

Розглянута можливість використання борошна сої та нуту зерна, яких пророщено у розчинах мінеральних солей. Досліджена можливість його використання у виробництві варено-копчених ковбас за рахунок зменшення м'ясної сировини. Отримані закономірності будуть використані під час розробки технології варено-копчених ковбас збагачених на йод та селен, дефіцит яких спостерігається у 17 % населення світу.

У результаті дослідження встановлено, що у всіх дослідних зразках спостерігалось покращення структурно-реологічних характеристик порівняно з контролем. Встановлено, що використання борошна бобових пророщених у розчинах мінеральних солей впливає на зміну рН м'ясних фаршів. Зразки із їх використанням мають рН на 0,2; 0,4; 0,7 °Т менше. У всіх дослідних зразках спостерігається зміна забарвлення від темно-червоного (контроль) до жовто-рожевого та жовто-сірого. Вміст масової частки йоду та селену у зразках, де використовували борошно бобових зерна, яких пророщені у розчинах мінеральних солей 5; 10; 15 % становили 13; 26; 39 мкг за вмістом йоду та 12,5; 25; 37,5 мкг за вмістом селену. Вміст незамінних амінокислот збільшується на 1,609; 2,756; 4,012 мг/100 г порівняно із зразками, де використовували борошно пророщених бобових у воді та на 2,134; 5,594; 8,468 мг/100 г порівняно із контрольним зразком. Загальний вміст замінних амінокислот зростає на 3,128; 6,254; 9,380 мг/100 г порівняно із контрольним зразком та на 1,054; 2,100; 3,150 мг/100 г порівняно із зразками, де використовували борошно бобових, пророщених у воді.

Визначені закономірності є науковим підґрунтям для розробки технології виробництва варено-копчених ковбас збагачених на йод, селен та амінокислоти. Розроблений продукт зможе скорегувати структуру харчування населення, яка має суттєві відхилення по споживанню мікроелементів

Ключові слова: борошно бобових, варено-копчені ковбаси, йод-дефіцит, селен-дефіцит, соя, нут, амінокислоти

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SUBSTANTIATING THE USE OF GERMINATED LEGUME FLOUR ENRICHED WITH IODINE AND SELENIUM IN THE PRODUCTION OF COOKED-SMOKED SAUSAGES

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1. Introduction

Today, the structure of the population's diet has significant deviations from the formula of a balanced diet,

primarily in the level of nutrient consumption, which leads to the formation of risk factors for the development of many alimentary and alimentary-dependent diseases. In many European countries, as well as in Ukraine, alimentary defi-

cits are widespread. Micronutrient deficiencies were found in 34 % of the population, among which iodine and selenium occupy leading positions [1]. Meat products, namely cooked and smoked sausages can be considered as a basic basis for the development of health products that will provide the human body not only with complete protein but with iodine and selenium [3]. It is important to develop cooked-smoked sausages from a combination of meat and vegetable raw materials enriched with iodine and selenium, which is possible due to the use of legume flour which is germinated in mineral solutions. Today, the range of such foods on the market is insufficient [4].

2. Literature review and problem statement

It is known that the use of meat products, and especially cooked-smoked sausages as health products, has so far been almost neglected in scientific circles [5]. However, the views of scientists have changed and now meat products are considered one of the main contenders for basic products for enrichment [6–8]. In this regard, the world is researching this area, which will make this scientific area a relevant field for research [9–11].

The analysis of the literature data shows that a promising direction in the development of enriched sausages is the use of germinated bean flour [12–14]. In [15], during the improvement of the technology of semi-smoked sausages, sprouted pea flour was used, due to which the mass fraction of bound moisture increases, the yield of finished products improves. The cost of new sausages was reduced by 10 and 15 %. “Economic attractiveness” for the manufacturer was substantiated. However, taking into consideration the imbalance of sausages in nutritional composition, it was useful to provide data on the content of amino acids and other nutrients, which are carried by the flour of sprouted peas.

In works [16, 17], where the technology of cooked sausages with lentils and spicy-aromatic herbs of thyme and juniper fruits was developed, the expediency of using native lentil flour was proved. The effect of native flour and germinated lentil flour on the physical and chemical characteristics of finished products was studied. It was found that products made using native flour have a better microstructure, but are inferior in protein content, which increases in products that used germinated lentil flour.

