product, as well as soften the unwanted components of taste and odour and give new sensations in the consumption of products.

Moreover, manufacturers can use this class of food additives for masking poor quality of the original product, for example, the old meat, stale fish, etc. Most often flavour enhancers are present in all fish, chicken, mushrooms, soy semi-products, chips, crackers, sauces, spices, beverages, confectionery, bouillon cubes and dry soups.

The list of the flavour enhancers permitted in Ukraine is presented in Appendix. This group includes a relatively small number of compounds belonging to several groups: derivatives of glutamic, guanylic, inosinic acids, ribonucleotides and derivatives of maltol.

Glutamic acid E620 and its sodium salt E621 providing a stimulating effect on the gustatory nerves enhance the sense of taste, the sense of "satisfaction", which has been called "the effect of glutamine."

Derivatives of glutamic acid enhance the bitter and salty taste in the greatest degree and in the least degree – the sweet taste. Large amounts of these additives are contraindicated for a person as they cause headaches, flushing, sweating, a feeling of
heaviness in the mouth, sore throat, chest pain, heart palpitations, shortness of breath. A set of these symptoms is known as "Chinese restaurant syndrome." It is impermissible the use of flavour enhancers in baby food.

Maltol E636 enhances the perception of a number of flavours (especially fruit and cream), and gives a sense of fat to low-calorie foods (yogurt, ice cream, mayonnaise).

![Maltol](image)

It is one of the first flavours have found in bread, and is currently used in bakery and pastry. Maltol exhibits bacteriostatic properties and is a plant growth regulator. It is prohibited in some countries.

Sodium inosinate E631 also has the ability to enhance flavour and aroma.

![Sodium Inosinate](image)

The effect resembles the effect extractable substances from animal products. It has a stronger "taste effect" than the salts of glutamic acid.

*Sweeteners.* There is a variety of their classifications: by origin (natural and artificial), by calories (high calorie, low-calorie, virtually non-nutritive), by degree of sweetness (with high and low sugar equivalent), by chemical composition, etc. One of the classifications is shown in Fig. 16.2.

![Classification of sweeteners](image)

**Fig. 16.2.** Classification of sweeteners.
In the food industry and cooking from ancient times substances with a sweet taste – sweeteners have been widely used.

In the food industry production and consumption of a variety of sugary starch products obtained by hydrolysis of starch (partial or complete) increase, sometimes with further modification of the individual components of hydrolysis. The first group of traditional sweeteners is starch syrups (maltodextrin, caramel, maltose, glucose, etc.).

Products of the complete hydrolysis of the starch, with possible modifications, include monohydrate and anhydride glucose, fructose, glucose, glucose-fructose syrups containing various amounts of fructose. A significant increase of production of sugary starch products is linked to their sweet taste, digestibility, economic profit. In addition, they have a function of structure-forming agents, fillers, sources of dry substances, and preservatives.

Fructose (levulose, fruit sugar) C6H12O6 is a monosaccharide, which in the free state is present in almost all sweet berries and fruits, flower nectar, seeds and honey.

Fructose is part of sucrose and it forms a high molecular weight polysaccharide inulin. Fructose can be obtained from sucrose and inulin by transformations of some other monosaccharides and by the method of biotechnology. At equal caloric content with sugar (380 kcal/100 g) it is 1.2-1.8 times sweeter (Table 1).

Many people prefer to replace the sugar not by synthetic drugs, but by natural fructose. However, studies show that consumers of fructose do not reduce the caloric content of food, but instead eat more sweet dishes. In the cells of the liver fructose is phosphorylated, and then is split into trioses, which are either used for the synthesis of fatty acids that can lead to obesity, as well as increase levels of triglycerides (which increases the risk of atherosclerosis), or used for glycogen synthesis (also partially converted into glucose during gluconeogenesis).

Fructose is reduces the risk of tooth decay and inflammation of the oral cavity by 20-30%; it is considered to be an irreplaceable sweetener for people with intolerance to glucose, it is not absorbed by the insulin-dependent tissues and almost completely absorbed and metabolized by the liver cells, assimilation of fructose (when using not more than 30 g per day) does not require the participation of insulin and it can be used in diabetes.
Table 16.2

Calorie and the sweetness coefficient for some sugar substitutes

<table>
<thead>
<tr>
<th>Name</th>
<th>Calorie, kcal/g</th>
<th>Sweetness coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suchrose</td>
<td>3.95</td>
<td>1.0</td>
</tr>
<tr>
<td>Fructose</td>
<td>3.76</td>
<td>1.2-1.8</td>
</tr>
<tr>
<td>Xylitol</td>
<td>2.4-4.0</td>
<td>0.85</td>
</tr>
<tr>
<td>Sorbitol</td>
<td>2.4-4.0</td>
<td>0.6</td>
</tr>
<tr>
<td>Aspartam</td>
<td>Very low</td>
<td>200</td>
</tr>
<tr>
<td>Saccharin</td>
<td>Very low</td>
<td>300</td>
</tr>
<tr>
<td>Cyclamate</td>
<td>Very low</td>
<td>30</td>
</tr>
<tr>
<td>Acesulfame K</td>
<td>Very low</td>
<td>200</td>
</tr>
</tbody>
</table>

Recently, with the requirements of the science of nutrition production of low-calorie products, products for people suffering from a number of diseases (especially diabetes), which has led to expansion of sucrose substitutes production, either natural or synthetic sweeteners, has been intensively developed.

They may have the same sweetness, or be in the hundreds of times sweeter than sucrose. The high coefficient of sweetness allows using them to produce low calorie, cheap diet products, fully or partially devoid of carbohydrate. The list of sweeteners and sugar substitutes permitted Ukraine is given in Appendix.

Let us start consideration of the individual representatives of sweeteners with natural products, including protein-containing ones. Attention to the latest ones increased from 60's of the twentieth century because of their high sweetness, low calorie and possible safety.

Miraculin is a glycoprotein, the source of its obtaining is the fruit of Richazdella dulcifia. Monelin is a protein; the source of obtaining is the fruit of Dioscoreophyllum cumminsii. It is 1500-3000 times sweeter than sucrose. When heated it loses sweetness. The sweetest of the known natural substances is thaumatin E 957, which is also a flavour enhancer. The source of its obtaining is the fruit of Thaumatococcus danielli. The sweet taste is not felt immediately, but long lasting.

Stevioside is a sweet crystalline glycoside isolated from the leaves of Stevia rebaudiana (Paraguay and Brazil). Stevioside is 25 times sweeter than sugar. It can be used in the form of fine grass powder, tincture, infusion, tea from the origin plant. Stevia leaf powder can be added into all meals, which usually need using sugar. Stevioside is well tolerated, has a good taste, affordable, heat stable, readily soluble and dosed, utilized without insulin. The regular use of stevia (stevioside) reduces blood glucose, stimulates secretion of insulin, strengthens blood vessels. Stevia has a positive effect on the activity of the liver and pancreas preventing formation of ulcers of the gastrointestinal tract, eliminates allergic diathesis in children, improves sleep, improves physical and mental performance shows the antiviral activity. Its safe dose is not more than 40 g per day.

**Sugar substitutes.** This group of substances includes polyols. Xylitol E967, sorbitol E420, lactitol E966 are the most widely used as sweeteners (sugar substitutes).
Sorbitol E 420 is a hexatomic alcohol, crystalline substance, by the sweetness is it close to glucose, well digested by the body and has an energy value.

![Chemical Structure of Sorbitol](image)

The sorbitol sweetness comparing to sucrose is 0.6. It is slowly absorbed from the intestine and does not change the level of glucose in the blood. When boiling sorbitol preserves the taste. The Recommended Daily Allowance of sorbitol is not more 30 g. The calorie content of sorbitol is similar to sugar and, therefore, should be taken into account when composting a diet.

Sorbitol is used in many cough syrups and labels usually indicate it as an inactive ingredient. But now it is believed that it should be reported as active since a great amount of sorbitol (about 10 grams or more for adults) can cause gastrointestinal failure, pain, gas and diarrhea. Sorbitol can aggravate the irritable bowel syndrome and cause malabsorption of fructose.

Sorbitol also exhibits the choleretic effect, helps the body to reduce the consumption of vitamins, improves the gastrointestinal microflora. Sorbitol can be used in the diet of diabetics. As a preservative it is added to juices and soft drinks. Food based on sorbitol remains fresh for a long time. Its safe dose is up to 30-40 g per day.

Xylitol E967 is a pentaatomic alcohol obtained by reducing xylose. It is contained in the cotton shell, in corn cobs, and has a vegetable origin.

![Chemical Structure of Xylitol](image)

Food xylitol is white crystals, odourless, sweet-tasting, chilling, readily soluble in water, is well absorbed by the body, has the energy value. It is used in food industry as a sugar substitute in confectionery for diabetes and obesity, part of some toothpastes and chewing gums because it has a the positive effect on the teeth as it is not is a nutrient medium for development of pathogens destroying tooth enamel.

The calorie content and the degree of sweetness are equal to simple sugar, but have no biological value. Xylitol slowly penetrates into the tissues and does not affect blood sugar levels. Xylitol is an energy sugar substitute that is important for the patients with diabetes. Diabetics can use xylitol harmless for health. It increases secretion of the gastric juice and has the choleretic effect.

In high doses xylitol exhibits the laxative effect. Its safe dose is up to 40-50 g per day. Xylitol is recommended for use as an emulsifier in production of ice cream to improve its quality and taste; in preparation of various desserts; in manufacture of jams, sweets, chocolate, chewing gum and soft drinks, as it exhibits the bactericidal activity.
**Intense synthetic sweeteners**

Acesulfame K E 950 is a sweetener of the sulfamide origin. These are colourless crystals, readily soluble in water; the sweetness coefficient is 200.

![Chemical structure of acesulfame K](image)

It is an organic salt obtained in 1973 in Germany. It is registered in more than 40 countries, but prohibited for use in Canada and Japan. It is not absorbed by the body and is rapidly eliminated, non-toxic, non-carcinogenic, its mutagenic and teratogenic effects have not been found. In high concentrations it has a bitter-metallic taste, so it is often used in combination with aspartame, does not cause allergic reactions and does not contain calories.

Products with this sweetener are not recommended to be used for children, pregnant and lactating mothers. Its safe dose is not more than 1 g per day. It is used to sweeten soft drinks, in the manufacture of cakes, gelatin desserts and chewing gum; it is also used as a sweetener of certain medicines (syrups).

Aspartame E 951 (NutraSweet, Sladex) is a dipeptide consisting of asparagine and phenylalanine residues, and methanol. The sweetness coefficient is 200. It is also a flavour enhancer.

![Chemical structure of aspartame](image)

It was found by Schlatter in 1965 during the preparation of food products, in the presence of moisture and at higher temperatures, aspartame is partially converted into diketopiperazine. It was tested for toxicity, carcinogenicity, and considered harmless. Methanol is dangerous to humans, but its concentration in aspartame is very small, much more methanol into the body comes with fruit and juices. Aspartame is contraindicated for people suffering from phenylketonuria. It contains methyl ester, which disturbs the CAS activity, and aspartic acid is an active stimulant for the nervous system and can eventually cause addiction.

The calorie content is about 4 kcal/g, but to create a sweet taste a very small amount of aspartame is required, so its contribution to the caloric content of food is not taken into account. Compared with sugar the taste of sweetness of aspartame appears slower and stays longer. Aspartame is available in tablet and powder; it is a part of complex sugar substitutes. Its safe dose is not more than 3.5 g per day. It is a part of about 6,000 different types of foods and beverages, often used in diet drinks and sugar-free chewing gum.
Cyclamic acid and its sodium, potassium, calcium salts E 952. The sweetness coefficient is about 30-50.

