

DEVELOPMENT OF COOKED SMOKED SAUSAGE ON THE BASIS OF MUSCOVY DUCK MEAT

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Abstract. This study considers the development of combined meat products containing, along with meat raw materials, other types of raw materials of animal and vegetable origin. The aim of the research is to substantiate the advantages of combining duck meat of regional origin with other types of raw materials in meat-containing cooked smoked sausages. A model for studying of the feasibility of combining duck meat of regional origin with other raw materials was a recipe for cooked smoked sausage containing meat of the Muscovy duck and also including pork hearts, salted pork side-fat, soybean isolates, pork skin protein, edible albumin "Aprored." In the model samples of forcemeat for meat-containing cooked smoked sausages, functional and technological properties have been determined according to standard methods. The biological food value of the finished products has been determined as well. The analysis of the results confirms that the combination of Muscovy duck meat and protein-containing secondary raw materials improves the moisture content, water-holding capacity, emulsifying ability, and stability of the emulsion. The study of the microbiological parameters of the sausages developed has indicated that the number of mesophilic aerobic and facultative anaerobic microorganisms (MAFAM) in all the samples studied was within the normal limits. The study of the number of bacteria of the E. coli group has not detected these microorganisms in any of the samples. For the ω -6 and ω -3 family, its high biological value as for the content of essential amino acids and its biological effectiveness as for the fatty acids have been confirmed. It has been proved that duck meat can be combined with traditional types of meat and vegetable raw materials to increase the biological effectiveness of meat-containing cooked smoked sausages. It has been determined that when Muscovy duck meat is combined with non-meat kinds of protein-containing raw material (pork skin protein, soybean isolate) as part of meat-containing cooked smoked sausage, it allows producing nutritious food with high quality characteristics.

Key words: muscovy duck, meat-containing cooked smoked sausage, functional-technological indicators.

РОЗРОБКА РЕЦЕПТУРИ ВАРЕНО-КОПЧЕНОЇ КОВБАСИ НА ОСНОВІ М'ЯСА МУСКУСНОЇ КАЧКИ

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Анотація. У роботі обґрунтовано доцільність комбінування м'яса качки регіонального походження з іншими видами сировини в складі м'ясо-місткої варено-копченої ковбаси. Розроблено рецептуру варено-копченої ковбаси із м'ясом мускусної качки, до складу якої також було включено серце свиняче, шпик боковий, соєвий ізолят, білковий стабілізатор із свинячої шкурки, альбумін харчовий «Апроред». Досліджено функціонально-технологічні властивості модельних зразків фаршів м'ясо-містких варено-копчених ковбас. Визначено біологічну цінність готової продукції. Доведено, що комбінування м'яса мускусної качки та білковмісної вторинної сировини сприяє покращенню наступних показників: вмісту вологи, волого утримувальної здатності, емульгувальної здатності і стабільності емульсії. Підтверджено високу біологічну цінність за вмістом незамінних амінокислот та жирних кислот ω -6 і ω -3. Вивчення мікробіологічних показників розроблених ковбас свідчить про те, що кількість мезофільних аеробних та факультативно-анаеробних мікроорганізмів в усіх досліджуваних зразках була в межах норми. Бактерій групи кишкової палички не виявило в жодному із зразків. Показано, що при комбінуванні м'яса качки мускусної з іншими, не м'ясними видами білковмісної сировини, а саме білкового стабілізатора з свинячої шкурки, соєвого ізоляту, в складі м'ясо-місткої варено-копченої ковбаси, можливо виробляти повноцінні за харчовою цінністю продукти з високими якісними показниками.

Ключові слова: мускусна качка, м'ясо-містка варено-копчена ковбаса, функціонально-технологічні показники.

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Introduction. Formulation of the problem

Raw material of biological origin used in meat industry is characterized by constant changes in its composition and properties. That is why one of the most important issues in this area is to ensure the constant quality of products. To solve this problem, the specific nature of the resources should be taken into account, too [1].

