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Development of Technology for the Production of Sausage Produce Using Secondary Collagen-Containing Raw Materials

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Abstract

One of the main requirements for modern technologies is to expand the range of meat products by creating combined products with a balanced composition of food and biologically active substances. The purpose of the study was to develop a technology for the production of such combined meat products. The research used secondary meat raw materials of the meat processing industry: horse meat, flank and other beef muscle tissue of the second grade, which, after fermentation by a consortium of microorganisms consisting of the following cultures: *Lactobacillus bulgaricus, Bifidumbacterium siccum, Staphilococcus carnosus*, were used instead of the main meat raw materials in the production of sausages. The following indicators of ready-prepared products were studied: organoleptic properties, chemical, vitamin and mineral composition, toxicity and harmlessness, storage duration. The results showed that the use of this consortium of microorganisms in the production of sausage products made it possible to use secondary collagen-containing raw materials for processing. The positive influence of the proposed biotechnological method of processing meat raw materials on the organoleptic, physical-chemical, structural-mechanical, microbiological characteristics and biological value of the finished product was revealed. It was found that the use of a consortium of microorganisms increased the quality of finished products. In addition, the proposed technology has the potential to reduce the cost of production and increase the share of waste-free production in the meat processing industry.

Keywords: Collagen-containing raw materials; Biomodification; Combined meat product; Lactic Acid bacteria

1 Introduction

Currently, in the meat industry, it is possible to produce new types of combined meat products with a balanced composition for both general and special medical and preventive purposes on the basis of biotechnology (Gabitov et al., 2018; Gizatov & Gizatova, 2015; Lamanov et al., 2020; Sultanova et al., 2019). Improving the methods of enzymatic processing of low grade meat raw materials can improve the functional and technological properties, as well as the quality indicat-

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ors of ready-prepared products (Antipova et al., 2011; Antipova et al., 2015; Armuzzi et al., 2001; Coton et al., 2012; Fletcher, 2002; Wang et al., 2013).

The traditional field of application of low-grade meat raw materials is canning and sausage production. Canned meat and sausages, saveloys, boiled and boiled-smoked sausages are the most popular meat products, primarily due to their low cost. However, the use of low-grade raw materials in the process of their production leads to a significant decrease in the quality of the finished product. For example, even hard heat treatment in the production of canned food does not get rid of hard connective tissue inclusions, with a negative impact on the consistency of the finished product. In the production of cooked and smoked sausages, where heat treatment is carried out in relatively mild conditions, this disadvantage is even more noticeable.

Taking into account the results of published research, it can be assumed that the most promising areas in the creation and use of microbial consortia are:

- processing of raw meat with a high content of connective tissue (low-grade) to reduce its stiffness, improve functional and technological properties in the process of processing, increase organoleptic parameters;
- acceleration of the process of maturation and salting of meat raw materials.

Production of functional products using a consortium of microorganisms can be implemented at any meat processing plant without the costs of significant capital investments for re-equipment. Full implementation of the proposed technologies will expand the range of functional products against the background of a shortage of dietary protein. Considering the traditional technological schemes for the production of cooked sausages, saveloys and sausages (for example, "Steppe"), it is obvious that the consortium of microorganisms must be introduced at the stage of salting of the raw materials. This solution is optimal, since it ensures the growth of microorganisms within 8 hours, during which time the complete distribution of microorganisms occurs, which significantly increases the efficiency of the consortium. It is recommended that the process of producing products using a consortium of microorganisms is organized according to the following technology. To obtain products (Antipova & Uspenskaj, 2016) that are in demand by the population, it is necessary to select such a ratio of components so that the products have a high nutritional and biological value, and an attractive presentation.

