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Evaluation of the biological value and food safety of restructured yak meat product

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ABSTRACT

The article aims to study the qualitative parameters of the restructured yak meat product. Yak meat was treated with a brine solution containing cherry plum juice, a rich source of organic acids. The raw meat material for the restructured product was ground on a spinner with a 16-25 mm diameter grate. Then salting was carried out for 6 hours at t = 10 -12 °C, with brine poured at 10 % by mass into the meat material. The raw meat material was sent to a stirrer for 60 minutes of massaging. Massaged raw meat was sent for maturation (τ = 24-48 h at t = 18ºC). During the maturation of yak meat, a certain degree of protein extraction occurred, as well as a muscle-relaxing effect caused by the presence of cherry plum juice and salt. Meat raw material, chopped and cooled at a temperature of 0 to +2 °C, was placed in a stirrer and stirred for 20-30 min with gradual introduction of hydrated lentil meal, spices, sodium nitrite, and water (ice) in an amount of 10% of the weight of the meat raw material. Then sausages were moulded into casings, and precipitation was carried out at τ =3 h and t =4-8ºC. The prepared sausage products were heat-treated. The chemical, mineral, amino acid, vitamin, and fatty acid compositions of the finished restructured products were studied. The use of cherry plum juice in massaging yak meat and lentil flour in the recipe of the experimental product also contributes to its enrichment with amino acids, vitamins, and minerals. Analysis of the amino acid composition of experimental and control products showed that in the experimental product, the amount of all essential amino acids significantly prevails in comparison with the control product. Thus, valine is more by 3289 mg, isoleucine by 1154 mg, leucine by 567 mg, lysine by 266 mg, methionine+cystine by 797 mg, threonine by 234 mg, tryptophan by 175 mg, phenylalanine+tyrosine by 1103 mg. Analysis of the mineral composition of the restructured products showed that the experimental product contains more minerals than the control product. The high iron content in the experimental product is due to the rich haemoglobin content in yak meat. The use of cherry plum juice in brine as an antioxidant during massaging helps reduce microbiological values.

Keywords: yak, meat, restructured meat product, lentil, flour, cherry plum juice, micronutrient profile, nutritional prevention, biological value, food safety.

INTRODUCTION

In a world where dietary preferences and environmental concerns are rapidly evolving, the food industry is continually seeking innovative approaches to meet consumers' changing needs. One such groundbreaking development is the concept of restructuring meat —a process with immense potential to transform the future of animal-based protein. A restructuring method has been developed to transform lower-value cuts into higher-value products. Restructuring refers to the process of breaking small pieces of meat and reforming them into the same or a new form **[1]**. Meat restructuring is the reconstitution of meat structure using secondary structure formation from individual pieces of meat that have been ground or subjected to other types of technological processing.

The purpose of restructuring is to imitate the appearance of a whole-muscle product. Restructuring makes it possible to regulate the organoleptic and structural-mechanical properties of products; attract raw materials limited by traditional technologies into production; expand the assortment; increase the depth of processing of meat raw materials; and increase the yield of finished products and the profitability of production. Restructuring can be applied to the production of hams and sausages from single-grade fatty raw materials left over from meat cutting or from poultry meat **[2]**, and **[3]**.

Meat restructuring technology offers the potential to convert meat trimmings and lower-value cuts into value-added products, thereby improving palatability and consumer acceptance. To further improve the quality and consistency of restructured meat products, detailed studies are still needed on particle size, blending conditions, meat tenderizing processes, color and flavor stability. Besides the economy, the restructuring process also provides healthier meat products, as restructured products are leaner and health-conscious consumers are increasingly demanding products low in fat, salt, and synthetic ingredients, and high in fibre. Some restructured products using various ingredients have been developed, but consumer acceptance remains challenging. At the same time, proper marketing and educating consumers about the importance of restructured products is essential **[4]**, **[5]**, and **[6]**.

Marinating meat is essential in the meat restructuring process. Marinating meat is a process that uses chemicals to tenderize it. This treatment increases the rate of natural proteolysis in meat by lowering its pH further after slaughter, thereby stimulating enzymatic proteolytic activity during muscle maturation. Salting of meat together with marinating is done in massagers or tumblers **[7]**, and **[8]**.

The mechanism by which marinade affects meat tenderization appears to involve several factors, including weakening of structures due to meat swelling, increased proteolysis induced by cathepsins, and increased conversion of collagen to gelatin at low pH during cooking **[9]**, and **[10]**.

