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Использование биологически активных добавок растительного происхождения в колбасном производстве

The use of biologically active additives of plant origin in sausage production

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Аннотация. *Пищевые добавки, позволяющие регулировать функционально-технологические свойства, обеспечивать качественные и количественные характеристики готовых изделий имеют существенное значение в мясных технологиях. Продукты переработки семян льна, вследствие высокой концентрации функционально ценных компонентов и выраженным технологическим свойствам белка и полисахаридов, являются идеальным компонентом для замещения мясного сырья в колбасных изделиях. Цель работы – разработка технологии мясных продуктов, обогащенных биологически активными добавками растительного происхождения на основе семян льна. Теоретическая часть исследований проведена на базе кафедры пищевых технологий ДонГАУ, выработка опытных партий продуктов - в производственных условиях ООО «Мясокомбинат», с. Развильное, Песчанокопский р-н, Ростовская область. Цель исследований – изучить возможность использования семян льна в качестве белковой добавки в технологии производства колбасных изделий. Установлено, что введение в рецептуры мясопродуктов добавки семян льна улучшает органолептические и физико-химические характеристики готовых изделий. Опытные образцы отличались более нежной консистенцией и более высокой однородностью фарша на разрезе, отмечено также увеличение массовой доли белка и уменьшение доли жира. Разработана технология производства колбас с биологической активной добавкой на основе семян льна, функциональные свойства и пищевая ценность которого в сочетании с экономической целесообразностью позволяют использовать его в качестве белкового ингредиента при производстве комбинированных колбас.*

Ключевые слова: биологически активная добавка, функционально-технологические свойства, пищевая ценность, колбасы, органолептические характеристики

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Abstract. *Food additives that allow regulating functional and technological properties, providing qualitative and quantitative characteristics of finished products are essential in meat technologies. Flax seed processing products, due to the high concentration of functionally valuable components and pronounced technological properties of protein and polysaccharides, are an ideal component for replacing meat raw materials in sausage products. The purpose of the work is to develop the technology of meat products enriched with biologically active additives of plant origin based on flax seeds. The theoretical part of the research was carried out on the basis of the Department of Food Technologies of DonGAU, the development of experimental batches of products was carried out in the production conditions of LLC "Meat Processing Plant", Razvilnoye village, Peschanokopsky district, Rostov region. The purpose of the research is to study the possibility of using flax seeds as a protein additive in sausage production technology. It has been established that the introduction of flax seed additives into the formulations of meat products improves the organoleptic and physico-chemical characteristics of finished products. The prototypes were distinguished by a more delicate consistency and higher uniformity of minced meat on the cut, an increase in the mass fraction of protein and a decrease in the proportion of fat were also noted. A technology for the production of sausages with a biologically active additive based on flax seeds has been developed, the functional properties and nutritional value of which, combined with economic feasibility, allow it to be used as a protein ingredient in the production of combined sausages.*

Keywords: biologically active additive, functional and technological properties, nutritional value, sausages, organoleptic characteristics

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Introduction. The development of recipes for new types of meat products should be based, first of all, on medical and biological aspects; the products being developed must comply with physiological nutritional standards in terms of biological and nutritional value or be close to them [1, 4].

Proteins constitute the most expensive and scarce component of food diets, and therefore it is absolutely necessary to justify acceptable and realistic ways of directly using in nutrition that part of plant protein, which until recently has been used with low efficiency [9, 13].

Plant raw materials, unlike meat, are rich in micro and macroelements, vitamins, including fiber, pectin substances, i.e. is a source of biologically active substances that are lacking in meat. The use of plant raw materials in the production of meat products allows not only to enrich them with functional ingredients and increase digestibility, but also to obtain products that meet physiological nutritional standards [3, 11, 16].

Of particular interest is the production of protein preparations based on flax and its processed products, as a promising source of protein and vegetable raw materials. Flax seeds contain various organic compounds and nutrients: complete plant protein, mineral elements, fiber, vitamins A, B, E, F [2, 10].

Materials and research methods. These studies were carried out at the Department of Food Technologies of the Don State Agrarian University. The purpose of the research is to study the possibility of using flax seeds as a protein additive in sausage production technology.

The following research objects were used: flaxseed flour produced by the Research and Production Association "Siberian Oil Company" LLC and meat raw materials - first grade trimmed beef, low-fat trimmed pork, semi-fat trimmed pork, pork belly.