Application of new types of raw materials and wider use of traditional ones, rational use of regional raw materials in meat and meat-containing formulations are important tasks to achieve the high quality, nutritional and biological value of food.

A promising protein-containing raw material of animal origin in Ukraine is waterfowl meat. Its production in various regions of Ukraine is steadily developing [2,3].

The increase in prices of traditional types of meat raw materials, the tendency to reduce the production of these types of meat makes highly important the development of new types of meat-containing products based on raw materials of regional production. The use of these raw materials allows obtaining products of high biological value with good functional, technological, and consumer characteristics.

Analysis of recent research and publications

In recent years, the number of cattle and pigs in Ukraine has been reducing. However, the poultry meat market is constantly increasing. Duck meat has a niche product status in the world. The volumes of its production are slowly but steadily increasing every year. In the world, the duck market is 5% of the chicken market. According to FAO (Food and Agriculture Organization of the United Nations), in 2014, the duck meat market in the world was estimated at 4.4 million tons and reached 1,359.3 million heads. In the period from 2000 to 2010, the average annual growth rate was 3.4%, which means that 0.11 million tons was added annually [3].

These factors create prospects for the development of new combined products high in quality protein and based on waterfowl meat.

By chemical composition, fowl meat is different from that of slaughtered animals with a high content of biologically valuable proteins and easily digestible fat. Waterfowl meat contains 50–70% of water, 16–22% of proteins, 16–45% of fat and minerals and vitamins. Such distribution contributes to good assimilation of poultry meat and fat by the human body [4].

Two major breeds of broiler ducks are grown in the world: Peking and Muscovy. Muscovy ducks have certain biological characteristics; their main advantage is excellent meat qualities.

Duck meat contains 15–17% of protein, 24–38% of fat and 45–56% of water. The Muscovy duck meat is a source of essential amino acids, especially lysine and methionine. Studying the content of fatty acids of different parts of duck carcasses has shown a high concentration of monounsaturated acid C18:1 – 26.89–40.24% in the

total content of fatty acids and polyunsaturated fatty acids (PUF) – arachidonic and linoleic [5,6].

At present, a topical issue is the development of combined meat products, which contain, along with meat raw materials, other types of raw materials of animal and vegetable origin. Combined products can meet people's need of a rational and balanced nutrition. Particularly popular are multicomponent meat-containing sausages, with raw materials of regional origin, that have a long shelf life.

Studies devoted to the development of meat and meat-containing products that contain duck meat [7,8] have shown that according to their functional, technological and organoleptic characteristics, these products are not inferior to the traditional ones based on pork and beef meat. So, the development of new combined food products containing waterfowl meat is a topical task today.

The aim of the research is to prove how practical it is to combine duck meat of regional origin with other types of raw materials in meat-containing cooked smoked sausages.

To achieve this aim, the following **tasks** were set to be solved:

- to study the possibility of using duck meat in a recipe for meat-containing cooked smoked sausages;
- to study functional, technological, organoleptic, and microbiological parameters of the meat-containing cooked smoked sausage developed;
- to analyse the biological value and biological effectiveness of the meat-containing cooked smoked sausage developed.

Research materials and methods

To solve the tasks, the semi-smoked sausage "Utiana" was chosen as the formulation of an analogue [9].

The study used forcemeat of the Muscovy duck obtained after separating the meat from the bones and crushing in a meat grinder with the diameter of grid holes 2–3 mm.

To increase the economic efficiency of production, semi-fat pork (32%) was replaced in the recipes with 20% of pork skin protein stabilizer, 11.5% of soybean protein isolate, and reduced the duck meat by 7–15%. The pork skin protein stabilizer contributed to an increase in the functional and technological properties (FTP) of sausages. The share of salt, sodium nitrite, and spice in the experimental and control samples did not change [10].