Meat and meat products, rich in various nutrients, are easily contaminated by widespread environmental microbes. The presence of microorganisms in meat and meat products. poses a significant challenge in producing high-quality, safe food products for consumers. Processed meat is more susceptible to microbial contamination at various stages of processing. Therefore, the process of salting meat with plant additives with antioxidant properties is of great importance in meat product technology. Modern meat product technologies employ various methods to incorporate antioxidants into the salting and marinating processes **[11]**, **[12]**. The cherry plum fruits can be distinguished among the plant raw materials with antioxidant properties and a large number of fruit acids **[13]**. In nature, it occupies a vast area, stretching from Central Asia through the Caucasus and Asia Minor to the Balkan Peninsula. In the Kyrgyz Republic, cherry plum is represented by the subspecies Prunus sogdiana Vass. **[14]**. The most incredible diversity of Sogdian cherry plum is observed in the territory of Southern Kyrgyzstan, where it grows in abundance in nut-fruit forests. In culture, the Sogdian cherry plum has spread everywhere and is used by the population as a fresh food, in the manufacture of various processed products, and as a rootstock for domestic plums. The use of cherry plums in the composition for salting and marinating restructured yak meat products has scientific novelty and current significance.

Scientific Hypothesis

It is hypothesized that the incorporation of cherry plum juice and lentil flour will enhance the amino acid, mineral, and vitamin profile, as well as improve the microbiological characteristics of the final restructured yak meat product, thereby imparting functional properties.

Objectives

Primary objectives: The main aim of this study was to develop a restructured yak meat product enriched with plant-based ingredients such as cherry plum juice and lentil flour, and to conduct a comprehensive assessment of its amino acid, mineral, and vitamin composition, as well as its microbiological characteristics.

MATERIAL AND METHODS

Samples

Samples description: The following raw materials were used to produce the restructured products: grade 1 yak meat obtained at the “Kapka-Tash” Breeding Farm (Kyrgyz Republic), grade 1 turkey meat (“Agro Kush” Poultry Farm, Kyrgyz Republic), and lentil flour produced by “Dan Agroprodukty”, Kyrgyz Republic. The recipes for the test samples included additional raw materials: cherry plum fruits collected in the botanical garden of the Kyrgyz Republic, salt produced by the Manas factory (Issyk-Ata, Kyrgyz Republic), sodium nitrite according to GOST 32781 (2014), ground black pepper, coriander, fresh and dried garlic produced by “Tatymal Group”

(Kyrgyz Republic), sugar produced by "Aprosakh", Kyrgyz Republic. The raw materials were purchased at the food market in Bishkek, Kyrgyz Republic.

Samples collection: Sample collection was conducted to ensure the representativeness and reliability of the data obtained. Experimental samples of the restructured product were made in strict accordance with the established recipe. The control sample was purchased from a retail shop in Bishkek, Kyrgyzstan. Samples were collected and temporarily stored in a refrigerator at 0-4°C.

Samples preparation: Samples of the restructured yak meat product were made according to the above-mentioned methodology, cooled to 0 °C, and transported in a thermal container capable of maintaining the product temperature for 48 hours.

Number of samples analysed: 18.

Chemicals

For microbiological analysis: 1-naphthol; L-lysine decarboxylase medium; Christensen's agar; bismuth-sulfite agar (Ploskirev's medium, Endo's medium, Levin's medium, brilliant green agar); distilled water; glucose; double-substituted potassium phosphate; single-substituted potassium phosphate; potassium hydroxide; creatine monohydrate; tri-sugar glandular agar (TSI-agar) or Kligler's agar or Olkenitsky's medium; tryptone/tryptophan medium or Hottinger's broth or meat-peptone broth with L-tryptophan; physiological solution; acid fuchsin; carbolic genzianviolet, lugol solution, ethyl alcohol, aqueous solution of fuchsin or safranin.

