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Original article

Extruded chickpea and wheat in technology of sausage products of enhanced biological value

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Summary. The meat product market is rapidly developing. There is a constant trend of meat production and consumption to increase, which is caused by demand for ready-to-eat products and modern lifestyle of consumers. Despite a large variety of food, there are few products of therapeutic, preventive and functional actions, while the problem of unbalanced nutrition is relevant in modern society. This article considers the possibility of solving the problem of deficiency of essential amino acids, iodine and selenium by creating products enriched with these components. This consideration has been exemplified by the development of a technology for functional boiled-smoked sausage products. The exclusive formulation contains a special additive that is a mixture of the best grades of chickpeas and wheat and enriched with trace elements. The article presents the formulation, results of organoleptic assessment and balance of nutritional components, including iodine, selenium, and amino acid composition. Final stage contains calculation of the direct production cost and profit from an operating small production enterprise. The product obtained had a more balanced amino acid composition, increased content of dietary fiber and key minerals. The investigation has determined the optimal dose of the additive. The best indices of biological value were achieved due to 15% of the plant component containing extruded chickpeas and wheat in a ratio of 2:1 previously germinated in solutions of potassium iodide and sodium selenite. Vegetable raw material made the recipe cheaper, which is a good advantage of technology presented. The product is recommended for all categories of the population.

Key words: nutrition, boiled-smoked sausage, iodine, selenium, amino acids, chickpea, wheat, functional product.

Introduction

Currently, the food market is one of the largest markets. Meat products rank fourth in the list of products for demand among the population in many countries and are inferior only to dairy products, vegetables and fruit. Modern lifestyle does not allow people to spend enough time preparing food, so most part of the population has to eat "on the go." Therefore, most consumers prefer fast food and ready to eat meat production because the products are very nutritious and convenient in use (1). Nevertheless, when eating food of that kind, people do not think of its quality and value, so the cases of unbalanced diet have become more frequent. For instance, the problem of deficiency of high-grade protein, iodine and selenium is challenging for the population's nutrition.

The program of World Health Organization is known to contain a concept of healthy nutrition. In general, nutrition is eating of food products in accordance with the dietary needs of the body. Adequate nutrition, that is, proper well-balanced food combined with regular physical activity is a basis of good health. A healthy diet throughout life helps to avoid the problem of malnutrition in all its forms and prevent a number of noncommunicable diseases (NCDs) and condi-

tions. However, the increase in the output of processed foods, rapid urbanization and changes in lifestyle have caused some changes in the diet (2).

In accordance with the above, the main strategic task of the food industry is to meet the needs of all population groups in high-quality, biologically adequate and safe food. In production of balanced food products, it is very important to proscribe synthetic additives from formulations and use natural extracts of vegetable and animal origin that contain essential biologically active substances.

Subnormal content of biologically active substances in the diet or their total absence is one of the causes of poor health and reduced life expectancy. Enrichment of food is the most effective way to solve the problem of protein, minerals and vitamins deficiency. The protein deficiency is not only an economic, but also social problem of the modern world. Products of animal origin are not always widely available. For example, in the southern regions of Africa, tropical Latin America and Asia, where the population is involved in heavy manual and agricultural labor, the problem of animal protein deficiency is particularly acute. Among the most common sources of macro- and microelements, chickpea has an increased content of protein, essential fatty acids, vitamins, minerals and other dietary nutrients and deserves special attention. In addition, in recent years, there has been a growing interest in the extrusion in processing of plant raw materials that is an environmentally friendly, resource-saving and universal process; extrusion makes it possible to produce low residue, thermally sterilized products with enhanced nutritional value and improve structural and functional properties and organoleptic characteristics (3).

The unbalanced amino acid composition of products is a relevant problem in many countries. Selecting products, some consumers are guided by general data on the content of food components indicated on the label. However, this information is not exhaustive, as it does not give a more detailed idea of the product composition. The protein content of the product can be high, but the absence of any one essential amino acid can minimize the assimilation of other amino acids, as well as lead to the emergence of various diseases that lead to disorders in metabolism and organism as a whole.