In Italy, *Micrococcus sp., Lactobacillus plantarum* strains were tested to study the organoleptic properties of dry sausages as starter cultures. In England, *Lactobacillus* and *Micrococcus* starter cultures are used in the ratio 50:50 for the production of fermented Lefkas-type sausages (Sufiyanova et al., 2012). Several other crops were used to compare the technological effects: *Petrostreptococcus parubus, L. plantarum, Pediococcus acidilactici*, as well as their combinations with *Streptococcus carnosus* MIII. In all variants of microorganisms tested, the best results are obtained with *Lactobacillus pentosus.* The effect was expressed as a rapid decrease in pH, obtaining a sausage of an attractive colour, a mildly sour taste and a well-pronounced meat aroma (Digaitiene et al., 2012). Optimal variants for organoleptic parameters were obtained using a mixed starter containing 90% *S. carnosus* and 10% *L. plantarum*, in particular in the production of Turkish smoked sausages (Antipova & Uspenskaj, 2016). The role of starter cultures *L. plantarum 4045, Staphylococcus sp., L. plantarum 4045 + Micrococcus 12 and L. plantarum 4045 + Staphylococcus sp.*, and endogenous meat enzymes in the process of lipolysis in dry fermented sausages was studied. Samples with *L. plantarum* had the lowest pH rates, but the content of free fatty acids was higher in the inoculated samples compared to the control ones as mainly endogenous meat enzymes play an important role in the process of lipolysis (Hatakka et al., 2001).

The purpose of this study was to develop functional products from biomodified low-grade raw materials using consortia of microorganisms. Within the framework of this goal, we had the following objectives:

- to study the cultural properties of the selec-

ted microorganisms (i.e. *Lactobacillus bulgaricus, Bifidumbacterium siccum, Staphilococcus carnosus*);

- to study the biochemical properties of the selected microorganisms and the synergy of microorganisms in the consortium;
- to study the functional and technological properties of model minced meat from low-grade raw materials with the addition of a consortium of microorganisms;
- to develop recipes and production technologies for functional products based on biomodified secondary raw materials.

The influence of the consortium on the functional and technological properties of biomodified model minced meat from horse meat, flank and other beef of second grade was studied. The technological scheme of production of functional probiotic sausages using a consortium of microorganisms was described and the quality of finished products was assessed.

2 Materials and Methods

2.1 Sausage production technology

In order to determine the competitiveness of new products in the consumer market, their nutritional and biological value, a comprehensive assessment of their properties was carried out. The following product indicators were studied: organoleptic; chemical, vitamin, mineral composition; microbiological indicators; storage duration.
Samples of beef and horse meat for research were selected according to All Union State standard R 51447, All Union State standard 9792 (Fischer, 2007; Fletcher, 2002; Knol et al., 2001) after which they were made into a combined sample and wrapped in parchment labelled to identify the sample. For the production of sausages in addition to raw meat, we used skimmed cow milk according to All Union State standard 10970; flour according to All Union State standard 26574, not lower than first grade; *Staphylococcus carnosus* (bacterial concentrate freeze-dried) according to Commodity Specification 9229-074-04610209; *L. bulgaricus* (No. 8P-A3 bacterial concentrate freeze-dried in culture medium with the addition of protective sucrose-gelatose-dairy medium) produced by FSUE "SPU" "Microgen" of Ministry of Health, RF, branch in Perm "the Perm SPU "Biomed"; *Bifidobacterium siccum* (No. 1, 791, LVA-3, bacterial concentrate freeze-dried in culture medium with the addition of protective sucrose-gelatose-dairy medium) produced by FSUE "SPU" "Microgen" of Ministry of Health, RF, branch in Perm "the Perm SPU "Biomed"; food additives - carrageenan GPI 200, GPI 521 obtained for imports and approved for use by State Sanitary and Epidemiological Surveillance Agency of Ministry of Health of the Russian Federation; salt according to All Union State standard R 51574 not lower than first grade; hen eggs according to All Union State standard 27583; drinking water by Sanitary Regulations and Standarts 2.1.4.1074; extracts of spices according to Commodity Specification 9169-032-04801346; sodium nitrite according to All Union State standard 4197.
Grinding of raw meat for sausages was carried out using traditional technology. The meat was ground through a perforated plate with hole diameters of 2-3 mm. A leaven of a consortium of microorganisms in the amount of 1ml/ 100 g of raw material was introduced into the ground flank and beef veins. After that, the veins and the flank were separately mixed with table salt in a minced meat mixer. The duration of mixing was 4-5 minutes. Salted raw meat was kept at a temperature of 0-4 ^{o}C for 6-12 hours, depending on the type of sausage. After maturation, fine grinding was performed on a cutter for 6-8 minutes with the addition of the remaining components of spices according to traditional technology. The filling of the casings was carried out with a syringe. Polyamide shells were used. Further, heat treatment was performed in heat chambers. Due to the use of polyamide shells, roasting was excluded from the technological scheme. In heat chambers, sausage loaves were initially kept at a temperature of 60-65°C for 20 to 40 minutes, and then steamed at a temperature of 80°C, until they reached 72°C in the centre of the loaf. After cooking, the sausage was cooled with cold water for 5-10 minutes to a tem-

perature no higher than 8°C. Storage time never exceeded 30 days at a temperature of 2-6°C.