For the determination of protein: sulphuric acid, density 1.84 g/cubic centimetre; copper (II) sulphate; sodium sulphate; sodium hydroxide, solution with a mass fraction of 33%; sulphuric acid fixanal, solution of 0.05 mol/ cubic decimetre (0.1 n); sodium hydroxide fixanal, 0.1 mol/ cubic decimetre (0.1 n) solution; phenolphthalein, alcohol solution with a mass fraction of 1%; ethyl alcohol; distilled water; methylene blue, aqueous solution with a mass fraction of 0.1% (solution 1); methyl red, alcohol solution with a mass fraction of 0.02% (solution 2); mixed indicator (to 25 cubic centimetres of methylene blue solution with a mass fraction of 0.1% add 3 cubic centimetres of alcohol solution of methyl red with a mass fraction of 0.02%); litmus paper. To determine fat: chloroform according to GOST 20015; rectified ethyl alcohol according to GOST 5962; extracting mixture. It is prepared by mixing chloroform and ethyl alcohol in a 2:1 ratio, and hexane, diethyl ether, and petroleum ether.

For the determination of carbohydrates: sodium hydroxide according to GOST 4328, chemically pure; standard solutions of carbohydrates arabinose, glucose, ribose, mannose, galactose, fructose, xylose, sucrose mass concentration of 1 μg/cm and lactose mass concentration of 10 μg/cm or standard samples of the above carbohydrates with a content of the main substance of not less than 98.0%; distilled water according to GOST 6709 or water for laboratory analysis according to GOST ISO 3696 first degree of purification.

To determine moisture: hydrochloric acid according to GOST 3118, chemically pure; distilled water according to GOST 6709, or water for laboratory analysis according to GOST ISO 3696. River sand or quartz sand.

For determination of amino acids: standard samples of amino acids; phenylisothiocyanate; acetonitrile; isopropyl alcohol; sodium acetate; hydrochloric acid; sodium hydroxide; argon gas and helium of high purity.

For determination of vitamins: orthophosphoric acid; potassium phosphoric acid, single-substituted; hydrochloric acid; sulphuric acid; sodium carbonic acid; sodium hydroxide; trichloroacetic acid crystalline; zinc acetic acid 2-water; acetonitrile; enzymatic preparation - amylase from Aspergillus oryzae with amylolytic activity 2000 units/g.

Animals, Plants and Biological Materials

Grade 1 yak meat obtained at the "Kapka-Tash" Breeding Farm (Kyrgyz Republic), grade 1 turkey meat ("Agro Kush" Poultry Farm, Kyrgyz Republic), lentil flour produced by "Dan Agroprodukty", Kyrgyz Republic, and cherry plum fruits collected in the botanical garden of the Kyrgyz Republic.

Instruments

Lab-Line OBF light microscope (Kern & Sohn, Germany), laboratory scales with the limit of absolute error of single weighing ±0.01 mg (Shinko Denshi, Co., Ltd, Japan), SHS-80-01-SPU - Drying cabinet up to 350°C (Russia), liquid chromatography (HPLC) SHIMADZU LC-20AD Prominence (Shimadzu, Japan), portable moisture meter DM300R for meat (China), infrared express-analyser MeatScan (FOSS Electric, Denmark), homogenizer Stegler DG-360 (China), refrigerator Birusa (Russia), muffle furnace L 9/11/SKM (Nabertherm, Germany), electric meat grinder MFW45020 (Bosch, Germany), amino acid analyser liquid chromatograph LC-20 Prominence ('Shimadzu corporation', Japan), rotary evaporator Stegler RI-213 (China), atomic absorption spectrometer MGA-915 (Lumex, Russia), apparatus for mineralisation under pressure 'Minotaur-2'.

Laboratory Methods

The restructured yak meat products were the objects of the study. After processing and before storage, the sausages were analyzed for moisture, protein, and fat content following GOST methods. The analyses were performed in triplicate; all reagents were of analytical grade.

The moisture and protein content were determined in accordance with GOST 9793-2016. Methods for determining moisture in meat products; GOST 25011-2017. Methods for determining protein in meat products. The fat content was determined by the Soxhlet method, and the ash content by combustion at 550 °C.

The mineral composition was determined by flame atomic absorption according to GOST R 55484-2013. Meat and meat products.

The amino acid composition of meat products was determined by gas chromatography at 254 nm. The analysis temperature was 30 ° C. Calculation method: absolute calibration of the device.

The fatty acid composition of the restructured product was determined in accordance with GOST 34987-2023. Meat and meat products. Methods for determining fatty acid composition.

The following normative and technical documentation methods were used for microbiological studies:

- GOST R 54354-2011. Meat and meat products. General requirements and methods of microbiological analysis. The standard applies to meat (of all types of slaughtered animals), semi-finished products, offal, sausages, and meat products.
- GOST 7702.2.1-2017. Poultry slaughter products, poultry products, and objects of the surrounding production environment. Methods for determining the number of mesophilic aerobic and facultative anaerobic microorganisms.
- GOST R 51448-2010. Meat and meat products. Methods for preparing samples for microbiological studies.