Cyclamates have a pleasant taste, without the metallic bitterness, do not have calories, easily soluble in water and can withstand very high temperatures, so this sugar substitute is the most available for sweetening food during cooking. They are usually introduced into the complex tabletted sugar substitutes (saccharin: 10 parts of cyclamate to 1 part of saccharin). Cyclamate is allowed in 55 countries (including the European Union), but is prohibited in the USA since 1969.

According to some reports, cyclamate may be carcinogenic. It can not be used in patients with renal insufficiency, as well as during pregnancy and breastfeeding. Its safe dose is not more than 0.8 g per day.

Saccharin (sodium, potassium, calcium salt) E-954 – ortho-sulfamide of benzoic acid is a colourless crystalline substance with a sweet taste, slightly soluble in water, commonly used in the form of salts, which are 300-500 times sweeter than sugar. Saccharin is not absorbed by the body and is excreted with the urine, has a weak diuretic effect, almost without calories.

Saccharin is added only into ready food since by boiling it partly decomposes with elimination of the imido group and formation of ortho-sulfobenzoic acid having a taste of phenol (a bitterish taste). This sugar substitute is included into tableted sugar substitutes.

Some experts argue that saccharin contains carcinogens, and therefore, it is not recommended to consume drinks with it on an empty stomach and without taking carbohydrate foods. There is also a suspicion that saccharin leads to exacerbation of gallstone disease. It is prohibited in Canada. Its safe dose is 0.2 g per day. Saccharin has no nutritional value and is typical of xenobiotics. Currently, the use of saccharin into food is greatly reduced, although sweeteners on the base of saccharin are still produced and in beverages and other products mixtures of these sweeteners are used.

Rules of application of sugar substitutes
Xylitol and sorbitol should be used in small doses (10 to 15 g per day). It is necessary to consider calorie of these sweeteners.
If there are side effects associated with the use of sugar substitutes (such as nausea, heartburn, or bloating), the dose should be reduced, and in some cases, the drug should be discontinued (or replaced).

The dietary meals of physiological type should be used, i.e. in the diet there should be sufficient amount of a normal (physiological) components.

**Food flavourings.** The aroma of the food is an integral factor due to the presence of a complex mixture of organic compounds in it previously contained in the raw material and/or further formed under the influence of some technological factors during treatment and specially introduced when obtaining flavours.

The aroma and taste of the final product depend on a large number of factors: the composition of the raw material, the nature and quantity of the aromatic substances contained in it, peculiarities of the technological process of its processing such as duration, temperature, the presence of enzymes, the chemistry of the processes and the character of the compounds formed, the flavours introduced, flavour enhancers, etc.

Aroma is created by a large number of compounds. The important role is played by the "key" compounds: in lemons it is citral, in raspberries – p-hydroxy-3-butanone, in garlic – allyl sulfide, in vanilla – vanilline, etc.

The content and composition of aromatic substances is changing during plants mature, enzymatic and thermal processes, in destruction of fruits and berries (processing of coffee, tea fermentation, cheese ripening, baking of bread, etc.). In addition, during storage, a partial loss of taste and aroma takes place. It causes the introduction of flavourings into foods.

Food flavourings are flavouring substances intended to give flavour and / or taste to food (except for sweet, sour, salty), with or without carriers, excipients or diluents, fillers, additives and the food raw material. According to modern concepts they do not belong to the group of food additives and are an independent group, they are not assigned a serial number.

Flavourings do not include juices, syrups, wines, spices as they can be used as a food product, although their use may affect the taste and flavour. Food flavours are divided into natural, identical to natural and artificial, in accordance with components used in their preparation or methods of preparation. A wide range of flavours, their different nature, diversity of sources of their chemical composition (multicomponent mixtures of compounds) set very complex problems in determining their safety.

Sources for obtaining of aromatic substances used in the food industry are essential oils and extracts, spices and their products, chemical and microbiological synthesis. The aromatic substance obtaining in most cases is a mixture of compounds, and only in some cases it is the individual compound.

All these flavourings are divided into: aromatic substances (natural, nature identical and artificial), flavouring agents (mixture of substances extracted from the raw material by physical and biotechnological methods), technological flavourings and smoking flavours.

Flavourings identical to the natural ones are complex compositions of aromatic substances of different origin in a suitable solvent or mixed with a solid carrier, such
as starch, lactose, protein, etc. Their structure can be up to 20-30 components of the various chemical nature.

Using only natural sources for obtaining flavourings is not rational because it requires a large amount of original material, and the yield is characterized by instability of flavour (except essential oils). The most effective is to use flavours, including natural and identical to natural ingredients. Artificial flavours by their structure correspond to natural compounds, but they are more stable.

Artificial flavourings (including components that have no natural analogues) require a special study of safety but they are very stable, have the intense scent and low price.

The chemical nature of flavours is very diverse and can be presented by essential oils, aldehydes, alcohols, esters, and other isoprenoids.

The main consumers of flavours are manufactures of soft drinks, ice cream, alcoholic beverages, chewing gum, confectionery; flavours are added into the jelly, margarine, syrup, milk, meat and other products.

The information about a flavoring agent should be on the label (natural, natural identical and artificial).

Although flavours in comparison with other classes of food additives are used in much lower concentrations, there is no guarantee that they can not carry the risk to human health.

In approving the list of flavours allowed in the EU experts often make decisions based on very limited toxicological information concerning individual aromatic substances. One of the arguments in favour of the flavours used by the Expert Committee for their approval by the EU is the fact that most of the substances used as flavouring agents are naturally present in food, and are often used by people for a long time with no apparent danger for them.

The Committee assumes that flavourings can cause hypersensitivity in some individuals, but emphasizes that such reactions can not be provided in tests *in vitro*. In addition, with inclusion of aromatic substances in the list of permitted substances the information about the mutagenicity study was considered in relation to particular substances.

Thus, most of the food additives and flavourings, especially synthetic, are substances with which the organism does not faced in the course of its evolution, so in the human organism there is no any effective system of detoxification; the widespread use of the same food additives leads to accumulation of them in the human daily diet and exceed the ADI, which can adversely affect the human body (benzoates, nitrates, sorbates, phosphates, etc.). Some dietary supplements have the limited sphere of use (for example, boric acid and borates for conservation of fish caviar), which testifies their high toxicity; the recommended values for many additives vary from 0 up to a certain maximum level, indicating appropriateness of their absence in food.

The absence of specific, sensitive enough express methods of determination for many classes of food additives and flavouring components complicates the effective control of their use. All facts mentioned above create the necessity to limit the use of food additives, especially by children.
QUESTIONS FOR SELF-CHECKING

1. Define the concept of food additives. Name causes of widespread use of food additives in modern food products.
2. Give a list of the main classes, subclasses, and the corresponding technological function of food additives.
3. How are food additives indicated by manufacturers on the packing?
4. Classification of food additives in accordance with the system of digital encoding, according to their purpose.
5. Safety of food additives. The list food additives prohibited in Ukraine.
6. Describe the food additives belonging to the class of food dyes.
7. Describe the food additives belonging to the class of preservatives.
8. Describe the food additives belonging to the class of antioxidants.
9. Describe the food additives belonging to the class of stabilizers.
10. Describe the food additives belonging to the class of emulsifiers.
11. What food additives belong to the class of taste enhancers?
12. What sweeteners are used as food additives?
13. Describe the group of natural sweeteners.
14. Describe a group of sugar substitutes.
15. Describe the group of intense artificial sweeteners.
16. What are the basic rules of sugar substitutes use?
17. Describe the food additives belonging to the class of food flavourings.
TASKS FOR SELF-CHECKING

1. Which group of dyes includes carotenoids?
   A. synthetic dyes
   B. natural dyes
   C. do not belong to the group of dyes
   D. semi-synthetic dyes
   E. azo dyes

2. Choose dyes that are dangerous for children:
   A. tartrazine
   B. indigo
   C. Ponceau 4 R
   D. anthocyanins
   E. acidic fuchsin

3. What preservative destroys vitamin B\textsubscript{12}?
   A. sulfur dioxide
   B. lactic acid
   C. salicylic acid
   D. benzoic acid
   E. sorbic acid

4. What emulsifiers are considered to be the most dangerous because they cause diseases of the gastrointestinal tract and liver?
   A. phosphates
   B. esters of glycerol
   C. salicylic acid
   D. benzoic acid
   E. tweens

5. What kind of a sweetener referring to the group of intense artificial sweeteners is contraindicated for patients suffering from phenylketonuria?
   A. aspartame
   B. saccharin
   C. acesulfame K
   D. xylitol
   E. stevioside
1. DRUG-FOOD INTERACTIONS

**Drinking and mineral water**

Most medicines are rationally to take on an empty stomach (30-60 min before meals) in a crushed form with drinking 50-100 ml of boiled or distilled water.

<table>
<thead>
<tr>
<th>Food product</th>
<th>Medicine</th>
<th>Result of interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkaline mineral water</td>
<td>Medicines with unstable coating</td>
<td>It can cause destruction of the coating and disintegration of the active substance</td>
</tr>
<tr>
<td></td>
<td>Sulphanilamide</td>
<td>The alkaline medium promotes transition of sulphanilamides to the salt form, prolongs the antibacterial effect of sulphanilamides, slows down acetylation during metabolism. In the alkaline medium acetylated sulphanilamides are in the dissolved state and excreted easily, and it excludes and reduces crystalluria</td>
</tr>
</tbody>
</table>

**Milk and dairy products**

<table>
<thead>
<tr>
<th>Food product</th>
<th>Medicine</th>
<th>Result of interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk</td>
<td>Preparations of calcium, glucocorticoids (prednisolone, dexametasone), non-steroidal anti-inflammatory drugs (phenylbutazone, indomethacin)</td>
<td>The rate and completeness of absorption of these drugs increase. It is recommended to take them 30-40 minutes before meals with milk</td>
</tr>
<tr>
<td></td>
<td>Antibiotics – tetracyclines, penicillins, cephalosporins, fluoroquinolones, viral protease inhibitors (nelfinavir)</td>
<td>The rate and completeness of absorption decrease due to chelation with calcium caseinate containing in milk, as well as decrease of the pH of the gastric juice</td>
</tr>
<tr>
<td></td>
<td>Vitamin D</td>
<td>Absorption of the vitamin</td>
</tr>
</tbody>
</table>
is increased; its excess is dangerous, especially for the central nervous system

<table>
<thead>
<tr>
<th>Caffeine</th>
<th>It leads to binding of about 30% of the drug with the milk protein; the drug release is very slow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron preparations</td>
<td>There is a limited absorption of the drug due to formation of slightly soluble compounds</td>
</tr>
<tr>
<td>Bismuth preparations</td>
<td>The gastroprotective properties of the drug are decreased</td>
</tr>
<tr>
<td>Drugs with an acid-resistant coating (potassium salts, pancreatin, pancurmen, bisacodyl)</td>
<td>There is a danger of premature dissolution of the coating, resulting in undesired release of the active ingredient</td>
</tr>
<tr>
<td>Dairy products (all kinds of cheeses, yogurt)</td>
<td>Antidepressants, psychostimulants, isoniazid</td>
</tr>
<tr>
<td></td>
<td>Tyramine and serotonin containing in dairy products may seriously affect the pharmacodynamics of drugs, reduce their therapeutic activity and cause intensification of side effects in the form of blood pressure increase (“cheese effect”, which is characterized by increased toxicity, hypertensive crisis, seizures, death)</td>
</tr>
<tr>
<td>Milk and diary products</td>
<td>MAO inhibitors and preparations containing caffeine</td>
</tr>
<tr>
<td></td>
<td>Combined use is not recommended</td>
</tr>
</tbody>
</table>

**Meat and meat products**

Food that is rich in protein can enhance or reduce the absorption process of various drugs and affect their activity.