The iodine and selenium deficiency in nutrition is also an important problem affecting many regions of our country and can cause hypothyroidism, mental retardation among children and adolescents and diseases associated with the thyroid hormones deficiency. Therefore, the prevention of iodine and selenium deficiency is another important task in the solution of the problem of adequate and balanced nutrition.

To solve the problems, it is necessary to create and implement a functional balanced meat product. Quality meat products are very expensive now, therefore, when developing and implementing new types of products, the manufacturer has to find a balance between the quality and cost. Nevertheless, consumers prefer to buy meat products made without synthetic additives and meat substitutes, so they cost more (4). This article considers the possibility of creating of a boiled-smoked sausage product with a balanced amino acid composition and increased content of trace elements of iodine and selenium, which can solve two problems of adequate nutrition at once. The presented theoretical calculation and experimental determination of food and biological values allowed estimating the implementability of the developed product on the food market as an additional source of high-grade protein, bioavailable iodine and selenium.

Experimental methods

The research was performed in the laboratory of the Volga research institute of production and processing of meat and dairy products and the Department of Food Technology at the Volgograd State Technical University. A comparative analysis of organoleptic parameters and nutritional values of the test and control samples of boiled-smoked sausages was carried out on test samples produced in conditions of the Volgograd Meat Processing Plant. In the finished samples, organoleptic parameters were assessed in accordance with the requirements of the GOST 9959-2015 “Meat and meat products. General conditions of organoleptical assessment.” In the plant additive, there was determined the content of trace elements, i.e., iodine according to the GOST R 31660-2012 “Foods. Anodic stripping voltammetric method of iodine mass

concentration determination" and selenium according to the GOST 31707-2012 "Foodstuffs. Determination of trace elements. Determination of the total arsenic and selenium by hydride generation, and absorption of the spectrometry (HGAAS) after pressure digestion." Their values were compared with the daily requirement. The balance of nutritional components was also established. It included the weight fraction of protein in accordance with the requirements of the GOST 25011-81 "Meat and meat products. Methods of protein determination," amino acids according to the GOST R 55569-2013 "Feedstuffs, compound feeds, feed raw materials. Determination of proteogenic acids using capillary electrophoresis," fat by the express method according to the GOST 23042-2015 "Meat and meat products. Methods of fat determination," carbohydrates according to the GOST 31470-2012 "Poultry meat, edible offal and semi-processed products. Methods for organoleptic and physico-chemical examinations" and vitamins. At the final stage of the investigation, the direct production cost and profits from an enterprise of a small-scale production of boiled-smoked sausages were calculated.

Statistical analysis

The data on different variables, obtained from the experiment, were statistically analyzed by Statistica 10 package (StatSoft Inc.). The significance of differences between the indices was determined using the criteria of nonparametric statistics for the linked populations (differences with P<0.05 were considered significant: [a]P<0.001; [b]P<0.01; [c]P<0.05; ns = not significant at P>0.05). Student's t-test was applied for the statistical analysis. The mean of a set of measurements was calculated according to the formula: $\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n}$, where is a mean value; $\sum_{i=1}^{n} x_i$ is the sum of all x_i with i ranging from 1 to n, n is a number of measurements. The residual variation is expressed as a root mean square error (*r.m.s.e.*): $\sigma = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n-1}}$ The standard error of mean (*s.e.m.*) was calculated by the formula: $s.e.m.(\bar{x}) = \frac{\sigma}{\sqrt{n}}$. The reliability of a sample difference (*Student's t-distribution*) was estimated by the test of the difference validity, which is the ratio between the sample difference to the non-sampling error. The test of the difference validity was determined by the formula: $t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{s.e._1^2 + s.e._2^2}} \geq t_{st}(d.f. = n_1 + n_2 - 2)$, where t is a Student's t-distribution; $(\bar{x}_1 - \bar{x}_2)$ is a difference of the sample mean measurements; $\sqrt{s.e.m._1^2 + s.e.m._2^2}$ is a sample difference error; $s.e.m._1$, $s.e.m._2$ is a non-sampling error of the sample statistics compared; t_{st} is a standard criterion according to the t-Table for the probability threshold preset depending on degrees of freedom; n_1, n_2 is a number of measurements in the samples compared; *d.f.* is a degrees of freedom for difference of two mean measurements (5).