Description of the Experiment

Study flow: The technological processes of cutting, boning, and trimming of yak meat were carried out in production facilities with an air temperature of 11±1°C and a relative air humidity of no more than 70%. Chilled yak meat carcasses with a temperature in the thickness of the muscles of 0–4 °C were sent for cutting. Turkey meat was washed with tap water at no more than 25 °C and sent for cutting and trimming. After dividing the yak half-carcasses into cuts, only high-quality meat raw materials were selected for the production of premium hams: the pulp of the shoulder, back-rib, lumbar, and hip parts of the half-carcasses with a connective and fatty tissue content of no more than 6%. After boning and trimming, the meat was sent for grinding and salting. The components presented in Table 1 were used to prepare the restructured product.

Table 1 Recipe for the restructured product from yak meat.

Quantity	Cooked ham sausage grade 1 (TU 10 RSFSR 952)	Experimental product
Raw materials, kg per 100 kg	-	-
Trimmed beef, grade 2	50	-
Pork, semi-fat	48	-
Wheat flour or starch	2	-
Trimmed yak meat, grade 1	-	70
Turkey meat	-	20
Lentil flour	-	10
Total	100	100
Spices and materials, g per 100 kg of unsalted raw materials	-	-
Cherry plum	-	4500
Sodium chloride (Cooking salt)	2500	2500
Sodium nitrite, kg	7.4	7.4
Sugar	130	130
Black pepper	100	100
Coriander	100	100
Fresh garlic, peeled, chopped	300	300
Dried garlic	150	150
Spice mix No. 2	150	150

Yak meat was treated with a brine containing cherry plum juice, which contains various common organic acids, including citric, acetic, and tartaric acids. This accelerates meat maturation by reducing the time required to soften.

When pieces of meat are immersed in an aqueous solution containing ingredients such as salt and cherry plum juice, the ingredients gradually penetrate the meat by osmosis.

Salting of raw meat materials includes the following operations: preliminary grinding, salting, massaging (mixing), and mincing. Raw meat materials for the restructured product were minced in a mincer with a 16-25 mm grid. Then, salting was performed (τ = 6 h at t = 10-12 °C) and the meat was poured with brine (10% of the raw meat's mass). Then they were sent for massaging or mixing in a mixer-tenderizer for 60 minutes.