<table>
<thead>
<tr>
<th>Food product</th>
<th>Medicine</th>
<th>Result of interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein-rich food</td>
<td>β-blockers</td>
<td>Their bioavailability is</td>
</tr>
</tbody>
</table>

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increase, side effects are intensified

Carbidopa/levodopa, theophylline  The concentration and therapeutic activity are decreased

Metformin, levothyroxine, digoxin, penicillines  Proteins can bind medicines lowering their concentration

Oxacillin, ampicillin, isoniazid  Absorption of drugs in the intestine is decreased and their concentration is reduced

Tetracycline  Approximately 50% reduction of the drug concentration in the blood serum occurs

Corticosteroids and steroid hormones  To prevent complications (change of the water-salt, protein, carbohydrate and fat metabolism) it is appropriate to increase intake of high-grade protein from non-fat meats

Pork, lamb (fatty foods)  Phenyl salicylate, griseofulvin, neomycin sulfate  The effect of drugs is reduced

Ham, sausage, smoked meats  Anorectics, antidiabetics, biguanides, MAO inhibitors, tetracyclines, chlorpromazine  It can lead to formation of carcinogenic nitrosamines

Liver  MAO inhibitors  It leads to dramatic increase of toxicity, hypertensive crisis, seizures and death (!)

**Fish and fish products**

The quantitative and qualitative composition of food (especially proteins) can change the biotransformation of drugs in the body. Fish food affects the pH, which changes excretion of weak acidic or basic drugs.

<table>
<thead>
<tr>
<th>Food product</th>
<th>Medicine</th>
<th>Result of interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fish and fish products</td>
<td>Medicines containing levodopa</td>
<td>The therapeutic effect is reduced</td>
</tr>
<tr>
<td>Fresh and salted fish, smoked, salted, dried, pickled, canned fish, red and black caviar</td>
<td>MAO inhibitors, psychostimulants, vasoconstrictors</td>
<td>Hypertensive crises and a number of complications associated with the pressor effect of biogenic amines such as strong headache, tachycardia, rapid increase</td>
</tr>
<tr>
<td>Food product</td>
<td>Medicine</td>
<td>Result of interaction</td>
</tr>
<tr>
<td>--------------</td>
<td>----------</td>
<td>----------------------</td>
</tr>
<tr>
<td>Fish (cod)</td>
<td>Isoniazid</td>
<td>Development of such side effects as headache, shortness of breath, nausea, tachycardia can be observed</td>
</tr>
<tr>
<td>Fish (fat)</td>
<td>Acetylsalicylic acid</td>
<td>The risk of bleeding complications increases</td>
</tr>
<tr>
<td>Fish products</td>
<td>Paracetamol, corticoterphion, methylandrostendiol and other anabolic drugs</td>
<td>Side effects of drugs are decreased</td>
</tr>
</tbody>
</table>

**Fruits and juices**

<table>
<thead>
<tr>
<th>Food product</th>
<th>Medicine</th>
<th>Result of interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bananas, pineapples, figs, currants (white, red)</td>
<td>Antidepressants, psychostimulants, isoniazid</td>
<td>The therapeutic activity is decreased, side effects are increased</td>
</tr>
<tr>
<td>Grapefruit, sour orange and juices from them</td>
<td>Amiodarone, carbamazepine, cyclosporine, sirolimus, tacrolimus</td>
<td>They can exceed the plasma concentrations of drugs that require close monitoring (having more than 1 cup of juice or half a grapefruit – IS DANGEROUS!)</td>
</tr>
<tr>
<td>Grapefruit juice</td>
<td>Amiodarone, budesonide, buspirone, carbamazepine, ciclosporin, diltiazem, erythromycin, felodipine, fluvoxamine, nicardipine, nimodipine, nisoldipine, praziquantel, quinidin, sertalin, sildenafil, sirolimus, tacrolimus, verapamil, inhibitors of GMC-CoA-reductase</td>
<td>Possible toxicity or increased toxicity can be observed</td>
</tr>
<tr>
<td></td>
<td>Albendazole, benzodiazepines, estrogens, warfarin</td>
<td>Potentiation of action is possible</td>
</tr>
<tr>
<td></td>
<td>Etoposide, fexofenadine, indinavir, itraconazol, methylprednisolone, theophylline</td>
<td>Weakening of action is possible</td>
</tr>
<tr>
<td>Food product</td>
<td>Medicine</td>
<td>Result of interaction</td>
</tr>
<tr>
<td>--------------------------------------------------</td>
<td>-----------------------------------------------</td>
<td>---------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Sour juices</td>
<td>Ampicillin, macrolides</td>
<td>Absorption of drugs is reduced; insoluble complexes with drugs can be formed</td>
</tr>
<tr>
<td>Currant, cherry juices</td>
<td>Furosemide, calcium chloride, ibuprofen, isoniazid, metamizole sodium</td>
<td>Absorption of drugs is reduced</td>
</tr>
<tr>
<td>Pineapple, lemon, orange, mandarine, grape, currant juice</td>
<td>Psychostimulants, MAO inhibitors</td>
<td>They can cause a hypertensive crisis</td>
</tr>
<tr>
<td>Cherry, apple, pear juices</td>
<td>Drugs metabolized in the intestine</td>
<td>The course of enzymatic reactions in the liver is slowed down, and the action of drugs is intensified</td>
</tr>
</tbody>
</table>

**Vegetables**

<table>
<thead>
<tr>
<th>Food product</th>
<th>Medicine</th>
<th>Result of interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sour vegetable juices</td>
<td>Some antibiotics (erythromycin, ampicillin, cycloserine)</td>
<td>Neutralization of the pharmacological effect is observed</td>
</tr>
<tr>
<td></td>
<td>Salicylates, barbiturates, nitrofuranes</td>
<td>Intensification of the pharmacological effect is observed</td>
</tr>
<tr>
<td></td>
<td>Ibuprofen, furosemid</td>
<td>Delayed absorption is observed</td>
</tr>
<tr>
<td>Legumes and products containing phytin</td>
<td>Iron preparations</td>
<td>Absorption is limited due to formation of poorly soluble complexes</td>
</tr>
<tr>
<td>Avocado and other products containing tyramine</td>
<td>Antidepressants, psychostimulants, isoniazid</td>
<td>The therapeutic effectiveness is reduced, development of the “cheese effect” is possible</td>
</tr>
<tr>
<td>Broccoli, Brussels sprout, spinach, lettuce, zucchini, garden cress, soybean, cauliflower</td>
<td>Anticoagulants with indirect action</td>
<td>They contain vitamin K which is an antagonist of these medicines</td>
</tr>
<tr>
<td>Cabbage, lettuce, garden radish</td>
<td>Antithyroid drugs</td>
<td>The pharmacological effect is intensified</td>
</tr>
<tr>
<td></td>
<td>Hormonal medicines of the</td>
<td>The action is reduced</td>
</tr>
<tr>
<td>Food</td>
<td>Medicine</td>
<td>Result of interaction</td>
</tr>
<tr>
<td>------------------------------</td>
<td>-----------------------------------------------</td>
<td>---------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Beet</td>
<td>Thyroid gland</td>
<td>Hypotension may develop</td>
</tr>
<tr>
<td>Vegetables rich in oxalic</td>
<td>Hypotensive medicines</td>
<td>Hypotension may develop</td>
</tr>
<tr>
<td>Vegetables (spinach, purslane, rhubarb, lettuce)</td>
<td>Calcium preparations</td>
<td>The therapeutic effectiveness is reduced, unsoluble substances are formed. Combined use is prohibited</td>
</tr>
<tr>
<td>Food which rich in cellulose</td>
<td>Digitalis preparations</td>
<td>Combined use is prohibited because reduction of the treatment effectiveness is possible</td>
</tr>
<tr>
<td>Food with the high content</td>
<td>Diuretics (especially thiazide and loop</td>
<td>Combined use prevents the possibility of development of arrhythmias</td>
</tr>
<tr>
<td>of potassium and the low</td>
<td>diuretics)</td>
<td>Combined use is prohibited because reduction of the treatment effectiveness is possible</td>
</tr>
<tr>
<td>content of sodium (for</td>
<td></td>
<td>Combined use is prohibited because reduction of the treatment effectiveness is possible</td>
</tr>
<tr>
<td>example, carrot juice)</td>
<td></td>
<td>Combined use is prohibited because reduction of the treatment effectiveness is possible</td>
</tr>
<tr>
<td>Tomato juice</td>
<td></td>
<td>Combined use is prohibited because reduction of the treatment effectiveness is possible</td>
</tr>
<tr>
<td>Products rich in potassium</td>
<td>Potassium-sparing diuretics</td>
<td>Combined use is prohibited because reduction of the treatment effectiveness is possible</td>
</tr>
<tr>
<td>Legumes, greens and other</td>
<td>Corticotropin, deoxycorticosterone</td>
<td>Combined use is rational</td>
</tr>
<tr>
<td>food rich in folate</td>
<td></td>
<td>Combined use is rational</td>
</tr>
<tr>
<td>Legumes, culinary herbs</td>
<td>Anticonvulsants</td>
<td>Combined use is rational</td>
</tr>
<tr>
<td>Green vegetables</td>
<td>Carbamazepine, amidopyrine</td>
<td>Combined use is rational</td>
</tr>
<tr>
<td>Cucumbers, zucchini, parsley</td>
<td>Ascorbic acid</td>
<td>Combined use is rational</td>
</tr>
</tbody>
</table>

**Bread and bakery products**

<table>
<thead>
<tr>
<th>Food product</th>
<th>Medicine</th>
<th>Result of interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flour products</td>
<td>Sulfonamides, antibiotics</td>
<td>The process of absorption and concentration of drugs is disturbed</td>
</tr>
<tr>
<td>Iron preparatons</td>
<td></td>
<td>The process of absorption of the</td>
</tr>
<tr>
<td>Drug/Complex</td>
<td>Result of interaction</td>
<td></td>
</tr>
<tr>
<td>--------------</td>
<td>-----------------------</td>
<td></td>
</tr>
<tr>
<td>Paracetamol, furosemide, cardiac glycosides</td>
<td>Medicines bind fibre, which reduces the efficiency of treatment</td>
<td></td>
</tr>
<tr>
<td>Acetylsalicylic acid</td>
<td>The therapeutic activity is reduced</td>
<td></td>
</tr>
<tr>
<td>Glucocorticoids, steroid hormones</td>
<td>The carbohydrate metabolism is disturbed</td>
<td></td>
</tr>
<tr>
<td>Pancreatins, bisacodyl, preparations of potassium salts</td>
<td>50% decrease of the drug concentration in the blood is observed</td>
<td></td>
</tr>
<tr>
<td>Levodopa</td>
<td>The therapeutic effect is decreased</td>
<td></td>
</tr>
<tr>
<td>Tricyclic antidepressants</td>
<td>The serum level of medicines is reduced</td>
<td></td>
</tr>
<tr>
<td>Antidepressants</td>
<td>There is threat of a hypertensive crisis</td>
<td></td>
</tr>
</tbody>
</table>

**Groats**

<table>
<thead>
<tr>
<th>Food product</th>
<th>Medicine</th>
<th>Result of interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groats</td>
<td>Calcium preparations</td>
<td>Absorption of calcium is reduced</td>
</tr>
<tr>
<td>Tetracycline antibiotics, penicillamine</td>
<td>Complex compounds that reduce iron absorption and the antimicrobial activity of antibiotics are formed</td>
<td></td>
</tr>
<tr>
<td>Food rich in vitamin B₆</td>
<td>Medicines containing levodopa</td>
<td>The therapeutic effect is reduced</td>
</tr>
<tr>
<td>Isoniazid</td>
<td>Prevention of pellagra occurrence</td>
<td></td>
</tr>
<tr>
<td>Oat flakes, buckwheat, pearl barley</td>
<td>Tricyclic antidepressants, digitalis preparations</td>
<td>Absorption of drugs is blocked</td>
</tr>
</tbody>
</table>