A similar pattern is described in paper [18], where the change in the amino acid composition of mash grain during the germination process was proved. It was found that the total content of amino acids in native grain and grain germinated in aqueous solutions increases from 288.8 to 443.6 µg/g of dry matter, respectively. However, in contrast to the above works, researchers proved the benefits of using flour from germinated mash grain over native grain not only as an enriching but also as a structuring ingredient.

In work [19], the issue of sausage enrichment with essential micronutrients, such as iodine, selenium, which are not contained in raw meat, and in vegetable, if any, in meager quantities, remained unresolved. This may be due to difficulties associated with the emergence of specific organoleptic characteristics and unstable micronutrient composition, which directly depends on the organic or mineral bond of the micronutrient-enrichment [20].

To replenish the body's reserves, micronutrients can come in two types of bonds – mineral (inorganic) and organ-

ic. In the case of iodine, mineral iodine is iodine that is not bound to any organic molecule (alcoholic iodine solution, iodides and potassium iodates, etc.) [21]. Organic iodine is iodine that is chemically bound to any organic compound (sugar, amino acid) [22]. Organically bound micronutrients do not take part in most chemical reactions when they enter the human body. This favorably distinguishes organically bound micronutrients from any source of micronutrients with an inorganic bond, because the possibility of overdose is excluded [23].

There is a method of producing soy flour germinated in an aqueous extract of kelp *Laminaria japonica* or *Laminaria saccharina*, [24]. The essence of the method is the germination of soybeans in an aqueous extract of kelp *Laminaria japonica* or *Laminaria saccharina* that includes hydromechanical grain processing and grinding. The proposed method makes it possible to obtain a product containing iodine, but the weakness of this method is the low content of a vital trace element – iodine and unexplored use of the developed flour in the sausage production.

Studies are underway [25, 26] on the development of cooked sausages with the combined use of germinated soybean flour with seaweed as an organic carrier of micronutrients. The producers developed a technology in which the finished products have an improved amino acid composition, are carriers of iodine, selenium, zinc, and other microelements. However, the use of seaweed in the amount of more than 15 % by weight of raw meat has the effect of reducing organoleptic characteristics.

An option to overcome the corresponding difficulties may be the use of flour germinated in a solution of sodium hydro selenite (NaHSeO_3), chickpea grain, and germinated in a solution of potassium iodide (KI) soybeans. In papers [27, 28], it was proved that in the composition of sprouted soybeans and chickpeas 90 and 95 % of iodine and selenium are in the cotyledon in the protein fraction. This indicates a high degree of conversion of micronutrients into organic form during their germination in solutions of mineral salts. As there is insufficient data to address the above issues, it is necessary to deepen and expand research in this area.

3. The aim and objectives of the study

The study aims to substantiate the use of germinated legume flour enriched with iodine and selenium in the production of cooked and smoked sausages.

To achieve this goal, the following tasks were set:

- to investigate the dependence of changes in acidity and structural and rheological parameters of minced cooked and smoked sausages on the use of soybean flour and chickpeas, the grains of which are germinated in different media on the share of raw meat substitutes;

- to investigate the dependence of changes in organoleptic, physical and chemical parameters of cooked-smoked sausages on the use of soybean and chickpea flour, the grains of which are germinated in different media, on the share of raw meat substitutes;

- to study the dependence of changes in the amino acid composition of cooked- smoked sausages on the use of soybean and chickpeas flour, the grains of which are germinated in different media on the share of raw meat substitutes.

