CHAPTER 6

Justification and development of biotechnology of cooked sausage products for health purposes

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Abstract

Today, meat products are the most important component of the population's diet, as their share in the total volume of consumption amounts to a quarter, with the largest portion attributed to sausage products. However, the consumption of sausage products can have negative health consequences, since such finished products contain from 2 to 6% of table salt, as well as sodium nitrite. Given this, our main task was to reduce the amount of sodium entering the human body and reduce the amount of sodium nitrite used.

According to the research results, a recipe for "Ozdorovchi" sausages was developed using blood plasma protein in the amount of 1.0%, citrus dietary fiber in the amount of 0.5%, rosemary extract in the amount of 15 g/100 kg of the main raw material. The cumulative effect of the action of raw materials of plant and mineral origin in reducing the addition of sodium nitrite in the production of new types of sausages was established. The possibility of using the above food ingredients was proven, which made it possible to increase the functional and technological properties and biological value of new types of health-improving sausages.

Keywords

Sausage products, rosemary extract, bacterial preparation, sea salt with laminaria, biological value.

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6.1 Introduction

Nutrition is one of the most important factors in normalizing health [1]. One of the important conditions that is set when organizing a well-balanced and, specifically, health-conscious diet is the absence in the diet of substances that can have a negative impact on the health of the consumer [2].

Currently, the prevailing trend in the modern food industry is to improve traditional and develop innovative technologies and meat products in order to obtain finished products characterized by a high level of quality, environmental friendliness, and biological safety [3–5].

One of the largest components of the modern consumer's diet is meat products. According to the World Health Organization (WHO), the share of such food products in the total consumption accounts for more than 1/4, and among them, the largest share is sausage products [6].

However, consumption of food products derived from meat can lead to negative consequences for human health. For instance, sausage mince contains 2...6% of table salt, potentially dangerous for human health sodium nitrite, and, usually, finished products derived from meat using traditional technology are not always characterized by increased nutritional value [7].

One of the promising ways to avoid these negative impacts is the partial or complete replacement of traditionally used additives and ingredients with non-traditional types and their additional inclusion in the recipe compositions of meat products, in particular, to intensify the technological process [8].

Therefore, improving the technology of meat products with research and scientific justification for the use of promising raw materials, additives, and ingredients of animal, mineral, and plant origin is of important scientific and practical importance and is an urgent task.

6.2 Justification of the use of ingredients and additives to improve sausage technology

The task was to develop an improved technology for minced meat mixtures, characterized by an increased level of safety for the health of potential consumers and improved physicochemical and organoleptic properties. The product proposed for implementation is intended to be used in the production of health-improving sausages.

The objects on which the research was conducted were sausage minced meat modified with functional additives determined according to the research results (hereinafter coded as "Experiment 1") and sausages after the full technological production cycle, for the manufacture of which this minced meat was used (coded as "Experiment 2"). The object of comparison was selected as sausages according to DSTU 4436:2005 "Cooked (boiled) sausages, Sausages, Small Sausages, Meat Loaves. General technical requirements" is given in the **Table 6.1**.

Table 6.1 Formulation of "Liubytelski" sausages

Name of raw materials, spices and materials	Norm
Unsalted raw materials, kg/100 kg	
Beef, trimmed, first category	35
Lean pork, trimmed	40
Back fat	25
Spices and materials, g/100 kg of unsalted raw material	
Table salt	2500
Sodium nitrite	5.6
Granulated sugar or glucose	110
Ground black or white pepper	85
Ground nutmeg or cardamom	55

Source: [9]

Determination of the influence of table sea salt on the functional properties of meat raw materials. Functional (technological) properties of meat raw materials in the sausage production process are understood as a complex of physicochemical indicators of the influence on the structure and consumer properties of minced meat systems obtained from it. In their formation, an important role belongs to muscle tissue proteins, which, not taking into account the water inherent in meat systems (56...72%), are their main component – 15...22% and one of the main properties of interest to technologists is the ability of minced meat to retain and bind and retain moisture by mass (otherwise – water-holding capacity (WHC)) [10].

In part, polar water molecules contained in muscle tissue are tightly held by the characteristic localized charge polar groups of protein molecules due to hydrogen bonding and do not migrate outward from this close vicinity [11].

Ground muscle tissue can hold 700 to 800 grams of moisture per 100 grams of protein, but after slaughter, the muscle's ability to hold moisture decreases, mainly due to an increase in the number of lactic acid bacteria in the meat mass and the lactic acid they generate [12].

The inevitable loss of part of the bound moisture mass by meat affects its organoleptic properties, primarily tenderness and juiciness, which are of primary importance to consumers of meat products. It follows that the primary task set in this work was to develop a method for improving the taste and tactile characteristics of meat products aimed at finding ways to retain a sufficient amount of water in the meat system.

The first discovered way to achieve the task was to use the method of periodic mixing of the minced meat system with the neutralization of part of the lactic acid formed in it, which is the optimal condition for accelerating meat aging. This also allows to reduce the time of loss of moisture by meat in the process of postmortem stiffening, accompanied by the loss of the ability of the mass to retain calcium in the intercellular space and the destruction of hydrogen bonds existing during life between water and polar groups of actin and myosin of muscle tissue [11].

However, in the process of muscle tissue aging, the phenomenon of hardening disappears, and its resolution is accelerated under the action of microorganisms' strains introduced with starter cultures. As a result, muscle tissue cells acquire the ability to take a certain part of the water from the intercellular space of meat, for which the osmotic pressure of free moisture should be reduced in them. Usually, the problem of increasing the level of WHC is solved by salting meat raw materials. As a result of the diffusion of salt introduced with brine, the osmotic pressure of water in the cells decreases and becomes less than in the intercellular space. The result is the diffusion of part of the free water from it into the cells, accompanied by improved tenderness and increased juiciness of the meat component [11].

This technique, which is also an integral part of the technological process of sausage production, has become the subject of research, since correctly selected parameters and durations of salting allow obtaining a finished product of the best quality with the least costs. The first, determining criterion when choosing a salt grade for salting was to determine the probable differences in the sensation of saltiness of samples prepared with ordinary table salt and with sea salt enriched with laminaria according to TU U 14.4-34161267-001:2007. The reason, as noted, is that the only salt that actually has a salty taste is sodium chloride, and its content in sea salt is approximately 30% lower than in commercial table salt. Their respective compositions are given in **Table 6.2**.

The degree of saltiness of real minced meat prepared with these salts was not determined for a number of reasons, but the degree of saltiness of their aqueous solutions was investigated in the concentration range of 0.5...2.5% by sensory evaluation method with subsequent scoring. This range was chosen for the reasons that the mass fraction of salt in the most concentrated solution approximately corresponded to the corresponding indicator of the mass fraction of NaCl, traditionally used in sausage products. The assessment of the level of saltiness in points was carried out using the organoleptic method. The results of the assessment are shown in **Fig. 6.1**.

Table 6.2 Standardized composition of table salt and laminaria-enriched sea salt

Indicator	Norm in terms of dry matter	
	Premium quality table salt	Sea salt with laminaria
Sodium	38.4	30.6
Chloride	59.3	55.0
Calcium	0.4	1.2
Potassium	0.1	1.1
Magnesium	0.005	3.7
Iron	0.8	n. i.
Sulfate	–	7.7
Hydrocarbonate	0.85	0.41
Iodine	–	5×10^{-6}
Insoluble residue	0.25	0.03
Humidity	3.20	0.10

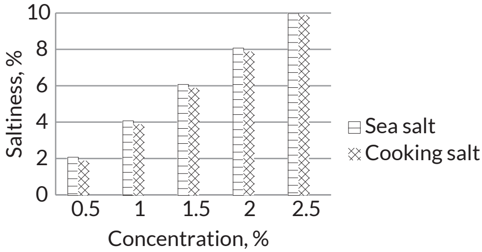

Fig. 6.1 Results of organoleptic evaluation of the solutions saltiness degree

The obtained data show that the solutions saltiness, despite the significantly different ionic composition of the dissolved salts, practically does not differ in the entire studied range. On this basis, it was concluded that when salting, it is advisable to use not rock salt, but sea salt and thus achieve a significant reduction in the potential adverse effects of salt on the human body [13].

In addition, sea salt contains more than 40 trace elements, the most significant of which (in comparison with the corresponding quality indices of ordinary salt) should be recognized as the following (**Table 6.3**).