Experimental studies included the use of modern physicochemical, structural-mechanical, functional-technological, microbiological and organoleptic research methods, according to GOST [5, 6, 7, 8].

Research results and their discussion. The many valuable properties of flaxseeds and their processed products make this production promising all over the world. 100 g of flaxseed contains 24% of the daily protein intake, fats - 50% and carbohydrates - 9%. The nutritional value of flax seeds is presented in Table 1**.**

Table 1 – Nutritional value of flax seeds

Indicators	Squirrels	Fats	Carbohydrates
Quantity	18.29 G	42.16 G	1.58 G
Calorie content	~ 73.16 kcal	~ 379.44 kcal	~ 6.32 kcal
Energy ratio	13%	71%	1%

Of the fat-soluble vitamins, flaxseed contains E and K. Of the water-soluble vitamins, there are vitamins C, B1, B2, B3 (PP), B4, B5, B6 and B9 (Table 2).

Table 2 – Chemical compound seeds flax

Magnitude	Quantity per 100 grams
Water	6.96 grams
Alimentary fiber	27.3 grams
Mono- and disaccharides	1.55 grams
Vitamins	B1, B2, B3, B5, B6, B9, C, E, K, PP, Choline
Minerals	Potassium (813 mg.), Calcium (255 mg.), Magnesium (392 mg.), Sodium (30 mg.), Phosphorus (642 mg.), Iron (5.73 mg.), Copper (1220 mcg.) and etc.

The presence of magnesium and potassium helps strengthen the heart muscle, improve hematopoietic processes and maintain normal functioning of the nervous system [15].

Table 3 shows the amino acid composition of flax seeds.

Table 3 – Amino acid composition of flax seeds

Name	Content per 100 grams
Essential amino acids	
threonine	0.77 g
valine	1.07 g
methionine	0.37 g
isoleucine	0.9 g
leucine	1.24 g
phenylalanine	0.96 g
tryptophan	0.3 g
lysine	0.87 g
Nonessential amino acids	
asparagine	2.05 g
serine	0.97 g
glutamic acid	4.04 g
proline	0.81 g
glycine	1.25 g
cysteine	0.34 g
tyrosine	0.49 g
histidine	0.47 g
arginine	1.93 g

When assessing the prospects for using flax seeds in the technology of meat products as components that impart functional properties to new products, it is important to know the level of their safety. The content of toxic elements, aflatoxin, nitrosamines, hormonal drugs and pesticides in seeds should not exceed the maximum permissible levels established by the hygienic

requirements for the quality and safety of food raw materials and food products SanPiN 2.3.2.560-96 [12].

Microbiological safety indicators of flax seeds are presented in table. 4.

Table 4 – Microbiological safety indicators of flax seeds

Indicator name	Indicator value	
	Flax seeds	GOST 31645-2012
KMAFAnM, CFU/g	$3.2 \cdot 10^3$	No more than $5\text{-}10^4$
Yeast, CFU/g	Not detected	No more than 100
Mold, CFU/g	Not detected	No more than 200
Coliforms in 0.1 g of product	Not detected	Not allowed

The data obtained indicate that for all safety indicators according to SanPin 2.3.2.1078–01, no excesses of established standards were found, which characterizes the studied flax seed samples as a safe raw material suitable for use as food components in food products.

Requirements for the permissible level of toxic substances in food products are regulated by Sanitary and Epidemiological Rules and Standards SanPin 2.3.2.1078-01. The content of toxic elements in flax seeds does not exceed the permissible level regulated by SanPin 2.3.2.1078-01 (Table 5).

Table 5 – Content of toxic elements in flax seeds

Toxic element	Content	Acceptable level according to SanPiN
Lead	0.34 ±0.028	1.0
Cadmium	0.06 ±0.007	0.1
Copper	10.1 ±0.11	Not standardized
Zinc	48.7 ±0.18	Not standardized

The lead content in flax seeds does not exceed 30%, and the cadmium content does not exceed 65% of the permissible level in oilseeds. Content of copper and zinc in food products since 2001. SanPiN does not regulate, however, according to the international trade rules approved by the FAO/WHO commission, seven heavy metals, including copper and zinc, are controlled in food products. In the studied samples of flax seeds, the content of these elements does not exceed the level that was established for oilseeds according to SanPiN of 1996 (for copper - 10 mg/kg, for zinc - 50 mg/kg).

Flaxseed flour is made from flaxseed by grinding and cleaning the flaxseed, and the resulting raw material is then defatted and dried. Defatting is an important step in the flour preparation process, so flour and ground flaxseed are completely different products [14].