4. Methods, raw materials, and technologies used in the research

4.1. Raw materials, experimental test sample solutions

Grains of early-ripening soybean variety – “Diamond”, grains of early-ripening variety of chickpea “Krasnokutsky 195”, ripening period 95...105 days, 2018 harvest. Samples of the collection nursery “Agrotek” Kyiv (Ukraine). Characteristics of soaking solutions: sodium hydro selenite (NaHSeO₃), 39 g per 1,000 cm³ of H₂O, potassium iodide (PI) 76.5 g per 1,000 cm³ of H₂O, soaked for 48 hours at a temperature of 17...19 °C. Experimental samples were prepared as follows: germinated soybean chickpea flour was added to the meat raw materials in the amount of 5, 10, 15 % in a ratio of 1:1, due to the reduction of meat raw materials, namely: lard of pork and trimmed, semi-fat pork. They were stirred, then the spices – salt, sugar, black pepper, fresh garlic, and nutmeg – were added. After cooking the minced meat was filled into the protein shell. After that, the shells were filled with minced meat using hydraulic piston syringes under pressure of 1.3...1.5 MPa. Filled loaves were compacted from the open end by hand and tied with twine, precipitated for 2 days at a temperature of 6...8 °C, heat-treated with a smoke-air mixture obtained during the hardwood burning, smoked at a temperature of 75 °C for 2 hours, cooked with a steam-air mixture in steam cooking chambers at 74 °C for 60 minutes, cooled for 6 h at a temperature not exceeding 20 °C, dried for 6 days in drying chambers at a temperature of 10...12 °C and a relative humidity of 75 %.

4.2. Determining the acidity and structural-rheological parameters of cooked-smoked sausage mince

The dependence of the bound moisture content, in % to the total moisture in the product (BMC), change in emulsion stability, change in emulsifying ability, shear stress, ductility, and acidity, were determined by the methods described in [29].

4.3. Studying the organoleptic parameters of cooked-smoked sausages

Organoleptic parameters were determined under DSTU 4591:2006 “General technical conditions for cooked and smoked sausages” during an open tasting in five different consumer groups. The commissions were attended by qualified specialists familiar with the production technology and tasting rules. Cooked and smoked sausages were tested for such parameters as color, structure and consistency, the appearance of the surface of the slices, taste, and smell. The products were evaluated according to verbal and point systems of tasting evaluations.

The mass fraction of moisture in the experimental samples of cooked and smoked sausages was determined on the device “Chizhova” by drying method (LLC Olis, Ukraine). The prepared sample was weighed, fixing the mass of the sample under study and the mass of the sample with paper. The sample was fixed on the plate of the apparatus heated to a temperature of 100...105 °C, closed and dried. After that, it was weighed every 20 minutes until the mass became constant, indicating the absence of moisture in the sample. The experiment was performed in parallel in 2 analyzes and the average value was taken as the result.

The mass protein fraction was determined according to GOST 25011 by the Kjeldahl method. The method is based

on the mineralization of organic substances of the sample by the subsequent determination of nitrogen by the amount of formed ammonia.

The fat mass fraction was determined under GOST 23042 by the refractometric method. The fat mass fraction in the samples of the cooked and smoked sausage was determined by the difference between the refractive indices of the solvent and the solution of fat in the solvent.

The mass fraction of iodine and selenium was determined using a voltammetric analyzer “AVA-2” and “AVA-3” (Burevesnik, Russia). Statistical data processing was performed using the Statistical 10.0 programming environment.

The study of color characteristics (spectrophotometric studies) was performed by the colorimetric method. On the spectrophotometer CI 7860, (X-Rite manufacturer, USA), which is used to control color change at all stages of production, including food by well-known methods [30].

4.4. Studying the amino acid composition of cooked-smoked sausages

Analysis of the amino acid composition of the test samples was performed by ion exchange and liquid chromatography on an amino acid analyzer AAA T-339M (Czech Republic) and liquid chromatograph TM Shimadzu LC-20 (Japan).

The samples were prepared as follows: portions weighing 0.5 g were filled with 15 cm³ of distilled water and 18 cm³ of concentrated sulfuric acid, dried in an oven (*t* –130 °C) for 7.5 hours, filtered, washed with distilled water, evaporated on an electric stove to a volume of 0.5...1.0 ml and passed through a membrane filter with a diameter of 0.45 μm.

The prepared samples were loaded into the ion exchange column of the analyzer of the device. Then the analysis was performed automatically for 100 minutes. After completion of the analysis, the obtained chromatogram was decoded and the peak areas of each amino acid were calculated.

Tryptophan in acid hydrolysis of the protein is almost completely decomposed, so its determination was performed on a liquid chromatograph TM Shimadzu LC-20. The sample was subjected to alkaline hydrolysis (NaOH at 100 °C, 16...18 hours in the presence of 5 % tin chloride). The hydrolysate after neutralization by a mixture of the citric and hydrochloric acids (for the prevention of gem formation) was analyzed on an amino acid analyzer. Statistical data processing was performed in the Statistical 10.0 programming environment.

