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Study of Sausage Products Prepared Using Biologically Active Additives from Sprouted Wheat and Cattle by Products

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Abstract: The production of meat and meat products is closely related to the development of livestock farming and the processing industry. A promising direction for the development of the meat industry could be an increase in the depth of processing of meat raw materials, including an increase in the production of meat products from by-products that are in high demand among the population. The main problem in this industry is the lack of raw materials. This problem can be solved by optimizing meat production through the use of by-products, in particular, such as fat. Despite the fact that the use of fat in meat production is not something new, no research has been conducted on the use of fat in combination with vegetable raw materials in the Republic of Kazakhstan. At the same time, the practical significance of combining fat with vegetable raw materials is due to the properties of high-quality plant raw materials, which are valuable for the food industry, providing the opportunity to produce products with a high content of useful substances. The article analyzes the possibility of using a dietary supplement using fat obtained from animal fat and vegetable raw materials in the production of sausages. The purpose of the study is to increase the range of sausage products by increasing the volume of useful, easily digestible, low-cost raw materials. Chemical indicators according to GOST 9959-2015 and microbiological indicators according to GOST R 54354-2011 of control and test samples of sausage products were studied. The possibility of using a biologically active fat additive in sausages has also been considered. It has been proven that the use of dietary supplements allows saving raw meat up to 20-25% and in combination with beef it makes sausages a high-calorie food product with increased digestibility. The use of the proposed method makes it possible to increase the possibility of replacing raw meat by up to 20-25%, increase the biological and energy value, and improve the organoleptic properties of the final product. Ready-made sausages have a good presentation, and juicy consistency and have a pronounced specific smell and taste.

Keywords: Tallow, Vegetable Additives, Sprouted Wheat, Meat Production, Sausage Products

Introduction

There is a misuse of raw materials which are rich in connective tissue proteins in the meat industry. Thus, the annual production of low-value by-products of the II category is more than 1000 thousand tons, skin and tallow -30 thousand tons, about 140-150 thousand tons of meat trimmings (Belousova and Manuilova, 2007). Such collagen-containing raw materials as meat scraps, fascia, skin, broth, etc., remain practically unclaimed for food purposes. Irrational and incomplete use of collagen-containing resources is one of the reasons for the current situation of insufficient provision of the population's diet with animal protein, which led to a general protein deficiency in the human diet (about 26%), including 33% of the total amount of protein consumed by animal origin (Faivishevsky, 2006; Willy *et al*., 2023). The collection and rational use of waste from the meat industry is of great importance for increasing production efficiency and solving environmental problems.

Therefore, ensure waste-free technology and use such waste that is discharged into water, polluting the atmosphere and soil and causing irreversible negative changes in the environment.

During the processing of fatty tissue of farm animals, in particular, in the production of rendered fats as a by-product, tallow is produced, mainly represented by the residue of connective tissue which has undergone thermal degradation. The tallow can be obtained mainly by dry and wet rendering. In the case of the wet method, the proteins of the adipose tissue are denatured, and the collagen, which is insoluble in water, turns into soluble gluten (Al-Qassab *et al*., 2019; Khimych and Rodionova, 2023). This causes the adipose cell membranes to rupture, allowing the fat to migrate in a liquid state from the ruptured cells. The released fat under the action of gluten is able to emulsify and, depending on the modes of heat treatment, undergo hydrolysis to some extent with the formation of free fatty acids (Belousova and Manuilova, 2007). As a result of such processing, a three-phase system is obtained, including fat, broth, and tallow.

In the case of the dry method, the proteins of adipose tissue dehydrate, and the adipose cell membranes become brittle and are destroyed. The fat contained in the cells melts and is released from them. After rendering, you get a two-phase system consisting of dry fatty tallow and fat. The analysis of the chemical composition of the tallow shows a significant content of proteins in it and confirms the feasibility of its use in meat processing. It was found that the total protein content in the tallow is 53.6±6.08%. It is known that the composition of the tallow proteins includes 22-44% collagen and 19-30% elastin. Connective tissue is now seen as ballast and an essential component of nutrition. In this regard, there is an increasing practical interest in the rational and complete use of tallows for food purposes (Vechtomova *et al*., 2022).