Table 6.3 Trace element content in table salt and laminaria-enriched sea salt

Element name	Element concentrations in salt samples, μg/g	
	Table salt	Sea salt with laminaria
Sulfur	46349.74 ± 3807.10	76442.78 ± 4992.50
Manganese	–	1.62 ± 0.89
Chrome	–	3.97 ± 1.33
Cobalt	–	2.44 ± 1.09
Copper	3.81 ± 1.76	2.40 ± 0.94
Selenium	5.98 ± 2.07	1.43 ± 0.47
Zinc	144.76 ± 7.04	3.56 ± 1.09
Bromine	6.40 ± 1.26	319.80 ± 7.37
Rubidium	83.05 ± 3.21	10.38 ± 1.12
Strontium	–	13.28 ± 1.29
Zirconium	–	1.76 ± 0.44
Iodine	62.2 ± 15.68	3.86 ± 1.46

The aim of the study was to determine the change in organoleptic properties of minced meat when switching from regular rock salt to sea salt. The objects of the study were beef and pork, which were salted in comparison with sea salt in parallel with regular table salt. Salting was carried out according to the technology generally accepted in the meat industry: salt was added to the minced meat mixture at the rate of 2.4 grams per 100 grams of minced meat, and the mixture was kept at 4°C and periodically stirred for 24 hours. The obtained indicators of the ability of meat to bind moisture after salting are shown in **Fig. 6.2** and **Fig. 6.3**.

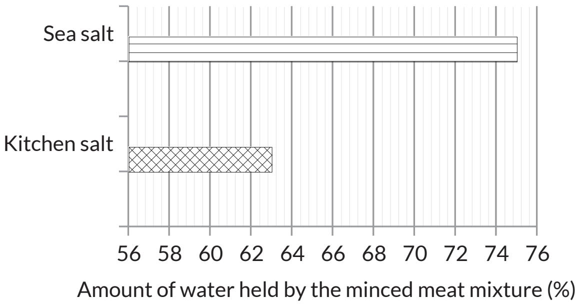

Fig. 6.2 Amount of water retained by beef during salting, %

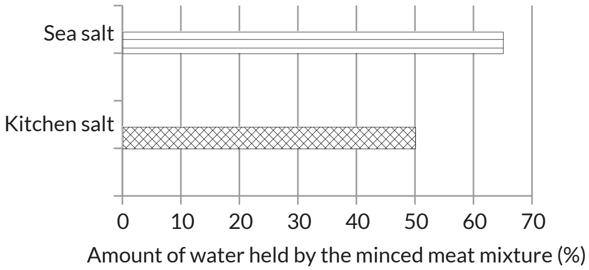

Fig. 6.3 Amount of water retained by pork during salting, %

The data obtained indicate that the use of sea salt during salting allows to increase the moisture binding capacity of both beef and pork, the reason for which is probably the presence in the system of a sufficient number of potassium, magnesium and potassium ions, which are characterized by an increased hydration number, and are absent in significant quantities in table salt [11].

An additional argument in favor of this conclusion is the enrichment of the minced meat mixture with acutely deficient iodine and a number of beneficial trace elements. Since iodine is not synthesized in the body, the only way to obtain it is to consume iodine-rich foods: fish, eggs, nuts, meat, bread, dairy products, algae, and iodized table salt. In the absence of the possibility of consuming a sufficient amount of these products in food, according to the recommendations of the World Health Organization, it is advisable to add iodine compounds to sodium chloride used for food purposes [14]. On this basis, let's conclude that replacing the rock table salt usually used for salting meat raw materials with sea salt is advisable.

The next step of the research was to find a way to enrich the salt used for salting meat raw materials with mineral salts that are vital for the normal state of the body, primarily potassium compounds and iodine, which is acutely deficient in most regions of Ukraine. The task facing us when choosing the type of salt recommended for use in salting was to find the optimum, under which the necessary conditions for the aging of meat raw materials would be ensured while providing the human body with a sufficient amount of minerals necessary for its normal functioning, primarily potassium, the need for which for an adult reaches 3500 milligrams per day [15].

Elementary calculations show that parity in sodium and potassium intake would be achieved if the ratio of their chlorides in the mixture recommended for consumption was about 50:50 by weight. However, despite the fact that most everyday products contain a fairly large amount of potassium, the content of which in some of them is the amount of potassium added with salting salt, may be less. Therefore, like most foreign developers, it is possible to believe that when salting meat raw materials, it would be more rational to use salts that would contain 30% potassium chloride and 70% sodium chloride.

In Ukraine, according to the requirements of the national standard DSTU 4307:2004, iodized salt with a mass fraction of iodine in $(40 \pm 15) \times 10^{-4}$%, or 40 ± 15 milligrams of iodine, is produced with the addition of potassium iodate (KJO_3) and, to counteract caking, a microadditive of toxic potassium ferrocyanide. The level of its use in cooking allows, to some extent, to reduce iodine deficiency in the diet [16].

However, with the recommended weekly intake of approximately 100 micrograms of iodine for a 70-kilogram person consuming only iodized salt and the actual daily intake of approximately 10 grams of salt, the body will consume 400 ± 150 micrograms of iodine during this period, which may cause health problems, primarily due to the negative impact on the retina. The negative impact of inorganically bound iodine can be partially mitigated by using sea salt, which contains significant amounts of organically bound iodine, as well as its commercially available varieties enriched with seaweed [11].

The choice of a specific type of algae recommended for addition to the salt used for salting meat raw materials was made by us taking into account their commercial availability and actual iodine content. Analysis of world experience and availability of iodine-rich algae resources showed that the optimal choice is laminaria, and the method of enriching salt with this trace element is the introduction of its finely ground leaves or extract into the system. Organically bound iodine introduced into the system, in contrast to iodine added with potassium iodate, is stored in the mass for a long time and is not destroyed by light and during food preparation. The advantage of this form of its presence is almost complete digestibility, moreover, in the quantities necessary for normal life, since excess iodine is excreted from the body without any toxic effects [11].

The product also contains vitamins A, B_1, B_2, B_{12}, C and D and a whole range of micro- and macroelements important for the body (**Table 6.4**).

Taking into account this factor and the analysis of the salt market in Ukraine, the requirements are fully met by the first-grade sea salt TU U 14.4-34161267-001:2007, which consists of 70% sodium chloride, 30% potassium chloride and contains an additive of ultra-crushed dry laminaria leaves (seaweed). The salt, in preference to rock salt, also contains a number of valuable trace elements (**Table 6.5**).

The use of this salt, characterized by a reduced sodium content and enriched with potassium and valuable trace elements, can be recommended for widespread use, especially for the following population groups [17]:

– people with high blood pressure;
– with obesity and edema;

– for people who control their blood sugar levels;
– people with increased emotional and physical stress.

Table 6.4 Trace element content in dry laminaria leaves (mg/100 g)

Element	Contents
Magnesium	1.26
Silicon	0.51
Phosphorus	0.41
Iodine	0.25
Calcium	0.22
Iron	0.12
Zinc	0.002
Vanadium	0.0016
Manganese	0.001
Nickel	up to 0.00017
Cobalt	< 0.00016
Molybdenum	0.000096

Table 6.5 Trace element content in sea and table salt, μg/kg

Element	Salt grade	
	Sea	Table
Chrome	3.97 ± 1.33	–
Iodine	3.86 ± 1.46	–
Zinc	3.56 ± 1.09	5.98 ± 2.07
Cobalt	2.44 ± 1.09	–
Copper	2.40 ± 0.94	3.81 ± 1.76
Manganese	1.62 ± 0.89	–
Selenium	1.43 ± 0.47	–

Justification and research of the use of dietary fibers in meat products. One of the ways to eliminate the deficiency of dietary fiber consumption is their introduction into food compositions. Currently, there is a large number of fibers of plant origin on the market and the criteria that should be taken into account when choosing a specific type of fiber are their chemical composition, respectively, and the physiological orientation of the main components [18].

When developing the recipe for minced meat for health-improving sausages, let's conduct studies to determine the ability of fibers available in mass production of the product to retain moisture in the composition. For comparison, the same test method was applied to ready-to-eat fiber-modified meatballs made according to the same recipe (200 grams of ground beef + 2 grams of salt + 1% of the corresponding fiber). The data obtained during the experiment are shown in **Fig. 6.4**.

According to this data, the greatest amount of moisture is retained by orange dietary fiber, the specific composition of which is given in **Table 6.6**.

