The Effectiveness of the Use of Vegetable-Protein Additives in the Production of Combined Meat Products

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Abstract. One of the promising directions in the creation of meat products is the development and production of combined products that combine a balanced complex of nutrients necessary for the body. In recent years, soy processing products have been most intensively used as a vegetable component in the production of meat products. Protein additives obtained by processing soy have found wide application in the meat processing industry due to their high functional and technological characteristics, positive effect on organoleptic parameters and nutritional value of the product. The purpose of the work is to study the nutritional value and technological indicators of soy protein concentrate "Arkon-S". 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 the sausage factory of CJSC "VEPOZ", Rostov-on-Don. The technology of production of boiled sausages with soy concentrate "Arkon-S" 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 meat products.

Keywords: Soy protein concentrate "Arkon-S" · Functional and technological properties · Nutritional value · Combined sausages · Food technology

1 Introduction

Meat products are an indispensable and integral part of human nutrition. In any economic situation, meat products of the food industry are in high consumer demand. Due to the shortage of high-quality raw materials, the meat industry is increasingly using various protein additives of vegetable origin as sources of high-grade protein.

Soy is the most common among legumes and oilseeds. It serves as a raw material for a wide range of food products, and the high content of protein and valuable food components allows it to be used as an inexpensive and useful meat substitute [3, 11, 13].

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In recent years, soy processing products have been most intensively used as a vegetable component in the production of meat products. They are most widely used in sausage production, to give products the appropriate texture, increased nutritional properties, high taste and functional qualities while reducing the cost of basic raw materials. [4, 10, 16].

One of the features of soy bean processing products is the binding of fat and water in the stuffing systems and providing a stabilizing effect. Soy products retain water and proteins better and allow for a better balance of food products in terms of nutritional value and physiological needs of the body [2, 9, 14].

Soy contains in its composition a significant amount of high-value protein, dietary fiber, minerals that determine its nutritional value and attract numerous researchers to find the most effective ways to use soy and its processed products in order to create new types of functional products and increase their nutritional value [12, 14–16].

Analysis of the chemical composition of soybeans showed that they not only contain an increased amount of proteins, but also that they are biologically close to animal proteins, and their digestibility depends on the processing method and reaches 90% on average [3].

The protein content in soybean seeds, according to various authors, varies between 27 and 50%, and they are the recognized world leader in dietary protein, the biological value of which is 96 units, and the digestibility is 91% (Table 1).

Table 1. Nutritional value of soybeans

Nutritional value	Content (per 100 g)
Caloric content	364 kcal
Squirrels	34.9 g
Fats	17.3 g
Carbohydrates	17.3 g
Water	12 g
Fiber	13.5 g
Glycemic index	21

The amount of fat in soybeans, which includes polyunsaturated fatty acids, varies within 20%. It also lacks cholesterol, which highly characterizes the biological value of soy lipids. Taking into account these two circumstances, soy fat can be attributed to one of the most valuable types of vegetable oils. The carbohydrate fraction of soybeans is represented by polysaccharides, disaccharides and monosaccharides [12]. Soy proteins are distinguished by the presence of a significant number of essential amino acids, including lysine, leucine, threonine, tryptophan. In addition, they are the most balanced in amino acid composition, although one of the essential amino acids, methionine, is present in insufficient amounts in soy protein. This determines their high biological value, approaching the proteins of meat, milk, eggs (Table 2).

Table 2. Amino acid composition of soybeans

Essential Amino acids	Content in 100g (mg)	Percentage of daily requirement (%)
Tryptophan	654	262
Isoleucine	1643	82
Valin	1737	50
Leucine	2750	55
Threonine	1506	269
Lysine	2183	136
Methionine	679	52
Phenylalanine	1696	85
Arginine	2611	52
Histidine	1020	68

Soy grain contains a number of vitamins: P-carotene, vitamin E, pyridoxine (B6), niacin (PP), pantothenic acid (VZ), riboflavin (B2), thiamine (B1), choline, as well as biotin and folic acid. However, soy beans contain compounds that make it difficult for the body to use a number of vitamins: A, D, B12, E, - anti-vitamins. All of them, with the exception of the factor that prevents the utilization of vitamin A, are thermolabile (Table 3).