5. Results of studying the use of germinated bean flour enriched with iodine and selenium in the production of cooked-smoked sausages

5.1. Studying the acidity, structural and rheological parameters of cooked- smoked sausage mince

The change in acidity and structural and rheological parameters of minced cooked-smoked sausages from the use of flour of soybeans and chickpeas, germinated in a different medium, depending on the share of raw meat substitution, was studied.

The dependence of bound moisture content, in % to total moisture in the product (BMC), change of emulsion stability, change of emulsifying ability, shear stress, plasticity, and acidity of minced systems of cooked-smoked sausages on the share of raw meat substitution was studied. The results are given in Table 1.

Table 1
Dependence of changes in acidity, structural and rheological parameters of minced meat on the use of soybean and chickpea flour, the grains of which are germinated in different media, on the share of raw meat substitutes

Sample	pH,	BMC _a , %	Emulsion stability, %	Emulsifying ability, %	Shear stress, Pa	Plasticity, cm ² /g
Control	5.8±0.2	74±0.6	40±0.6	73.5±0.5	595±2.6	20.5±0.9
D. 1 5 %	5.8±0.6	76±0.8	41±0.5	73.7±0.3	605±3.5	22.2±0.6
D. 2 5 %	6.0±0.4	81±0.5	43±0.6	80.5±0.9	617±2.0	24.1±0.8
D. 3 10 %	5.8±0.3	79±0.9	44±0.8	75.1±0.6	615±1.6	25.3±0.6
D. 4 10 %	6.2±0.2	83±0.8	46±0.6	82.6±0.9	622±1.2	27.5±0.8
D. 5 15 %	5.8±0.6	81±0.9	47±0.9	77.2±0.9	620±1.1	28.3±0.9
D. 6 15 %	6.5±0.7	87±0.6	49±0.7	84.7±1.0	626±0.6	31.2±0.5

Note*: K – Control (without flour). D. 1; D. 3; D. 5 – sample of minced meat, in which a flour from germinated beans in aqueous solutions are used, the share of raw material substitution is 5; 10; 15 % (respectively). D. 2; D. 4; D. 6 – sample of minced meat, in which a flour from germinated beans in the solutions of mineral salts (soybean is in potassium iodide solutions, chickpea is in sodium hydro selenium solution), the share of meat raw material substitution is 5; 10; 15 % (respectively).

It was found that the germination of soybean in solutions of potassium iodide and chickpeas in a solution of sodium hydro selenite affects the pH of minced meat in the direction of a less acidic environment. Samples where raw meat was replaced by 5; 10; 15 % of the above flour (D. 2; D. 4; D. 6) have a pH of 0.2; 0.4; 0.7 less than controls and samples of minced meat with grain flour germinated in aqueous solutions (D. 1; D. 3; D. 5). The content of bound moisture in the experimental sample D. 2; D. 4; D. 6 of 7; 10; 13 % (respectively) more than the control and 5; 4; 6 % more compared to samples D. 1; D. 3; D. 5. In all experimental samples, in which the flour of germinated legumes is used, there is an increase in the stability of the emulsion. In samples D. 2; D. 4; D. 6 the stability of

the emulsion was 3; 4; 9 % more (respectively) compared to control and 2 % more compared to samples D. 1; D. 3; D. 5. The replacement of raw meat with sprouted legume flour has affected the emulsifying ability of minced meat to increase it. In the experimental sample D. 2; D. 4; D. 6 this figure increases by 7; 9; 11 % (respectively) compared to control and 7% more compared to samples D. 1; D. 3; D. 5. Shear stress limit of explored minced specimens, where raw meat was replaced by 5; 10; 15 % of legume flour, which is germinated in solutions of mineral salts (D. 2; D. 4; D. 6), increases by 22; 27; 31 Pa compared to control and by 12; 7; 6 Pa compared with the samples (D. 1; D. 3; D. 5). There is an increase in the plasticity of the experimental samples, where raw meat was replaced by 5; 10; 15 % flour germinated in solutions of mineral salts of legumes - (D. 2; D. 4; D. 6) by 4; 7; 11 cm²/g more (respectively) compared to the control and 2; 2; 3 cm²/g more than the samples (D. 1; D. 3; D. 5).