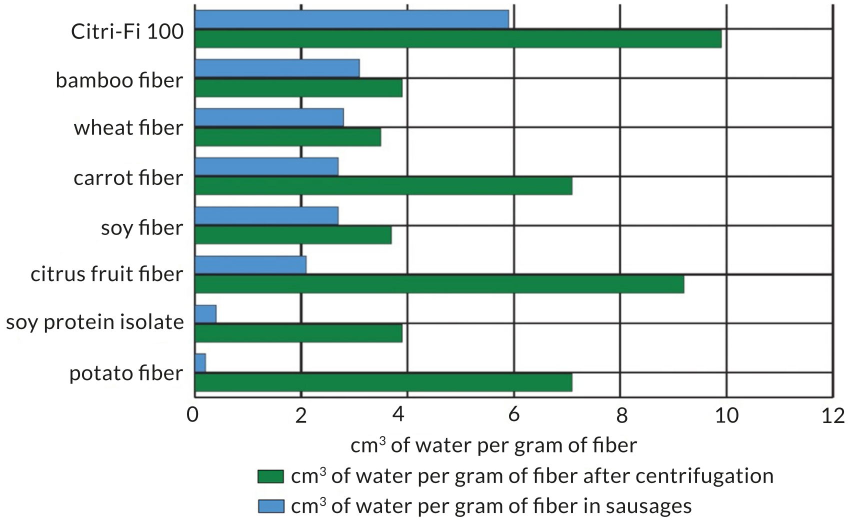

Fig. 6.4 The ability of dietary fibers of plant origin to retain moisture

Table 6.6 Chemical composition of orange fibers Citri-Fi 100, %

Indicator	Parameter value
Mass fraction of moisture	9.25 ± 0.10
Mass fraction of insoluble dietary fiber	53.07 ± 1.23
Mass fraction of soluble dietary fiber	17.97 ± 1.40
Mass fraction of proteins	0.43 ± 0.08
Mass fraction of fat	6.57 ± 0.52
Mass fraction of ash substances	3.43 ± 0.04
Mass fraction of the sum of phenols	4.89 ± 0.02

The positive properties of orange dietary fibers include the fact that they contain a large number of flavonoid components with antioxidant activity and, to a certain extent, bactericidal properties (2.2-azino-bis-3-ethylbenzothiazoline-6-sulfonic acid, 2.2-diphenyl-1-picryldrazyl, 2.2-azobis-2-methyl-propanilamide, etc.). For these reasons, minced meat modified with the addition of orange fibers is characterized by an extended shelf life and does not require additional addition of synthetic antioxidants, many of which have a negative effect on the condition of the gastrointestinal tract. The significant advantages of Citri-Fi fibers include their ability to sorb and remove slags and heavy metals with the insoluble fiber fraction, i.e., providing products containing them with certain therapeutic and prophylactic properties, including practically stopping the formation of inflammatory mediators, primarily nitrogen monoxide [19].

The introduction of orange dietary fibers into meat compositions makes it possible, in addition to providing the body with functions of improving digestion and removing toxins from the body, to use fattier raw materials in production and, at the same time, reduce the fat taste in the composition, optimize the stages of dosing and packaging of the finished product, improve its structure, reduce calorie content, and reduce the risk of brine inclusions in the mass [19].

Due to the high content of bioactive substances, orange fibers are recommended for use in the food industry, in particular the meat industry, to increase juiciness and improve the structure of sausages, salami and low-fat products. The main advantages of their use should be recognized as [19]:

– prevention of cancer due to the presence of flavonoids and limonene;

– preventing the accumulation of mucus in the lungs and preventing the development of lung diseases due to the presence of vitamin C;

– alleviation of the effects of diabetic complications due to the presence of pectin, which helps normalize the amount of glucose in the blood;

– promoting health due to the presence of the flavonoid hesperidin, which helps lower blood pressure and eliminate cholesterol;

– promoting weight loss by reducing the amount of fiber-rich foods consumed;

– preventing eye inflammation and increasing visual acuity due to the presence of limonene and citral;

– reducing the likelihood of developing caries.

The complex of such properties was the reason why it is possible to choose the orange fibers Citri-Fi 100, which are widely available on the market when developing the recipe for sausage minced meat.

Justification of the feasibility of using blood plasma proteins in minced meat compositions. Modern trends in increasing the nutritional and biological value of meat products from the point of view of protein consumption, taking into account the reduction of meat resources, are implemented in the development and increasingly widespread use of sausage production technologies, where some of the meat components, in particular fat, are replaced by alternative raw material sources and one of the main requirements for products of modified composition is their improved consistency and organoleptic quality indicators and a sufficient amount of food protein as a source of building body cells. However, at the same time, according to the principles of nutrition, the human body needs not just food protein but protein characterized by a complete amino acid composition, which is what animal proteins are best suited for. Among the ingredients recommended for widespread use in meat systems, proteins obtained by processing blood occupy a prominent place. They contain albumins, globulins, a significant amount of essential amino acids, and some other components [20].

Characteristics and justification for the use of rosemary extract. Meat systems are a set of a large number of components, most of which are unstable and undergo changes when exposed to air. In many cases, during the attack on them by oxygen, unstable peroxides and free radicals are formed in the system – highly chemically active groups of atoms characterized by the presence of an unpaired electron. These newly formed compounds are characterized by an adverse effect on cell membranes, resulting in the cells losing their inherent protective properties and a person ages prematurely. Such processes are characteristic, however, not only for living organisms but also for meat obtained after slaughtering an animal, especially that which is characterized by a high fat content [11].

The problem of ensuring high-quality storage of the product on the one hand and the stability of organoleptic and physicochemical properties on the other, in the case of meat systems, becomes particularly critical since their main component meat is characterized by a large number of compounds capable of oxidation, primarily lipids, and rancidity and general spoilage of products. Therefore, one of the main tasks in the meat industry is to solve the issue of safe inhibition of oxidative processes in meat products. To minimize the speed of these processes, the food industry uses a number of methods, including control of climatic conditions for storing finished products, careful selection of packaging methods and packaging materials, etc. Usually, this problem is solved by introducing substances with antioxidant properties into the composition. Among those used to extend the guaranteed shelf life of meat products, plants and plant extracts are widely used, which, as products of their metabolism, contain the so-called characteristic antibacterial flavonoids (natural phenolic compounds that accumulate in all plant organs in the form of glycosides) [21].

Despite the fact that rosemary has practically no nutritional value (15.1 kJ/kg), its introduction into minced meat compositions can also be recommended in view of giving them a "spicy" flavor since the plant contains from 0.5% to 2.5% of volatile aromatic compounds, mainly terpenes [11].

Introduction into the minced meat mixture of an additive characterized by an active antioxidant effect (i.e., the property of priority interaction with oxidants) of rosemary extract, which, in addition to giving the finished product pleasant aromatic properties, almost entirely – 0.912 grams in one gram – consists of compounds characterized by the ability to primarily interact with oxidants and thereby protect other compounds present in the system from oxidation by newly formed in the minced meat mass and characteristic active oxidative properties of tetravalent and pentavalent nitrogen compounds (respectively, NO_2 and HNO_3) [11].

In this variant, the nitrite ion added to give the meat mass an attractive pink-red color is almost quantitatively spent on the target reaction of nitrosomyoglobin formation, which allowed to significantly reduce the dosage of toxic nitrite when realizing the desired color of sausage products while its practical absence in the finished sausage products [11].

In order to determine the optimal dosage of rosemary extract from the point of view of extending the guaranteed shelf life, its additive was introduced into the sausage stuffing and the dynamics of changes in the peroxide value of the sample during storage were determined. The indicator characterizes the instability over time of the meat system due to the interaction of its components with atmospheric oxygen, accompanied by the formation of peroxides (compounds of a peroxide nature) and other substances with characteristic oxidizing properties. The higher the peroxide value of the antioxidant-modified substance, the lower its stability over time and the shorter the guaranteed shelf life. The presence of peroxides is detected due to their ability to interact with potassium iodide with the release of molecular iodine. The quantitative content of the formed peroxides is further determined by titration of the released iodine with sodium thiosulfate [11]

$$2Na_2S_2O_3 + J_2 \rightarrow 2NaJ + Na_2S_4O_6.$$

The mechanism of the protective action of the additive is that nitrogen dioxide NO_2, characterized by high oxidative activity, formed during the rapid decomposition of unstable nitric acid in the biological environment, almost instantly interacts with the antioxidant components of rosemary extract with repeated conversion into nitrogen monoxide NO and the process of oxidation-reduction of nitrogen occurs in accordance with its acquisition of oxidation states II (NO) $\rightarrow$ IV (NO_2) $\rightarrow$ II (NO), that is, "in a circle". The positive effect of using rosemary extract occurs according to this method due to the fact that nitrogen monoxide NO, formed either during the initial decomposition of sodium nitrite after its introduction into minced meat in the form of salt or due to the interaction of the newly formed nitrate ion with antioxidants introduced with rosemary, is spent on the formation of the target compound nitrosomyoglobin almost entirely. This is the difference of the claimed method, according to which a reduced dosage of sodium nitrite is used in the preparation of the product, part of which, according to traditional technology, is spent on the synthesis of the ballast additive sodium nitrate [11].