Flaxseed flour is a free-flowing brown powder with dark inclusions of undestroyed seed shells, sweetish in taste, with a slight bitterness, and has a faint herbaceous odor (Fig. 1).

Figure 1 – Flaxseed flour

The amount of protein in flaxseed flour reaches 50% of the total mass of the product; the content of fat and carbohydrates is lower. About 30% comes from fiber and dietary fiber (Table 6).

Table 6 – Nutritional value of flax seeds and flaxseed flour (g/100 g of product)

Index	Flax seeds	Flaxseed flour
Protein	18.29	40.5
Fat	42.16	10.2
Carbohydrates	28.9	9.0
Alimentary fiber	27.3	33.7
Calorie content	534 kcal	270 kcal
Ash	3.72	5.79

Dietary fiber in flax flour is 33.7 g, which significantly exceeds this figure in wheat flour. A distinctive feature of flaxseed flour is that all vitamins and minerals are easily absorbed by the body. The nutritional value of low-fat flaxseed meal is presented in table. 7.

Table 7 – Nutritional value of flaxseed flour

Indicator name	Meaning
Moisture content, %	5.0
Mass fraction of fat (per a.s.v.), %	1.5
Mass fraction of crude protein (at dry weight), %	49.6
Mass fraction of crude fiber (on a.s.v. basis), %	5.0
Ash content, %	2.9

A significant amount of protein contained in flaxseed flour allows this product to be used as an additive to products with low nutritional value. Flaxseed flour proteins have high biological value, as they have a fairly balanced amino acid composition. The completeness of the amino acid composition is characterized by an adequate content of essential amino acids, sufficient to maintain the growth of the body (Table 8).

Table 8 – Biological value of flaxseed flour

Essential amino acids	Flaxseed flour/100g product	Amino acid score
Isoleucine	2.78	1.42
Leucine	4.78	1.40
Lysine	2.12	0.79
Methionine + Cystine	2.06	1.20
Phenylalanine + Tyrosine	7.80	2.65
Threonine	3.01	1.54
Tryptophan	1.67	3.41
Valin	4.01	1.64

The only limiting amino acid in flaxseed flour is lysine. Flaxseed flour is characterized by a high content of sulfur-containing acids.

The beneficial properties and nutritional value of flax seed flour allow it to be used as a dietary supplement of plant origin. in the technology of production of meat products.

To study the effect of flax flour on the FTS of model minced meat systems, we used the recipe for the Armavir sausage (category B), produced in accordance with GOST 31785-2012 “Semi-smoked sausages. Technical specifications" without additives (control) and using flaxseed flour instead lean raw meat - trimmed beef (test samples).

Based on an analysis of literary sources, it was established that in the production technology of meat-and-vegetable sausages, the share of herbal preparations is within limits not exceeding 20%. When preparing a hydrated herbal preparation, the ratio of dry preparation: water was 1:2. Recipes for experimental minced meats with different levels of substitution are presented in Table. 9.

Table 9 – Recipes of experimental minced meat

Name of ingredients		Prototypes		
	Control	10%	15%	20%

Unsalted raw materials, kg (per 100 kg of raw materials)				
Trimmed beef 1st grade	20.0	18.0	17.0	16.0
Pork, trimmed, lean	20.0	20.0	20.0	20.0
Pork, trimmed, semi-fat	30.0	30.0	30.0	30.0
Pork belly	30.0	30.0	30.0	30.0
Hydrated flax meal	-	2.0	3.0	4.0
Total	100.0		100.0	100.0

With an increase in the amount of additive based on flax seed flour in model minced meat systems, the moisture-binding capacity of minced meat increases; the increase in WSS when adding a protein additive to a meat emulsion is associated with the biochemical properties of the additive, capable of binding water and forming a water-protein matrix (Fig. 2).

The emulsifying ability and stability of minced meat emulsion characterize the interaction of fat, protein and water. The system consists of a dispersed phase - hydrated protein micelles, fat granules and a dispersion medium - an aqueous solution of proteins and low molecular weight substances. An additive based on flax seed flour helps create a stable meat emulsion and is involved in regulating the properties of the protein component of minced meat (Fig. 3).