Table 3. Vitamin composition of soybeans

Vitamins	Content in 100 g	Percentage of daily requirement (%)
Vitamin A	12 mcg	1
Vitamin B1	0.94 mg	63
Vitamin B2	0.22 mg	12
Vitamin E	1.9 mg	19
Vitamin B3 (PP)	9.7 mg	49
Vitamin B4	270 mg	54
Vitamin B5	1.75 mg	35
Vitamin B6	0.85 mg	43
Vitamin B9	200 mcg	50
Vitamin H	60 mcg	120

Soybeans contain up to 5% of minerals, including calcium, phosphorus, magnesium, iron and other elements. The mineral component (K, Ca, F, Mg) has an alkaline reaction, as a result of which the body accumulates nitrogen when fed with soy protein.

Soy contains in its composition a significant amount of high-value protein, dietary fiber, minerals that determine its nutritional value and attract numerous researchers to find the most effective ways to use soy and its processed products in order to create new types of functional products and increase their nutritional value [3].

Soy proteins are traditionally produced in various forms: soy flour, soy protein concentrate and soy protein isolate.

Currently, a new generation of soy proteins has appeared on the market – functional concentrates Arkon-C, Danpro-NVX, Danpro-S-760, which are obtained as a result of acid washing and high-temperature treatment [1].

In this regard, the purpose of the work is to study the nutritional value and technological indicators of soy protein concentrate "Arkon-S".

2 Materials and Methods

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 the sausage factory of CJSC "VEPOZ", Rostov-on-Don.

The following were used as research objects:

- Meat raw materials – veined beef of the first grade, veined pork, bold, side fat;
- High-functional soy protein concentrate "Arkon-S" (Netherlands, FEZ No.77.99.04.916.D.008850.12.02);
- Other ingredients according to the recipe.

Experimental studies provided for the use of modern physico-chemical, structural-mechanical, functional-technological, microbiological and organoleptic research methods, according to GOST.

3 Results

At the beginning of the research, the assessment of the main physico-chemical parameters of soy protein concentrate "Arkon-S" (Netherlands, FEZ No.77.99.04.916.D.008850.12.02) was carried out (Table 4).

Soy protein concentrate "Arkon-S" contains: 68–70% protein, 7.8–8.0% moisture, 0.9–1.0% fat, 4.9–5.0% ash, does not contain cholesterol, has a neutral taste, high solubility, water-binding and fat-emulsifying ability. The fatty acid composition of soy protein concentrate "Arkon-S" is presented in. The research methodology provided for the study of the effect of soy protein concentrate "Arkon-S" on the technological properties of model stuffing systems. As a control sample, minced meat was used, consisting of grade 1 veneered beef, semi-fat veneered pork and side bacon.

Soy concentrate "Arkon-S" was introduced into minced meat in the form of a pre-prepared gel.

To give the hydrated protein a pink color, it was stained using shaped elements of stabilized blood or blood in an amount of up to 0.5% by weight of the gel, or with the help

Table 4. Physico-chemical parameters of soy protein concentrate "Arkon-S"

Name	Content (%)
Colour	Light
Protein	68–70%
Moisture	7.8–8.0%
Fat	0.9–1.0%
Ash	4.9–5.0%
Total dietary fiber	19–20.0%
pH	6.8–7.2

of food dyes approved for use by the State Sanitary and Epidemiological Surveillance authorities.

When hydrating proteins, salt is not added to the gel, but it is applied to the meat when composing minced meat. Hydrated soy proteins, gels, protein-fat emulsions can be stored for 24 h at a temperature of 0–4 °C.