According to the results of the experiment, it was determined that the peroxide value monotonically increases in all the samples studied, but in the presence of rosemary, the rate of its increase was significantly lower than in the control sample with the simultaneous refusal to add synthetic antioxidants to the mass, and the optimal dosage should be considered to be 0.15% of the extract in relation to the meat raw material since its further addition practically does not affect the rate of growth of the controlled parameter [11].

Another criterion for improving the quality of minced meat by modifying it with the addition of rosemary extract is the dynamics of the change in the acid number of minced meat over time as a criterion for the rate of hydrolytic oxidation of lipids with the formation of fatty acids. The purpose of the determination was to establish an additional criterion for the feasibility of using rosemary extract in extending the shelf life of meat products at what we estimated as the optimal dosage of rosemary extract (0.15%) [11].

Given the implementation of undesirable transformations in the system of the traditional composition, the second task of developing a solution characterized by patent novelty was to find a way to avoid undesirable interactions. The task was proposed to be solved by introducing into the minced meat mixture an additive of rosemary extract, characterized by an active antioxidant effect (i.e., the property of priority interaction with oxidants), which, in addition to providing the finished product with pleasant aromatic properties, consists almost entirely – 0.912 grams in one gram – of the characteristic ability to primarily interact with oxidants and thereby protect other compounds present in the system from oxidation by newly formed in the minced meat mass and characteristic active oxidizing properties of tetravalent and pentavalent nitrogen compounds (respectively, NO_2 and HNO_3) [11].

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To determine the effectiveness of the antioxidant effect of the rosemary extract supplement, the preparation was added to the test samples of minced meat in an amount of 0.15% by weight. A sample of minced meat without the addition of the extract was used as a control. The samples were kept at +8°C for 10 days, and their acid number was periodically determined. The results of the determinations are shown graphically in **Fig. 6.5**.

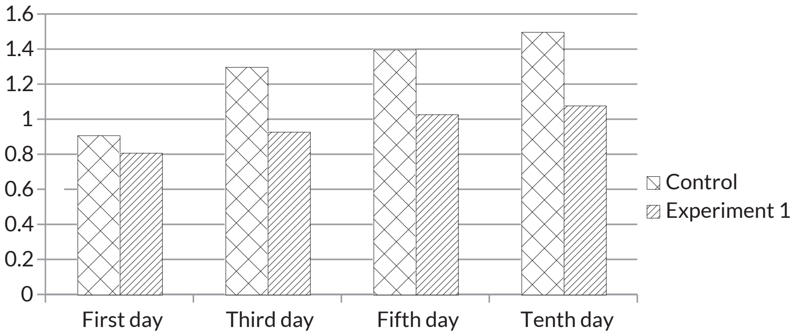


Fig. 6.5 Dynamics of changes in the acid number of control and experimental samples of sausage minced meat during storage

Studies confirm the high antioxidant activity of rosemary extract and its ability to inhibit the process of lipid oxidation in sausages effectively. The addition of the extract in an amount of 0.05–0.15% allows to slow down the hydrolytic oxidation of minced meat lipids by 29.75–40%, and the extract itself, depending on the technology used, can be added directly to the product in the form of a powder or a solution in water [13].

Justification of the feasibility of using the bacterial preparation "Iprovit LRR". Certain methods of modifying its composition and the sequence of technological operations are usually used to extend the guaranteed shelf life of the product. This approach was used by us in studying the dynamics of changes in the qualitative and quantitative composition of microflora and determining rational production parameters. The object of the study was the operation of salting meat raw materials. The duration of the process is quite high (up to 24 hours) at a temperature of 0...4°C and a relatively low concentration of sodium chloride in the mass. Such conditions are quite favorable for rapid development with sufficiently high bacterial contamination of meat raw materials [11].

Our studies showed that the beef and pork used to prepare the control and experimental samples contained a sufficiently large number of dangerous microorganisms: colonies of Escherichia coli (*E. coli*) were detected in samples weighing 0.0001 grams (with a detection rate of 0.01 grams), and mesophilic aerobic and facultative aerobic microorganisms (MAFAM) in the same sample were found in an amount of 2.9×10^5 colony-forming units (CFU) at the established rate ($1 \div 2 \times 10^3$) [11].

The commonly used method of further reducing their number by heat treatment at the stage of cooking sausage products allows to significantly reduce the level of bacterial contamination of the product at the time of manufacture, however, the meat composition is not protected from the reproduction of microorganisms in the future, as shown by the product analyses conducted over two days, when the number of MAFAM group bacteria formed is equal to colonies with the norm of absence within the limits of the used methodology (1×10^3). According to the results of the experiment, minced meat standardized by the DSTU 4436 standard contained 3.1×10^5 in one gram of MAFAM sample and showed the presence of Escherichia coli bacteria in the product in samples weighing 0.001 grams (the permissible level is the detection of presence in samples weighing 0.01 grams) [11].

Thus, it was faced with the task of solving two problems simultaneously: to reduce the level of bacteriological contamination of minced meat and maintain its acceptable level after the completion of the process of producing a sausage product from it, as well as to reduce the dosage level of the toxic impurity sodium nitrite in minced sausage [11].

The procedure for directed influence was the addition of the bacterial preparation "Iprovit LRR" recommended by the Institute of Food Resources to the minced meat, which includes bacteria of the *L. rhamnosus* strain and micrococci *Kocuria rosea*. The dosage of the preparation, according to the recommendations of the Institute of Food Resources of Ukraine, was 50 milligrams of dry preparation per kilogram of meat raw materials. The use of the preparation allows for the significant improvement of the microbiological safety of the processed sausage minced meat due to the rapid development of beneficial microflora in the system (**Table 6.7**).

Table 6.7 Main parameters of microorganisms' growth in the preparation "Iprovit LRR"

Cultivation conditions	Components TC	$X \cdot 10^9$, CFU/cm^3	v_{max}, hour^{-1}	v, hour^{-1}	T_l, hour	g, hour
Stationary conditions, with periodic neutralization	LAB	(4.0 ± 0.3)	0.85	0.59	2.33	1.18
	MC	(0.1 ± 0.1)	0.40	0.24	4.13	2.5
Without mixing, with periodic neutralization	LAB	(6.8 ± 0.1)	1.03	0.64	2.19	0.97
	MC	(0.2 ± 0.1)	0.44	0.27	2.82	2.27
	MC	(0.06 ± 0.2)	0.42	0.29	1.40	2.38
With stirring and with periodic neutralization	LAB	(3.0 ± 0.2)	0.95	0.56	0	1.05
	MC	(0.08 ± 0.2)	0.44	0.30	1.19	2.27

The mechanism of the positive effect of the preparation can be summarized as follows:

1) acceleration of the increase in the acidity level of the mass due to the faster growth of lactic acid bacteria of the Lactobacillus rhamnosus strain in it;

2) intensification of the denitrification process under the action of microorganisms of the Kocuria rosea strain of residual amounts of nitrite added to the minced meat and sodium nitrate formed from it.

An additional effect of using the preparation is the dominance of the reproduction of beneficial bacteria and the formation of substances (bacteriocins, antibiotics, peroxides, etc.) by the introduced strains of microorganisms during the metabolism process, which while preserving the biological value of enriched meat products, counteract the reproduction of undesirable microflora [11].

The antagonistic effect of the preparation is achieved due to the increase in the acidity level (reduction in pH) due to the formation of a complex of organic acids and the formation of substances in the process of vital activity of the introduced microorganisms, inhibiting the development of undesirable microflora (for example, bacteriocins, antibiotics, peroxides). Due to this effect, it becomes possible to extend the shelf life and preserve the biological value of sausage products [11].

To confirm this position, i.e. to achieve a positive effect from the use of the recommended additive, studies were conducted to compare the microbiological composition of the control sample and two experimental samples of sausage minced meat. The first conclusion from the results of the study was confirmation that, according to the indicators of microbiological contamination, the minced meat of the experimental composition (test sample) complied with the standards of current regulatory documentation in terms of contamination with pathogenic microorganisms, including bacteria of the genus *Salmonella* and sulfite-reducing clostridia (absence). The total number of mesophilic aerobic and facultative anaerobic microorganisms in the comparison object was within 7×10^5 in one gram of product, and in the experimental samples, their presence was not detected at all. The corresponding indicators are given in **Table 6.8**.