Features of the functional additive

Healthy lifestyle has become more popular among different age groups of the population, which has in turn contributed to an increase in demand for healthy products including foods with high content of dietary fiber, vitamins and minerals. To enrich the products, a variety of raw materials and, first of all, grain is used. However, in the production of grain raw materials, the most valuable parts are removed. In this respect, seedlings are of special interest. The germination of the grain substantially causes an increase in the content of many substances, and its biological value rises. The grain glume fiber in food strengthens the intestinal peristalsis, normalizing the process of digestion.

Wheat germs provide stable operation of vital processes in the body, improve metabolism, increase immunity and normalize the intestinal microflora due to the available dietary fibers, have a beneficial effect on the digestive system and liver function, remove cholesterol and the products of cell activity from the body and promote active ageing. Chickpea sprouts contain high-quality proteins, fats, fiber, a large amount of calcium and minerals such as magnesium and potassium; in addition, they contain vitamins A and C. They exceed other legume crops by the number of main essential acids – methionine and tryptophan.

The functional additive consists of "Don" chickpea enriched with iodine and "Kamyshanka-4" wheat enriched with selenium. The wheat and chickpea breeds are widespread in the South of the Russian Federation. The plant component underwent a gradual preparation: wheat and chickpeas were washed, germinated on solutions of key microelements, washed, dried, extruded, then hydrated and added at the stage

of forcemeat. Chickpea is known to contain about 2% of phytic acid that is an antinutrient preventing the absorption of nutrients, such as potassium, magnesium, iron, calcium, zinc, phosphorus and other macro- and micronutrients (6). Therefore, in order to increase the absorption of minerals by the body, the chickpea was previously soaked in an acidic medium (pH 3.5-4.0) to inactivate phytic acid that would form chelate complexes with metals and remove them from the body. The phytase enzyme formed during soaking inactivated the phytic acid (7). The technological scheme for obtaining the additive is shown in Figure 1. The total protein content in wheat was about 12%, and in chickpea up to 30%. The mixing of these two cultures with the predominance of chickpeas made it possible to obtain a balanced amino acid functional additive. A mixture of that kind added to the sausage products slightly increased the values of protein, but noticeably enriched the finished product with amino acids and key trace elements.