Tallow is a by-product of rendering suet, it also consists of collagen. Properties specific to collagen- increased water and fat retention capacity, and gelling ability make it possible to expand the scope of application of collagen-containing by-products (Ponomarev and Yunusov, 2023). They can be used as a filler and direct additive, or raw material in the production of boiled and semi-smoked sausages and sausages. One of the rational directions for industrial processing of by-products is the preparation of mixtures that approach the content of total, complete protein and functional and technological properties of raw meat.

Progress in the development of scientifically-based methods for isolating native collagen from connective tissue, which allows preserving the molecular structure and biological activity of this protein at the maximum level of its purification from accompanying biopolymers, has made it possible to significantly expand the ways of using collagen-containing waste from the meat processing industry (Mindlin *et al*., 2021; Rutaganira and Glamazdin, 2022).

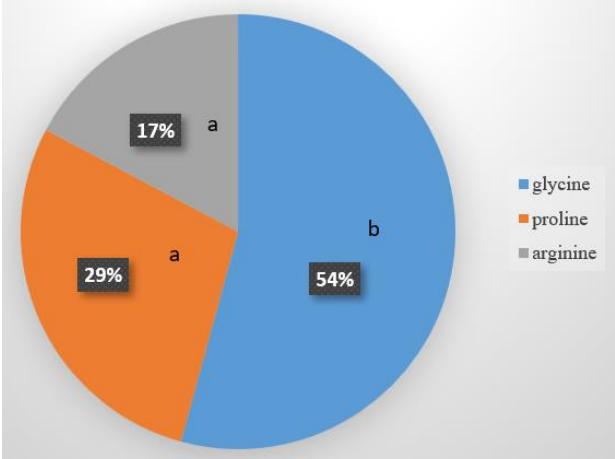

Fig. 1: Ratios of various amino acids in collagen. Indicated values: a-b Values with different letters inside the graph mean a significant difference between different batches ($p<0.05$)

The use of waste from the meat industry, including fat in the production of sausages, will reduce the cost of production of main products, expand the range of sausages, and develop domestic production.

The quantitative predominance of amino acids in collagen (Fig. 1) determines the ability of this protein to act as a carrier of macro and microelements, aromatic substances due to the formation of sufficiently strong bonds of various nature (Fig. 1) (Choe *et al*., 2016). Practical application is mainly for collagen-containing raw materials, this is due to the ability of collagen to form gels when interacting with water.

The above-mentioned properties of tallow make it an attractive product for use in meat, in particular in sausages and the use thereof in combination with useful vegetable raw materials allows you to make a dietary supplement for mass production of such quality that will not only increase the biological and energy value of the finished product but also improve its organoleptic indicators while preserving the quality and taste properties of the finished product.

The possibility of using pork rinds in the production of meat sausage products has been considered in many studies. Tak, Ye. A. Ilyinykh proves that the use of tallow in the fried sausage processing allows the product to be enriched with dietary fibers of animal origin and solves the problem of rational and complete use of raw materials (Rant *et al*., 2019; Mushtruk *et al*., 2023). This position could not be more acceptable, as the use of tallow in minced meat production does save on meat raw materials, and the properties of tallow as a collagen-containing component allow for a decent quality of meat products.

Chebakova and Nafonov have developed a liver sausage "Traditional" production technology with the use of tallow and proved that the use thereof in the liver sausage does not worsen the quality of the finished

product, but rather improves its certain physical, chemical, and organoleptic parameters, in particular indicators of the mass fraction of protein, fat, salt content (Chebakova and Nafonov, 2018). Tallow has a higher smoking point than lean ground beef, which means it won't burn as easily when cooked. Tallow also helps make ground beef more juicy, tender, and flavorful. It's important to note that each type of tallow has its own unique flavor profile, so it's important to choose the one that best complements our dish.