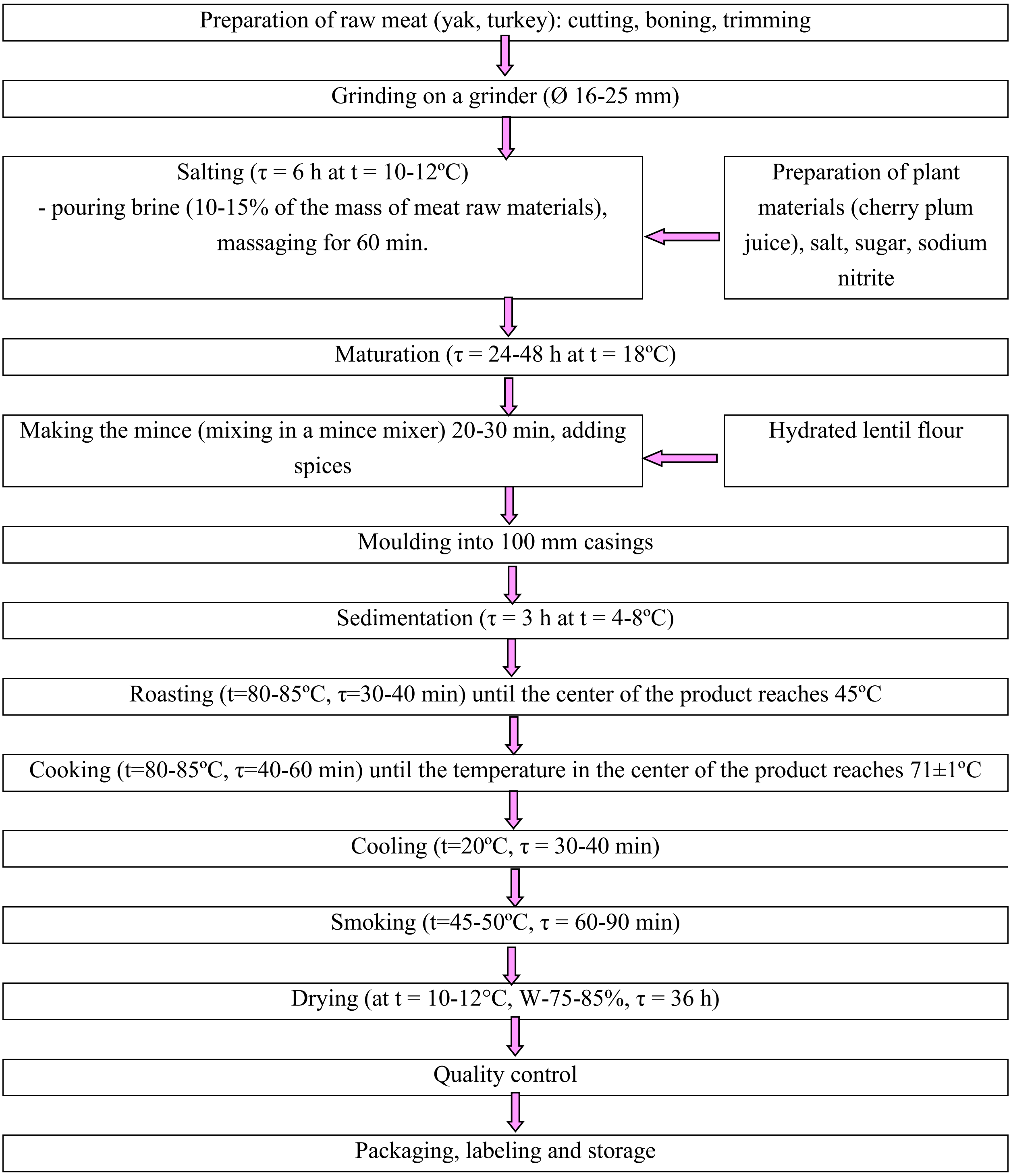

Figure 1 Flow chart of the production of restructured yak meat product.

The massage process is recommended to be carried out at a massager loading factor of 0.6–0.8, with a meat raw material temperature of no higher than 6°C and a vacuum depth of 80–90%. After loading the raw meat materials and curing ingredients into the massaging machine, water (ice) was added at a rate of 10% of the total weight of the meat (Figure 1).

The massaged meat raw material was unloaded into carts and sent for maturation (τ = 24-48 h at t = 18ºC). The process ended with a resting (maturation) phase, during which a certain degree of protein extraction continued, along with the muscle-relaxing effect caused by cherry plum juice and salt.

When preparing minced meat in a mixer, the meat raw material, chopped and cooled at a temperature of 0 to +2 °C, was placed in a mixer and mixed for 20-30 minutes with the gradual addition of hydrated lentil flour, spices, sodium nitrite and water (ice) in an amount of 10% of the mass of the meat raw material.

Then, the product was molded into natural (edible) casings with a diameter of 100 mm, and sedimentation was carried out at τ = 3 h and t = 4-8°C.

The thermal treatment of the restructured product was carried out under the following parameters:

- roasting (t = 80-85°C, τ = 30-40 min) until the center of the product reached 45°C;
- cooking (t = 80-85°C, τ = 40-60 min) until the center of the product reached 71±1°C; cooling (t = 20°C, τ = 30-40 min);
- smoking (t = 45-50°C, τ = 60-90 min).

The sausage casings were filled with minced meat using syringes and a vacuum. The pumping pressure was supposed to ensure a dense filling of the minced meat. After applying the looped staples, the sausages were hung on sticks, which were then placed on frames to prevent them from touching one another and sticking. The appearance of yak meat sausage with turkey when sliced is shown in Figure 2.

Figure 2 Restructured yak with turkey meat product

Quality Assurance

Number of repeated analyses: 3

Number of experiment replication: 3

Reference materials: amino acids valine, leucine, isoleucine, lysine, methionine+cystine, threonine, tryptophan, phenylalanine+tyrosine were determined in a gas chromatograph. Vitamins B4, E, B6, B1, PP, C, B2, B3, and B5 were determined by high-performance liquid chromatography. Minerals potassium, calcium, sodium, phosphorus, magnesium, and iron were determined by the flame atomic absorption method. Saturated, monounsaturated, and polyunsaturated fatty acids were determined by gas chromatography.