**Chocolate**

<table>
<thead>
<tr>
<th>Food product</th>
<th>Medicine</th>
<th>Result of interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chocolate</td>
<td>Anti-inflammatory drugs</td>
<td>It leads to development of pseudoallergic reactions</td>
</tr>
<tr>
<td>Antidepressants, psychostimulants, isoniazid</td>
<td>The therapeutic activity of drugs is decreased and side effects are increased</td>
<td></td>
</tr>
<tr>
<td>Cardiovascular medicines</td>
<td>Combined use is not recommended</td>
<td></td>
</tr>
<tr>
<td>Laxatives</td>
<td>Combined use is not recommended because</td>
<td></td>
</tr>
</tbody>
</table>
there is a possibility of development of the inverse effect

### Tea

<table>
<thead>
<tr>
<th>Food product</th>
<th>Medicine</th>
<th>Result of interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tea</td>
<td>Paracetamol, metamizol sodium, acetylsalicylic acid</td>
<td>The effect of drugs is potentiated, the effect of theophylline is intensified and prolonged</td>
</tr>
<tr>
<td>Theophylline</td>
<td></td>
<td>The effect is enhanced and prolonged</td>
</tr>
<tr>
<td>Insulin</td>
<td></td>
<td>Potentiation of action is possible</td>
</tr>
<tr>
<td>Monoamine oxidase inhibitor</td>
<td></td>
<td>The metabolism of caffeine is slowed down, reciprocal enhancement of toxicity</td>
</tr>
<tr>
<td>Haloperidol and other antipsychotic agents</td>
<td></td>
<td>The effect is weakened</td>
</tr>
<tr>
<td>Iron preparations</td>
<td></td>
<td>Uptake of iron from medicines is prevented</td>
</tr>
<tr>
<td>Erythromycin, penicilline antibiotics</td>
<td></td>
<td>The effect is weakened</td>
</tr>
<tr>
<td>Clozapine, dipyridamole, disulfiram</td>
<td></td>
<td>Hypererethism and nervousness, headache, tachycardia, hyperactivity, irritability appear</td>
</tr>
<tr>
<td>Paracetamol, amiodarone, carbamazepine, isoniazid, methotrexate, erythromycin, phenytoin, lovastatin</td>
<td></td>
<td>The risk of the liver injury increases</td>
</tr>
<tr>
<td>Codeine, haloperidol, atropine, morphine, papaverine, platyphylline</td>
<td></td>
<td>Absorption of drugs is reduced</td>
</tr>
<tr>
<td>Cimetidine, oral contraceptives, MAO inhibitors</td>
<td></td>
<td>The drug toxicity is intensified</td>
</tr>
<tr>
<td>Statins</td>
<td></td>
<td>Cramps of legs and the lower jaw are developed</td>
</tr>
</tbody>
</table>

### Coffee

Coffee due to caffeine changes the pharmacological effect of certain medicines.

<table>
<thead>
<tr>
<th>Food product</th>
<th>Medicine</th>
<th>Result of interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coffee due to caffeine changes the pharmacological effect of certain medicines.</td>
<td></td>
<td>--------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Coffee</td>
<td>Sedatives, hypnotics</td>
<td>The therapeutic effect decreases</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Medicines for the treatment of osteoporosis and diseases of the thyroid gland, antidepressants and hormonal medicines</td>
<td>Combined use is prohibited</td>
<td></td>
</tr>
<tr>
<td>Citramon, citrapar</td>
<td>The drug action is intensified</td>
<td></td>
</tr>
<tr>
<td>Vitamins of group B, vitamin A, carotene, selenium</td>
<td>The drug action is reduced</td>
<td></td>
</tr>
<tr>
<td>Homeopathic medicines</td>
<td>Combined use is not recommended</td>
<td></td>
</tr>
</tbody>
</table>

**Alcohol and alcoholic drinks**

<table>
<thead>
<tr>
<th>Food product</th>
<th>Medicine</th>
<th>Result of interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohol and alcoholic drinks</td>
<td>Medicines inhibiting the CNS (sedatives, tranquilizers, neuroleptics), histamine antagonists, analgesics, antipyretics, NSAIDs</td>
<td>The inhibitory action on the CNS is potentiated</td>
</tr>
<tr>
<td></td>
<td>Hypnotics and benzodiazepines tranquilizers</td>
<td>The inhibitory action on the CNS is potentiated; development of habituation and addiction to ethanol is stimulated</td>
</tr>
<tr>
<td></td>
<td>Antidepressants - monoamine oxidase inhibitors</td>
<td>A hypertensive crisis is developed</td>
</tr>
<tr>
<td></td>
<td>Dipheninum</td>
<td>Biotransformation of dipheninum is blocked, its toxicity increases</td>
</tr>
<tr>
<td></td>
<td>Hypotensive medicines</td>
<td>The orthostatic collapse is developed</td>
</tr>
<tr>
<td></td>
<td>Vasodilators</td>
<td>The vasodilating effect is potentiated, collapse</td>
</tr>
<tr>
<td></td>
<td>Nitroglycerin, coronarodilators, spasmolytics</td>
<td>There is a vasogenic shock, collapse</td>
</tr>
<tr>
<td></td>
<td>Diuretics</td>
<td>Hypokalemia occurs (vomiting, diarrhea, decrease of blood pressure)</td>
</tr>
<tr>
<td></td>
<td>Anticoagulants with the indirect action</td>
<td>Bleeding, hemorrhages into internal organs (including into the brain) can appear</td>
</tr>
<tr>
<td></td>
<td>Oral contraceptives</td>
<td>The contraceptives</td>
</tr>
<tr>
<td>Substance</td>
<td>Effect</td>
<td></td>
</tr>
<tr>
<td>---------------------------------</td>
<td>------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Paracetamol</td>
<td>Toxicity of paracetamol is significantly increased, the hepatotoxic action develops</td>
<td></td>
</tr>
<tr>
<td>Aspirin</td>
<td>The anti-aggregation ability of aspirin is sharply increased, bleeding is increased; the gastric mucosa is ulcerated</td>
<td></td>
</tr>
<tr>
<td>Vitamin B₃, tryptophan, zinc preparations</td>
<td>The toxic effect of ethanol on the liver is potentiated</td>
<td></td>
</tr>
<tr>
<td>Thiamine, ascorbic acid, antioxidants</td>
<td>The toxic effect of ethanol on the liver is reduced</td>
<td></td>
</tr>
<tr>
<td>Metronidazol, furazolidone, cephalosporins, antihyperglycemic drugs, derivatives of sulfonylurea, arsenic preparations, mercury preparations, thiol poisons</td>
<td>The toxic effect of ethanol is considerably enhanced (due to blockade of alcohol dehydrogenase)</td>
<td></td>
</tr>
<tr>
<td>Unithiolum, acetylcysteine, methionine</td>
<td>The toxic effect of ethanol is reduced (due to increase of the alcohol dehydrogenase activity)</td>
<td></td>
</tr>
<tr>
<td>Inducers of microsomal hepatic enzymes (barbiturates, diphenium, glucocorticosteroids, etc.)</td>
<td>Crossed tolerance is developed</td>
<td></td>
</tr>
</tbody>
</table>
2. The calorie content of basic foods tables

The human need for energy is measured in kilocalories (kcal). The word "calorie" is translated from Latin as "heat". All food products have a certain energy value. The present table shows the calorie content of basic foods.

<table>
<thead>
<tr>
<th>Milk and diary products</th>
<th>kcal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk</td>
<td>58</td>
</tr>
<tr>
<td>Condensed milk</td>
<td>135</td>
</tr>
<tr>
<td>High fat kefir</td>
<td>59</td>
</tr>
<tr>
<td>Low fat kefir</td>
<td>30</td>
</tr>
<tr>
<td>Baked milk</td>
<td>86</td>
</tr>
<tr>
<td>Cream 10%</td>
<td>118</td>
</tr>
<tr>
<td>Sour cream 20%</td>
<td>206</td>
</tr>
<tr>
<td>The Russian cheese</td>
<td>371</td>
</tr>
<tr>
<td>The Holland cheese</td>
<td>361</td>
</tr>
<tr>
<td>Bold cottage cheese</td>
<td>156</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fats, margarine, butter</th>
<th>kcal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Butter</td>
<td>748</td>
</tr>
<tr>
<td>Vegetable oil</td>
<td>899</td>
</tr>
<tr>
<td>Mayonnaise</td>
<td>627</td>
</tr>
<tr>
<td>Milk margarine</td>
<td>746</td>
</tr>
<tr>
<td>Pork speck</td>
<td>816</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bread, bakery products, flour</th>
<th>kcal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rye bread</td>
<td>214</td>
</tr>
<tr>
<td>Wheat bread</td>
<td>254</td>
</tr>
<tr>
<td>Wheat rusks</td>
<td>331</td>
</tr>
<tr>
<td>Wheat flour</td>
<td>327</td>
</tr>
<tr>
<td>Rye flour</td>
<td>326</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cereals</th>
<th>kcal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buckwheat</td>
<td>329</td>
</tr>
<tr>
<td>Semolina</td>
<td>326</td>
</tr>
<tr>
<td>Oatmeal</td>
<td>345</td>
</tr>
<tr>
<td>Pearl barley</td>
<td>324</td>
</tr>
<tr>
<td>Rice</td>
<td>323</td>
</tr>
<tr>
<td>Wheat</td>
<td>334</td>
</tr>
<tr>
<td>Corn</td>
<td>325</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Vegetables</th>
<th>kcal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eggplants</td>
<td>24</td>
</tr>
<tr>
<td>Green peas</td>
<td>72</td>
</tr>
<tr>
<td>Courgettes</td>
<td>27</td>
</tr>
<tr>
<td>Cabbage</td>
<td>28</td>
</tr>
</tbody>
</table>

| Cauliflower | 29 |
| Potato      | 83 |
| Onions      | 43 |
| Carrot      | 33 |
| Cucumbers   | 15 |
| Pepper      | 27 |
| Parsley     | 45 |
| Radish      | 20 |
| Lettuce     | 14 |
| Beet        | 48 |
| Tomato      | 19 |
| Kidney beans | 32 |
| Horseradish | 71 |
| Garlic      | 106 |

<table>
<thead>
<tr>
<th>Fruit and berries</th>
<th>kcal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apricot</td>
<td>46</td>
</tr>
<tr>
<td>Pineapple</td>
<td>48</td>
</tr>
<tr>
<td>Bananas</td>
<td>91</td>
</tr>
<tr>
<td>Cherry</td>
<td>49</td>
</tr>
<tr>
<td>Pomegranate</td>
<td>52</td>
</tr>
<tr>
<td>Pear</td>
<td>42</td>
</tr>
<tr>
<td>Peach</td>
<td>44</td>
</tr>
<tr>
<td>Plum</td>
<td>54</td>
</tr>
<tr>
<td>Persimmon</td>
<td>62</td>
</tr>
<tr>
<td>Dates</td>
<td>281</td>
</tr>
<tr>
<td>Sweet cherry</td>
<td>52</td>
</tr>
<tr>
<td>Apple</td>
<td>48</td>
</tr>
<tr>
<td>Orange</td>
<td>38</td>
</tr>
<tr>
<td>Lemon</td>
<td>31</td>
</tr>
<tr>
<td>Tangerine</td>
<td>35</td>
</tr>
<tr>
<td>Grapes</td>
<td>69</td>
</tr>
<tr>
<td>Cranberries</td>
<td>28</td>
</tr>
<tr>
<td>Gooseberry</td>
<td>44</td>
</tr>
<tr>
<td>Raspberries</td>
<td>41</td>
</tr>
<tr>
<td>Currant</td>
<td>38</td>
</tr>
<tr>
<td>Rosehips</td>
<td>253</td>
</tr>
<tr>
<td>Seabuckthorn</td>
<td>30</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Legumes</th>
<th>kcal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beans</td>
<td>58</td>
</tr>
<tr>
<td>Peas</td>
<td>303</td>
</tr>
<tr>
<td>Soy beans</td>
<td>395</td>
</tr>
<tr>
<td>Kidney beans</td>
<td>309</td>
</tr>
<tr>
<td>Product</td>
<td>kcal</td>
</tr>
<tr>
<td>--------------</td>
<td>-------</td>
</tr>
<tr>
<td>Lentil</td>
<td>310</td>
</tr>
</tbody>
</table>