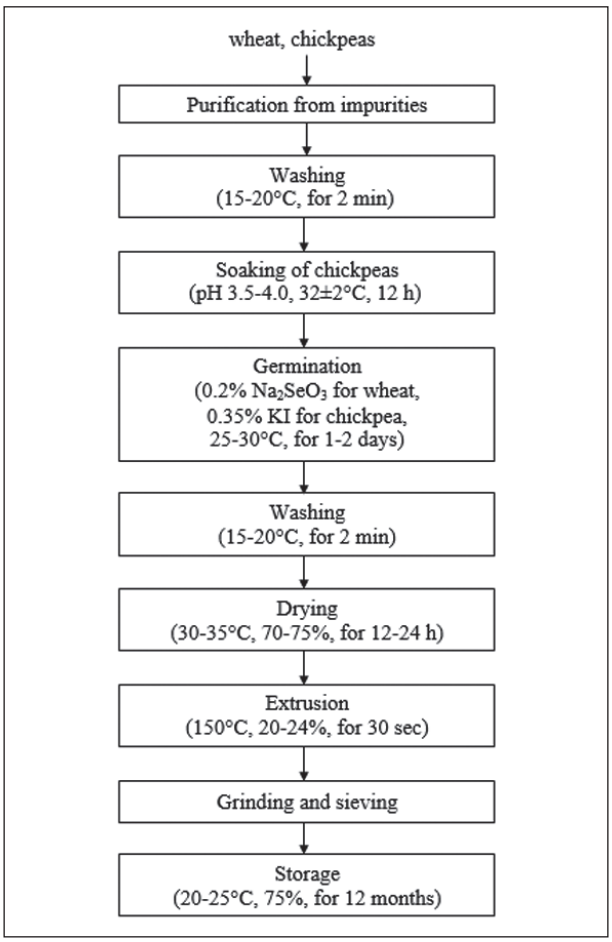

Figure 1. Technological scheme for obtaining a plant additive

Extrusion is one of the proven ways to increase the nutritional value of the grain mass. During the extrusion, the starch decomposes into simple sugars, the harmful microflora is disinfected, and the vitamins and acids contained in the cereals are preserved almost completely due to the short-term process (8). Grain extrusion increased the digestibility of dry matter by 2.1%, organic matter by 1.9, crude protein by 4.5 and raw fat by 3.8% (9). As a consequence, it is necessary to emphasize the main positive effects of the extruded plant additives of our own design. These are:

- simplification of the technology in comparison with enrichment methods known;
- improving the quality of plant materials; and
- increase in the content of vital elements, in particular iodine and selenium.

The mechanism of action of salt solutions on the plant component should also be noted. Solutions of sodium selenite and potassium iodide affected the permeability of cell membranes of chickpea and wheat seeds, including facilitating loosening of their membranes, which led to an active diffusion of iodine and selenium ions from the solution into the internal space of the seeds. Further, the process of assimilation of the incoming ions occurred, resulting in formation of new bio-accessible organic iodine and selenium-containing structures. Selenium is considered as an iodine synergist, so a more complete and intensive conversion of trace elements occurred (10, 11).

Method of production of boiled-smoked sausages

The method proposed for the production of boiled-smoked sausage products included the following stages: preparation of meat raw materials, salting, mincing of salted raw material, preparation of a vegetable component, formation of forcemeat, filling casings and sausage twine wrapping, sludge, heat treatment in universal heat chambers, drying and cooling of the finished product. In all model experiments, the basic recipe for boiled-smoked "Delicatesnaya" sausage of premium quality was used, taking into account the requirements of the GOST R 55455-2013 "Boiled-smoked meat sausages. Specifications." The production cycle of the boiled-smoked sausage lasted 5 days. The recipe of our own development

(Table 1) is notable for an equal ratio between beef and pork, a reduced content of table salt, increased spice content and adding of hydrated plant additives at the stage of forcemeat formation. The dose of application was 15% of the hydrated additive in place of meat raw materials.

Results and discussion

First of all, an organoleptic assessment of the finished product was carried out. Its results are presented in Table 2. No deviations were observed when compared with the control sample.

In general, it can be noted that the organoleptic indices of the test sample did not differ much from those of the control sample. The obtained results showed that the introduction of the hydrated plant additive into the test sample had practically no effect on the organoleptic indices. With respect to the consistency criterion, the elasticity of sausage links was noted to enhance, the color was tinctured with a slightly noticeable yellowish hue, which could be explained by the presence of the extruded plant additive. Chickpea and wheat had a stabilizing effect on forcemeat, as they contained dietary fiber and gluten in their composition. Due to these components, water in forcemeat was completely bound, fat was partially bound, so the forcemeat had a more viscous and elastic consistency. The use of forcemeat of that kind in filling decreased the probability of voids in sausage links and fatty stains in the finished product. These factors did not affect the taste of the product and did not worsen its appearance (11). However, further increase in the dose of the additive caused deterioration of the organoleptic parameters: a clearly expressed a yellowish tinge on the cut and a pea flavor appeared. Therefore, at this stage of the study, the selected dose of the plant additive to the product was considered optimal.