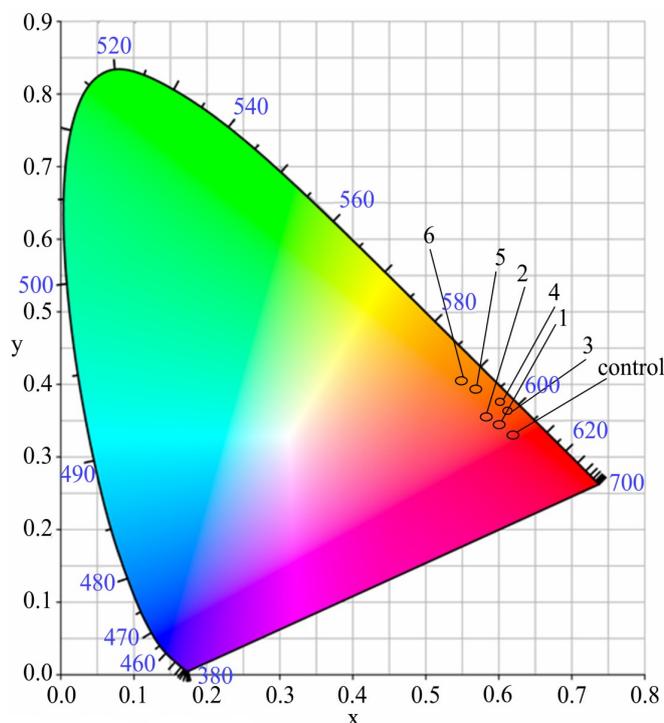
5. 2. The organoleptic and physical-chemical parameters of cooked-smoked sausages containing the flour of soybean and chickpeas whose grains were germinated in different media

The dependence of changes in organoleptic and physical-chemical parameters of cooked-smoked sausages on the use of soy and chickpea flour, the grains of which are germinated in different media, on the share of raw meat substitution was studied. The results of the study of organoleptic parameters are given in Table 2 and shown in Fig. 1. The results of the physical-chemical parameters are given in Table 4.

Table 2
The dependence of change of organoleptic parameters of cooked-smoked sausages on the use of soybean and chickpeas flour, the grains of which are germinated in different media, on the share of change of meat raw materials

Sample	Color	Structure and consistency	Physical appearance of samples' surface	Test and smell	Score
C.	dark red	elastic without cavities	dry, without stains, conglutinations, influx of minced meat	pleasant, slightly spicy, moderately salty, with a pronounced smoking aroma	4.8
D. 1	red	elastic without cavities	dry, clean, without stains, conglutinations, the influx of minced meat	pleasant, slightly spicy, moderately salty, with a pronounced smoking aroma without extraneous taste and smell	4.9
D. 2	red	elastic without cavities	dry, clean, without stains, conglutinations, the influx of minced meat	pleasant, slightly spicy, moderately salty, with a pronounced smoking aroma without extraneous taste and smell	4.9
D.3	yellow-pink	elastic without cavities	dry, clean, without stains, conglutinations, the influx of minced meat	pleasant, slightly spicy, moderately salty, with a pronounced smoking aroma without extraneous taste and smell	5.0
D.4	yellow-pink	elastic without cavities	dry, clean, without stains, conglutinations, the influx of minced meat	pleasant, slightly spicy, moderately salty, with a pronounced smoking aroma without extraneous taste and smell	5.0
D. 5	yellow-gray	solid without cavities	not elastic, fragile	pleasant, slightly spicy, moderately salty, has a pronounced taste of legumes	4.2
D. 6	yellow-gray	solid without cavities	not elastic, fragile	pleasant, slightly spicy, moderately salty, has a pronounced taste of legumes	4.2

Color determining was performed using sensations, which members of the tasting commission expressed verbally. It is known [31] that the color perception in each person is different and depends on the sensitivity of the eye, which arises as a result of the brain processing of information from the visual analyzer. Fig. 1 shows the results of the study of the dependence of the color change of cooked-smoked sausages using the values of color measurements that make it possible for us to explore colors numerically and convey information about them not only through sensations but also through figures.