**Meat, poultry**

<table>
<thead>
<tr>
<th>Product</th>
<th>kcal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lamb</td>
<td>203</td>
</tr>
<tr>
<td>Beef</td>
<td>187</td>
</tr>
<tr>
<td>Horse meat</td>
<td>143</td>
</tr>
<tr>
<td>Pork</td>
<td>316</td>
</tr>
<tr>
<td>Veal</td>
<td>90</td>
</tr>
<tr>
<td>Geese</td>
<td>364</td>
</tr>
<tr>
<td>Turkey</td>
<td>197</td>
</tr>
<tr>
<td>Chicken</td>
<td>165</td>
</tr>
<tr>
<td>Duck</td>
<td>346</td>
</tr>
</tbody>
</table>

**Sausage and sausage products**

<table>
<thead>
<tr>
<th>Product</th>
<th>kcal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boiled sausage &quot;Doctor’s&quot;</td>
<td>260</td>
</tr>
<tr>
<td>Milk sausages</td>
<td>277</td>
</tr>
<tr>
<td>Pork wiener</td>
<td>332</td>
</tr>
<tr>
<td>Boiled and smoked &quot;Amateur’s&quot;</td>
<td>420</td>
</tr>
<tr>
<td>Boiled and smoked &quot;Cervelat&quot;</td>
<td>380</td>
</tr>
<tr>
<td>Smoked “Moskovskaya”</td>
<td>473</td>
</tr>
</tbody>
</table>

**Eggs**

<table>
<thead>
<tr>
<th>Product</th>
<th>kcal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chicken egg</td>
<td>157</td>
</tr>
<tr>
<td>Quail egg</td>
<td>168</td>
</tr>
<tr>
<td>Dry protein</td>
<td>336</td>
</tr>
<tr>
<td>Dry yolk</td>
<td>623</td>
</tr>
</tbody>
</table>

**Fish and seafood**

<table>
<thead>
<tr>
<th>Product</th>
<th>kcal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gobies</td>
<td>145</td>
</tr>
<tr>
<td>Pink salmon</td>
<td>147</td>
</tr>
<tr>
<td>Flatfish</td>
<td>88</td>
</tr>
<tr>
<td>Carp</td>
<td>96</td>
</tr>
<tr>
<td>Chum salmon</td>
<td>138</td>
</tr>
<tr>
<td>Icefish</td>
<td>75</td>
</tr>
<tr>
<td>Salmon</td>
<td>219</td>
</tr>
<tr>
<td>Alaska pollock</td>
<td>70</td>
</tr>
<tr>
<td>Capelin</td>
<td>157</td>
</tr>
<tr>
<td>Perch</td>
<td>117</td>
</tr>
<tr>
<td>Sturgeon</td>
<td>164</td>
</tr>
<tr>
<td>Halibut</td>
<td>103</td>
</tr>
<tr>
<td>Pacific saury</td>
<td>262</td>
</tr>
<tr>
<td>Herring</td>
<td>242</td>
</tr>
<tr>
<td>Mackerel</td>
<td>153</td>
</tr>
<tr>
<td>Zander</td>
<td>83</td>
</tr>
</tbody>
</table>

**Caviar**

<table>
<thead>
<tr>
<th>Product</th>
<th>kcal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chum salmon granular</td>
<td>251</td>
</tr>
<tr>
<td>Sturgeon granular</td>
<td>203</td>
</tr>
</tbody>
</table>

**Nuts**

<table>
<thead>
<tr>
<th>Product</th>
<th>kcal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazelnuts</td>
<td>704</td>
</tr>
<tr>
<td>Almonds</td>
<td>645</td>
</tr>
<tr>
<td>Walnuts</td>
<td>648</td>
</tr>
<tr>
<td>Peanuts</td>
<td>548</td>
</tr>
<tr>
<td>Sunflower seeds</td>
<td>578</td>
</tr>
</tbody>
</table>

**Sweets**

<table>
<thead>
<tr>
<th>Product</th>
<th>kcal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Honey</td>
<td>308</td>
</tr>
<tr>
<td>Candied fruit jelly</td>
<td>296</td>
</tr>
<tr>
<td>Candies glazed with chocolate</td>
<td>398</td>
</tr>
<tr>
<td>Sugar</td>
<td>374</td>
</tr>
<tr>
<td>Halva</td>
<td>510</td>
</tr>
<tr>
<td>Dark chocolate</td>
<td>540</td>
</tr>
<tr>
<td>Milk chocolate</td>
<td>547</td>
</tr>
<tr>
<td>Cream cake</td>
<td>544</td>
</tr>
<tr>
<td>Sponge cake</td>
<td>386</td>
</tr>
</tbody>
</table>
3. Vitamins and vitamin-like substances

<table>
<thead>
<tr>
<th>Fat-soluble vitamins</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Names</strong></td>
</tr>
<tr>
<td>1. Vitamin A (Retinol, retinol acetate, retinal, retinoic acid, axeroftol)</td>
</tr>
</tbody>
</table>
### 2. Vitamin D
(ergocalciferol \( \text{D}_2 \), cholecalciferol \( \text{D}_3 \))

- **Ergocalciferol (\( \text{D}_2 \))**
  
  ![Ergocalciferol](image)

- **Cholecalciferol (\( \text{D}_3 \))**
  
  ![Cholecalciferol](image)

**Sources of the vitamin**: fish oil, fatty fish, butter, egg yolk, animal liver, milk and dairy products. Cholecalciferol can be synthesized in the skin from sterols under the action of UV rays and can be ingested with food. Ergocalciferol can only be taken with food.

### 3. Vitamin E
(Tocopherols: \( \alpha \)-tocopherol, \( \beta \)-tocopherol, \( \gamma \)-tocopherol, \( \delta \)-tocopherol)

- **\( \alpha \)-tocopherol acetate**
  
  ![\( \alpha \)-tocopherol acetate](image)

**Unrefined plant oils** (sunflower, corn, cottonseed, olive, peanut, soybean, sea buckthorn), nuts, green leafy vegetables, cereals, legumes, soybeans, oatmeal, wheat germ, egg yolk, milk

1. It provides bone mineralization, prevents osteoporosis
2. It reduces susceptibility to diseases of the skin, heart, thyroid gland
3. Vitamin E is a potent antioxidant.
4. It accelerates healing of wounds and burns.
5. It supports metabolism and the digestive system.
6. It is involved in the heme synthesis, prevents anemia, strengthens the blood vessels walls.
7. It is involved in reproduction, provides the normal functioning of the
### 4. Vitamin K
(Naphthoquinone derivatives)

<table>
<thead>
<tr>
<th><img src="image1.png" alt="Chemical Structure" /></th>
<th><img src="image2.png" alt="Chemical Structure" /></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>vitamin K&lt;sub&gt;1&lt;/sub&gt; (phyloquinone)</strong></td>
<td><strong>vitamin K&lt;sub&gt;2&lt;/sub&gt; (menaquinone)</strong></td>
</tr>
</tbody>
</table>

The green parts of plants: spinach, all types of cabbage, nettle, asparagus, carrots, tomatoes, green tea, rose hips, soybeans, wheat, oatmeal, corn, fish oil, brown seaweed, egg yolk. It is contained in significant quantities in olive oil. It is synthesized by intestinal bacteria in amounts sufficient for the body.

1. It is involved in the synthesis of prothrombin in the liver providing blood clotting.
2. It is involved in the metabolism in bones and connective tissues regulating the blood calcium and normal renal function.

| gonads |

---

266
<table>
<thead>
<tr>
<th>Vitamin</th>
<th>Structure</th>
<th>Sources</th>
<th>Function</th>
</tr>
</thead>
</table>
| **5. Vitamin F**            | ![Structure](image) | Vegetable oils: wheat, flaxseed, sunflower, safflower, soybean, peanut; in almonds, avocado, oatmeal, corn, brown rice, nuts | 1. It is involved in the synthesis of fats, the cholesterol metabolism.  
2. It stimulates the immunity.  
3. It has the effect on spermatogenesis.  
4. Together with vitamin D it is involved in the bone formation |
| **6. Ubiquinone**           | ![Structure](image) | Beef, pickled herring, trout, peanuts, pistachios, sesame oil, soybean oil, chicken meat | 1. It is required for the functioning of tissues with a high level of the energy metabolism (the highest concentration is in the myocardium).  
2. It is an antioxidant, which is synthesized in the organism. It regenerates the antioxidant activity of vitamin E |
| **7. Vitamin B₁**           | ![Structure](image) | Sources of the plant origin: bread and bakery products from whole-grain flour; cereals (rough rice, oats), wheat germ, rice bran, vegetables (asparagus, | 1. It regulates the activity of the nervous system.  
2. It is a precursor of enzymes that play an important role in the carbohydrate, lipid, protein |
| 8. Vitamin B₂  
(Riboflavin) | thiamine | thiamindiphosphate | broccoli, Brussels sprouts, legumes (peas), nuts, oranges, raisins, plums, prunes, rose hips, berries (strawberries, blueberries, black currants, sea buckthorn), brewer's yeast. Sources of the animal origin: meat (pork, beef), liver, poultry, egg yolk, fish. It is synthesized by the microflora of the large intestine and energy metabolism. 3. It is necessary for the muscle tone of the digestive tract, stomach and heart. 4. It improves the blood circulation and is involved in hematopoiesis. 5. It takes part in the metabolism of amino acids and improves the neuromuscular transmission.

|  | thiamine | thiamindiphosphate | milk, liver, kidney, meat, yeast, cheese, leafy green vegetables, pickled vegetables, fish, eggs, bread. It is synthesized by the intestinal microflora 1. It is involved in the metabolism of proteins, fats and carbohydrates, and the energy metabolism. 2. It supports the skin health. 3. It is involved in the vision and low-light vision, reduces eye fatigue, and plays an important role in prevention of cataract. 4. It is necessary for formation of the red blood cells. 5. It increases pyridoxine conversion into the active form. |
### 9. Vitamin B₃
(Nicotinic acid, niacin, antipellagra vitamin, vitamin PP)

<table>
<thead>
<tr>
<th>Vitamin B₃</th>
<th>Nicotinic acid</th>
<th>Niacinamide</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Nicotinic acid" /></td>
<td><img src="image" alt="Niacinamide" /></td>
<td></td>
</tr>
</tbody>
</table>

Sources of the plant origin: whole grains, brewer's yeast, wheat bran, nuts, beans, broccoli, carrots, cheese, corn flour, dates, potatoes, tomatoes. Sources of the animal origin: beef liver, poultry, fish, lean meats (especially beef), milk and dairy products, eggs. In the body it is synthesized by intestinal bacteria.

1. It is necessary for the normal function of the nervous system. It has a mild sedative effect, is used in the treatment of emotional and mental disorders.
2. It supports the skin health.
3. It decreases the cholesterol level, participates in the protein, carbohydrate, and energy metabolism.
4. It supports the digestive system, improves liver function.
5. It is involved in the synthesis of sex hormones, cortisone, thyroxin and insulin.

### 10. Vitamin B₅
(Pantothenic acid, pantothen)

<table>
<thead>
<tr>
<th>Vitamin B₅</th>
<th>Pantothenic acid</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Pantothenic acid" /></td>
<td></td>
</tr>
</tbody>
</table>

Sources of the plant origin: legumes and whole grain products, yeast, hazelnut, green leafy vegetables, buckwheat and oats, cauliflower. Sources of the animal origin: variety meats, poultry, eggs, milk, and dairy products, caviar. In the body it is synthesized.