When preparing the forcemeat for the control and test samples of boiled-smoked sausages, the viscidity and plasticity of the forcemeat was visually noted to enhance, depending on the proportion of the vegetable additive; therefore, an experimental study of these factors was performed. This experiment was carried out three times; the results given in Table 3 are the averaged values.

The samples under study showed an increase in plasticity and shear stress, which resulted in a forcemeat with a more viscous and dense consistency. The use of forcemeat of that kind in filling decreased the

Table 1. Formuation for boiled-smoked sausages with vegetable additive

N°	Name of raw material	Value
Raw material unsalted		
1	Pork trimmed, 1st grade	32.50
2	Semifat pork trimmed	32.50
3	Pork fat back	20.0
4	Flour from sprouted wheat and chickpeas enriched with selenium and iodine	5.0
5	Water for flour hydration	10.0
TOTAL raw unsalted, kg		100.0
Spices and materials		
6	Nitrite salt	2.15
7	Sand sugar	0.20
8	Pepper black	0.20
9	Garlic fresh	0.30
10	Nutmeg	0.04
11	Phosphate food grade	0.30
12	Rice fermented	0.05
13	Drinking water	4.0
TOTAL raw materials, spices and materials, kg		107.24
Product yield, kg (%)		101.90 (95)

Table 2. Organoleptic parameters of boiled-smoked sausages

Parameter	Value	
	control sample	test sample
Appearance	link sausage with a clean dry surface, free of blemishes, damages or purges	
Colour	the surface is dark red; on the cut, from light pink to dark red	the surface is dark red; on the cut, from light pink to dark red with a barely noticeable yellowish tinge
Flavor	pronounced meat flavour with aroma of smoking and spices	
Consistency	elastic, fat cubes are evenly distributed, forcemeat is without gray spots or voids	elastic, fat cubes are evenly distributed, forcemeat is without gray spots and voids, there are subtle inclusions of ground plant additives
Taste	pleasant meat taste, slightly spicy, moderately salty, no foreign flavor, characteristic for this type of product	

Table 3. Structural and mechanical properties of forcemeat

Index	control sample (without plant additive)			test sample (15%)		
	mean	s.e.m.	P*	mean	s.e.m.	P*
Plasticity, cm^2	2,8	0.1	c	3,4	0,1	c
Limit shear stress, Pa	4,2	0.1	c	4,6	0.1	c

*Note: a – P<0.001; b - P<0.01; c – cP<0.05; ns – not significant at P>0.05.

probability of voids in sausage links, and the packing density increased. The improvement of structural and mechanical properties of forcemeat directly depended on the amount of the vegetable additive: the more amount of hydrated flour was added, the higher these indices were. Germination of chickpea and wheat seeds on solutions of iodine and selenium did not affect these indices.

The component composition of the developed product and its compliance with the physiological norms of the daily human need are presented in Table 4. The content of key trace elements increased due to the functional additive. The content of iodine and selenium in the test sample did not exceed the allowable values. In the control sample, selenium and iodine were not detected. The recommended daily rate of consumption of boiled-smoked sausage is 70 g.