Calibration: During the study, equipment and methods were calibrated to ensure measurement accuracy and reliability. Calibration of laboratory equipment was performed in accordance with the manufacturer's standards and recommendations. Standard and control samples complying with international standards were used to verify accuracy. Both the equipment and methods used were calibrated to ensure the accuracy and reliability of the study results. The laboratory equipment was calibrated in accordance with established standards and manufacturer recommendations. This ensures that the equipment is functioning within tolerances and provides reliable measurements.

Laboratory accreditation: The experiments were conducted in the testing laboratory of Nutritest LLP, accredited by the National Accreditation Center of the Republic of Kazakhstan (accreditation certificate No. KZ987702B056813929).

Data Access

Data confirming the results of this study can be obtained upon request.

Statistical Analysis

The obtained results were statistically analyzed using the software program "Statistica" v. 12.0 (StatSoft Inc., USA), and the arithmetic mean, standard deviation, and standard error of the mean were calculated for each parameter. A Student's t-test was employed to assess differences, and they were considered significant at $p \leq 0.05$. The presented results are based on repeated experiments conducted to evaluate the microbiological analysis of the samples and their vitamin, mineral, amino acid, and fatty acid compositions.

RESULTS AND DISCUSSION

Restructured products are in high demand among consumers **[1]**. The literature review data showed that to ensure the necessary functional and technological properties of restructured products, brines and compositions containing plant-origin protein and carbohydrate components are used **[15]**. The use of plant-origin components in the production technologies of restructured products is aimed not only at improving the consistency of meat products, but also at enhancing their nutritional and biological value **[16]**. Yak meat is a promising raw material for the production of restructured meat products. However, scientists have found that yak meat has a tougher consistency than beef and a darker colour **[17]**. This paper proposes using cherry plum fruit juice to enhance the salting and massaging of yak meat, thereby improving the nutritional and biological value of the restructured product.

There is information about the use of cherry plum puree in sausage technology **[18]**. Still, there is no scientifically validated technology for restructured yak meat products using cherry plum fruit juice for salting and massaging.

The theoretical justification for the use of cherry plum fruit juice in the composition for salting yak meat at massaging is the high content of organic acids that contribute to the softening of meat, improve the quality of finished products, and reduce the time of heat treatment **[13]**. In addition to organic acids, the juice of cherry plum fruit has a high content of ascorbic acid, which has antioxidant properties **[14]**.

For the production of restructured yak meat product from hard yak meat, the process of preliminary mechanical treatment - mechanical tenderisation of meat using a roller tenderiser with disc knives - was used **[19]**. Such processing contributes to the loosening of the structure of raw material fibres, destruction of cell membranes, and an increase in their permeability **[20]**. Organic acids in alycha fruit juice, when interacting with proteins, lipids, and carbohydrates, contribute to the formation of a strong spatial structure **[21]**. A brine formulation has been developed for salting yak meat. The brine consists of alycha, table salt, and sodium nitrite. The brine was introduced into the meat at 20% by injection into the muscles and 10% by pouring it into the meat during massaging **[22]**. The control contains only salt and nitrite.

In the production of meat products, determining the presence of microorganisms is of great importance **[23]**. Sausage products provide a favourable environment for the development of various microorganisms that cause microbial spoilage: thermophilic lactic acid bacteria (souring), mould fungi, and proteolytic bacilli (rotting) **[24]**. Cooked, smoked, and cooked sausage products with humidity of more than 40-50% spoil quickly, especially in case of violations of the temperature and humidity conditions of storage **[25]**. Raw smoked products are less susceptible to spoilage due to low moisture content (20-30%) **[26]**.

The degree of initial microbial contamination of sausage mince depends on the sanitary and hygienic conditions of production and compliance with technological regimes **[27]**. During the preparation of sausage products, minced meat is contaminated with various microorganisms that get into it from auxiliary materials: dairy, egg, flour products, protein stabilisers, salting mixtures (salt, sugar, nitrates), spices, onions, garlic and other components **[28]**.

Bacteriological examination of sausages is aimed at determining the amount of QMAFAnM, Escherichia coli, Salmonella, Proteus sp., and spoilage microorganisms—mainly yeasts and mould fungi **[29]**.

The restructured yak meat product, after heat treatment, was tested for microbial content. The results of the studies are presented in Table 2.