Samples characteristics on the colorimetric circle

Sample	Peak absorption length, Nm	Color perception	Color intensity, %
Control	605	dark red	100
1	600	red	97
2	595	red	95
3	595	yellow-pink	89
4	597	yellow-pink	87
5	590	yellow-gray	92
6	585	yellow-gray	90

Fig. 1. Dependence of color change of cooked-smoked sausages on the use of soybean and chickpea flour, the grains of which are germinated in different media, on the share of changed meat raw material: Control (without flour); 1, 3, 5 – the sample of cooked-smoked sausage, in which soybean and chickpea flour germinated in aqueous solutions are used, the share of changed meat raw material is 5, 10, 15 % (respectively); 2, 4, 6 – the sample of cooked-smoked sausage, in which soybean and chickpea flour germinated in the solutions of mineral salts (soybeans are in the potassium iodide solutions, chickpeas are in sodium hydro selenum solution) are used, the share of changed meat raw material is 5, 10, 15 % (respectively)

It was found that the peak of the absorption length of the control sample is observed at 605 Nm, which according to the

used method is characterized as dark red. A sample with 5 % germinated bean flour (1 and 2) has an absorption peak at 600 and 595 Nm, respectively, which characterizes the color of the test samples as red. The sample with 10 % legume flour (3 and 4) has an absorption peak at 595 and 597 Nm, respectively, which characterizes the color of the test samples as yellow-pink. The sample with 15 % of legume flour (5 and 6) has an absorption peak at 590 and 585 Nm, respectively, which according to the used method is characterized as yellow-gray. Samples 3 and 4 have almost the same absorption peak with samples 1 and 2 (600; 595 and 595; 597 Nm), but the color saturation of the latter is 8 % higher.

The dependence of change of physical and chemical parameters of cooked-smoked sausages on the used soybean and chickpeas grain flour germinated in different media, on the share of changed meat raw material is studied. The experimental results are given in Table 3.

Table 3

Dependence of change of physical and chemical parameters of cooked-smoked sausages on the use of soybeans and chickpeas flour, the grains of which are germinated in different media, on the share of changed meat raw material

Sample	Mass fraction of moisture, %	Mass fraction of protein, %	Mass fraction of fat, %	Mass fraction of iodide, µg/g	Mass fraction of selenium, µg/g
Control	48±0.2	13±0.5	45±0.4	–	–
D. 1	47±0.1	18±0.3	41±0.2	–	–
D. 2	47±0.5	23±0.4	40±0.4	13.0±0.02	12.5±0.02
D. 3	45±0.4	24±0.5	35±0.5	–	–
D. 4	45±0.2	35±0.5	32±0.5	26.0±0.02	25.0±0.02
D. 5	42±0.5	33±0.2	31±0.4	–	–
D. 6	42±0.5	41±0.5	29±0.5	39.0±0.02	37.5±0.02

The mass moisture content of all experimental samples using germinated bean flour ranged in almost the same range from 42...47 %, there is a decrease in the mass fraction of moisture in the samples with the maximum amount of used flour. In the control sample, the mass fraction of moisture was 48 %. The protein content in the experimental samples D. 2, D. 4, D. 6 increases by 10, 22, 28 % (respectively) compared with the control and by 5, 11, 8 % compared with samples D. 1, D. 3, D. 5.

The fat content in experimental samples D. 2, D. 4, D. 6 is decreased by 5, 13, 16 % (respectively) compared to the control and by 1, 3, 2 % compared to samples D.1, D.3, D. 5.

The content of mass fraction of iodine and selenium in the samples, in which grain flour germinated in solutions of mineral salts (D. 2, D. 4, D. 6) are used, are 13, 26, 39 µg (iodine content) and 12.5, 25, 37.5 µg (selenium content). The content of the above-mentioned microelements in experimental samples D. 1, D. 3, D. 5, and the control sample is not detected.

5.3. The amino acid composition of cooked-smoked sausages containing the soybean and chickpea flour whose grains were germinated in different media

The dependence of changes in the amino acid composition of cooked-smoked sausages on the use of soybean and chickpea flour, the grains of which are germinated in

different media, on the share of raw meat substitution was studied.

The results of the study of the dependence of the change of essential amino acids are given in Table 5. The results of the study of the dependence of changes in substituted amino acids are shown in Table 6.