Soy concentrate was introduced into the model stuffing systems, replacing part of the beef of the 1st grade in an amount from 10 to 30%.

4 Discussion of the Results

In the experimental samples, there was an increase in pH from 6.03 to 6.11, which is due to the presence of soy protein concentrate "Arkon-C" (pH 7.1), the control sample had the lowest pH value - 5.8. The moisture binding capacity of the experimental samples exceeds the control data, which is caused by a decrease in the number of myofibrillar proteins involved in the structure formation of the finished product and an increase in moisture content, due to the preliminary hydration of soy concentrate. In the production conditions of the sausage factory of CJSC "VEPOZ" (Rostov-on-Don), the development of prototypes of combined sausages with various levels of replacement of meat raw materials with soy protein concentrate "Arkon-S" was carried out. The sausage recipe "Separate" was used as a control (GOST 33673-2015 "Boiled sausage products: Technical conditions"), a protein additive was introduced into the recipe of prototypes. The conducted organoleptic evaluation indicates that the evaluation indicators of prototypes using soy concentrate "Arkon-S" correspond to the characteristics of boiled sausage "Separate", and in some positions, in particular, consistency and juiciness, slightly exceed the values of the control sample (Table 5).

With an increase in the amount of concentrate to 30%, these indicators decrease, the smell and taste are not peculiar to this type of product, have a characteristic taste of soy. Table 6 shows the physico-chemical quality indicators of experimental samples of combined sausages.

In comparison with the control, there was a decrease in the mass fraction of fat, which is a positive factor in the light of modern trends in the field of healthy nutrition.

Table 5. Organoleptic indicators of boiled sausages

Test samples	Appearance	Color on the cut	Smell	Taste	Consistency	Juiciness	Average rating
Control	4.5	4.6	4.3	4.7	4.3	4.3	4.45
10%	4.5	4.6	4.4	4.7	4.5	4.3	4.50
20%	4.5	4.5	4.3	4.7	4.5	4.3	4.46
30%	4.3	4.4	4.2	4.5	4.2	4.3	4.31

Table 6. Physico-chemical quality indicators of prototypes

Test samples	Content, %				
	Moisture	Protein	Fat	Ash	Carbohydrates
Control	65.16 ± 1.32	11.10 ± 0.20	20.21 ± 0.18	2.33 ± 0.01	1.2 ± 0.02
10%	68.71 ± 1.37	11.41 ± 0.22	15.22 ± 0.16	2.53 ± 0.02	2.04 ± 0.01
20%	68.74 ± 1.30	11.45 ± 0.23	15.17 ± 0.12	2.55 ± 0.03	2.18 ± 0.01

The results of the analysis of the chemical composition of boiled sausages indicate that formulations containing from 10 to 20% soy concentrate have a sufficiently high biological value.

The yield of finished products is one of the criteria determining the economic feasibility of the production of boiled sausage products, which, at the same time, is closely related to the functional properties of the proteins of the stuffing system, which determine the juiciness of the finished product. The results of determining the yield and weight loss of sausage products are presented in Table 7.

Table 7. Yield and weight loss of boiled sausages

Indicators (%)	Control	10%	20%
Exit	113.3 ± 1.7	117.6 ± 1.8	117.8 ± 1.8
Mass loss	13.1 ± 0.3	11.3 ± 0.3	11.2 ± 0.3

The results of determining the yield indicate that the maximum value of the studied indicator is in a sample containing 20% of Arkon-S soy concentrate.

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 provided for the determination of the total bacterial contamination of the finished product

(CMAFAnM), the presence of conditionally pathogenic microorganisms - coagulase-positive staphylococcus (S. aureus), sulfite-reducing clostridium (C. perfringens), bacteria of the genus proteus (P. vulgaris) and pathogenic microorganisms of the genus Salmonella.

Microbiological indicators of sausage products are presented in Table 8.