Despite the fact that the use of tallow in meat production is not new, there are currently no studies on both the territory of the Russian Federation and the Republic of Kazakhstan devoted to the use of tallow in meat processing or to the use of an additive based on a combination of two substances tallow and vegetable raw materials (for example, vegetables or sprouted wheat).

The practical significance of the combination of tallow with vegetable raw materials is due to the properties of high-quality vegetable raw materials that are valuable for the food industry due to the ability to produce products with a high content of useful substances, as well as the properties of pork rinds as the most important source of natural collagen, so necessary for the human body.

In addition, the practical significance of using a combination of tallow with vegetable raw materials in production is due to a reduction in the cost of producing sausages. At the moment, the Republic of Kazakhstan, like many other countries of the world, is experiencing the consequences of a pandemic caused by coronavirus infections. In these conditions, national producers of meat products, despite the availability of state support, are forced to revise a number of working principles in favor of optimizing production processes. In such a difficult period for the Republic of Kazakhstan, it is necessary to improve existing results and find new solutions. In addition, due to the unstable economic situation, citizens of the Republic of Kazakhstan are forced to reduce their expenses and buy cheaper products and this fully applies to sausage products.

Comparative studies have shown that it is necessary to create a highly efficient waste-free technology while ensuring the safety and usefulness of sausage products. The purpose of this study is to increase the range of sausage products by increasing the volume of useful, easily digestible, low-cost raw materials.

Materials and Methods

A recipe for sausages made from minced meat with the addition of dietary supplements based on fat and sprouted wheat was developed. The dietary supplement was prepared as follows:

1. Wheat sprouts were obtained: A plastic container and wheat were used to sprout wheat. 200 g of wheat were poured into a container and filled with distilled water at room temperature 1 cm above the grains, left overnight in a dark place at room temperature. Then they were washed with running water, and what floated up was removed along with the water and washed again. After this, the water was drained, and the containers were closed with a lid with holes and placed in a cool place. Every 12 h, wheat samples were washed with running water. The conditions for wheat germination are moisture, the wheat must be moist. After 2 days, wheat sprouts hatched, the best condition for consumption is 1-2 mm of white sprouts. Wheat grains germinate unevenly; unsprouted grains should not be eaten. After germination, the samples were crushed in a laboratory mill LMT-1
2. A mixture, that is, a biologically active additive, was obtained from tallow and the resulting crushed sprouted grain. And then it is used to prepare sausages

Organoleptic indicators were studied in accordance with GOST 23670-2019 (2019): Appearance, consistency, taste, cut, smell, and color of the sausage product, as well as the shape and size of the product.

The following chemical parameters were studied:

1. The mass fraction of protein was determined according to GOST 25011-2017 (2018) using the Kjeldahl method. The method is based on the mineralization of organic matter in the sample, followed by the determination of nitrogen by the amount of ammonia formed

The mass fraction of protein X, %, is calculated using the formula:

$$X = \frac{0.0014 * (V_1 - V_2) * K * 100}{m} = 6.25$$

where:

0.001 = Amount of nitrogen equivalent to 1 cm^3 of 0.1 moL/dm^3 hydrochloric acid solution or 0.05 moL/dm^3 sulfuric acid solution, g
V_1 = Volume of 0.1 moL/dm^3 of hydrochloric acid solution or volume of 0.05 moL/dm^3 spent on titration of the test sample, cm^3
V_2 = Volume of 0.1 moL/dm^3 of hydrochloric acid solution or volume of 0.05 moL/dm^3 used for titration of the control sample, cm^3
K = Correction factor to the nominal concentration of hydrochloric acid solution
100 = Percentage conversion factor
m = Sample weight, g
6.25 = Protein conversion factor

The mass fraction of fat was determined according to GOST 23042-2015 (2019) using a Soxhlet extraction

apparatus SER 148 from Velp (Italy) for 6 samples. The method is based on repeated extraction of fat with a solvent from the dried analyzed sample in a Soxhlet extraction apparatus, followed by removal of the solvent and drying of the extracted fat to constant weight.