Table 4. Balance of nutrient components in functional boiled-smoked sausage

N°	Index	Indicator value				Daily rate
		g / 70 g of product		% of daily allowance		
		mean	s.e.m.	mean	s.e.m.	
1	Amino acids, g	13.73	0.02	22.90	0.03	60.0
2	PUFA, g	1.72	0.01	13.23	0.08	13.0
3	MUFA, g	11.31	0.02	21.75	0.04	52.0
4	UFA, g	9.20	0.04	26.28	0.11	35.0
5	Carbohydrates, g	3.36	0.50	0.84	0.13	400.0
6	Water, g	35.72	1.42	1.78	0.07	2000.0
7	Dietary fiber, g	0.26	0.01	1.73	0.07	15.0
	Vitamins:					
8	A, mg	0.25	0.01	24.60	0.70	1.0
9	B_1, mg	0.60	0.02	29.80	1.10	2.0
10	B_2, mg	0.17	0.04	5.60	1.17	3.0
11	PP, mg	3.27	0.10	16.33	0.52	20.0
12	B_5, mg	0.75	0.03	7.53	0.34	10.0
13	B_6, mg	0.53	0.05	26.70	2.70	2.0
14	B_9, μg	5.77	0.04	2.88	0.02	200.0
15	B_{12}, μg	2.18	0.01	109,00	0.50	2.0
16	E, mg	0.89	0.01	3.56	0.05	25.0
17	C, mg	0.12	0.02	0.19	0.03	60.0
	Minerals:					
18	Iodine, μg	20.30	2.40	13.53	1.60	150.0
19	Selenium, μg	11.60	0.88	16.60	1.26	70.0

However, the recommended rate of consumption of the finished product will not fully satisfy any of the nutritional components presented. It must be taken into account that the diet should include not only sausages, but also other food products; therefore, the composition presented is quite adequate. In addition, the consumption of functional foods within the norm should satisfy no more than 40% of the daily requirement for the key elements contained in this product (12).

Traditional sausage products contain a small amount of vitamins; their main source is meat raw material. The introduced vegetable component enriched the product with vitamins; new vitamins appeared in the composition, and the content of already available vitamins increased. During the heat treatment, most of the vitamins were destroyed. Nevertheless, the content of certain vitamins increased, for example, pyridoxine and niacin by the factor of 1.5, riboflavin, thiamine and cobalamin by the factor of 2, folic acid 3 times and the content of vitamin A substantially enhanced.

The amino acid composition of the samples of boiled-smoked sausages was also examined; the results are shown in Fig. 2. The study was carried out according to the procedure in the GOST R 55569-2013 using capillary electrophoresis system "Kapel-105M"

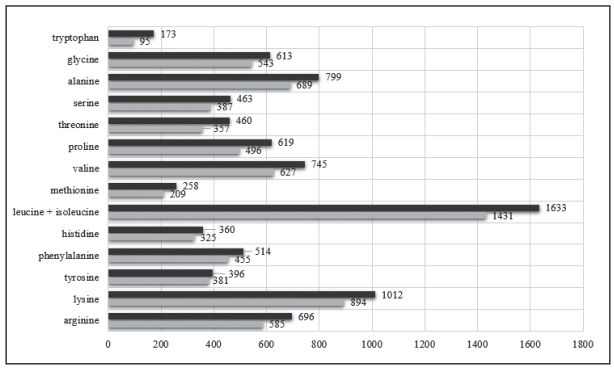

Figure 2. Amino acid composition of boiled-smoked sausages with a functional additive: gray is for boiled-smoked sausage with 10% functional additive; black is for boiled-smoked sausage with 15% functional additive

("Lumex-marketing," Russia). The method involved decomposing of a sample for analysis by acid hydrolysis with amino acids to be transformed into free forms, producing phenylthiocarbamyl (PTC) derivatives of amino acids, their further separating and quantitative determinating by the capillary electrophoresis. The amino acid composition was determined in two samples of the boiled-smoked sausages, i.e.:

- a boiled-smoked sausage product with a functional additive in an amount of 10% of the mass of unsalted raw material; the additive is a mixture of wheat and chickpea in a ratio of 1: 2, enriched with selenium and iodine; and
- a boiled-smoked sausage product with a functional additive in an amount of 15% of the mass of unsalted raw material enriched with iodine and selenium.