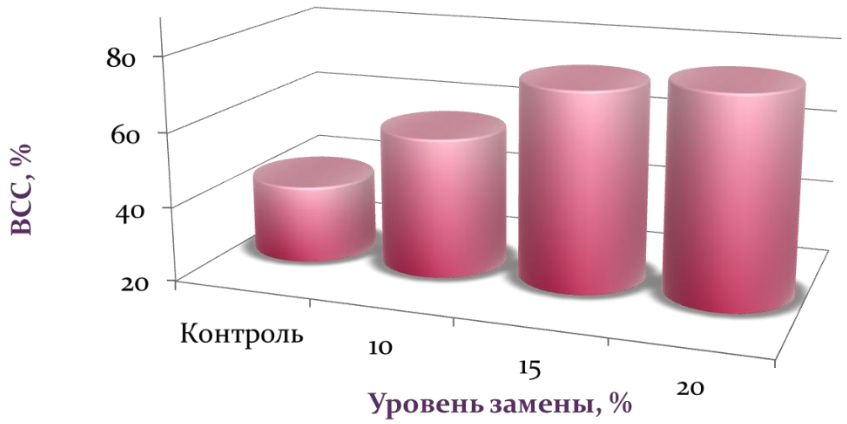

Figure 2 – The effect of the amount of flax flour additive on the moisture binding capacity of minced meat

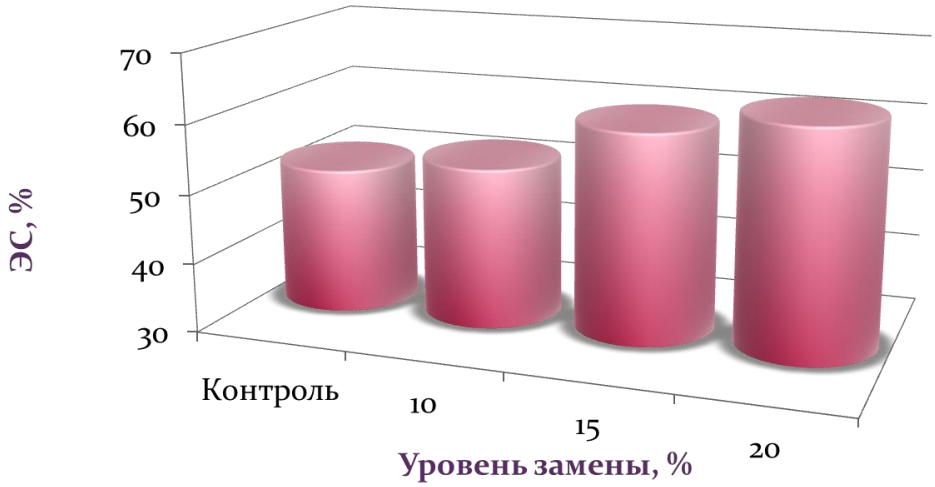

Figure 3 – The effect of the amount of flaxseed flour additive on the emulsifying ability of minced meat

As a result of a study of the influence of an additive based on flax flour on the structural and mechanical characteristics of finished products, it was found that at a replacement level of up to

15%, flax flour effectively improves elastic-plastic properties, increasing the density and juiciness of meat products. Flax flour at a 20% replacement level does not cause significant changes in rheological parameters, but contributes to the deterioration of the organoleptic properties that characterize the consistency of sausage products.

Analysis of research results indicates that the optimal level of replacement of meat raw materials is a mass fraction of flaxseed flour of 15 %. The research methodology involved the production of semi-smoked sausage with the replacement of 15% of ground beef with flax seed flour, based on the recipe for Armavir sausage (GOST 31785-2012 Semi-smoked sausages). The recipe for semi-smoked sausages without the use (control sample) and with the use (test sample) of a protein additive based on flaxseed flour instead of raw meat is presented in Table 10.

Table 10 – Formulation of semi-smoked sausages

name of raw materials	Control sample	Prototype
Unsalted raw materials, kg (per 100 kg of raw materials)		
Trimmed beef 1st grade	20.0	17.0
Pork, trimmed, lean	20.0	20.0
Pork, trimmed, semi-fat	30.0	30.0
Pork belly	30.0	30.0
Hydrated flax seed meal	-	3.0
Food additives, spices, materials, kg (per 100 kg of unsalted raw materials)		
Sugar	0.135	0.135
Table salt	3,000	3.000
Sodium nitrite	0.008	0.008
Black pepper ground	0.100	0.100
Before fragrant ground	0.090	0.090
Fresh garlic	0.200	0.200

One of the technological risks when fortifying food products, which is accompanied by modification of the recipe composition, is a change in their organoleptic properties. This becomes a critical control point in the development of functional foods. Therefore, special attention was paid to preserving the organoleptic characteristics of sausage samples when replacing raw meat with flour. A comparative assessment of the organoleptic characteristics of the control and experimental sample of semi-smoked sausages in accordance with the requirements of GOST 31785–2012 is presented in Table 11.