The mass fraction of fat X, %, is calculated using the formula:

$$X = \frac{(m_1 - m_2) * 100}{m}$$

where:

m_2 = Mass of the extraction flask with fat, g
m_1 = Mass of the extraction flask, g
100 = Conversion factor into percent
m = Mass of the analyzed sample, g

The mass fraction of Sodium Chloride (NaCl) was determined according to GOST 9957-2015 (2016) by the titrimetric method (Mohr's method). The method is based on the titration of chlorine ions isolated from meat, meat, and meat-containing products, with silver ions in a neutral environment in the presence of potassium chromate as an indicator.

The sample is crushed in a homogenizer or passed through a meat grinder twice and mixed thoroughly. In this case, the sample temperature should be no more than 25°C. 5 g of the prepared analyzed sample is weighed and the weighing result is recorded to the second decimal place. Add 100 cm^3 of distilled water and heat in a water bath to a temperature of 40°C and maintain this temperature for 45 min. Cool to a temperature of 20°C and filter through a paper filter. 5-10 cm^3 of the filtrate is added to a glass with a capacity of 150 and 0.5 cm^3 of potassium chromate solution is added and titrated with a solution of silver nitrate until an orange color appears.

The mass fraction of sodium chloride X, %, is calculated using the formula:

$$X = \frac{0.00292 * K * V * 100 * 100}{V_1 * m}$$

where:

0.00292 = Mount of sodium chloride equivalent to 1 cm^3 of 0.05 moL/dm^3 silver nitrate solution, g/cm^3
K = Correction factor for the titer of 0.05 moL/dm^3 silver nitrate solution
V = Volume of 0.05 moL/dm^3 silver nitrate solution used for titration of the analyzed sample, cm^3
100 = Volume to which the analyzed sample is diluted, cm^3
100 = Percentage conversion factor
V_1 = Volume of filtrate taken for titration, cm^3
m mass of analyzed sample, g

The following microbiological indicators were also determined according to GOST R 54354-2011 (2013):

- The number of mesophilic aerobic and facultative anaerobic microorganisms
- Bacteria of the *Escherichia coli* group
- Mold

Results

Currently, there is a great demand among the population for inexpensive meat products imported from various countries. However, the quality of such products is quite low. At the same time, there are opportunities on the national market to increase the quality potential of meat products and at the same time sell it at prices that will be beneficial to the national consumer. For this purpose, it is necessary to work out new sausage production processes, which will be based on the use of vegetable raw materials, which will improve the organoleptic and chemical properties of minced meat sausages (Lebedeva *et al*., 2016).

It is proposed to use sprouted wheat as a vegetable raw material for the production of a dietary supplement based on tallow. The use of sprouted wheat, as noted in many studies, has shown its high practical significance due to the content of a high proportion of biologically active substances and vitamins in such wheat (Awulachew, 2022). Sprouted wheat is a natural supplement with a balanced composition that ensures maximum absorption of the product. At the moment of germination, protein substances concentrated in grains break down into amino acids and subsequently into nucleotides. In this case, starch becomes maltose and fats are transformed into valuable fatty acids. All components that are not assimilated by the human body are re-cleaved into bases from which nucleic acids are built, which serve as material for genes. Besides, a number of works are devoted to the study of the benefits of using sprouted wheat in the food industry: Such a benefit, in particular, consists of giving the finished products a certain taste range and increasing the share of useful substances in the finished product (Berezhnaya *et al*., 2013; 2015; Sidhu *et al*., 2007)

Figure 2 shows the vitamin content in ordinary wheat grain and in sprouted wheat grain. As can be seen from the data presented in Fig. 2, the vitamin content in ordinary wheat grain is much less than the content of similar vitamins in sprouted wheat grain. A similar situation is developing with leptides, carbohydrates, and proteins. The main benefit of sprouted seeds is that during the germination process, all useful substances are activated. Sprouts are an easily obtained and cheap natural source of vitamins, minerals, enzymes, and amino acids; they are found in the most concentrated form in the seeds. Moreover, unlike dry seeds, in sprouts, all these substances are in the most accessible form for the body.