The technological scheme of making cooked smoked sausages is presented in Fig. 1. The pork skin protein stabilizer was manufactured according to the following technology. After the raw material was taken, the bristle residues were removed from the skins, after which it was chopped into 5x5 cm pieces, and water was added in the ratio 1:1.5 and boiled at $t=95-98^{\circ}\text{C}$, $\tau=40-45$ min. The cooked skin was chopped with the addition of 50% of the cook water and put into moulds. After that, it was cooled at $t=2-4^{\circ}\text{C}$, $\tau=10-12$ h. After cooling, the cooled pork skin protein stabilizer was used to stuff the smoked sausage. Variants of the recipes are shown in table 1.

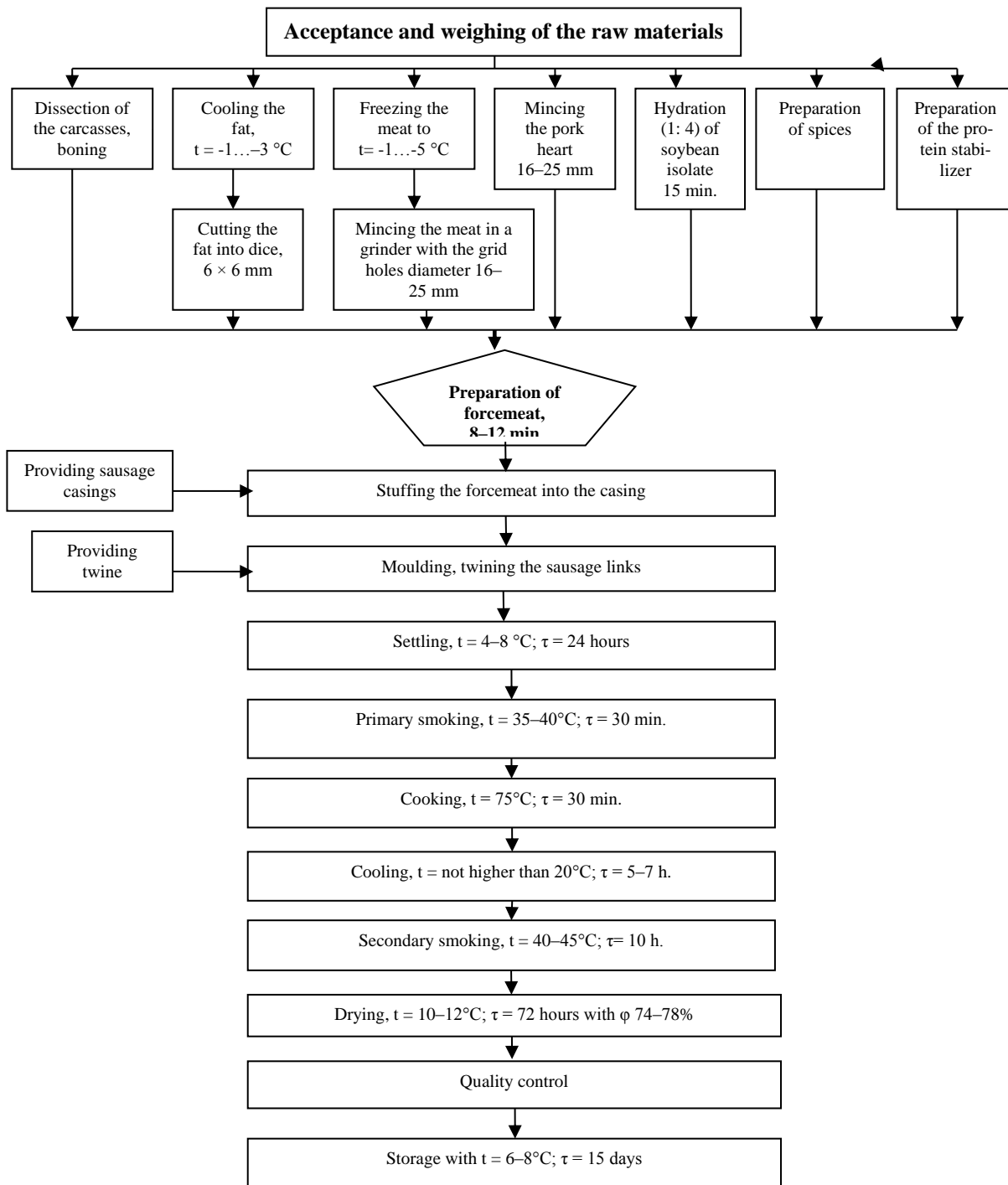


Fig. 1. Technological scheme of manufacturing meat-containing cooked smoked sausage with duck meat.

In the model samples of the forcemeat of meat-containing cooked-smoked sausages, functional and technological properties were determined according to standard methods: water binding capacity of the forcemeat in relation to the total moisture content in the batch (WBC_a), water holding capacity (WHC), emulsifying ca-

pacity (EC), emulsion stability (ES) [11], and biological value.

The number of mesophilic aerobic and facultative anaerobic microorganisms (NMAFAM) was determined by the following method (SSTU 8446:2015).

Detection of the *E. coli* group (coliform bacteria) was carried out as follows (SSTU 8446:2015).

Table 1 – Recipes of experimental samples of cooked smoked sausage

Ingredients	Control sample	Recipe 1	Recipe 2	Recipe 3
Basic raw material, kg, per 100 kg of unsalted raw material				
Muscovy duck meat	55	48	45	40
Semi-fat pork	32	–	–	–
Pork fat	13	10	10	10
Pork heart	–	10	13	18
Soybean protein isolate	–	11.5	11.5	11.5
Pork skin protein stabilizer	–	20	20	20
Aproned	–	0.5	0.5	0.5
Spices and auxiliary materials, g, per 100 kg of unsalted raw materials				
Salt	3000	3000	3000	3000
Sugar	100	100	100	100