The dependence of changes in the essential amino acid composition of cooked-smoked sausages on the use of soybean and chickpea flour, the grains of which are germinated in different media, on the share of raw meat substitution (mg per 100 g of product)

Sample	Content of the essential amino acids							
	Lysine	Leucine	Isoleucine	Valine	Methionine+Cystine	Phenylamine+Tyrosine	Threonine	Total
Control	1.413±0.04	1.274±0.03	0.506±0.01	0.55±0.01	0.653±0.01	1.29±0.02	0.698±0.02	6.384
D. 1	1.460±0.04	1.563±0.02	0.653±0.02	0.71±0.01	0.764±0.01	1.61±0.02	0.853±0.02	7.613
D. 2	1.774±0.04	1.712±0.04	0.682±0.04	0.76±0.02	0.830±0.02	1.81±0.02	0.950±0.02	8.518
D. 3	1.50±0.047	1.852±0.03	0.800±0.02	1.25±0.02	0.875±0.01	1.93±0.02	1.008±0.03	9.222
D. 4	2.135±0.04	3.862±0.09	0.854±0.02	0.92±0.01	0.875±0.01	2.13±0.02	1.202±0.02	11.978
D. 5	1.554±0.04	2.141±0.07	0.947±0.02	1.80±0.02	0.986±0.01	2.25±0.02	1.163±0.02	10.840
D. 6	2.496±0.04	6.012±0.06	1.009±0.02	1.13±0.02	0.096±0.01	2.65±0.02	1.459±0.03	14.852

Table 5

The dependence of changes in the substituted amino acid composition of cooked smoked sausages on the use of soybean and chickpea flour, the grains of which are germinated in different media, on the share of raw meat substitution (mg per 100 g of product)

Sample	Content of the non-essential amino acids							
	Arginase	Serine	aspartic acid	glutamic acid	Proline	Glycine	Alanine	Total
Control	0.962±0.01	0.676±0.04	1.378±0.04	2.797±0.04	0.719±0.04	0.784±0.04	0.980±0.01	8.296
D. 1	1.305±0.04	0.844±0.04	1.438±0.04	3.334±0.04	1.035±0.04	1.105±0.04	1.309±0.04	10.370
D. 2	1.402±0.04	0.962±0.04	1.712±0.04	3.707±0.04	1.130±0.04	1.174±0.04	1.337±0.04	11.424
D. 3	1.648±0.04	1.012±0.04	1.498±0.04	3.877±0.04	1.351±0.04	1.426±0.04	1.638±0.04	12.450
D. 4	1.842±0.04	1.246±0.04	2.046±0.04	4.617±0.04	1.541±0.04	1.564±0.04	1.694±0.04	14.550
D. 5	1.991±0.04	1.180±0.04	1.558±0.04	4.414±0.04	1.667±0.04	1.747±0.04	1.967±0.04	14.520
D. 6	2.282±0.04	1.530±0.04	2.380±0.04	5.527±0.04	1.952±0.04	1.954±0.04	2.051±0.04	17.670

Table 6

It was found that cooked-smoked sausages with germinated legume flour contain essential amino acids such as lysine, leucine, isoleucine, valine, methionine+ cystine, phenylalanine+tyrosine, threonine, and essential amino acids, namely: arginine, serine, aspartic acid, glutamic acid, proline, glycine, alanine.

The total amount of amino acids increases compared to the control and depends on the increase in the amount of flour used from germinated legumes. Quantitative preference has those samples where grain flour germinated in mineral salt solutions was used.

In samples D. 2, D. 4, D.6 the total content of essential amino acids increases by 1.609, 2.756, 4.012 mg/100 g compared to samples D. 1, D. 3, D. 5 and by 2.134, 5.594, 8.468 mg/100 g compared to the control sample.

The total content of substituted amino acids in samples D. 2, D. 4, D 6, increases by 1.054, 2.100, 3.150 mg/100 g compared to samples D. 1, D. 3, D. 5 and by 3.128, 6.254, 9.380 mg/100 g compared to the control sample.

6. Discussion of results of studying the use of the flour of germinated legumes in the production of cooked-smoked sausages

Minced meat is a complex heterogeneous system, the functional properties of which depend on the ratio of proteins, fats, water, and morphological components in muscle tissue [32]. Minced cooked-smoked sausages belong to plastically viscous systems, so its structural and rheological parameters are characterized better by the values of shear stress, plasticity, emulsion stability, emulsifying ability, moisture-binding ability [33]. It was found that the above parameters increase when using flour from germinated legumes with a share of raw meat replacement in the amount of 5...15%. Experimental samples D. 2, D. 4, D. 6, where soybean and chickpea flour germinated in solutions of mineral salts were used, have better structural and rheological parameters in comparison with flour germinated in water (Table 1). Probably, this tendency is connected with the alkaline environment in which legumes were germinated. Bean flour germinated in mineral salts changes the pH of the minced meat environment and acts as a synergist for table salt, which increases the swelling of muscle proteins and improves the moisture-binding and emulsifying ability. A similar effect during experimental studies was obtained in [34]. Changes in pH medium have been shown to affect the emulsifying ability of meat systems. Analyzing the obtained dependences, it was found that the rational range of use of germinated legume flour to improve the structural and rheological characteristics of minced cooked-smoked sausages is 5...15% by weight of raw meat.