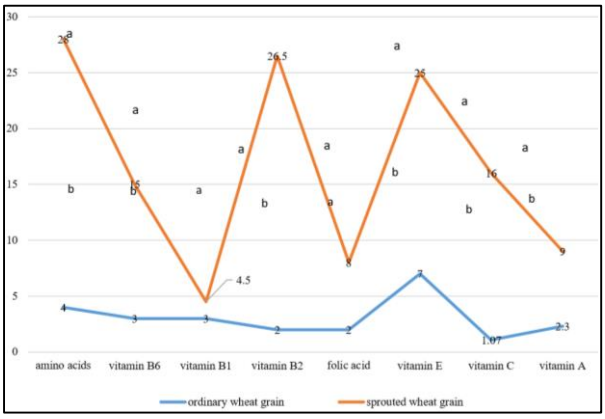

Fig. 2: The content of vitamins in ordinary wheat grain and in sprouted wheat grain. Indicated values: a-b Values with different letters inside the graph mean a significant difference between different batches ($p<0.05$)

The production of high-quality minced meat products requires compliance with a whole list of process requirements for the production and selection of raw materials and a certain ratio of components. The reason for this is that the finished meat product needs not only to have good nutritional properties, but it shall also have an attractive appearance in order to attract the consumer's attention. Drawing the consumer's attention is quite important in the Republic of Kazakhstan because, as mentioned earlier, shop shelves are filled with low-quality, cheap products from other countries and consumers tend to "outweigh" the latter when choosing between a quality product and a product with a low price (Popkova *et al*., 2016; Vieira *et al*., 2009; Mrdovic *et al*., 2019; Sethi *et al*., 2022). In the context of this study, it is essential to develop a product based on tallow, which would meet all these requirements at the same time would be inexpensive, and would have high-quality properties.

During the practical part, the development of the sausage production process of minced meat with the addition of dietary supplements based on tallow and sprouted wheat was developed.

Based on these results, a new sausage product formulation was developed for minced meat based on a dietary supplement of tallow and sprouted wheat juice (Table 1). As can be seen from the data presented in Table 1, the initial meat products in the production of sausage products from minced meat-beef of the first and beef of the second grade are required much less if a dietary supplement based on tallow is used.

The practicality of using dietary supplements is proved by the analysis of chemical, and organoleptic indicators of the quality of minced meat products (sausages) in comparison with the indicators of control samples (minced meat products without the use of an additive based on tallow). The analysis of microbiological indicators responsible for the quality of the product was also carried out, among which the content was estimated: The number of mesophilic aerobic and facultatively anaerobic microorganisms, bacteria of the Escherichia coli group, and mold.

The following organoleptic indicators (Table 2) were evaluated: The appearance, consistency, taste, cut, smell, and color of the sausage product, as well as the shape and size of the product made with the additive and the sausage product made without the additive. From the data in Table 2 it can be seen that the appearance of both samples is the same, that is, a smooth surface of the product without sagging minced meat consistency: The control sample corresponds to this type of product, the sample with the additive is tender, juicy, homogeneous, of moderate density. The taste of the control sample corresponds to this type of product, the test sample has a delicate, slightly piquant taste, characteristic of this type of product. The smell of both samples is well expressed, characteristic of this type of sausage. The color and appearance of the section are the same for the control and experimental samples: Dark red with white spots of fat shape and size: The control sample has a straight shape in a natural casing, 41 cm long and the test sample with an additive has a straight shape in a natural casing, 42 cm long. Compared to the control sample, the organoleptic characteristics of the prototype with the additive showed better results.