Table 11 – Organoleptic assessment of the quality indicators of the developed semi-smoked sausages

Indicator name	Characteristics of the indicator		
	Control sample	Prototype	Requirements GOST 31785–2012
Appearance	**Loaves with a clean, dry surface, without stains, slips, shell damage, minced meat deposits**		
Consistency	Dense		Dense
Color and type of minced meat	Red	Rose red	Pink to dark red
Smell and taste	Characteristic for this type of product, without foreign tastes and odors, the taste is slightly spicy, moderately salty with a pronounced aroma of spices		Characteristic for this type of product, without foreign tastes and odors, the taste is slightly spicy, moderately salty with a pronounced aroma of spices

The organoleptic assessment of the samples and the consumer properties of the sausage were assessed on a 5-point scale, taking into account the following indicators: taste and aroma, cut color, appearance, consistency. Organoleptic evaluation of prototypes and consumer properties of sausages are presented in Table 12.

Table 12 – Comparative assessment of consumer properties of semi-smoked sausages (points)

Index	Control sample	Prototype
Taste and aroma	4.7	4.5
Color on the section	5.0	5.0
Appearance	5.0	5.0
Consistency	5.0	4.9
Average score	4.9	4.8

The use of a protein additive based on flaxseed flour improves to a greater extent the plastic properties and juiciness, without affecting the elasticity and density of meat products. It should be noted that the experimental sample, produced with the addition of flaxseed flour as a vegetable additive, was practically not inferior to the control sample.

There were minor differences in the commission's assessment of such indicators as taste and aroma (0.2 points), consistency (0.1 points). The addition of herbal additive enriches prototypes of boiled sausages with vitamins, macro- and microelements, and other biologically active substances, which increases their biological value and transforms them into a range of functional food products.

Sausages, like other meat products, are the main sources of protein, so their nutritional value should be determined by both the total protein content and the amount of complete proteins. The amount of fat should be within the limits at which the quality indicators of sausages improve (taste, consistency), since in excessive quantities fat impairs the taste of products and their digestibility. The main physical and chemical parameters of semi-smoked sausages are presented in Table 13.

Table 13 – Physico-chemical parameters of semi-smoked sausages

Index	Requirements GOST 31785-2012	Sample data	
		Control	Experienced
Mass fraction of moisture, %, no more	44	43.0±0.16	42.3±0.12
Mass fraction of protein, %, not less	14	14.3±0.08	14.6±0.10
Mass fraction of fat, %, no more	42	39.7±0.19	39.5±0.03
Mass fraction of sodium chloride, %, no more	3.2	3.1±0.02	2.9±0.03
Mass fraction of sodium nitrite, %, no more	0.005	0.005	0.005

The research results indicate that the experimental and control samples of sausages met the requirements of GOST 31785-2012 in terms of physical and chemical indicators, however, in the experimental sample, compared to the control sample, there was a decrease in the mass fraction of moisture by 0.7% ($p \geq 0.95$), fat by 0.2% and an increase in the proportion of protein by 0.3%.

The concept of quality of meat products implies not only the presence of the desired sensory characteristics, but also ensuring its safety. The research methodology included determining the total bacterial contamination of the finished product (QMAFAnM), the presence of opportunistic microorganisms - coagulase-positive staphylococcus (S. aureus), sulfite-reducing clostridia (C.

perfringens), bacteria of the genus Proteus (P. vulgaris) and pathogenic microorganisms of the genus Salmonella. Microbiological parameters of sausage products are presented in Table 14.