2.2 Determination of meat pH and protein content

The pH value of solutions and meat systems was determined by a potentiometric method using a universal pH-121 ionometer. Each sample of meat weighing 10.00±0.02 g was extracted with distilled water in a ratio of 1: 10 for 30 minutes at 20±5 ^{o}C, mixed and filtered through a folded paper filter. Determination of the mass fraction of proteins in muscle tissues was performed using the Kjeldahl method. 0.2 g of collagen gel was added to the Kjeldahl flask with a capacity of 50 cm^3. The samples were crushed, then using a piece of glass, the suspension was lowered to the bottom of the flask.1-2 cm^3 of concentrated sulfuric acid was added, followed by 1 g of a mixture of copper sulphate and potassium sulphate as a catalyst. The contents of the flask were heated in a fume hood. When the mixture turned brown, the flask was removed from the heat, cooled at room temperature, added 2-3 cm^3 of hydrogen peroxide solution with a mass fraction of 30% and continued to heat until a colorless solution was obtained. The latter was used for quantitative determination of protein (Ammor & Mayo, 2007; Zinina et al., 2016).
The hot sample was cooled, quantitatively transferred to a volumetric flask with a capacity of 250 cm^3, the volume was brought to the mark with distilled water, and the contents were mixed. 5 cm^3 of the resulting mineralized sample solution was added to a measuring flask with a capacity of 100 cm^3, and the volume was re-adjusted to the mark with distilled water. To conduct a colour reaction, 1 cm^3 of the secondarily diluted mineralized sample was introduced into the test tube and 5 cm^3 of reagent 1 and 5 cm^3 of reagent 2 were added sequentially, the contents of the test tube were mixed. At the same time, a control solution was prepared using a control mineralized sample (a sample using distilled water). After 30 minutes, the optical density of the solutions was determined using a photoelectrocolorimeter with a red light filter. The measurement was performed in comparison with the control solution. Determination of lactic acid was carried out by colour reaction with para-oxydiphenylene (Digaitiene et al., 2012).

2.3 Sausage quality evaluation

10 cm^3 of trichloroacetic acid solution (10% w/v) and 2-4 g of minced meat was added to the mortar and dispersed using the pestle for 10 minutes. The resulting suspension was transferred to a volumetric flask with a capacity of 50 cm^3, using first a 20 cm^3 solution of trichloroacetic acid (10% w/v), and then a few cubic centimeters of distilled water. The flask was left for 30 minutes at room temperature, shaken every 10 minutes, then the volume was brought to the mark with distilled water, the flask was closed with a cork, the contents were mixed well, transferred to centrifuge tubes, and centrifuged with a rotation speed of 50 s^{-1} for 10-15 minutes. The supernatant was drained into a dry flask, 25 cm^3 of clear liquid was taken, transferred to a 100 cm^3 volumetric flask, and the volume was brought to the mark with distilled water. Analysis: to precipitate carbohydrates, 1 cm^3 of copper sulphate solution (20% w/v)was added to 2 cm^3 of the diluted supernatant (distilled water was added using a pipette or burette to bring the volume of the liquid to 10 cm^3., ; 1 g of powdered calcium hydroxide was then added followed by vigorous shaking and left to stand for 30 minutes, shaking from time to time, and then centrifuged. The supernatant was poured into a flask. To perform the colour reaction, 1 cm^3 of the supernatant was transferred to a tube of about 25x200 mm in size; 1 drop of copper sulphate solution (4% w/v) and the tube was placed into ice water. Whilst stirring, 6 cm^3 of concentrated sulphuric acid was added from a microburette, the test tube was placed for 5 minutes in a water bath at a boiling point, and then cooled in cold water to 20°C. 0.1 cm^3 of the vapour - oxidiphenyl solution was added to the test tube, mixed very carefully and thoroughly, and then the test tubes were placed for 30 minutes in a water bath at 30°C, with occasional gentle shaking. After this period, the test tube was placed in a vigorously boiling water bath for 90 seconds, then cooled in cold water and the colour intensity was measured using

a spectrophotometer at a wavelength of 560 nm In 1 cm cuvettes. The control with only the reagents was carried out after precipitation of carbohydrates, which was used instead of 2 cm^3 of our sample centrifugate of 0.3 cm^3 of a solution of trichloroacetic acid and 1.7 cm^3 of distilled water. The A calibration curve was made using lactic acid standards. (Antipova et al., 2001).