Black pepper	100	100	100	100
Sodium nitrite	5	5	5	5
Ground nutmeg or coriander	50	50	50	50
Fresh garlic, peeled	200	200	200	200

The amino acid composition of the sausages was determined by ion-exchange column chromatography with an amino acid analyser BIOTRONIK (Germany). The amino acids content is calculated in g per 100 g of the product (SSTU ISO 13903:2009). To prepare the samples, the batch (0.1 g) is placed in a stoppered test tube, and covered with 10 cm³ of distilled water and 10 cm³ of concentrated hydrochloric acid. The tube is tightly sealed and placed in a dry-heat oven, with a temperature of 130°C, for 8 hours. The hydrolysate obtained is filtered through a cotton filter and washed with 3 times as much distilled water. The resulting solution is transferred to a porcelain cup and evaporated on an electric hot plate to the volume 0.5–1.0 cm³. The sample is diluted with distilled water and filtered through a paper filter into a 50 ml test tube. The filter is washed until the test tube is filled to 35–40 cm³. Quantitative determination of amino acids is carried out by taking 1 ml and adding 1 cm³ of the buffer solution with pH=2.2. The sample is passed through a membrane filter with the pore diameter 0.45 µm. 50 µl of purified sample is selected and introduced into the chromatographic ion exchange column of the analyser. The analysis is then carried out automatically by the preset program for 115 minutes. After the completion of the analysis, the resulting chromatogram is interpreted, and the peak areas of each amino acid are calculated by the external standard method.

The fatty acid content of the sausages was determined by gas-liquid chromatography with an automated gas chromatograph Kupol-55 (SSTU ISO 15885/IDF 184:2008). To determine the FA, a sample was prepared by lipid extraction. A mixture of chloroform-methanol (1:2) and water in the ratio 30:3 ml was added to 6 g of the sample. The mixture was homogenized for 2 min. at room temperature.