Table 6.8 Results of microbiological analysis of control and experimental samples of sausage minced meat and raw materials used for its production

Sample name	Name of microorganisms			
	Escherichia coli bacteria	micrococci	MAFAM	LAB
Salted beef	Presence in 0.01 g	1×10^3	7.4×10^5	1.8×10^4
Fatty salted pork	Presence in 0.01 g	2.2×10^3	7.3×10^5	1.0×10^4
Low-fat salted pork	Presence in 0.1 g	2.7×10^3	7.2×10^5	5.0×10^4
Control (minced meat)	Presence in 0.01 g	7×103	3.1×105	4.1×10^4
Experiment 1 (minced meat)	Presence in 0.1 g	7×10^5	Not detected	1.3×10^6
Experiment 2 (minced meat)	Presence in 0.01 g	2×10^5	Not detected	4×10^5
Experiment 1 (sausages)	Presence in 0.001 g	2.2×10^5	Not detected	2.2×10^6
Experiment 2 (sausages)	Presence in 0.001 g	3.2×10^5	Not detected	6.3×10^6

An additional effect of the preparation is the acceleration of the acidification process (reduction of the pH value) of the meat system, which, in addition to contributing to the increase in tenderness and juiciness of the meat. In addition to the microorganisms introduced with the bacterial preparation, an increase in the number of lactic acid bacteria (LAB) responsible for the formation of organic acids in the system (reduction of the pH level) was also recorded in the meat raw material during the aging process of minced meat. The analysis results show that their content in the test samples is higher than in the raw material to which the preparation was not introduced during the entire fermentation period. The dynamics of the increase in their number in ready-to-sell products under stationary conditions is shown in **Fig. 6.6**.

Another, no less important positive aspect of the claimed method of using the bacterial preparation "Iprovit-LRR" is its high denitrifying activity, associated with the growth in the number of lactic acid bacteria of the *L.rhamnosus* strain in minced meat within 48 hours to ($4 \times 10^5 \div 1.3 \times 10^6$) versus 4.1×10^4 at the beginning of its aging. Their vital activity led to a rapid increase in the acidity level of minced meat of the experimental composition to pH values = 4.8–5.2 versus the corresponding pH indicator of minced meat of the control composition of 6.3 units [22].

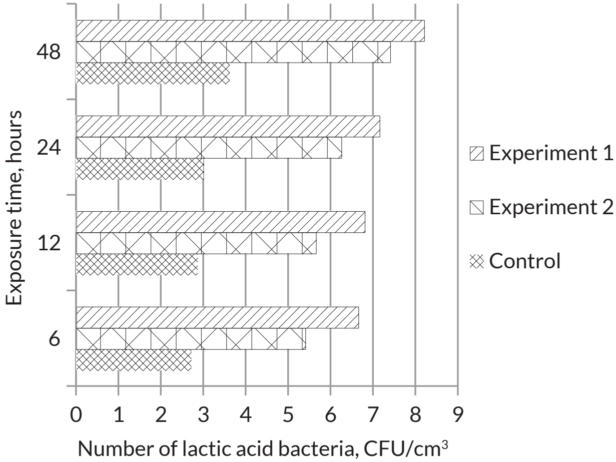


Fig. 6.6 Dynamics of growth of the number of lactic acid bacteria in raw meat

A concomitant effect is the conversion of sodium nitrite, added to preserve the red color of minced meat, into unstable nitrite acid in an acidic environment (pH < 6.0) $NaNO_2$ [11]

$$NaNO_2 + H^+ \rightarrow HNO_2 + Na^+.$$

This acid quickly decomposes to form water and nitric oxide (II) NO**,** which, according to its intended purpose, prevents the formation of undesirable metmyoglobin in meat and instead participates in the transition of myoglobin to nitrosomyoglobin and thus preserves the usual red color of the meat mixture [11]

$$3\,HNO_2 \rightarrow HNO_3 + 2\,NO + H_2O.$$

Part of the newly formed nitric acid HNO_3 partially dissociates with the entry of nitrate ion NO_3 into the aqueous medium, partially decomposes to form nitrogen dioxide [11]

$$4\,HNO_3 \rightarrow 4\,NO_2 + O_2 + 2\,H_2O.$$

In conditions of a huge amount of water, nitrogen dioxide re-forms two acids in the system: nitric and nitrite [11]

$$2\,NO_2 + H_2O \rightarrow HNO_3 + HNO_2.$$

Ideally, the process under the conditions of dissociation of nitric acid to nitric oxide and its (NO) interaction with meat myoglobin should be repeated until the nitrate ion is completely depleted in the system, however, due to the fact that the acidity of the meat environment remains insufficiently high ($pH \geq 4.8$), the absolute majority of the nitrate ion is not decomposed, remains in the minced meat, giving it a high oxidation-reduction potential (ORP) and in the process of sausage production due to insufficiently high processing temperature remains there. As a result, the product is contaminated with an undesirable admixture of sodium nitrate, and part of the sodium nitrite introduced into the meat mixture is lost [11].

At the same time, the cumulative impact on the health of consumers of residues in the product of both salts – nitrite and sodium nitrate – has not been studied, which all the more poses for technologists, in addition to the problem of minimizing the amount of added toxic sodium nitrite additive, the question of finding a way to reduce the amount of sodium nitrate formed in the mass [11].

In our opinion, the problem can be solved at the stage of minced meat production by introducing additives with antioxidant action into the mixture, i.e. those that surpass myoglobin in the ability to absorb active oxygen – either the one that migrates deep into the meat upon contact with air or the one that is formed during the decomposition of nitrate ion [11].

As a substance of similar action in this study, a rosemary extract supplement was used, which contains no less than 29 compounds, including 4.77% of sesquiterpenes characterized by antioxidant activity: 2.1% 1.8-cineole, 0.6% camphor, 0.55% α-pinene, 0.4% β-pinene and rosmarinic acid, characterized by the highest antioxidant properties – 5.5–6.0%, where the attack of oxidants occurs on the double bond $C = C$ of the carbon chain, which connects two cresol cycles.

In determining the optimal dosage, the dynamics of peroxide value changes were investigated over a 10-day storage period in both the control sample of sausage mince (without the addition of rosemary extract) and the experimental samples, to which 0.05%, 0.10%, 0.15%, and 0.20% of the extract were added. The results obtained during the study are presented in **Fig. 6.7**.

Considering the results obtained, it was recommended to introduce the additive into the minced meat in an amount of 0.15% relative to its total mass, since its further addition did not have a positive effect on the increase in the antioxidant activity of the sample [13].

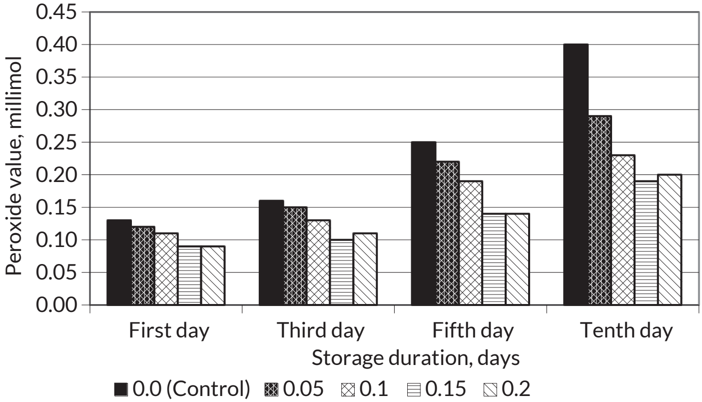


Fig. 6.7 Dynamics of changes in the peroxide value of control and experimental samples of sausages enriched with rosemary extract

An additional action aimed at reducing the dosage of sodium nitrite while ensuring the desired color of the meat mixture is the addition of the orange dietary fiber Citri-Fi 100, characterized by a two-factor effect, to the minced meat at the stage of its formation. In addition to the main function of retaining the increased amount of moisture in the minced meat among all those studied in the work, the largest amount of water is retained by the orange fibers Citri-Fi 100, characterized by a developed surface area and, accordingly, the ability to adsorb [11].

The positive properties of orange dietary fiber supplements include the fact that they contain a large number of phenolic components of flavonoid nature (2.2-azino-bis-3-ethylbenzothiazoline-6-sulfonic acid, 2.2-diphenyl-1-picryldrazyl, 2.2-azo-bis-2-methyl-propanilamide, etc.) characterized by antioxidant activity and, to a certain extent, bactericidal properties [11].

Considering that both additives recommended for use in sausage minced meat are characterized by antioxidant effects, it is possible to study their cumulative effect on the dynamics of peroxide compounds accumulation in minced meat over 10 days. The addition of rosemary extract to minced meat was introduced in the amount of 0.15%, recognized as optimal in previous studies [11].