To determine the amino acid composition, the products were first hydrolyzed with hydrochloric acid at a concentration of 6 mol / dm^3. The amino acid composition and the content of free amino acids were determined by ion exchange chromatography in an automatic amino acid analyzer AAA T-339 (Czech Republic) (Antipova et al., 2015). Amino acid separation was performed on an analytical column filled with an ion exchange resin Ostion LGFA with step-by-step elution with three sodium citrate buffers with different pH values (3.50; 4.25; 9.50). Peaks of light absorption in the eluate from the column were used to detect the presence of individual amino acids in the hydrolysate, as judged by the location of the peaks, and their quantitative content determined by the area of the peaks.

The fatty acid composition was determined by gas-liquid chromatography (Antipova et al., 2015) followed by GC-MS-C analysis (liquid chromatography-mass spectrometry-computer). Identification and quantitative determination of methyl esters of fatty acids using a Varian-3400 chromatograph with FID detector; column length of 25 m, internal diameter of 0.25 mm. Gas carrier: nitrogen; flow rate: 1.18 cm^3 / min. The temperature of the injector and detector was 250 and 300°C respectively. Rate of temperature rise was from 150 to 300°C/min.

Determination of iron was done by colorimetric method that changes the colour intensity of divalent iron with orthophenanthroline according to All Union State standard 26928 (Rakhimov et al., 2018).

The content of mineral substances (trace elements) was determined by the atomic absorption method on an atomic absorption spectrophotometer, as well as by the calculation method (Antipova et al., 2015; Gabitov et al., 2019). For the determination of calcium and magnesium, trilonometric methods were used (Antipova & Uspenskaj, 2016). Phosphorus was determined by the colorimetric method using a molybdenum-vanadium reagent (Sydykova et al., 2019).

The mass fraction of vitamins was determined according to generally accepted methods, as well as the calculated method (Antipova & Uspenskaj, 2016; Gavrilova et al., 2019; Sydykova et al., 2019; Zinina et al., 2016). Vitamin B_1 (thiamine) by a fluorimetric method; vitamin B_2 (Riboflavin) by a fluorimetric method (luminoflavin variant), vitamin PP (Niacin) by a colorimetric method.

Determination of toxic elements: mercury was determined according to All Union State standard 26927, arsenic according to All Union State standard 26930, lead according to All Union State standard 26932, cadmium according to All Union State standard 26933 (Andreeva et al., 2018; Nesterenko et al., 2018).

2.4 Express Biotest

The determination of safety and biological activity used a method with the test culture *Paramecium caudatum* a free-living, easily cultured single-celled organism. The Express Biotest reacts quite sensitively to the active substances contained in the test samples, and reflects their reaction to the viability of the body. The activity of the test organism's vital processes depends on the quality and quantity of the food substrate. The sample was dried at a temperature not higher than 30 ^{o}C to a constant mass. Then 10 g of suspension, crushed if necessary, was sifted through a 72 mesh sieve into a dish to obtain particles of no more than 225 microns. Three samples of 1 g were taken from the dish and 10 ml of distilled water was poured in. The mixture was kept for 24 hours, shaken 2-3 times, and centrifuged. For further work, we used the supernatant that represented a dilution of the test sample of 1: 10.

Express Biotest included three stages:

Stage I assessment of the biological activity of the samples. 9.9 ml of infusory culture was poured into test tubes. The control sample was filled with 0.1 ml of distilled water. The one with active culture was filled with 0.1 ml of decanted fluid of prepared test sample giving a dilution of 10^{-3}. Serial dilutions

of 10^{-4}, 10^{-5} and 10^{-6} were then made. The state of the infusoria was evaluated after 0.5, 1.0, 3.0, 6.0 and 24.0 hours of cultivation at 25 ^{o}C, determining the number and nature of infusoria movements according to the following criteria: ID – indifference – cells made uniform Brownian movements; BA – bioactivity – cell movements were changed (BC – biocidality, toxic effect: BC-50 – 50±10% of cells died, BC – 100 – 90±10% of cells died (when diluted 10^{-3} – the object had a weakly toxic effect; 10^{-4} – medium toxic effect; 10^{-5} – strong toxic effect; 10^{-6} – very strong toxic effect).