1. It plays an important role in formation of antibodies.
2. It is involved in the metabolism of carbohydrates, proteins, fats, and the energy metabolism; activates the redox processes in the body, promotes the absorption of other
| Coenzyme A | by intestinal bacteria | vitamins.  
3. It stimulates the synthesis of adrenal hormones, sex hormones, and growth hormones; the levels of cholesterol, histamine, acetylcholine, and hemoglobin |

**11. Vitamin B₆**  
(Pyridoxine, adermin)  

<table>
<thead>
<tr>
<th>Pyridoxine</th>
<th>Pyridoxal</th>
<th>Pyridoxamine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brewer's yeast, bran, wheat germ, liver, melon, cabbage, milk, eggs, beef, bananas, corn, fish, oysters, walnuts</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In the body the three forms of vitamin can change one into another. The main metabolically active forms of vitamin are PLP and PMP.

<table>
<thead>
<tr>
<th>Pyridoxal 5-phosphate (PLP)</th>
<th>Pyridoxamine 5-phosphate (PMP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. It is involved in the amino acid metabolism, the synthesis of proteins, enzymes, histamine; hemoglobin and red blood cell production.</td>
<td></td>
</tr>
<tr>
<td>2. It is involved in fatty acid metabolism, reduces the level of cholesterol in the blood, is essential for the normal functioning of the liver.</td>
<td></td>
</tr>
<tr>
<td>3. It is responsible for formation of antibodies; is involved in the synthesis of neurotransmitters (including serotonin), is required for the normal functioning of the nervous system.</td>
<td></td>
</tr>
<tr>
<td>4. It improves the contractility of the heart muscle.</td>
<td></td>
</tr>
<tr>
<td><strong>12. Vitamin B&lt;sub&gt;6&lt;/sub&gt;, B&lt;sub&gt;9&lt;/sub&gt;</strong> (folate, folic acid, folacine, pteroyl-L-glutamic acid)</td>
<td><img src="image" alt="Chemical Structure" /></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>In tissues it is changed in tetrahydrofolate (THF): <img src="image" alt="Chemical Structure" /></td>
<td>5. It promotes the conversion of folic acid to its active form, participates in the synthesis of vitamin B&lt;sub&gt;3&lt;/sub&gt;</td>
</tr>
<tr>
<td></td>
<td>1. It is involved in the synthesis of the red blood cells, DNA, serotonin, norepinephrine. Folic acid derivatives are involved in the metabolism of proteins and nucleic acids. 2. It is involved in formation of the fetus nervous system. 3. It improves supply and regeneration of tissues.</td>
</tr>
</tbody>
</table>
13. **Vitamin B₁₂**  
(corrinoids, cobalamines  
anti-anemic vitamin)  

Milk, liver, kidney, fish  
products, eggs, cheese, algae,  
mushrooms

1. It participates in  
hematopoiesis.
2. It activates the protein  
metabolism, is involved in  
the biosynthesis of nucleic  
acids, affects the  
carbohydrate and lipid  
metabolism.
3. It affects the nervous  
system.
4. It possesses a strong  
lipotropic effect, prevents  
fatty liver infiltration.
5. It increases the  
consumption of oxygen by  
cells in acute and chronic  
hypoxia.

---

14. **Vitamin C**  
(ascorbic acid, antiscurvy  
vitamin)

The main sources are  
vegetable products: berries,  
vegetables and fruit (rose  
hips, cabbages, potatoes,  
lemons, oranges,  
blackcurrant, red pepper,  
green leafy vegetables). It is  
contained in a small amount  
in animal products (liver,  
kidneys, and adrenals).

1. It possesses the  
antioxidant activity, takes  
part in regulation of redox  
processes.
2. It takes part in the  
collagen and procollagen  
synthesis, the folic acid and  
iron metabolism, as well as  
the synthesis of  
catecholamines and steroid.
3. It regulates blood coagulation, normalizes permeability of capillaries, is necessary for hematopoiesis, and possesses the anti-inflammatory and anti-allergic activity.
4. It affects beneficially the body’s immune reactions, promotes synthesis of antibodies, and increases the reactivity, leucocyte phagocytic activity and disease resistance.

| 15. Vitamin P  
(bioflavonoids, polyphenols, permeability vitamin) | ![Chemical Structure] | It is contained abundantly in green tea, rose hips, citrus fruit, persimmon, blackcurrant, chokeberries, apples, grapes, plums, chili, and buckwheat. 
It has antioxidant properties and prevents ascorbic acid from oxidation. 
3. It decreases blood coagulation and increases elasticity of erythrocytes | 1. Together with ascorbic acid it takes part in redox processes. 
2. It promotes increasing the content of hyaluronic acid, which increases elasticity of capillaries and decreases their permeability. 
3. It has antioxidant properties and prevents ascorbic acid from oxidation. 
4. It decreases blood coagulation and increases elasticity of erythrocytes |
| **16 Vitamin H, B₇**  
(biotin, coenzyme R) | ![N-carboxybiotin](image) | It is contained in small amounts in all kinds of products. Liver, kidneys, egg yolk, yeasts, cauliflower, pissums, soy products, mushrooms contain it abundantly. It is synthesized in a sufficient amount in the human body by the intestinal flora.  
1. It takes part in the metabolism of carbohydrates, proteins, fats, takes part in the glucose synthesis.  
2. It is necessary for functioning of the stomach and intestines, affects the immune system and functions of the nervous system, and promotes healthy hair and nails. |
| **17. Vitamin B₁₅**  
(pangamic acid, calcium pangamate, calgame) | ![Pangamic acid](image) | A part of cereals, drupes cores, rice bran, pumpkin, barns. It is contained in the blood and liver. It is synthesized in a sufficient amount in the human body by the intestinal flora.  
1. It promotes the metabolism, increases the lipid metabolism, oxygen consumption by tissues, increases the amount of creatine phosphate in muscles and the amount of glycogen in the liver and muscles, keeps tissues functions under hypoxia conditions.  
2. It takes part in the lipid metabolism, in the body’s redox processes, increases the oxygen... |
18. Vitamin N (lipoic acid)

<table>
<thead>
<tr>
<th>Chemical Structure</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HOOC-(CH₂)₂C─S─SH + 2H⁺</td>
<td>Lipoic acid is found practically in every kind of food. It is contained abundantly in beef (especially in liver), milk, rice, cabbage, herbs</td>
</tr>
</tbody>
</table>

1. It is a strong antioxidant, intensifies the action of other antioxidants and promotes their reduction in case of the decreased activity.
2. It accelerates absorption and decomposition of glucose, showing the insulin-like function.
3. It has the lipotropic activity, protects hepatic cells from injury.

19. Vitamin B₄ (choline)

<table>
<thead>
<tr>
<th>Chemical Structure</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HO─C─N─CH₃</td>
<td>Animal sources: meat, liver, kidneys, fish, eggs (egg yolk), milk, cheese, cottage cheese. Vegetable sources: legumes, cabbage, vegetable oils, brans, tomatoes, carrots, spinach.</td>
</tr>
</tbody>
</table>

1. It is an important component of phospholipids (lecithin, cefaline, serinphosphatides, and plasmalogens).
2. It serves as a donor of methyl groups in the synthesis of
Particularly, it is synthesized in the human body from serine methionine, adrenaline, creatine, purine and pyrimidine bases.  
3. It takes part in acetylcholine production.  
4. It maintains the integrity of cell membranes, decreases the liver damage in alcoholism and hepatitis.  
5. It reduces cholesterol, has the antischlerotic effect

| **20. Vitamin B₈** (inositol, myoinositol) | Particularly, it is synthesized in the human body from serine methionine, adrenaline, creatine, purine and pyrimidine bases.  
3. It takes part in acetylcholine production.  
4. It maintains the integrity of cell membranes, decreases the liver damage in alcoholism and hepatitis.  
5. It reduces cholesterol, has the antischlerotic effect |
| Sources: meat products (liver, brain, heart), eggs, bread, green peas, legumes, nuts, citric fruit, sesame oil, yeasts, cabbage, carrots, bran, brown rice, melon, blackberries, gooseberries.  
Temperature processing of products leads to the loss of inositol | 1. It is necessary for the microorganism growth.  
2. It is a part of phosphoinositols, especially in the nerve tissue.  
3. As a phospholipids component it has the lipotropic activity |

| **21. Vitamin B₁₃** (orotic acid) | Particularly, it is synthesized in the human body from serine methionine, adrenaline, creatine, purine and pyrimidine bases.  
3. It takes part in acetylcholine production.  
4. It maintains the integrity of cell membranes, decreases the liver damage in alcoholism and hepatitis.  
5. It reduces cholesterol, has the antischlerotic effect |
| Sources: milk, dairy products, whey, liver, yeasts, root vegetables.  
It is synthesized in the human intestines | 1. It takes part in the synthesis of nucleic acids, stimulates the protein synthesis, division, growth and reproduction of cells, the tissue regeneration, and increases hematopoiesis.  
2. It has the hepatoprotective activity.  
3. It has the anti-anemic activity.  
4. It affects beneficially fetaion |
| 22. Vitamin U  
(S-methylmethioninesulfonium, antiulcer agent) | ![chemical_structure](attachment:chemical_structure.png) | Sources: cabbage (especially broccoli), tomatoes, parsley, potatoes, celery, turnip, liver, eggs | 1. It has the anti-ulcer activity, increases the mucous membrane epithelisation, reduces the gastric secretion.  
2. It has the analgetic activity.  
3. It takes part in proteins and lipid metabolism, neutralizes toxins, has the hepatoprotective activity.  
4. It has the anti-allergic activity. |
|---|---|---|---|
| 23. Para-aminobenzoic acid  
(PABA) | ![chemical_structure](attachment:chemical_structure.png) | Animal sources: yeasts, liver, kidneys, eggs, milk, cheese. Vegetable sources: mushrooms, unrefined grains, bran, potatoes, syrup, nuts. It is synthesized in the human body by the intestinal flora | 1. It is the necessary growth factor for microorganisms.  
2. It promotes the synthesis of purines, pyrimidines, DNA, and RNA.  
3. It affects the thyroid function (inhibits the thyroxin secretion).  
4. It affects metabolism in the human body, has the antioxidant activity. |
| 24. Vitamine B<sub>1</sub>  
(carnitine) | ![chemical_structure](attachment:chemical_structure.png) | It is contained in meat products, liver, kidneys, heart, diary products. Particularly it is synthesized in the human body by the intestinal flora | 1. It affects the β-oxidation process of fatty acids.  
2. It promotes the skeletal muscles development.  
3. It reduces the blood cholesterol, has the antisclerotic activity. |
## 4. Proteinogenic amino acids