The experimental data obtained indicate the effectiveness of the proposed additives, characterized by antioxidant activity, in inhibiting by more than half the rate of formation of substances associated with the presence of reactive oxygen, and thereby in reducing the dosage of sodium nitrite [11].

Thus, all parameters of the composition of the experimental minced meat of the modified composition are, from the point of view of its consumer value and organoleptic properties, better compared to the corresponding properties of meat mixtures where it was not introduced. On this basis, it is possible to conclude that it is appropriate to introduce the preparation "Iprovit LRR" into the developed minced meat recipe with its subsequent aging until full maturation at the temperature +2°C recommended by the Institute of Food Resources of Ukraine for two days [11].

6.3 Determination of functional and technological properties of minced meat systems

The research was conducted on minced meat of improved composition, samples corresponding to the norms of the standard DSTU 4436:2005 "Cooked (boiled) sausages, Sausages, Small Sausages, Meat Loaves" served as control. When assessing the balance of the chemical composition of meat products, priority attention is paid to the qualitative and quantitative analysis of amino acids, which determine the level of protein completeness, and for the characteristics of the biological value of sausages, the most important parameters are their protein quality index and the index of essential amino acids. On this basis, it was faced with the task of developing the composition of sausages, which, along with their health-improving properties, would also be characterized by the completeness of the protein composition. In order to determine the achievement of the set goal in developing a complete protein composition of minced sausage, research was conducted, the results of which are presented in **Table 6.9**.

The data presented indicate that the minced meat of the developed composition contains all eight essential amino acids in quantities that all, without exception, exceed the recommended FAO/WHO content level. A similar phenomenon is observed when comparing the corresponding indicators of the composition of the developed minced meat with that of the standardized national standard DSTU 4436:2005 "Cooked (boiled) sausages, Sausages, Small Sausages, Meat Loaves. General technical requirements". The obtained data indicate the high quality and biological value of the research product.

Each ingredient recommended for inclusion in the composition of the developed minced meat has a significant characteristic effect on their physicochemical indicators. Thus, the use of sea salt, characterized by a reduced content of sodium chloride and enriched instead with hygroscopic chlorides of potassium and magnesium, as well as fiber and other types of dietary fiber, significantly increases the content of moisture contained in meat mixtures and, therefore, water activity. The use of bacterial preparations contributes to a rapid change in the acidity of the mixture and shortens the aging period of minced meat. The use of blood plasma protein, in addition to enriching the mixtures with this valuable component, also improves their plasticity indices.

Table 6.9 Characteristics of the amino acid composition and biological value of the experimental and control samples

Essential amino acid name	FAO/WHO standard g/100 g of protein [23]	Samples			
		Control		Experiment	
		g/100 g protein	amino acid ratio, %	g/100 g protein	amino acid score, %
Leucine	7	10.0 ± 0.46	142.8	11.4 ± 0.46	162.8
Methionine + cystine	3.5	4.2 ± 0.21	120	4.28 ± 0.22	122.3
Valine	5	6.0 ± 0.26	120	6.6 ± 0.26	132
Lysine	5.5	8.2 ± 0.29	149.1	9.0 ± 0.3	163.6
Threonine	4	6.1 ± 0.21	152.5	7.1 ± 0.21	177.5
Phenylalanine + tyrosine	6	8.1 ± 0.31	135	9.2 ± 0.32	153.3
Tryptophan	1	1.1 ± 0.05	110	1.6 ± 0.05	160
Isoleucine	4	6.1 ± 0.23	152.5	6.5 ± 0.23	162.5
Sum of essential amino acids	36	49.8 ± 2.06		55.6 ± 2.08	

However, the total result of their application due to the complexity of the interaction mechanisms of the mixture components cannot be predicted based on the results of studying the individual influence of each of them. Therefore, in practice, an empirical approach is used to determine the properties of each of the individual mixtures, among which one of the important ones is the ability of minced meat to form emulsions that are stable over time, which are understood as dispersed systems consisting of a liquid dispersion medium and a colloidal dispersed phase. The dispersed phase in such a system is formed by fat particles of different sizes, and the dispersion medium is a solution of proteins and low-molecular substances.

The stability of the emulsion is provided by substances (emulsifiers) that adsorb on the surface of fat droplets and thus prevent their sticking together. These include, for example, protein films that significantly affect the stability of meat emulsions and, accordingly, the quality of meat products. The fat-protein-water interaction occurs due to the presence of a large number of hydrophilic and hydrophobic groups in protein molecules. Hydrophobic groups form a strong adsorption layer on the outer surface of the droplets, which plays the role of a barrier in preventing fat coalescence. Hydrophilic groups are oriented towards external moisture and form a sufficiently strong network in volume that does not delaminate throughout the entire guaranteed shelf life of the sausage product.

On this basis, the blood plasma protein was used as an agent that should contribute to the formation of minced meat emulsion. The results of the experiment are shown in **Fig. 6.8**.

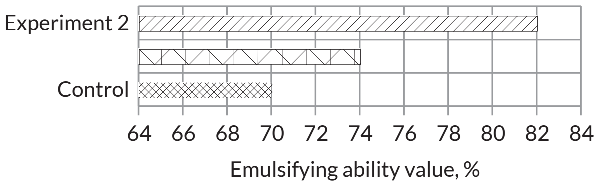


Fig. 6.8 Emulsifying ability of the control and experimental samples of minced meat

Emulsions formed with the participation of blood plasma protein were sufficiently stable the experimental minced meat systems possess an increased, in comparison with the control, ability to form a stable emulsion, which is quantitatively characterized by emulsifying capacity indicators – 82% in Experiment No. 2 versus 70% in the control – and emulsion stability – 96% in the same experiment versus 88% in the control, as presented in **Fig. 6.9**.

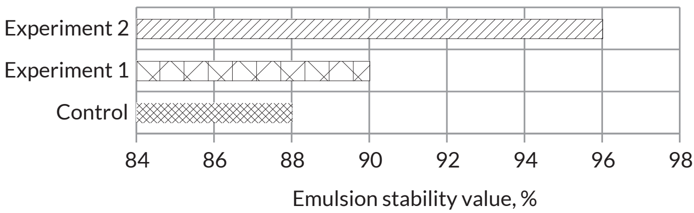


Fig. 6.9 Indicators of emulsion stability of the control and experimental samples

This pattern is explained by the fact that the additives introduced with orange dietary fibers, as well as blood plasma protein, causes high reactivity and reliable binding of the water component. The addition of blood plasma protein also allowed to improve the plasticity index of the meat emulsion, and the addition of rosemary extract, in addition to enriching the taste and aroma of the finished product, also allowed to extend the period of its guaranteed storage due to certain antioxidant properties (**Table 6.10**).

Table 6.10 Functional-technological and physico-chemical quality indicators of control and experimental samples of meat products

Indicator	Sample name		
	Control	Experimental No. 1	Experimental No. 2
Active acidity, pH units	5.8 ± 0.03	5.6 ± 0.03	5.54 ± 0.03
Mass fraction of moisture, %	75.29 ± 3.11	74.24 ± 3.16	75.44 ± 3.16
Redox potential, mV	140 ± 7.5	–75.3 ± 3.8	–76 ± 3.8
Water activity, A_w	0.952 ± 0.05	0.953 ± 0.05	0.957 ± 0.05
Water binding capacity, % of total mass	85.1 ± 2.31	88.7 ± 2.33	90.2 ± 2.33
Plasticity, cm^2/g	32.9 ± 1.03	37.2 ± 1.03	45.7 ± 1.03
Yield shear stress, Pa	605 ± 30.25	792 ± 39.55	805 ± 39.55

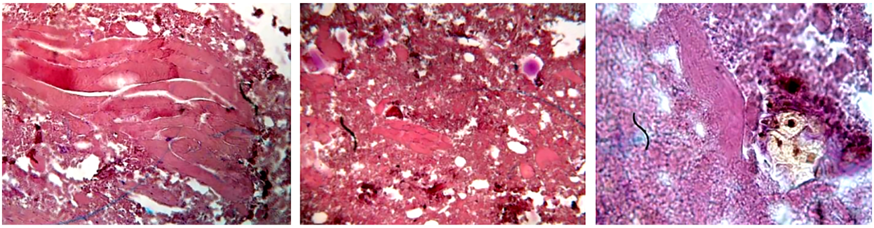
Thus, the specified set of additives allowed to improve the organoleptic and physicochemical properties of the product, primarily with regard to the indicators of plasticity and elasticity of the finished product compared to the corresponding properties of a product of standardized composition.