Stage II assessment of the biological activity of the samples by the method of resolving influence. The essence of the method was to identify the biological effect of a sample on the mechanism of adaptation and resistance of the cell using an additional enabling adverse factor. The work used a culture of infusoria from the first stage, which was in contact with different concentrations of the sample under study for 24 hours. The study consisted of determining the time of death of 100% of cells under the action of 8% sodium chloride solution.

Stage III assessment of the biological activity of the samples based on the intensity of reproduction of *Paramecium caudatum.* A culture of infusoria in the exponential growth phase was added to the prepared samples. The density of the inoculate was determined. Then they were cultured for 3 days at 25 ^{o}C. At the end of the cultivation time, the density of the inoculate was determined. The index of reproduction intensity at = 1,000 ± 0.100 showed that the object was not biologically active, at > 1,000 ± 0.100 – the object stimulated cell reproduction, at < 1,000 ± 0.100 – the object inhibited cell reproduction. The value of the index of reproduction intensity in combination with the concentration of a given object in the medium characterized the degree of its influence on the reproduction mechanism.

2.5 Organoleptic evaluation

Before conducting an organoleptic evaluation, tasters (five untrained people, without any special selection) were familiarised with the objectives of the tasting and the requirements of regulatory documentation for the quality of the products being evaluated. Samples of products were presented for tasting in the following order: first of all, products with a weakly expressed smell or subtle aroma, less salty and spicy were evaluated; then products with a moderate smell (aroma) and salinity; after that, products with a strong smell (aroma), salty and spicy. A 10-point scale was used in all sensory assessments. Last of all, in each group of similar products, products were evaluated heated (sausages, saveloys, shpikachki, etc.) or heat-treated (ready-to-eat products, pelmeni, chops and other semi-finished products); the order of their presentation was also determined by the degree of intensity of the smell (aroma) and taste. Indicators of the quality of meat and meat products were determined on the whole (uncut) one firstly, and then on the cut product. An organoleptic evaluation of a whole product was performed on a single product unit. Quality indicators of the whole product were determined in the following sequence:

1. appearance, colour and surface condition - visually, by external inspection;
2. smell (aroma) - on the surface of the product. If it was necessary to determine the smell in the depth of the product, a special wooden or metal needle was taken, inserted into the thickness, and then it was quickly removed and determined the smell remaining on the surface of the needle;
3. the consistency - pressing with a spatula or fingers.

The quality indicators of the cut product were determined in the following sequence:

1. before the assessment, meat and meat products were removed from consumer packaging, shell and twine (clips), bones were removed (if any) and using a sharp knife, it was cut into thin slices perpendicular to

the surface of the product, so as to ensure the characteristic appearance and pattern of this product along the cut;

2. colour, appearance and pattern on the section, structure and distribution of ingredients was determined visually on the newly made transverse and longitudinal sections of the product;

3. smell (aroma), taste and juiciness was assessed by testing slices of meat and meat products. This determined the odour (aroma) and taste (the degree of intensity of salty, sour, sweet, bitter taste, etc.); the strength of fragrant spices, fermentation and smoking; the presence or absence of foreign smell and/or taste, aftertaste; d) consistency - pressing, and cutting, a chewing. Consistency was determined by assessing the density, looseness, tenderness, stiffness, crumbling, elasticity and mass uniformity. The aroma, taste, juiciness of sausages, saveloys and shpikachki was determined hot, for which they were lowered into warm water at 50 ^{o}C to 60 ^{o}C and brought to a boil. The juiciness of these hot sausages, saveloys and shpikachki in a natural casing was determined by making a puncture. Where punctured, a juicy sample produced a drop of liquid. After conducting an organoleptic evaluation of 7 to 8 samples a break was taken for at least 10 minutes. Products were evaluated according to a point system - for compliance of quality indicators with the requirements of regulatory documentation (Antipova et al., 2001).