Table 14 – Microbiological parameters of boiled sausages

Name of product samples, ND standardizing safety indicators	Microbiological safety indicators	Permissible levels, mg/kg, no more	Numbers of RD regulating test methods	Detected concentration, mg/kg
Sowing time: 3 days	KMAFAnM, CFU/g, no more	$1x10^{3}$	GOST 10444.15-94	$1.2x10^{2}$
Sowing time: 6 days	KMAFAnM, CFU/g, no more	$1x10^{3}$	GOST 10444.15-94	$1.7x10^{2}$
Sowing time: 9 days	KMAFAnM, CFU/g, no more	$1x10^{3}$	GOST 10444.15-94	$2.4x10^{2}$
Sowing time: 12 days	KMAFAnM, CFU/g, no more	$1x10^{3}$	GOST 10444.15-94	$3.6x10^{2}$
Sowing time: 15 days	KMAFAnM, CFU/g, no more	$1x10^{3}$	GOST 10444.15-94	$5.2x10^{2}$
Sowing time: 18 days	KMAFAnM, CFU/g, no more	$1x10^{3}$	GOST 10444.15-94	$6.5x10^{2}$
Sowing time: 21 days	KMAFAnM, CFU/g, no more	$1x10^{3}$	GOST 10444.15-94	$7.9x10^{2}$

It should be noted that all samples of sausages with protein additives meet the requirements of SanPiN according to microbiological safety indicators. The results of bacteriological studies of samples of cooked sausages are presented in table. 15.

Table 15 – Results of bacteriological studies of sausage samples during 21 days of storage

Indicator name	Acceptable levels, no more than:	Time, day	Control	Replacement level	
				10%	20%
Coliform bacteria, S. aureus, are not allowed in (g) of the product	1.0	3-21	not found in 1.0 g		
Sulfite-reducing clostridia are not allowed in (d) product	0.1	3-21	not found in 0.1 g		
Pathogenic microorganisms, including salmonella, are not allowed in the product	25.0	3-21	not detected in 25.0g		

According to biometric processing data, the total number of microorganisms was within acceptable limits, which indicates the positive effect of the protein additive on reducing the total microbial contamination of the meat product.

To substantiate the economic feasibility and efficiency of the production of semi-smoked sausages with a protein additive based on flaxseed flour, calculations were made of the costs of main and auxiliary raw materials for the production of 100 kg semi-smoked sausages according to the traditional recipe and according to the developed one, using flaxseed flour (Tables 16 and 17).

Table 16 – Calculation of the cost of basic raw materials for the production of semi-smoked sausages

Name of main raw materials	Price 1 kg, rub.	Control sample		Prototype	
		Consumption, kg	Price	Consumption, kg	Price
Trimmed beef 1st grade	460.00	20.0	9200.00	17.0	7820.00
Pork, trimmed, lean	210.00	20.0	4200.00	20.0	4200.00
Pork, trimmed, semi-fat		30.0		30.0	

	230.00		6900.00		6900.00
Pork belly	270.00	30.0	8100.00	30.0	8100.00
Hydrated flaxseed meal	40.00	-	-	3.0	120.00
Total:	-	100.0	28400.00	100.0	27140.00

From the data presented it is clear that the cost of the main raw materials for the production of prototypes is lower than for the control, since the cost of flaxseed flour is 40 rubles. per 1 kg, which is significantly lower than the cost of raw meat.

Table 17 – Calculation of the cost of auxiliary raw materials for the production of semi-smoked sausages

Name of main raw materials	Price 1 kg, rub.	Control sample		Prototype	
		Consumption, g	Cost, rub.	Consumption, g	Cost, rub.
Table salt	10.00	2475.0	24.75	2475.0	24.75
Sodium nitrite	68.00	7.4	0.50	7.4	0.50
Granulated sugar	27.00	150.0	4 .0 5	150.0	4 .0 5
Ground black pepper	145.00	100.0	14.5 0	100.0	14.5 0
Allspice	170.00	100.0	17, 0 0	100.0	17, 0 0
Fresh garlic	137.00	120.0	16.44	120.0	16.44
Total:			77.24		77.24

These economic efficiency assessments indicate that the costs of the main raw materials for the production of prototypes with an additive based on flax seed flour are lower than for the control. The economic effect at a 15% level of replacement of lean meat raw materials with a protein vegetable additive amounted to 1260 rubles.

Conclusion. The conducted research allows us to recommend flaxseed flour as a protein additive in sausage production technology to increase their nutritional value, as well as to develop a range of functional products based on them. In comparison with the control, in the test samples there was a decrease in the mass fraction of fat, an increase in the total content of protein and carbohydrates, formulations containing from 15% to 20% flaxseed flour have a fairly high biological value. An organoleptic assessment of model minced meat systems showed that the use of a protein additive at a replacement level of up to 15% of raw meat effectively improves elastic-plastic properties, increasing the density and juiciness of meat products. Flax flour at a 20% replacement level does not cause significant changes in rheological parameters, but contributes to the deterioration of organoleptic properties.

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