<table>
<thead>
<tr>
<th>No.</th>
<th>Amino Acid</th>
<th>Molecular Structure</th>
<th>Sources</th>
<th>Functions</th>
</tr>
</thead>
</table>
| 1.  | Valine       | ![](valine.png)     | It is contained abundantly in meat, mushrooms, dairy products, cereals, legumes, peanuts | 1. It is necessary for keeping the normal nitrogen balance in the human body.  
2. It is used as the energy source for the muscles.  
3. It is one of the main components in the growth and synthesis of the body tissues.  
4. It reduces sensibility of the human body to pain, cold and heat. |
| 2.  | Isoleucine   | ![](isoleucine.png) | It is contained abundantly in chicken meat, eggs, fish, liver, meat, almonds, cashew, chick-peas, lentil, and soy products | It takes part in the formation of the muscular tissue and hemoglobin. |
| 3.  | Lysine       | ![](lysine.png)     | It is contained abundantly in fish (cod, sardines), meat (specifically in red meat), dairy products, cheese (specifically in Parmesan), eggs, wheat, nuts, and legumes | 1. It takes part in the synthesis of hormones, enzymes, and collagen formation.  
2. It is necessary for the synthesis of albumins.  
3. It supports the calcium absorption. |
| 4.  | Leucine      | ![](leucine.png)    | It is contained abundantly in meat, fish, lentil, nuts, seeds, chicken, eggs, and brown (“hulled” or “unmilled”) rice | 1. It is necessary for formation and development of the muscular tissue, takes part in the protein synthesis.  
2. It is necessary for strengthening the immune system, promotes wound healing.  
3. It reduces the blood sugar content and can serve as an energy source for cells.  
4. It takes part in the cholesterol synthesis process. |
<table>
<thead>
<tr>
<th><strong>5. Methionine</strong></th>
<th></th>
<th>biosynthesis</th>
</tr>
</thead>
</table>
| ![Methionine structure](image) | | 1. It takes part in the synthesis of nucleic acids, choline and adrenaline.  
2. It takes part in the vitamin metabolism (vitamin B₁₂, folic acid), in the metabolism of fats and phospholipids.  
3. It helps to reduce the cholesterol level, has the lipotropic activity.  
4. It takes part in elimination of heavy metals from the body, regulates ammonia formation and purifies urine from it.  
5. It affects hair follicles and supports the hair growth |

<table>
<thead>
<tr>
<th><strong>6. Tryptophan</strong></th>
<th><img src="image" alt="Tryptophan structure" /></th>
<th>It is contained abundantly in legumes, bananas, dried dates, nuts, sesame, milk, yoghurt, cottage cheese, fish, chicken, turkey, meat</th>
</tr>
</thead>
</table>
|                   |                   | 1. It takes part in the synthesis of albumins, globulins, serotonin, and vitamin PP.  
2. It accelerates secretion of the growth hormone.  
3. Being a natural relaxant it helps to fight with insomnia causing the normal sleep, as well as to fight with depression and anxiety.  
4. It strengthens the immune system |

<table>
<thead>
<tr>
<th><strong>7. Threonine</strong></th>
<th><img src="image" alt="Threonine structure" /></th>
<th>It is contained abundantly in dairy products, eggs, nuts, peas</th>
</tr>
</thead>
</table>
|                   |                   | 1. It takes part in the antibody production, formation of collagen and elastin.  
2. It has the lipotropic activity.  
3. It regulates the nerve impulses transfer by neurotransmitters, helps |
| 8. Phenylalanine | ![Phenylalanine](image) | It is contained abundantly in legumes, nuts, beef, chicken, fish, eggs, cottage cheese, and milk | 1. It regulates the thyroid functioning.  
2. It takes part in the pigment melanin formation, promoting the natural skin colour regulation.  
3. It takes part in the synthesis of adrenaline and noradrenaline |

**Conditionally essential amino acids**

| 9. Arginine | ![Arginine](image) | It is contained abundantly in squash seeds, pork, beef, peanuts, sesame, yoghurt, Swiss cheese | 1. It takes part in the tissue regeneration, the growth hormone synthesis, spermatogenesis, formation of urea, ornithine and creatine.  
2. It is a part of collagen.  
3. It strengthens the immune system |

| 10. Histidine | ![Histidine](image) | It is contained abundantly in tuna, salmon, pork tenderloin, beef filet, chicken breast, soy beans, peanuts, and lentil | 1. It is a starting material in the synthesis of histamine and biologically active peptides of muscles – carnosine and anserine.  
2. It is a part of hemoglobin.  
3. It is one of the main regulators of the blood coagulation |

| 11. Tyrosine | ![Tyrosine](image) | It is contained abundantly in milk, peas, eggs, peanuts, beans | 1. It stimulates the growth hormone synthesis.  
2. It is part of casein and insulin.  
3. It takes part in the synthesis of dopamine, adrenaline, melanin, and the thyroid hormones |
# Nonessential amino acids

<table>
<thead>
<tr>
<th></th>
<th>Structure</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>12. Alanine</td>
<td><img src="https://example.com/alanine.png" alt="Alanine structure" /></td>
<td>It is contained abundantly in gelatin, corn, beef, eggs, pork, rice, milk, soy products, and oat. 1. It is one of the sources for the glucose formation in the human body; takes part in the metabolism of sugars and organic acids. 2. β-Alanine is a part of the active catalysts – coenzyme A and pantothenic acid. 3. It strengthens the immune system by forming antibodies.</td>
</tr>
<tr>
<td>13. Asparagine</td>
<td><img src="https://example.com/asparagine.png" alt="Asparagine structure" /></td>
<td>Animal sources: milk, whey, poultry, eggs, fish, seafood. Vegetable sources: asparagus, tomatoes, legumes, nuts. 1. It is necessary for the normal functioning of the nervous system, takes part in the metabolism of the brain cells. 2. It binds and neutralizes the toxic endogenous ammonia.</td>
</tr>
<tr>
<td>14. Aspartic acid</td>
<td><img src="https://example.com/aspartic_acid.png" alt="Aspartic acid structure" /></td>
<td>Sources: beef, eggs, salmon, seafood (especially shrimps), legumes, nuts (peanuts, almonds, walnuts). 1. It takes part in DNA and RNA. 2. It takes part in the synthesis of immunoglobulins, takes part in functioning of the immune system.</td>
</tr>
<tr>
<td>15. Glycine</td>
<td><img src="https://example.com/glycine.png" alt="Glycine structure" /></td>
<td>Sources: meat (especially beef), liver, fish, cod-liver, chicken eggs, cottage cheese. Vegetable sources: nuts (peanuts), oat, and sunflower seeds. 1. It takes part in the synthesis of creatine, DNA, RNA, and purines. 2. It stimulates the growth hormone release.</td>
</tr>
<tr>
<td>16. Glutamic acid</td>
<td><img src="https://example.com/glutamic_acid.png" alt="Glutamic acid structure" /></td>
<td>It is contained in soy products, hard cheeses, sunflower seeds, cottage cheese, melted cheeses, meat, poultry, caviar, nuts, eggs, fish, seafood. 1. It takes part in the protein and hydrocarbon metabolism. 2. It stimulates oxidation processes and promotes the ammonia neutralization and elimination from the body, increases resistance of the body to hypoxia.</td>
</tr>
<tr>
<td><strong>17. Glutamine</strong></td>
<td><img src="image" alt="Glutamine structure" /></td>
<td>Animal sources: meat (beef, chicken), fish, eggs, milk, dairy products. Vegetable sources: cabbage, beet, beans, spinach, parsley</td>
</tr>
<tr>
<td><strong>18. Proline</strong></td>
<td><img src="image" alt="Proline structure" /></td>
<td>Sources: dairy products, eggs, fish, legumes, meat, nuts, seafood, green cabbage, soy products</td>
</tr>
<tr>
<td><strong>19. Serine</strong></td>
<td><img src="image" alt="Serine structure" /></td>
<td>It is contained in meat and milk products, soy products, peanuts and oat gluten</td>
</tr>
<tr>
<td><strong>20. Cysteine</strong></td>
<td><img src="image" alt="Cysteine structure" /></td>
<td>Animal sources: poultry, pork, eggs, diary products. Vegetable sources: red pepper, onion, garlic, Brussels sprout, broccoli, etc.</td>
</tr>
</tbody>
</table>
# 5. Fatty acids

## Saturated acids

<table>
<thead>
<tr>
<th>1. Caproic acid</th>
<th>CH₃ - (CH₂)₄ - COOH</th>
<th>Sources: vegetable oils and animal fats (butter, coconut, palm), goat milk, vanilla</th>
<th>It regulates the composition of the intestinal flora</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Butyric acid</td>
<td>CH₃ - (CH₂)₂ - COOH</td>
<td>It is contained in butter, Parmesan cheese, milk (especially goat, buffalo and sheep). It is a product of anaerobic fermentation of the intestinal flora</td>
<td>1. It takes part in genetic regulation of the inflammation and immune response at the intestinal mucosa level. 2. It is one of the main sources of energy for colonocytes; stimulates colonocyte proliferation. 3. It reduces T-lymphocytes reactivity; has the immunosuppressive activity. 4. It stimulates the bifidobacteria growth</td>
</tr>
<tr>
<td>3. Myristic acid</td>
<td>CH₃ - (CH₂)₁₂ - COOH</td>
<td>Sources: nutmeg, coconut oil (up to 20%), palm oil, corn oil</td>
<td>1. It enhances the skin protective functions. 2. The blood cholesterol level is greatly increased, thus associating with the highest risk of atherosclerosis development</td>
</tr>
<tr>
<td>4. Palmitic acid</td>
<td>CH₃ - (CH₂)₁₄ - COOH</td>
<td>It is contained in most vegetable oils and animal fats: coconut oil, palm oil (44%), olive oil, sesame oil, cocoa butter, butter, pork fat (30%)</td>
<td>1. It promotes activation of the synthesis of collagen, elastin, glycosaminoglycans and hyaluronic acid; stimulates the intercellular substance formation. 2. It increases the lipoprotein synthesis. 3. It binds calcium ions in the</td>
</tr>
</tbody>
</table>
### 5. Stearic acid
- **Formula:** \( \text{CH}_3 - (\text{CH}_2)_{16} - \text{COOH} \)
- It is contained in vegetable oils: coconut oil, palm oil, olive oil. Among the animal fats it is contained abundantly in sheep fat (up to 30%); in sebaceous glands secrete in a free form.
- **Properties:**
  1. Triglycerides are parts of lipids, which serve as an energy depot.
  2. It regenerates the skin protective functions.
  3. It increases the cholesterol absorption rate.

### Unsaturated acids

| 6. Arachidonic acid | **Formula:** \( \text{CH}_3 - (\text{CH}_2)_4 - (\text{CH} = \text{CH} - \text{CH}_2)_3 - \text{CH} = \text{CH} - (\text{CH}_2)_3 - \text{COOH} \) | **Sources:** meat (pork, poultry meat), eggs, cod-liver oil (up to 30%), butter, pork fat, new milk. It is synthesized in the human body from linoleic acid. | **Properties:**
  1. It takes part in the prostaglandin synthesis.
  2. It promotes the skeletal muscles growth.
  3. It reduces the blood cholesterol level; increases the vascular elasticity.
  4. It promotes renovation and development of nerve cells.
  5. It improves the cerebral circulation. |

| 7. Crotonic acid | **Formula:** \( \text{CH}_3 - \text{CH} = \text{CH} - \text{COOH} \) | **Sources:** croton oil (obtained from Croton tiglium). The intermediate product of biosynthesis and oxidation of fatty acids in the body. | **Properties:**
  1. It stimulates the protein synthesis. |

| 8. Clupanodonic acid (Docosahexaenoic acid) (DHA) | **Formula:** \( \text{CH}_3 - (\text{CH}_2 - \text{CH} = \text{CH})_5 - (\text{CH}_2)_5 - \text{COOH} \) | It is contained in cold-water oceanic fish oils and sea-food. | **Properties:**
  1. It normalizes the central nervous system functioning; improves memorization processes.
  2. It activates the immune system. |