3 Results

The initial stage of development of sausage production technology was the selection of the optimal combinations and concentration of the consortium of microorganisms. The consortium of microorganisms included strains of the following types of microorganisms: *L. bulgaricus* 354.0 x 10^5 CFU/g, *Bifidobacterium siccum* 290.0 x 10^5 CFU/g, *Staphylococcus carnosus* 400.5 x 10^5 CFU/g.

To activate the cultures of microorganisms, skimmed milk was used, which was autoclaved at 0.5 atm for 20 minuntes before use. The amount of the microbial consortium ferment introduced into the sausage mince was determined experimentally by changing the pH values of the medium and the stickiness of the model minced meat. The results of the studies are shown in Figures 1 and 2.

The results of the pH study showed that the minimum and maximum concentrations of microorganisms in the consortium affected the results negatively; the effect of lowering the pH of raw meat was not achieved at low concentrations, whereas with the highest concentrations the pH decrease was too great, which would lead to the acidification of the meat. Therefore, the optimal value was 1 ml/100 g. The results of previous experimental studies have shown that the action of microorganisms increased significantly the stickiness of minced systems (Armuzzi et al., 2001). In the presence of a consortium of microorganisms, the growth of the adhesive ability was somewhat faster, and achieved higher maximum stickiness values (2.6 -2.7 N / cm^2, depending on the type of minced meat). An increase in the duration of exposure (more than 8 hours) led to some stabilization of the growth of stickiness), which was probably due to the formation of low molecular weight proteolysis products that do not have a high adhesive ability.

According to physical and chemical parameters, the cooked products met the requirements specified in Table 1.

In terms of organoleptic characteristics, the new products were not inferior to the traditional ones. The decrease in the proportion of connective tissue proteins had a positive effect on the organoleptic characteristics of the finished product (Tables 2 and 3), primarily the consistency. There was a decrease in stiffness, increased tenderness, and improved chewability. The accumulation of free amino acids enhanced the taste qualities of the experimental samples.

Differences in the structural and mechanical parameters of control and experimental samples of sausages (Table 4).

Paramecium caudatum test was used to test the toxicity and harmlessness of the resulting cooked products. (Tables 5 and 6).

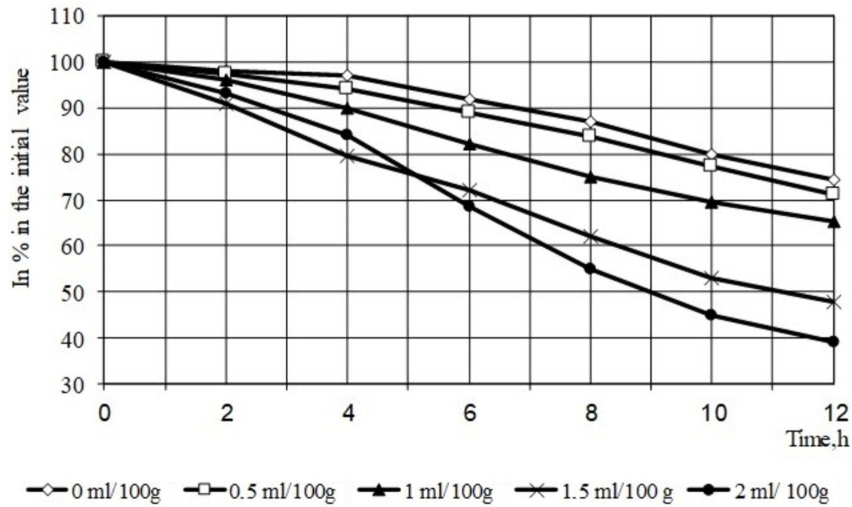

Figure 1: Change in the pH of the medium from the concentration of the consortium of microorganisms.