Considering the experimental data, it can be noted that the active acidity of the studied minced meat systems characterizes them as benign. The difference in pH values is explained by the activity of the bacterial preparation and rosemary extract introduced into the formulation of the experimental samples.

It should be noted that the experimental minced meat systems 1 and 2 are characterized by pronounced antioxidant properties since their redox potential is negative and is –75.3 mV and –76 mV, respectively, versus +140 mV in the control.

The moisture content in the tested samples is almost at the same level and is within the error range. The water binding capacity of the tested samples is higher than the control, and is 89.8% and 91.2%, respectively, against 88.8%.

Sausage mince belongs to plastic-viscous bodies therefore its structure and rheological properties are best characterized by the value of the yield shear stress and plasticity. Experimental data indicate the compaction of the mince and the increase in the plasticity of the experimental samples compared to the control. Thus, the yield shear stress of the experimental sample No. 2 is 805 Pa, the plasticity is 45.7 cm^2/g, and the control sample is 605 Pa and 32.9 cm^2/g, respectively. This is explained by the presence of dietary fiber and blood plasma protein in the recipe, which improve the structural and functional-technological properties of the mince system. An informative characteristic that complements the data on future changes in the consistency of finished products is the microstructure of the stuffing (**Fig. 6.10**).



Control sample Experiment 1 Experiment 2

Fig. 6.10 Microstructural characteristics of the control and experimental minced meat samples (magnification × 400)

The results of the microstructural analysis of the presented samples indicate that the control minced meat has a homogeneous structure of pink color with the inclusion of numerous vacuoles. It shows individual fragments of single muscle fibers, and sometimes entire groups, which are densely located next to each other and cut lengthwise and crosswise. Clusters of fat cells are also found. In most fragments of Experiment No. 1, the nuclei of muscle fibers and transverse striation are not detected. They are observed only in individual fibers. Small particles of yellow color are also found in the minced meat, which indicates the presence of rosemary granules. In another experimental sample, an eosinophilic substance (purple color) is observed in voids and vacuoles of various sizes and configurations (detection of blood plasma). Clusters of round and rectangular plant cells are also found in the minced meat, they have different sizes and shapes, painted in different shades of purple and yellowish colors. This indicates the presence of citrus fibers.

The experimental samples are characterized by a denser and more elastic consistency compared to the control, which is confirmed by an increase in the yield shear stress by 70%. The experimental samples show lower mass losses after heat treatment, compared to the control, as evidenced by an increase in yield by 7%. This effect was achieved without adding a phosphate mixture. The improvement of organoleptic quality indicators is associated with the introduction of fiber and a bacterial preparation into the recipe, which, due to the absorption of added moisture and the reduction of losses of natural moisture by meat raw materials. The chemical composition of the control sample compared to experimental samples 1 and 2 is given in **Table 6.11**.

Table 6.11 Chemical composition of control and experimental samples of minced meat, %

Component	Sample name		
	Control	Experiment No. 1	Experiment No. 2
Protein	12.3 ± 0.8	13.7 ± 0.7	15.0 ± 0.7
Fat	9.38 ± 1.16	11.49 ± 1.04	12.44 ± 1.04
Humidity	66.7 ± 0.7	69.6 ± 1.3	70.1 ± 1.3
Sodium chloride	1.20 ± 0.10	0.55 ± 0.09	0.41 ± 0.09
Sodium nitrite	0.0044 ± 0.0002	0.0012 ± 0.0002	0.0012 ± 0.0002
Water	0.97 ± 0.01	1.30 ± 0.01	2.20 ± 0.01

According to the requirements of the sausage production regulations, the protein content in the mass should not be less than 12%, and according to this indicator, both the control and experimental samples meet the norm. In terms of the mass fraction of fat, both samples do not deviate from the norm by less than 30%, however, in the experimental samples, according to the results of microscopy, the fat is evenly distributed throughout the entire volume of the product. As for water, the amount of moisture in the samples of the experimental composition due to the uniform distribution of blood plasma protein and fiber in the structure of the meat system exceeds the corresponding indicator of the sample of the control composition by 4.6%. The chloride and sodium nitrite content in all samples does not exceed the requirements set by regulatory documents. At the same time, the use of components with antioxidant and preservative effects reduced the content of toxic nitrite ion in the experimental samples by 0.032%, and the use of sea salt instead of ordinary table salt allowed while maintaining the desired level of product saltiness, to reduce the content of sodium ion in the experimental products.

Organoleptic evaluation of sausages of the control and experimental samples of sausage minced meat (Experimental No. 2) was carried out in the laboratory of the Department of Meat, Fish and Seafood Technology of the NULES of Ukraine. The evaluation of the samples was carried out according to the indicators regulated in DSTU 4436:2005 "Cooked (boiled) sausages, Sausages, Small Sausages, Meat Loaves". The evaluation results are given in **Table 6.12**.

According to the results of the organoleptic evaluation, the quality indicators of both experimental samples were better compared to the control, and the results of their evaluation according to the scoring system are shown in **Fig. 6.11**.

Table 6.12 Results of evaluation of organoleptic quality indicators of sausages of control and experimental samples

Indicator	Sample name	
	Control	Experiment No. 2
Appearance	Sausages with a clean, dry surface, no damage to the casing, slight broth swellings are present	Sausages with a clean, dry surface, without damage to the casing, the latter tightly adhering to the minced meat, without broth swellings
Consistency	Elasticity is reduced in the peripheral part	Dense on section, both in the periphery and in the center
Cutaway view	The minced meat is grey-pink, the color is heterogeneous, there are grey spots and relatively large cavities	The minced meat is pink, uniform, without large cavities and gray spots
Smell and taste	Inherent to this product but implicitly expressed, the saltiness is uneven, without foreign odors and flavors	Typical for this product, the saltiness is uniform, there are no foreign tastes or odors

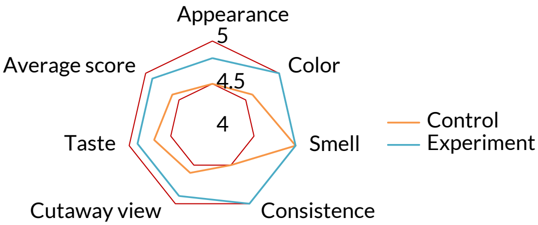


Fig. 6.11 Results of organoleptic evaluation of quality indicators of control and experimental (No. 2) sausage samples

A comprehensive analysis of the organoleptic evaluation shows that the test sample was distinguished by a denser, elastic and homogeneous consistency. It was also characterized by a pleasant "deep" taste and noble aroma, which can be explained by a more intensive accumulation of free amino acids during the salting process under the influence of lactic acid microflora. The tasting commission also noted a moderately pronounced, delicate, natural color on the cut of the test samples.

6.4 Development of a technology for the production of "Ozdorovchi" sausages using biotechnological techniques

According to the results of the conducted experimental work on the study of the influence of antioxidants, dietary fiber, salt with a reduced sodium content and bacterial preparation on the properties of minced meat systems and the justification of the feasibility of their use in the technology of sausage products, a recipe for "Ozdorovchi" sausages was developed (**Table 6.13**).

The recipe and quantity of substances used in the preparation of brine for salting meat raw materials are given in **Table 6.14**.

Table 6.13 Recipe for minced meat of experimental sausage samples

Raw material name	Norm
Unsalted raw material (kilograms per 100 kg of raw material)	
Beef, trimmed, first category	30
Semi-fat trimmed pork	26
Fatty trimmed pork, cheek, fat cuts	34
Blood plasma protein	1.0
Water for blood plasma protein hydration	2.0
Fiber (Citrus fiber Citri-Fi 100)	0.5
Water for fiber hydration	6.5
Total	100
Spices and materials (grams per 100 kg of raw materials)	
Sea salt with laminaria	2100
Granulated sugar	160
Sodium nitrite	5.0
Ground black or white pepper	160
Ground allspice	100
Ground nutmeg or cardamom	50.0
Bacterial preparation "Iprovit-LRR"	50.0
Rosemary extract	15.0
Water (kilograms)	30.0

Table 6.14 Brine recipe for salting raw meat (kg/100 kg)

Ingredient	Sample name
Sea salt with laminaria	2.1
Granulated sugar	0.1
Water	6.3
Total	8.55

The process consisted of: receiving raw materials, defrosting and primary grinding, soaking in a salting mixture, which contains a bacterial preparation "Iprovit-LRR", combining the minced meat and processing it in a cutter, shaping, settling, heat treatment, and cooling, characterized as follows [24].