The following chemical indicators were also studied: The mass fraction of protein and the mass fraction of fat, as well as the mass fraction of sodium chloride (the chemical formula is NaCl). The results are presented in Table 3.

The data presented in Table 3 show that, compared with the control sample, the mass fraction of protein in the test sample is lower by 1.2±0.02%, the mass fraction of fat is lower by 1.6±0.01%, the mass fraction of chloride sodium is lower by 1.2±0.03%

Table 4 shows the microbiological indicators of a sausage product using an additive and a sausage product without using an additive (control sample), made using traditional sausage production technology.

From the data in Table 4 it is clear that the control and test samples do not contain mesophilic aerobic and facultative anaerobic microorganisms, the norm according to TR CU 021/2011 is $1*10^3$ CFU/g (cm^3). The bacteria of the Escherichia coli group in the control sample is 0.00002 g/cm^3 and in the test sample 0.0001 g/cm^3. The norm according to the Technical Regulations of the Customs Union TR CU 021/2011 "On the safety of food products" (TR CU 021/2011, 2019) for Escherichia coli bacteria is 1 g/cm^3. No mold was found in all samples. The mold norm according to TR CU 021/2011 is 500 CFU/g.

Table 1: The recipe of the sausage product according to the content of ingredients per 100 kg

Name of the raw material	Control sample (kg)	The prototype (kg)
Beef of the first category	30.0	25.0
Beef of the second category	30.0	25.0
Salt	2.0	2.0
Sodium nitrite	0.2	0.2
Black pepper	0.1	0.1
Beef fat	10.0	10.0
A dietary supplement based on tallow and sprouted wheat juice	-	2.2

Table 2: Organoleptic parameters of experimental samples of sausage products

Name of the indicator	Name of the raw material for the product	
	Control sample	Sample with an additive
Appearance	The smooth surface of the product without minced meat sags	
Consistency	Soft, homogeneous, moderate density	Tender, juicy, homogeneous of moderate density
Taste	Characteristic of this type of product	Delicate, slightly spicy, characteristic of this type of product
Smell	Fresh meat, typical of this type of product is well expressed	
Colour	Dark red with white flecks of fat	
View of the section	Dark red with white flecks of fat	
Shape and size	A straight in a natural casing with a length of 41 cm	A straight in a natural casing with a length of 42 cm

Table 3: Chemical parameters of sausage product samples

Name of the indicator	Name of the raw material for the product	
	Control sample	Sample with an additive
Mass fraction of protein %	14.3±0.15[a]	13.1±0.13[b]
Mass fraction of fat %	22.7±0.11[a]	21,1±0.10[b]
Mass fraction of sodium chloride (chemical formula-NaCl) %	1.3±0.14	1.1±0.17

Indicated values: ± - standard deviation calculated from three parallel measurements. [a-b] Values with different letters inside the graph mean a significant difference between different batches ($p<0.05$)

Table 4: Microbiological indicators of sausage products

Name of the indicator	Name of the raw material for the product Control sample	Experimental sample with fermented additives (carrots and pumpkin)	Standard according to TR CU "On food safety"
The number of mesophilic aerobic and facultative anaerobic microorganisms,	Not detected	Not detected	$1*10^3$ CFU/g (cm^3)
Bacteria of the Escherichia coli group (g/cm^3)	0.00002	0.0001	1
Mould, CFU/g	Not detected	Not detected	500

Now we will draw up graphs of costs for the production of traditional sausage products from minced meat and sausage products using a tallow-based additive (Fig. 3).

From the data in Fig. 3, it is clear that the cost of producing 100 kg of sausages is: For the control sample - 134,000 tenge (about $298), for the sample with additives - 25,000 tenge (about $277). This is due to the fact that more meat is used in the control sample than in the experimental sample. Low-cost fat is used for the prototype. Therefore, the cost of producing sausages with additives is lower, and accordingly, the price of the finished product will be low.