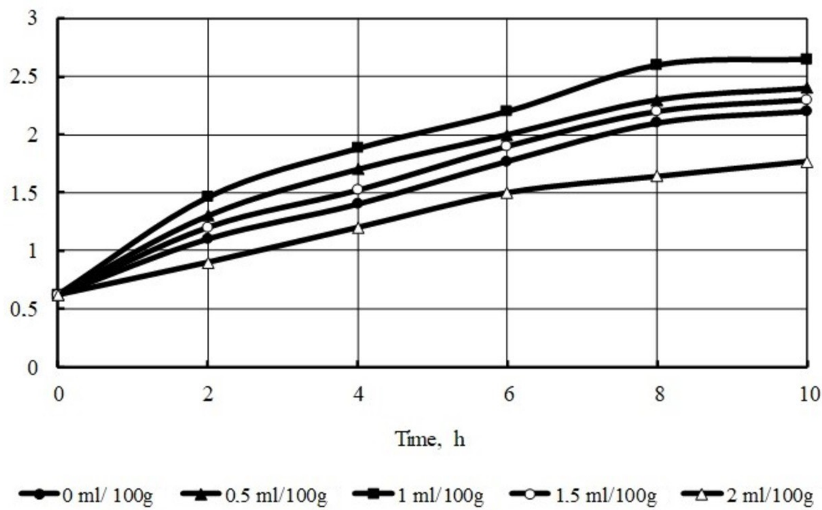

Figure 2: Dynamics of changes in the stickiness of model minced meat according to the concentration of the consortium of microorganisms.

As reported in Table 6, samples did not have any negative effect on the culture of the *Paramecium caudatum*. When the sausage extracts were diluted from 10^{-4} up to 10^{-6} there was no reduction in the viability of the test culture and the index of its biological activity. Thus, sausage products using low-value raw materials and with the addition of a consortium of microorganisms did not show toxicity as assessed by Express Biotest.

4 Discussion

During the development of the production technology, the optimal amount of microorganisms introduced by the consortium into the sausage meat was selected. The optimal amount was 1 l / 100 kg of minced meat. Production of sausages was carried out according to the traditional technology using second grade meat raw materials. According to physical and chemical parameters, the cooked products met the requirements for these types of sausages. In terms of organoleptic characteristics, new products were not inferior to traditional ones. The decline in the proportion of connective tissue proteins had a beneficial effect on the organoleptic properties of final products, primarily on consistency (Cheng & Sun, 2008; Holko et al., 2013; Karam et al., 2013) in terms of the marked reduction of rigidity, increased tenderness and improved chewability. The accumulation of free amino acids enhanced the taste qualities of the experimental samples. When producing food, special attention should be paid to safety, i.e. the absence of substances or concentrations of substances that can cause toxicity in the product. It was found that samples of products did not have a negative effect on the culture of *Paramecium caudatum*. The use of ciliated infusoria to assess the toxicity of human food is based on the fact that the infusoria has a number of enzyme systems similar to higher animals, as well as an acid-base type of digestion. In the presence of toxins, infusoria die. The advantage of the method is the speed of their implementation, good reproducibility and sensitivity, and low cost. The toxicity of finished products was determined by the safety of all infusoria after 24 hours, by its effect on the mechanisms of adaptation and resistance of cells, and by the intensity of reproduction of infusoria after cultivation at 25 ^{o}C for 3 days.

The use of the complex of lactic acid bacteria in the production of sausage products should be recognized as effective and cost-effective, since in the process of adding lactic acid and *Bifidobacteria*, the salting time was reduced and the low-value meat raw materials were softened. The nature of the action of the consortium of microorganisms allows the developed technology to be recommended for introduction into production in order to obtain combined and balanced sausage products.

Similarly, Baka et al. (2011) developed the use of starter cultures as additives to fermented sausages. Thus, the selected starter cultures (i.e. *Lactobacillus sakei 8416, Lactobacillus sakei 4413, and L. sakei 8426, L. Plantarum 7423, and L. curvatus 8427)* were used as starter cultures in addition to control processing in the production of fermented sausages. Starter cultures had rapid growth and prevailed throughout fermentation and maturation, and sensory properties improved compared to the control sample. In addition to the treatment obtained with *L. Sakei* 8416, all other starter cultures prevented lipid oxidation The sausages made with starter cultures *L. sakei* 4413 and *L. Sakei* 8416 had the highest ratings for all sensory properties (Casquete et al., 2011).

In order to improve the food safety of Chinese fermented sausages, Wang et al. (2013) introduced starter cultures of *Lactobacillus sakei* into sausages and studied the impact on sausage quality. The results showed that due to *L. sakei* inoculation, lactic acid bacteria quickly dominated over the microflora and growth of food pathogens such as *E. coli* and Enterobacteria, which were completely eradicated in fermented sausages. The pH of sausages fermented through *L. sakei* significantly decreased. In addition, the nitrite content of *L. Sakei* fermented sausages quickly dropped from 100 parts per million to 9.6 parts per million, while sensory properties improved (Antipova et al., 2011).