Table 8. Microbiological indicators of boiled sausages

Name of product samples, ND normalizing safety indicators	Microbiological safety indicators	Permissible levels, mg/kg, no more	ND numbers regulating test methods	Detected concentration, mg/kg
Sowing time: 3 days	KMAFAnM, CFU/g, no more	1×10^3	GOST 10444.15–94	1.2×10^2
Sowing time: 6 days	KMAFAnM, CFU/g, no more	1×10^3	GOST 10444.15–94	1.7×10^2
Sowing time: 9 days	KMAFAnM, CFU/g, no more	1×10^3	GOST 10444.15–94	2.4×10^2
Sowing time: 12 days	KMAFAnM, CFU/g, no more	1×10^3	GOST 10444.15–94	3.6×10^2
Sowing time: 15 days	KMAFAnM, CFU/g, no more	1×10^3	GOST 10444.15–94	5.2×10^2
Sowing time: 18 days	KMAFAnM, CFU/g, no more	1×10^3	GOST 10444.15–94	6.5×10^2
Sowing time: 21 days	KMAFAnM, CFU/g, no more	1×10^3	GOST 10444.15–94	7.9×10^2

It should be noted that all samples of boiled sausages with a protein supplement meet the requirements of the SanPiN according to microbiological safety indicators.

The results of bacteriological studies of samples of boiled sausage products. According to the biometric processing data, the total number of microorganisms was within acceptable limits, which indicates a positive effect of the protein supplement on reducing the total microbial contamination of the meat product.

To substantiate the economic feasibility and efficiency of the production of combined sausages with soy protein concentrate “Arkon-S”, calculations of the costs of the main and auxiliary raw materials for the production of 100 kg of boiled sausages according to the traditional recipe and according to the developed one using soy concentrate were carried out (Table 9).

The economic effect of the production of combined sausages with soy protein concentrate “Arkon-S” at a 10% level of replacement of meat raw materials amounted to 3409.8 rubles, at a 20% level of replacement of meat raw materials - 6819.6 rubles.

Table 9. Calculation of costs for auxiliary raw materials for the production of combined sausages

Name of auxiliary raw materials	Price 1 kg, rub	Control sample		Replacement level			
				10%		20%	
		Consumption, g	Cost, rub	Consumption, g	Cost, rub	Consumption, g	Cost, rub
Table salt, food	10.00	2500.0	25.00	2500.0	25.00	2500.0	25.0
Sodium Nitrite	85.00	6.4	0.54	6.4	0.54	6.4	0.54
Granulated sugar	36.00	150.0	5.40	150.0	5.40	150.0	5.40
Ground black pepper	87.00	100.0	8.70	100.0	8.70	100.0	8.70
Allspice	175.00	100.0	17.50	100.0	17.50	100.0	17.50
Fresh garlic	90.00	120.0	10.80	120.0	10.80	120.0	10.80
Total			67.94		67.94		67.94

5 Conclusions

Based on the conducted studies, the expediency of using hydrated soy concentrate "Arkon-S" in the production technology of combined sausages has been confirmed. In the experimental samples, there was an increase in pH from 6.03 to 6.11, which is due to the presence of soy protein concentrate "Arkon-C" (pH 7.1) in them, the control sample had the lowest pH value - 5.85 compared to the experimental ones. In comparison with the control, there was a decrease in the mass fraction of fat in the experimental samples, an increase in the total content of protein and carbohydrates, formulations containing from 10 to 20% soy concentrate have a sufficiently high biological value. Organoleptic evaluation of model minced meat systems showed that the use of soy protein concentrate "Arkon-S" in an amount of no more than 20% does not cause deterioration of indicators; with an increase in the amount of isolate to 30%, their decrease occurs, the smell and taste are unusual for this type of product, have a characteristic taste of soy. The use of soy protein concentrate "Arkon-S" in the technology of combined sausages made it possible to increase the moisture-holding capacity, reduce losses during heat treatment and consumption of meat raw materials.

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