Discussion

The paper examines the possibility of using a biologically active additive from tallow in sausages. The organoleptic, chemical, and microbiological parameters of sausage products were studied: A control and a test sample prepared using a biologically active additive.

The results showed that the organoleptic characteristics of minced sausage products using a tallow-based biologically active additive have a good presentation, juicy consistency, and a well-defined specific smell and taste. This is due to the fact that the dietary supplement dissolves quite well in minced meat and at the same time not only saves the final amount of raw materials but also provides the product with a beautiful appearance and taste.

When studying chemical indicators, it was found that the mass fraction of fat in the sample with the additive is significantly less than the mass fraction of fat in the control sample and there is also slightly less protein in the sample with the additive, which is due to the presence of an organic component in the additive-sprouted wheat.

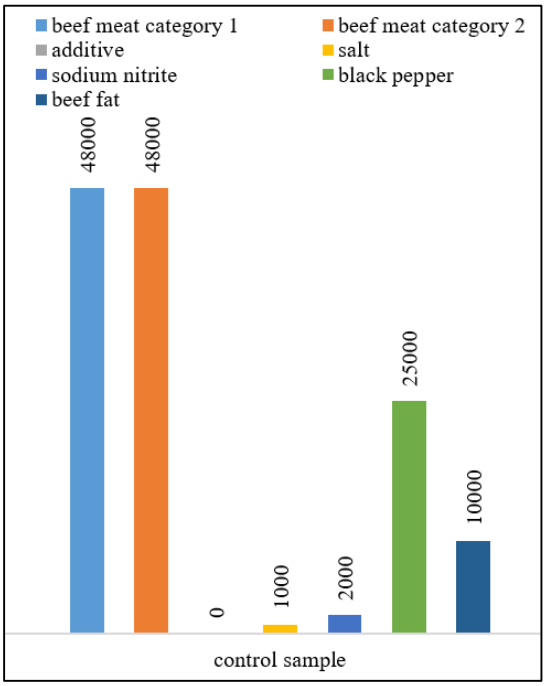

Fig. 3: Costs for the production of 100 kg of sausage products with and without additives (tenge) for individual ingredients

The results of a microbiological study showed that sausage products with food additives contain a small amount of Escherichia coli bacteria, but do not exceed the established standards and fully comply with the Technical Regulations of the Customs Union TR CU 021/2011 "on the safety of food products."

It has been proven that the use of dietary supplements allows for saving raw meat up to 20-25% and in combination with beef makes sausages a high-calorie food product with increased digestibility (Chomanov *et al*., 2020; 2019)

Conclusion

This study analyzes the possibility of using a dietary supplement using tallows obtained from animal fat and sprouted wheat in the production of sausages. The organoleptic, chemical, and microbiological characteristics of the control sample and the test sample with the additive were studied. The results showed that the organoleptic characteristics of the prototype are improved, the finished sausages have a good presentation, juicy consistency, characteristic smell, and taste. Chemical indicators are slightly reduced and microbiological indicators do not exceed the norm of the Technical Regulations of the Customs Union TR CU 021/2011 "On the safety of food products". The costs of producing 100 kg of sausages were also studied and calculated. It is about $298 for the control sample and about $277 for the sample with additives, that is, for the production of sausages with biologically active additives, the raw materials needed are $21 less than for the control sample. The use of the proposed method makes it possible to increase the possibility of replacing raw meat by up to 20-25%, increase the biological and energy value, and improve the organoleptic properties of the final product.

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Author's Contributions

Gulmira Kenenbay and Urishbay Chomanov: Wrote the manuscript and studied the relevant literature.

Tamara Tultabayeva: Developed the idea, looked for suitable literature, and compiled the first version.

Aruzhan Shoman and Nurzhan Tultabayev: Edited and reviewed the article.

Ethics

This article is original and contains unpublished material. The corresponding author confirms that all of the other authors have read and approved the manuscript and that no ethical issues are involved.

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