According to the results obtained, it can be concluded that an increase in the weight fraction of the plant additive in the product formulation contributed to an increase in the values of the amino acid composition of the product. The content of lysine and methionine, initially deficient amino acid components of the plant supplement, increased. Consequently, the ratio between chickpea and wheat in the functional additive was chosen optimally. However, the taste qualities of the developed sausage product should be also taken into account, because increased level of the additive over 15% caused deterioration of organoleptic characteristics.

At the final stage, the direct costing calculation of production was carried out. To calculate the production costs and payback period, OOO Volgograd Meat Processing Plant was chosen. This enterprise has been in business for a long time, its daily output reaches 140 tons of finished products, their main part (about 40 tons) are sausages. Volgograd Meat Processing Plant has a necessary list of equipment and facilities, so to implement our own development, minimum equipment and materials were purchased. The volume of production was 100 kg per day, provided that each new technological cycle started only on weekdays.

The results of the costs calculation for the production of functional boiled-smoked sausage are presented in Table 5. The total cost of the raw materials consumption, auxiliary materials and energy resources spent amounted to € 57970.7 per year. The larg-

Table 5. Costs calculation for boiled-smoked sausage of functional orientation

N°	Cost item, unit of measure	Norm for consumption, kg / t	Consumption rate, kg per year	Planned and procurement price, € / kg	Cost of consumption, € per year
Main raw materials					
1	Beef sturgeon, 1st grade	320.0	7094.0	3.0	21282.0
2	Semifat pork trimmed	320.0	7094.0	2.8	19863.2
3	Pork fat back	197.0	4865.9	1.3	6325.7
4	Flour from sprouted wheat and chickpeas enriched with selenium and iodine	50.0	1235.0	0.3	370.5
5	Water for flour hydration	99.0	2445.3	0.1	244.6
6	Nitrite salt	21.5	531.1	5.8	3080.4
7	Sand sugar	2.0	49.4	0.4	19.8
8	Pepper black	2.0	49.4	2.6	128.5
9	Garlic fresh	3.0	74.1	0.7	51.9
10	Nutmeg	0.4	9.9	7.2	71.3
11	Phosphate food-grade	3.0	74.1	0.8	59.3
12	Rice fermented	0.5	12.4	1.5	18.6
13	Drinking water	39.0	963.3	0.1	96.4
TOTAL main raw materials		1057.4	24497.9	–	51612.2
Auxiliary materials					
14	Clips, pcs.	1200.0	29640.0	0.5 € / 1000 pcs.	14.9
15	Synthetic casing «Belkozin», m	700.0	17290.0	5.8 € / bobbin (500 m)	200.6
16	Label paper	0.1	2.5	2.2	5.5
17	Wooden boxes returnable, pcs	40.0	20.0	3.6	72.0
18	Parchment substitute	0.6	14.9	0.9	13.4
19	Chipped wood for smoking	7.2	177.8	0.2	35.6
TOTAL auxiliary materials		–	–	–	342.0
Energetic resources					
19	Electricity, kWh	2262.2	55876.4	0.1	5587.7
20	Water, m^3	86.8	2144.0	0.2	428.8
21	Gas, m^3	–	–	62.9 € / 1000 m^3	–
TOTAL energetic resources		–	–	–	6016.5

est share of costs (€ 51612.2 per year) was the total consumption of main raw materials. The planned procurement prices were obtained taking into account the average inflation rate calculated for the last five years. The cost of wheat and chickpeas enriched with iodine and selenium included the cost of sodium selenite and potassium iodide.

The project cost calculation of the functional boiled-smoked sausage is presented in Table 6. It includes cost of raw materials, energy resources, labor, social insurance contributions, equipment maintenance expenses, shop's expenses and other production and non-production costs.

Calculating the equipment maintenance expenses took into account only the purchased equipment. The conversion factor is 15%.