The homogenized sample was centrifuged, the residue was re-extracted 38 ml. mixtures of chloroform:methanol:water (1:2:0.8) in a homogenizer for 2 min. The extract was separated by centrifugation, the combined supernatants were diluted in 20 ml of chloroform and 20 ml water. The water-methanol and chloroform phases were separated by centrifugation. The lower layer of chloroform concentrated on a rotary evaporator

at a temperature of 30–35°C. The residue was dissolved in 10 ml of chloroform.

For fattening, 10 g of fat, 3.9 g of KOH, and 50 cm³ of 96% ethyl alcohol were combined. During 2–3 hours, the mixture was heated with a reflux condenser in an inert gas atmosphere, with the flask occasionally shaken. After this time, the mixture was cooled, diluted with distilled water (1:1), neutralized with 10% H₂SO₄ to pH=7, and acidified to pH=2. The mixture was extracted in 200 ml divalent funnel by sulfuric ether; the procedure was repeated three times in the ratio 1:0.5. The combined ether extracts were washed twice with distilled water, then dried with anhydrous sodium sulfate.

The extract was concentrated on a rotary evaporator at a temperature not above 40°C. After being heated in a bain-marie for 50 min., the extract was diluted with water in the ratio 1:1. Then hexane extracts were obtained. The hexane was evaporated on a rotary evaporator to give chromatographically pure fatty acid methyl esters that were dissolved in hexane and chromatographed on the Kupol-55 (Russia) chromatograph on the 100 mm long column SP 2560 (USA) in.

Amino acid score (%) was calculated by (1) [11]:

$$AS = AA_x / AA_s \cdot 100, \quad (1)$$

where AS – amino acid score; AA_x – amino acid in the protein under study; AA_s – the same amino acid in a standard protein or according to the scale. The FAO/WHO Amino Acid Scale [12,13] was used as the standard to calculate the amino acid score.

The absolute error of measurement was determined by the Student criterion, the confidence interval was P=0.95, the number of repeat determinations was 3–4, the number of parallel tests of the samples under study was 3.

Results of the research and their discussion

In the course of the research, functional and technological characteristics of model samples of cooked smoked sausages with Muscovy duck meat were studied. The results are shown in Table. 2.

The results presented in Table 2 indicate that for the recipes of meat-containing cooked smoked sausage with duck meat and protein-containing secondary raw materials, the proportion of moisture is higher by 14.5–17.5%, as compared to the control. However, the formulations developed have higher WHC values and high values of EC, ES, and WBC_a.

The WBC_a value of forcemeat should be 85 % to ensure high quality of cooked smoked sausages. The results indicate that the highest values of WBC_a and WHC are those of sample 1 that contains 48% of Muscovy duck meat, 10% of pork heart, and 20% of pork skin protein stabilizer.

The analysis of the results confirms that combining Muscovy duck meat and protein-derived secondary raw materials in recipes improves the moisture content, WHC, ES, and provides high values of EC and WBC_a.

Combination of non-traditional raw materials in cooked smoked sausages can result in microbiological

damage, so meat-containing cooked smoked sausages have been studied for microbiological safety. The results of the study are presented in Table 3.

The results show that in samples 2 and 3 of the muscovy duck meat sausages, the number of MAFAM is higher than in the control, but the value of these parameters is not above the norm (which is 2.5×10^3) [11]. The study of the number of the *E. coli* group bacteria has not detected these microorganisms in any of the samples.

According to a comprehensive assessment of the samples of forcemeat and meat-containing cooked smoked sausages, as well as for the organoleptic qualities [10], the most successful combination of the selected types of raw materials is recipe 1. This sample has been selected for further study of biological value.

The results of studying the biological value by the number of essential amino acids in meat-containing cooked smoked sausage with Muscovy duck meat are presented in Table 4.