Table 1: Characteristics of cooked sausage "Useful"

Name of the indicator	Characteristic and norm for sausage
Mass fraction of moisture, % no more than	73
Mass fraction of sodium chloride, %	2,5
Mass fraction of fat, %	-
Mass fraction of protein, % not less than	10,2
Mass fraction of sodium nitrite, % not more than	0,005
Mass fraction of starch, % not more than	5,5
Residual activity of acid phosphatase, % not more than	0,006

Table 2: Organoleptic evaluation of cooked sausages (Five tasters, in triplicate)

The name of the sample	Indicator						
	Appearance	Appearance and color in the cut	Smell	Taste	Consistency	Juiciness	Overall assessment
Control:							
Sausages "Steppe"	8,2	7,5	7,2	8,4	8,5	7,5	7,9
Saveloys "Steppe"	6,5	5,3	7	7,9	5,8	5	6,2
Cooked sausage "Steppe"	6,5	5,7	6,8	7,6	6,2	5,7	6,3
Experience:							
Sausages "Useful"	8,3	7,6	7,6	8,8	8,4	7,4	7,9
Saveloys "Useful"	6,4	5,3	7,3	8	5,7	4,3	6,2
Cooked sausage "Useful"	6,5	5,9	7,1	7,8	6	5,5	6,2

Table 3: Structural and mechanical characteristics of sausage products

Layer	Control sample		Experimental sample	
	cutoff voltage, x 10-4 Pa	led cutting operation, J / m^2	cutoff voltage, x 10-4 Pa	led cutting operation, J / m^2
Central	2,8 ± 0,09	88,6 ± 2,1	1,55 ± 0,05	74,4 ± 1,9
Peripheral	4,92 ± 0,13	175 ± 3,27	2,01 ± 0,11	98,3 ± 2,27

Table 4: Vitamin and mineral composition of sausage products

Components	Sausage products "Useful" cooked sausage	sausages	saveloys
Vitamins, mg%:			
Folic Acid	0,007	0,005	0,005
B1	0,018	0,017	0,018
B2	0,006	0,007	0,005
B6	0,083	0,04	0,048
Nicotinic acid	0,007	0,006	0,006
Mineral substances, mg%:			
Calcium	98,75	88,35	94
Sodium	7,67	9,07	11,77
Magnesium	32,55	33,85	32,23
Iron	3,09	1,27	1,12

Table 5: Content of heavy metals in the product

Name of the indicator	Cooked	Sausages	Saveloys	Norm
Lead, mcg/g	0,026	0,02	0,021	0,5
Cadmium, mcg/g	0,009	0,004	0,004	0,05
Arsenic, mcg/g	0,089	0,087	0,088	0,1
Mercury, mcg/g	traces	traces	traces	0,03

Table 6: Evaluation of the biological activity of cooked products

The test sample	Index of biological activity in the breeding				
	1:100	1:1000	1:10000	1:100000	1:1000000
Cooked sausage	1,121	1,087	1,004	1	1
Sausages	1,104	1,029	1,014	1,002	1
Saveloys	1,107	1,032	1,02	1,008	1

5 Conclusions

In the course of this research, a technology for producing sausages with a balanced composition of food and biologically active substances was developed. By examining the physical and chemical parameters of the cooked products, we found full compliance with the necessary requirements. At the same time, it turned out that the new products were not inferior to the traditional ones. The decrease in the proportion of connective tissue proteins had a positive effect on the organoleptic characteristics of the finished product. There was a decrease in stiffness, increased tenderness, and improved chewability. The accumulation of free amino acids enhanced the taste qualities of the experimental samples.

When producing food, special attention should be paid to safety, i.e. the absence of substances or concentrations of substances that can cause toxicity in the product. For this purpose, studies were conducted on the content of the elements regulated by the standard. In addition to the analysis for the content of heavy metals, we conducted a biotest for biological activity with *Paramecium caudatum*. The test samples of sausages did not reduce the viability of the test object and the index of its biological activity. Thus, sausage products using low-value raw materials and with the addition of a consortium of microorganisms had high nutritional and biological value and did not show toxicity.

The results of these studies showed that the use of the consortium in the production of meat products allowed the speeding up of the ripening process of meat systems, and also allowed the use of low-value raw meat of low-grade in the fermentation process. It can be concluded that the sausage produced according to the developed technology showed improved functional and technological properties and sensory quality.

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