The workshop's costs included the following articles:

- depreciation of equipment;
- expenses for repairing buildings, constructions and equipment;
- costs of laboratory examination of the quality of raw materials and finished products;
- expenses for labor protection measures;
- expenses for depreciation of low-value and wearing parts of the workshops and the costs of repair and restoration during operation; and
- other expenses.

Many of the shop's costs listed above were not calculated, since they had already been taken into account in the current production. The equipment depreciation equaled the cost of the equipment itself, the cost of inventory repair amounted to € 428.6 per year, the cost of laboratory examination of the quality of raw materials and finished products was € 571.5 per year and expenses for depreciation of low-value and wearing equipment was €214.3 per year.

Other production costs took into account deductions for compulsory property insurance, i.e., 2% of the cost of equipment and inventory, and payments for maximum permissible discharges and emissions € 214.3 and 357.2 per year, respectively, in terms of the production implemented.

The non-production costs were expenses related to the sale of manufactured products that belonged to a full cost price in addition to its production cost. For sale, finished products were transported to retail locations in Volgograd and branded outlets of the Volgograd Meat Processing Plant. The average delivery cost by road was € 8.6 per lot.

The initial annual output was 24.7 tons. The cost price of one sausage link weighing 0.5 kg was € 1.5, which was a good result. In 2017, the average cost of boiled-smoked sausages was 4.9 € / kg. Taking into account recent cases of price increases and unstable economic situation in the country, the recommended selling price was 5.8 € / kg. At a given production capacity of the production, the annual revenue was € 143260; after deduction of the full cost price, the profit was estimated at 64939.1 € / year.

Table 6. Project costs calculation for functional boiled-smoked sausage

N°	Article of calculation	Expenses, € per year	Cost price, € per ton
1	Raw materials and basic materials	51954.2	2103.4
2	Energy resources for fuel and technological purposes	6016.5	243.6
3	Labor costs for production workers	6228.6	252.2
4	Social insurance contributions	5382.9	218.0
5	Equipment maintenance expenses	898.6	36.4
6	Shop's expenses	6394.3	258.9
	TOTAL shop costs	76875.1	3112.5
7	Other production costs	311.5	12.7
	TOTAL production cost	77186.6	3125.2
8	Non-production costs	1134.3	46.0
	TOTAL full cost	78320.9	3171.2

Conclusions

Thus, a functional boiled-smoked sausage processing was developed and a comprehensive study of consumer properties of finished products was carried out. The purpose was to obtain products with an increased content of bio-available trace elements, i.e., iodine and selenium, as well as a more balanced amino acid composition without loss of quality and deterioration of the organoleptic composition. Not all products on the market have a balanced protein composition and sufficient content of essential trace elements, which causes a metabolic disorder and increased exposure of disease. The proposed product has an improved

component composition; its intake will reduce the risk of iodine and selenium deficiency, diseases caused by inadequate protein intake, as well as improve the digestive processes in the intestine due to the available in the product dietary fiber. The developed vegetable additive is recommended to be added not only to boiled-smoked sausages, but also to other meat products.

The comparative analysis of the control and test samples of boiled-smoked sausages made it possible to emphasize the following advantages of the functional product:

- the introduction of the plant component improved the structural and mechanical properties of forcemeat, such as viscosity and ultimate shear stress;
- the organoleptic properties practically did not change: the color acquired an almost noticeable yellowish hue and the consistency became more elastic;
- the output of finished products increased to 95% of the mass of unsalted raw materials;
- the balance of nutritional components in boiled-smoked sausages improved;
- the content of key trace elements-iodine and selenium-increased;
- the amino acid composition of the finished product improved; and
- the cost price of the finished product decreased due to the reduction in the cost of the recipe by a partial replacement of meat raw materials with vegetable material.

The product meets the requirements of the Russian Federation state policy in the field of healthy nutrition for the period until 2020, the most important task of which is the development of food production that contributes to the preservation and promotion of health of various groups of the population. The introduction of the processing technology into the existing production will allow the products to occupy a worthy place in the sausage market.

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