Table 2 – Functional and technological properties of the studied forcemeat samples

Parameters	Forcemeat samples			
	Control sample	Recipe 1	Recipe 2	Recipe 3
Moisture content, %	62.76±2.74	71.92±0.26	73.29±1.24	73.73±0.08
WBC _a , %	94.05±6.89	93.82±1.26	92.6±0.40	91.65±0.83
WHC, %	43.51±2.91	67.61±1.90	52.56±2.67	55.06±2.06
EC %	76.00±5.66	80.00±0.00	62.00±2.83	54.00±8.49
ES %	59.83±7.62	56.07±0.75	67.03±0.51	62.45±2.05

Table 3 – Microbiological characteristics of cooked smoked sausages

Parameters	Samples of sausages			
	Control	1	2	3
NMAFAM, CFU/g, not more than	0.48×10^3	0.40×10^3	0.88×10^3	0.96×10^3
<i>E. coli</i> group bacteria in 0.001 g	Not found	Not found	Not found	Not found

Table 4 – Results of studying the biological value of proteins of meat-containing cooked smoked sausage with muscovy duck meat

No	Type of amino acid	Standard (FAO/WHO), g/100 g protein	Concentration, g/100 g product	Concentration, g/100 g protein	Amino acid score, %
1	Valine	5.0	1.09	4.54	90.80
2	Methionine	1.8	1.83	7.41	411.67
3	Isoleucine	4.0	1.07	4.33	108.25
4	Leucine	7.0	1.91	7.73	110.43
5	Phenylalanine+Tyrosine	6.0	1.59	6.44	107.33
6	Lysine	5.5	1.52	6.14	111.64
7	Threonine	4.0	1.30	5.26	131.50

The research of meat-containing cooked smoked sausage with Muscovy duck meat according to recipe 1 has allowed identifying all essential amino acids. These tables show that among the essential amino acids, the highest content is that of methionine and threonine. Evaluation of the protein quality by the amino acid score (AS) has shown that valine, the content of which in 100 g of the product is 1.09 g, is the limiting amino acid. The amino acid score of valine was 90.80%. This parameter for other amino acids ranged from 108.25 for isoleucine to 411.67 % for methionine.

The results of the analysis of biological effectiveness by fatty acids of meat-containing cooked smoked sausage with Muscovy duck meat are presented in Table 5.

Analysing the fatty acids content of meat-containing cooked smoked sausage with Muscovy duck meat confirms that the concentration of oleic acid cis-isomer in this product is at the level 37.62 g/100 g of total fat. The total amount of PUFA was 14.09 g/100 g of fat, including a high content of linoleic acid (11.93 g/100 g), which belongs to the ω -6 family.

According to the data obtained, the mass fraction of moisture in the samples studied was within the range

62.76–73.73% and depended on the composition of the recipe. The smallest amount of moisture was contained in the control sample of cooked smoked sausage, in the experimental samples, this parameter was by 14.60–17.48% higher.

In the WHC parameter, a similar tendency has been observed. This is due to collagen-containing raw materials and soy isolate present in the recipe, which are characterized by high functional properties. The high soluble proteins content, in comparison with the meat of slaughtered animals, explains the minor moisture losses during the heat treatment of products containing protein-derived raw materials of plant and animal origin, and also results in high juiciness and yield of finished products [12].

For the production of high quality products from multicomponent polydisperse systems, the values of EC and ES are significant. The research indicates that model forcemeats are high in EC and ES, which allows forming a protein matrix. This matrix allows introducing fat into its structure and obtaining a stable fat-in-water emulsion. At the same time, with high values of emulsifying properties for all recipes, the best EC value was that of recipe 1 – 80,00±0,00%. Combining duck meat, collagen-containing raw materials, and soy isolates allowed improving the EC of the emulsion by 5.26%. This is due to the formation of a more stable framework for stabilizing the fat phase due to water-soluble and salt-soluble proteins of duck meat, pork skin protein stabilizers, and soy isolate proteins [14,15].