Table 2 Results of microbiological studies of the restructured yak meat product.

№	Name of the indicator	ND GOST	Restructured product from yak meat
1	QMAFAnM, CFU/g, not more than (GOST 31746-12)	1×10^3	Negative
2	CGB (coli-forms) in the mass of the product, g (GOST 31747-2012)	1.0	Negative
3	Staphylococcus aureus (GOST 31659-2012)	1.0	Negative

It was established that the microbiological values in the studied meat products correspond to the hygienic standards of GOST 31746-12, GOST 31747-2012, GOST 31659-2012.

Tables 3, 4, 5, 6, and 7 show the results of the studies. Analysis of the chemical composition of the restructured products revealed that the protein content differed by only 0.6%. The control product contains 7.35% more moisture and 0.2% more ash than the experimental product. The fat content is almost identical, and the carbohydrate content differs significantly. Thus, the carbohydrate content of the experimental product is 6.6% higher than that of the control product. This is explained by the use of lentil flour in the recipe for the experimental restructured product and by the addition of cherry plum juice during yak meat massaging. Several authors have shown that when meat is massaged and salted with plant compositions, the meat not only becomes tender and juicy but is also enriched with biologically active substances, such as proteins, vitamins, minerals, and complex carbohydrates **[30]** and **[31]**.

The use of cherry plum juice during yak meat massaging and the addition of lentil flour to the recipe for the experimental product enriched it with amino acids, vitamins, and minerals. Scientists have demonstrated in their studies that combining meat and plant raw materials enriches the product with biologically active nutrients **[32]**. Vasyukova Ann T., Lyubimova K.V., and other authors have found that minced meat is enriched with dietary fiber, starch, and organic acids due to the introduction of vegetable products, which, along with these factors, will allow the formation of the structure and taste range **[33]**. Other authors argue that the enrichment of meat raw materials with vegetables and high-quality plant ingredients allows not only to preserve **[34]**, but also to improve the chemical and organoleptic properties of the product **[35]**, and **[36]**.

Table 3 Chemical composition of the experimental and control products, %.

№	Parameters	Control	Exprience
1	Protein	17±0.05	17.6±0.43
2	Fat	5.5±0.11	5.4±0.12
3	Carbohydrates	1.3±0.09	7.9±0.13
4	Moisture	72.8±0.52	65.5±0.4
5	Ash	3.4±0.07	3.6±0.09

Lentil flour is rich in aspartic acid, tyrosine, threonine, and methionine **[37]**. Analysis of the amino acid composition of the experimental and control products showed that in the experimental product, the amounts of all essential amino acids are significantly higher than in the control. Thus, there is 3289 mg more valine, 1154 mg more isoleucine, 567 mg more leucine, 266 mg more lysine, 797 mg more methionine + cystine, 234 mg more threonine, 175 mg more tryptophan, and 1103 mg more phenylalanine + tyrosine (Table 4).

Table 4 Amino acid composition of the experimental and control products, mg.

№	Parameters	Control	Exprience
1	Valine	3289±0.58	4097±2.08
2	Isoleucine	2126±0.58	3280±3.61
3	Leucine	4856±1.15	5423±2.89
4	Lysine	1480±1.53	1746±2.08
5	Methionine+Cystine	3598±1.53	4395±1.47
6	Threonine	2778±2.08	3012±1.53
7	Tryptophan	723±1.15	898±1.73
8	Phenylalanine+Tyrosine	4185±1.53	5288±3.06

Table 5 Vitamin composition of the experimental and control products, mg.

№	Parameters	Control	Exprience
1	B4	56.2±1.47	98,3±0.85
2	E	0.4±0.06	1.09±0.05
3	B6	0.4±0.06	0.9±0.01
4	B1	0.34±0.09	1.06±0.05
5	PP	7.0±1.15	16.11±0.04
6	C	-	17.5±0.05
7	B2	0.16±0.01	0.62±0.02
8	B5	1.2±0.06	2.28±0.16
9	B3	2.1±0.15	4.6±1.2

The experimental product contains many more vitamins than the control product. Thus, the experimental product includes 1.7 times more vitamin B4, 2.3 times more vitamin PP, 1.9 times more vitamin B5, and 2.1 times more vitamin B3 (Table 5). The control product contains no vitamin C, whereas the experimental product contains 17.5 g.

Table 6 Mineral composition of the experimental and control products, mg.