| 9. Linoleic acid | **Formula:** \( \text{CH}_3 - (\text{CH}_2)_4 - \text{CH} = \text{CH} - \text{CH}_2 - \text{CH} = \text{CH} - (\text{CH}_2)_7 - \text{COOH} \) | Animal sources: animal fats (beef, sheep, chicken), cold-water fish. Vegetable sources: vegetable oils (sunflower, cedar, wheat germ, | **Properties:**
  1. It reduces inflammation processes; stimulates cellular regeneration.
  2. It regulates the central nervous system functioning. |
| 10. Linolenic acid | CH₃-(CH₂-CH=CH)₃-(CH₂)₇-COOH | It is contained abundantly in fish (mackerel, tuna, herring, salmon, trout, perch, and sardines). Vegetable sources: pumpkin seeds, soy products, leafy greens, vegetable oils (linseed, grape, sesame, soy), nuts | 1. It reduces the blood cholesterol level, increases the vascular elasticity.  
2. It has the antioxidant activity.  
3. It improves cerebral circulation.  
4. It decreases inflammation processes and stimulates the tissue regeneration.  
5. It improves the immune system functioning.  
6. It regulates the adrenal function |
|-------------------|-----------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 11. Oleic acid | CH₃-(CH₂)₇-CH=CH-(CH₂)₇-COOH | It is contained in animal fats (beef, pork), cod-liver oil, vegetable oils (sunflower, olive, sesame, palm, corn, cocoa butter), nuts (peanuts, pistachios, hazelnuts, Brazil nuts, almonds) | 1. It stimulates the skeletal muscles growth.  
2. It has the antisclerotic activity.  
3. It normalizes metabolism and activates the lipid metabolism.  
4. It reduces the barrier functions of the epidermis |
| 12. Eicosapentaenoic acid (EPA) | CH₃-(CH₂-CH=CH)₅-(CH₂)₃-COOH | Sources: cod-liver oil, sea foods, oily fish (herring, salmon, mackerel, sardines), cod liver | 1. It supports the normal serotonin level; has the antidepressant activity.  
2. It has the antisclerotic and antithrombotic activity; improves the blood rheology; reduces blood levels of high density lipoproteins; normalizes the heart function.  
3. It prevents Alzheimer's disease development.  
4. It prevents osteoporosis.  
5. It activates the immune system |
# 6. Carbohydrates

| 1. Glucose | ![Glucose Structure](image) | Sources: grapes, sweet cherry, cherry, raspberries, strawberries, watermelon, pumpkin, bananas, plums, cabbage, carrots, honey | 1. It is the main source of energy for providing metabolic processes of the body.  
2. It takes part in plastic processes |
| 2. Fructose | ![Fructose Structure](image) | Sources: grapes, apples, pears, cherry, watermelon, black currants, raspberries, strawberries, cantaloupe, beets, cabbage, honey | 1. It takes part in the brain nutrition, blood sugar balance, glycogen formation, muscle activity.  
2. It is the basic element in the synthesis of hemolymph transport disaccharides and body depot fat |
| 3. Galactose | ![Galactose Structure](image) | Sources: dairy products, sugar beets. It is formed in the gastrointestinal tract by lactose cleavage | It is the energy source |
| **Xylose** | \[
\begin{array}{c}
\text{H} \\
\text{O} \\
\text{H} \\
\text{O} \\
\text{H} \\
\text{CH}_2\text{OH}
\end{array}
\] |
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sources</strong>: wine, brandy, cognac alcohols</td>
</tr>
<tr>
<td><strong>Xylose reduction products</strong> are used as sugar substitutes in diabetes</td>
</tr>
</tbody>
</table>

| **Mannose** | \[
\begin{array}{c}
\text{H} \\
\text{O} \\
\text{H} \\
\text{O} \\
\text{H} \\
\text{CH}_2\text{OH}
\end{array}
\] |
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sources</strong>: citrus fruit, mushrooms (chanterelles), kombucha</td>
</tr>
<tr>
<td>Mannose oxidation products are used in medicine as sugar substitutes in the diet of patients with diabetes</td>
</tr>
</tbody>
</table>

| **Rhamnose** | \[
\begin{array}{c}
\text{H} \\
\text{O} \\
\text{H} \\
\text{O} \\
\text{H} \\
\text{CH}_3
\end{array}
\] |
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sources</strong>: gums</td>
</tr>
<tr>
<td>It is the energy source</td>
</tr>
</tbody>
</table>

| **Sucrose** | \[
\begin{array}{c}
\text{CH}_2\text{OH} \\
\text{H} \\
\text{O} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{H} \\
\text{CH}_2\text{OH} \\
\text{H} \\
\text{O} \\
\text{H} \\
\text{H} \\
\text{H}
\end{array}
\] |
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>It is contained in beets (sugar beets), sugarcane, peaches, melons, plums, mandarins, carrots, honey, beer, treacle</td>
</tr>
<tr>
<td>It is the main energy source</td>
</tr>
<tr>
<td><strong>8. Lactose</strong></td>
</tr>
<tr>
<td>---------------</td>
</tr>
<tr>
<td><strong>9. Maltose</strong></td>
</tr>
<tr>
<td><strong>10. Trehalose</strong></td>
</tr>
<tr>
<td><strong>11. Starch</strong> (a mixture of two homopolysaccharides: amylose and amylopectin)</td>
</tr>
</tbody>
</table>
### 12. Cellulose (disaccharide B-cellobiose is a structural unit of cellulose)

<table>
<thead>
<tr>
<th><strong>Sources:</strong> vegetables (eggplant, cabbage, potatoes, leeks, rhubarb, spinach, horseradish, sorrel radish, radish, beets, melons), legumes, fruit (apricot, apple quince, oranges, bananas), nuts, dried apricots, raisins, berries (strawberries, blackberries, blueberries, gooseberries, raspberries, currants), grains (buckwheat, oatmeal), mushrooms, whole wheat bread</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. It stimulates peristalsis, adsorbs sterols (cholesterol) and prevents their reabsorption and excretion.</td>
</tr>
<tr>
<td>2. It normalizes the intestinal flora composition, reduces putrefactive processes and prevents toxic substances absorption</td>
</tr>
</tbody>
</table>
7. THE GLYCEMIC INDEX OF FOOD PRODUCTS (GI)

The glycemic index of a food product is a measure of how quickly a particular product breaks down in our organism, and how quickly the level of glucose – the main source of energy for cells – rises in the blood. The faster the product breaks down, the higher is the GI. Glucose is a standard and has the glycemic index of 100.

When the product with a high GI enters into the body, the blood sugar level dramatically increases; the pancreas begins producing insulin intensely, which performs two main functions:
- reduces the level of sugar in the blood, distributing it to various tissues of the body for short-term usage or for fat formation;
- does not allow the body fat to be converted again into glucose, which the body uses as fuel.

Food products with a low GI, such as apples, are retained for long time in the body, broken down gradually and do not increase the level of sugar in the blood dramatically providing a long-lasting feeling of satiety. Those who want to lose weight choose foods with a low GI.

**Food products with a low glycemic index**

<table>
<thead>
<tr>
<th>Product</th>
<th>GI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunflower seeds</td>
<td>8</td>
</tr>
<tr>
<td>Garlic</td>
<td>10</td>
</tr>
<tr>
<td>Lettuce</td>
<td>10</td>
</tr>
<tr>
<td>Tomatoes</td>
<td>10</td>
</tr>
<tr>
<td>Onion</td>
<td>10</td>
</tr>
<tr>
<td>Cabbage</td>
<td>10</td>
</tr>
<tr>
<td>Mushrooms</td>
<td>10</td>
</tr>
<tr>
<td>Aubergines</td>
<td>10</td>
</tr>
<tr>
<td>Walnuts</td>
<td>15</td>
</tr>
<tr>
<td>Peanuts</td>
<td>20</td>
</tr>
<tr>
<td>Fresh apricots</td>
<td>20</td>
</tr>
<tr>
<td>Black chocolate (70% of cacao)</td>
<td>22</td>
</tr>
<tr>
<td>Plumps</td>
<td>22</td>
</tr>
<tr>
<td>Pearl barley</td>
<td>22</td>
</tr>
<tr>
<td>Cherry</td>
<td>22</td>
</tr>
<tr>
<td>Apples</td>
<td>30</td>
</tr>
<tr>
<td>Peaches</td>
<td>30</td>
</tr>
<tr>
<td>Green bananas</td>
<td>30</td>
</tr>
<tr>
<td>Whole milk</td>
<td>32</td>
</tr>
<tr>
<td>Strawberry</td>
<td>32</td>
</tr>
<tr>
<td>Product</td>
<td>GI</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-----</td>
</tr>
<tr>
<td>Peanut oil</td>
<td>32</td>
</tr>
<tr>
<td>Raw carrot</td>
<td>35</td>
</tr>
<tr>
<td>Dried apricots</td>
<td>35</td>
</tr>
<tr>
<td>Natural yoghurt</td>
<td>35</td>
</tr>
<tr>
<td>Oranges</td>
<td>35</td>
</tr>
<tr>
<td>Fish sticks</td>
<td>38</td>
</tr>
<tr>
<td>White beans</td>
<td>40</td>
</tr>
<tr>
<td>Apple juice</td>
<td>40</td>
</tr>
<tr>
<td>Orange juice</td>
<td>40</td>
</tr>
<tr>
<td>Fresh peas</td>
<td>40</td>
</tr>
<tr>
<td>Grapes</td>
<td>40</td>
</tr>
<tr>
<td>Buckwheat</td>
<td>50</td>
</tr>
</tbody>
</table>

**Food products with a medium glycemic index**

<table>
<thead>
<tr>
<th>Product</th>
<th>GI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ice cream</td>
<td>52</td>
</tr>
<tr>
<td>Biscuits</td>
<td>55</td>
</tr>
<tr>
<td>Pies</td>
<td>59</td>
</tr>
<tr>
<td>Canned sweet corn</td>
<td>59</td>
</tr>
<tr>
<td>White rice</td>
<td>60</td>
</tr>
<tr>
<td>Pizza with tomatoes and cheese</td>
<td>60</td>
</tr>
<tr>
<td>Beetroot</td>
<td>64</td>
</tr>
<tr>
<td>Raisins</td>
<td>64</td>
</tr>
<tr>
<td>Rye bread</td>
<td>65</td>
</tr>
<tr>
<td>Semolina</td>
<td>65</td>
</tr>
<tr>
<td>Boiled potatoes</td>
<td>65</td>
</tr>
<tr>
<td>Melon</td>
<td>65</td>
</tr>
<tr>
<td>Ripe bananas</td>
<td>65</td>
</tr>
<tr>
<td>Muesli</td>
<td>66</td>
</tr>
<tr>
<td>Pine apple</td>
<td>66</td>
</tr>
<tr>
<td>Croissant</td>
<td>67</td>
</tr>
<tr>
<td>Milk chocolate</td>
<td>70</td>
</tr>
<tr>
<td>Sugar</td>
<td>70</td>
</tr>
<tr>
<td>Ravioli</td>
<td>70</td>
</tr>
<tr>
<td>Coca-cola, Fanta, Sprite</td>
<td>70</td>
</tr>
<tr>
<td>Pumpkin</td>
<td>75</td>
</tr>
<tr>
<td>Water melon</td>
<td>75</td>
</tr>
<tr>
<td>Potato chips</td>
<td>80</td>
</tr>
<tr>
<td>Pop-corn</td>
<td>85</td>
</tr>
<tr>
<td>Corn flakes</td>
<td>85</td>
</tr>
<tr>
<td>Mashed potatoes</td>
<td>90</td>
</tr>
</tbody>
</table>
## Food products with a high glycemic index

<table>
<thead>
<tr>
<th>Product</th>
<th>GI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boiled carrot</td>
<td>101</td>
</tr>
<tr>
<td>Wheat bread</td>
<td>103</td>
</tr>
<tr>
<td>Corn chips</td>
<td>105</td>
</tr>
<tr>
<td>French fries</td>
<td>107</td>
</tr>
<tr>
<td>Donuts</td>
<td>108</td>
</tr>
<tr>
<td>Baked potatoes</td>
<td>121</td>
</tr>
</tbody>
</table>
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ФАРМАЦЕВТИЧНА
БРОМАТОЛОГІЯ

ЛЕКЦІЇ ДЛЯ АНГЛОМОВНИХ СТУДЕНТІВ

Англійською мовою

Відповідальний за випуск В.А. Георгіянц