Table 5 – Results of studying the fatty acid composition of meat-containing cooked smoked sausage with Muscovy duck meat

Fatty acid type	Concentration, g/100 g of fat
<i>Saturated fatty acids (SFA)</i>	
C14:0	2.11
C16:0	26.96
C17:0	0.54
C18:0	13.72
C20:0	0.55
Total SFA	43.88
<i>Monounsaturated fatty acids (MUFA)</i>	
C16:1	3.82
C18:1 t	0.59
C18:1 c	37.62
Total MUFA	42.03
<i>Polyunsaturated fatty acids (PUFA)</i>	
C18:2 t	0.05
C18:2 c	11.93
C18:3	1.48
C20:2	0.39
C20:3	0.24
Total PUFA	14.09

Analysing the fatty acids content of meat-containing cooked smoked sausage with Muscovy duck meat confirms that the concentration of oleic acid cis-isomer in this product is at the level 37.62 g/100 g of total fat. The total amount of PUFA was 14.09 g/100 g of fat, including a high content of linoleic acid (11.93 g/100 g), which belongs to the ω -6 family.

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To check that cooked smoked sausages with Muscovy duck meat and protein-containing components conform with the standard, all samples have been tested for the NMAFAM and the number of the *E. coli* group bacteria. The results of studying the microbiological parameters of the sausages developed (which are unstable for sanitary-hygienic safety), are normative and confirm the microbiological safety.

The amino acid composition of meat-containing cooked smoked sausage with Muscovy duck meat proves that this product is a valuable source of all essential amino acids, except for valine. Sausage contains a significant proportion of methionine, which promotes digestion, provides detoxification processes, reduces muscle weakness, protects against the effects of radiation, is useful against osteoporosis and chemical allergy [16].

Fatty acids of the products are represented mainly by saturated acids: palmitic (26.96%), stearic (13.72%), and myristic (2.11%); and by unsaturated oleic (37.62%), linoleic (11.93%), α -linolenic (1.48%). A relatively high PUFA content is a risk of oxidative processes in the product during storage. Natural antioxidants such as rosemary extract, grape seed extract, and other compositions are used to prevent the oxidation of fats [17].

It has been experimentally established that in the lipids of meat-containing cooked smoked sausage with Muscovy duck meat, the level of MUFA is 42.03%, PUFA – 14.09%, SFA – 43.88% of the total amount of

fatty acids. The biological effectiveness of lipids in food products is characterized not only by the amount of MUFA and PUFA, but also by the ratio of ω -3 and ω -6 PUFA, which according to the recommended standards [18] should be within the range 1:4 to 1:10. It has been experimentally determined that in the developed meat-containing cooked smoked sausage, this ratio was 1:10, because duck meat characterized by a high PUFA content was introduced into the formulation. Also, the content of ω -3 and ω -6 PUFA in 100 g of the finished product satisfies a person's daily demand [19] by 100 % or more.

Conclusion

1. It has been determined that when combining Muscovy duck meat with other non-meat types of protein-containing raw materials (pork skin protein stabilizers, soybean isolates) in the composition of meat-

containing cooked smoked sausages, it is possible to produce high quality nutritional value products with high qualitative characteristics.

2. The analysis of the complex of indicators has confirmed the possibility of increasing the functional and technological properties of the model forcemeat-containing cooked smoked sausages in which Muscovy duck meat with other non-meat types of protein-containing raw materials was used: WHC – up to 67.61%, EC – up to 80.0%, ES – 67.03%. The developed sausages are microbiologically safe.

3. It has been confirmed that the product has a high biological value as for the essential amino acids content and the biological effectiveness of ω -6 and ω -3 fatty acids. Thus, a possibility is proved of combining waterfowl meat with traditional types of meat and vegetable raw materials to increase the biological effectiveness of meat-containing cooked smoked sausages.

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