№	Parameters	Control	Exprience
1	K	277±3.21	1414±1.15
2	Ca	26±0.25	86±2.31
3	Na	700±1.04	198±1.17
4	F	201±0.58	722±5.78
5	Mg	26±0.25	111±0.58
6	Fe	1.3±0.06	12.8±0.15

Analysis of the mineral composition of the restructured products showed that the experimental product contained more minerals than the control product (Table 6). Thus, the potassium content was 5.1 times higher in the experimental product than in the control product. The calcium, phosphorus, and magnesium content in the experimental product was 3.3, 3.6, and 4.2 times higher, respectively. The amount of iron was 9.8 times higher in the experimental product than in the control product. However, the sodium content was 7.1 times higher in the control product than in the experimental product. The high iron content in the experimental product is because yak meat is rich in hemoglobin **[38]**, and **[39]**.

The saturated fatty acid content of the experimental and control restructured products did not differ and was 2.2 mg per 100 g of product (Table 7). There were slight differences in the content of monounsaturated fatty acids – the experimental product contained 0.3 mg more. The content of polyunsaturated fatty acids in the experimental product was also slightly higher, 0.2 mg. This is because the experimental product is enriched with lentil flour **[37]**. Lentil flour contains 1-2% fat, while the fatty acid composition is rich in unsaturated components, the sum of which is 62.4% of the fat mass, including oleic acid (16.24%), linoleic (36.75%), and linolenic (8.55%) **[37]**.

Table 7 Fatty acid composition of the experimental and control products, mg.

№	Parameters	Control	Exprience
1	Saturated fatty asids	2,2±0,15	2,2±0,15
2	Monounsaturated fatty asids	3,1±0,1	3,4±0,14
3	Polyunsaturated fatty asids	0,3±0,01	0,53±0,06

Thus, the use of cherry plum juice during yak meat massage provides the restructured product with the necessary consistency and juiciness, ultimately enhancing its functional and technological properties and the nutritional and biological value of the finished product. Antioxidant properties of cherry plum fruit create the safety of the meat product **[13]**, and lentil flour enriches the product with dietary fibres **[37]**.

Creation of new restructured products enriched with dietary fibres is a modern requirement of time to meet the needs of the population in high-quality **[40]**, biologically complete food products **[41]**.

CONCLUSION

Based on the conducted research, the combined use of cherry plum juice during the massaging of yak meat and lentil flour in the formulation of the restructured product significantly improved its technological, nutritional, and biological properties.

Cherry plum juice, rich in organic and ascorbic acids, enhanced the softening of yak meat, improved juiciness, and contributed to the microbiological safety of the product. After heat treatment, the finished product showed no detectable mesophilic aerobic and facultative anaerobic microorganisms, no coliform bacteria, and no *Staphylococcus aureus*, confirming its safety.

Chemical analysis revealed substantial improvements in composition. The experimental product contained 6.6% more carbohydrates, slightly more protein (+0.6%) and ash (+0.2%), and lower moisture than the control. Lentil flour strongly enhanced the amino acid profile. In the experimental product, valine increased by 808 mg, isoleucine by 1154 mg, leucine by 567 mg, lysine by 266 mg, methionine with cystine by 797 mg, threonine by 234 mg, tryptophan by 175 mg, and phenylalanine with tyrosine by 1103 mg.

The vitamin content also improved dramatically. The experimental product contained 1.7 times more vitamin B4, 2.3 times more vitamin PP, 1.9 times more vitamin B5, and 2.1 times more vitamin B3. Notably, vitamin C—absent in the control—reached 17.5 mg, enhancing antioxidant capacity and helping inhibit microbial growth.

The mineral composition demonstrated further benefits. Potassium increased 5.1-fold, calcium 3.3-fold, magnesium 4.2-fold, and iron 9.8-fold relative to the control product, while sodium content was significantly lower. Partial replacement of yak meat with lentil flour also improved the lipid profile, with the experimental product showing 0.3 mg more monounsaturated fatty acids and 0.2 mg more polyunsaturated fatty acids.

Overall, the incorporation of cherry plum juice and lentil flour resulted in a restructured yak meat product with improved tenderness, enhanced nutrient density, stronger antioxidant properties, and confirmed microbiological safety. These findings demonstrate that the product has substantially higher nutritional and biological value, supporting its recommendation as a functional meat product enriched with essential amino acids, vitamins, minerals, and dietary fibre.

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