A characteristic feature of the proposed technology is the addition of 35–40% of ice from the mass of the ground raw material to the cutter during the meat grinding process and the introduction of dietary fiber, health-improving and antioxidant additives into the minced meat. The previously ground raw fat was added to the cutter at the stage of grinding the fatty raw material. The minced meat was formed into casings by injection molding at a residual pressure of $P = 0.8 \times 10^4$ Pa. The filled casing was shaped in the form of bars using special devices. The sausages were separated from each other, tied with twine and hung on sticks with an interval between the bars to prevent sticking, placed on frames and sent for heat treatment. Smoke for frying sausages was obtained by burning dry logs from hardwood trees in smoke generators. In universal heat chambers, sausages were dried and fried until the surface turned red for 30…50 minutes at a temperature of 90…100°C on the surface of the loaves and reaching a temperature in the center of the workpiece of not less than 55°C and for 5…10 minutes, they were treated in universal heat chambers with steam at 85…90°C and a relative humidity of 85…90% until the temperature in the centre of the bar reached 70 ± 1°C. After cooking, the sausages were cooled under a cold water shower for 6…10 minutes, then in a chamber at a temperature not higher than 8°C until the temperature in the center of the bar reached 0…15°C [13].

The sausage composition developed based on the results of the work performed is standardized by the technical specifications of the technical specifications. IN 10.1-00493706-064:2019 "Ozdorovchi sausages".

6.5 Conclusions

The effectiveness of using the following ingredients in sausage technology has been confirmed: bacterial preparation "Iprovit LRR", sea salt with a reduced sodium chloride content and the addition of laminaria extract; orange dietary fiber Citri-Fi 100 of preventive action with the content of biologically active flavonoids, citral and lemon; blood plasma proteins; rosemary extract.

The functional and technological properties of minced meat systems of the developed composition were studied. It was shown that the content of essential amino acids in minced meat of the developed composition is higher compared to the corresponding characteristic of minced meat of the standard composition. A similar advantage of the experimental samples was shown in terms of plasticity, yield shear stress and water binding ability. Comparison of the appearance and organoleptic properties of the developed product with the corresponding characteristics of the sample of the standardized composition showed the superiority of the experimental minced meat in all the studied indicators.

A recipe for minced meat for the experimental sample of minced sausages "Ozdorovchi" was developed with the inclusion of blood plasma protein, dietary citrus fibers and rosemary extract, as well as brine for its salting, where instead of rock salt, it is recommended to add a slightly smaller amount of sea salt and granulated sugar to the brine.

References

1. Bal-Prylypko, L., Nikolaienko, M., Cherednichenko, O., Stepasiuk, L. (2022). Trends of the Development of the Meat Processing Industry of Ukraine and Practical Approaches to the Optimization the Recipe of Sausage Products. Ekonomika APK, 29 (5), 10–19. https://doi.org/10.32317/2221-1055.202205010
2. Cherednichenko, O., Bal-Prylypko, L., Paska, M., Nikolaenko, M. (2021). Expediency of creation of technology of production of meat products of long term of storage of the combined structure. IOP Conference Series: Earth and Environmental Science, 723 (3), 032086. https://doi.org/10.1088/1755-1315/723/3/032086
3. Bal-Prylypko, L., Yancheva, M., Paska, M., Ryabovol, M., Nikolaenko, M., Israelian, V. et al. (2022). The study of the intensification of technological parameters of the sausage production process. Potravinarstvo Slovak Journal of Food Sciences, 16, 27–41. https://doi.org/10.5219/1712
4. Bal-Prylypko, L., Danylenko, S., Mykhailova, O., Nedorizanyuk, L., Bovkun, A., Slobodyanyuk, N. et al. (2024). Influence of starter cultures on microbiological and physical-chemical parameters of dry-cured products. Potravinarstvo Slovak Journal of Food Sciences, 18, 313–330. https://doi.org/10.5219/1960
5. Bal-Prylypko, L., Nikolaenko, M., Mushtruk, M., Nazarenko, M., Beiko, L. (2024). Physical and mathematical modelling of the process of cooking minced meat with spelt flour and champignon mushrooms. Animal Science and Food Technology, 15 (2), 38–55. https://doi.org/10.31548/animal.2.2024.38
6. Red and processed meat in the context of health and the environment: many shades of red and green: information brief (2023). World Health Organization.

7. Bal-Prylypko, L. V., Nikolayenko, M. S., Danylenko, S. H., Ustymenko, I. M., Ryabovol, M. V., Zhurenko, D. V. (2024). Justification of technology of sausages for herodietic purpose. Journal of Chemistry and Technologies, 32 (3), 759–765. https://doi.org/10.15421/jchemtech.v32i3.306991
8. Nazarenko, M. V., Ustymenko, I. M. (2023). Development of technology of boiled sausages enriched with spelt flour. Scientific Reports of the National University of Life and Environmental Sciences of Ukraine, 1 (101). https://doi.org/10.31548/dopovidi1(101).2023.012
9. DSTU 4436:2005Boiled Sausages, Frankfurters, Sardellas, Meat Loaves (2006). Kyiv: State Standard of Ukraine.
10. Bal-Prylypko, L. V., Ryabovol, M. V. (2020). Application of sea salt in minced meat. Innovative technologies and prospects for the development of the meat processing industry. Kyiv: NUFT.
11. Ryabovol, M. V. (2023). Obgruntuvannia ta rozrobka tekhnolohii sosysok z vykorystanniam biotekhnolohichnykh pryiomiv [PhD thesis; NULES of Ukraine].
12. Sultana, K., Jayathilakan, K., Sajeevkumar, V. A.; Chauhan, O. P. (Eds.) (2022). Chemistry of Animal Tissues. Advances in Food Chemistry. Singapore: Springer, 385–437. https://doi.org/10.1007/978-981-19-4796-4_11
13. Riabovol, M. V., Bal-Prylypko, L. (2021). Research and development of a technology for the production of healthy sausages. Animal science and food technology, 12 (1), 39–47. https://doi.org/10.31548/animal2021.01.039
14. Iodization of salt for the prevention and control of iodine deficiency disorders (2023). WHO. Available at: https://www.who.int/tools/elena/interventions/salt-iodization.
15. McLean, R., Wang, N.; Michael Eskin, N. A. (Ed.) (2021). Potassium. Advances in Food and Nutrition Research. Academic Press, 89–121. https://doi.org/10.1016/bs.afnr.2021.02.013
16. Hatch-McChesney, A., Lieberman, H. R. (2022). Iodine and Iodine Deficiency: A Comprehensive Review of a Re-Emerging Issue. Nutrients, 14 (17), 3474. https://doi.org/10.3390/nu14173474
17. Greer, R. C., Marklund, M., Anderson, C. A. M., Cobb, L. K., Dalcin, A. T., Henry, M., Appel, L. J. (2020). Potassium-Enriched Salt Substitutes as a Means to Lower Blood Pressure. Hypertension, 75 (2), 266–274. https://doi.org/10.1161/hypertensionaha.119.13241
18. He, Y., Wang, B., Wen, L., Wang, F., Yu, H., Chen, D. et al. (2022). Effects of dietary fiber on human health. Food Science and Human Wellness, 11 (1), 1–10. https://doi.org/10.1016/j.fshw.2021.07.001

19. Bal-Prylypko, L. V., Leonova, B. I., Ryabovol, M. V. (2019). Use of dietary orange fibers in the production of meat products. Scientific Works of the National University of Food Technologies, 6, 131–137.
20. Bohrer, B. M. (2023). Blood and Blood Constituents for Meat Processing. Current Food Science and Technology Reports, 2 (1), 17–25. https://doi.org/10.1007/s43555-023-00015-3
21. Efenberger-Szmechtyk, M., Nowak, A., Czyzowska, A. (2020). Plant extracts rich in polyphenols: antibacterial agents and natural preservatives for meat and meat products. Critical Reviews in Food Science and Nutrition, 61 (1), 149–178. https://doi.org/10.1080/10408398.2020.1722060
22. Bal-Prylypko, L. V., Leonova, B. I., Riabovol, M. V. (2019). A study of biotechnological changes in raw meat during salting process. Chemical Technology, Control and Management, 2, 16–22. https://doi.org/10.34920/2019.2.16-22
23. Dietary protein quality evaluation in human nutrition. Report of an FAQ Expert Consultation (2013). FAO food and nutrition paper, 92, 1–66.
24. Bal-Prilipko, L. V., Riabovol, M. V., Slobodianiuk, N. M., Pilipchuk, O. S., Nikolaenko, M. S., Nazarenko, M. V. (2021). Pat. No. 149343. Sposib pidvishchennia rivnia bezpechnosti kovbasnikh virobiv. MKP A23L13/60. No. u 2021 02435; declareted: 07.06.2021; published: 10.11.2021, Bul. No. 45.