It was found that the use of germinated flour in the amount of 5 to 10% by reducing the content of raw meat has a good effect on the organoleptic characteristics of cooked - smoked sausages, which were evaluated by tasters at 4.9...5 points out of 5. Increasing the share of raw meat substitutes to 15% changes the color of cooked-smoked sausages from dark red to yellow-pink and yellow-gray (Table 2). When using germinated legumes in the amount of 5 to 15%, the

legumes were germinated. Bean flour germinated in mineral salts changes the pH of the minced meat environment and acts as a synergist for table salt, which increases the swelling of muscle proteins and improves the moisture-binding and emulsifying ability. A similar effect during experimental studies was obtained in [34]. Changes in pH medium have been shown to affect the emulsifying ability of meat systems. Analyzing the obtained dependences, it was found that the rational range of use of germinated legume flour to improve the structural and rheological characteristics of minced cooked-smoked sausages is 5...15% by weight of raw meat.

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color of cooked-smoked sausages changes due to the reduction of raw meat. Spectrophotometric studies based on the law of light absorption of Bouguer-Lambert-Ber, gave a color characteristic of the samples. It is established (Fig. 1) that the color of cooked-smoked sausage without bean flour, according to the conducted method, is characterized as dark red (λ 605 Nm), with 100 % color intensity, pH of the sample corresponded to 5.8 units (Table 1). Samples 1 and 2 (Fig. 1), where the share of raw meat substitution was 5 %, are characterized by color as red (λ 600 and 595 Nm), with a color intensity of 97 and 95 %, pH of the samples corresponded to 5.8, 6.0 units (respectively). Samples 3 and 4 (Fig. 1), where the share of raw meat substitute was 10 %, are characterized as yellow-pink (λ 595 and 597 Nm), with a color intensity of 98; 97 %, pH of the samples corresponded to 5.8; 6.2 units (Table 1). Samples where the share of substitution of raw meat for flour from soybeans and chickpeas germinated in both water (sample 5) and mineral solutions (sample 6) was 15 %, have a yellow-gray color (λ 590 and 585 Nm), pH of the samples is 5.8, 6.5 units. This is not make it possible ed by the regulations for this type of product, the color of sausages should be from dark red to yellow-pink. It is proved that the medium for germination (water or solutions of mineral salts) do not affect the color change of cooked-smoked sausages. The color change depends on % of the substitution of raw meat for legume flour, and the color intensity decreases with increasing proportion of substitution. The obtained results can be explained by the change in acidity of cooked-smoked sausages. It is known [33] that the color of the medium depends on the acidity, the color is more intense with decreasing pH. The color change was also affected by the absence of sodium nitrite in the formulation, which in this system acts as a preservative and color stabilizer. It is rational to use soy and chickpea flour with a share of up to 10 % by weight of raw meat to preserve the usual organoleptic characteristics of cooked-smoked sausages.

It was found that in samples *D. 5* and *D. 6* (Table 3) with the share of raw meat replacement by 15 % of germinated soybean and chickpeas flour there is a decrease in the mass fraction of moisture by 6% compared to the control. In samples *D. 3.* and *D. 4* (Table 3) with a share of raw meat replacement by 10 %, there is a decrease in the mass fraction of moisture by 3 % compared to the control. In samples *D. 1,* *D. 2* (Table 3) with the share of raw meat replacement by 5 % there is a decrease in the mass fraction of moisture by 1 % compared to the control. The protein content in the experimental samples *D. 2,* *D. 4,* *D. 6* increases by 10, 22, 28 % (respectively) compared with the control and by 5, 11, 8 % compared with samples *D. 1,* *D. 3,* *D. 5*). The fat content in the experimental samples *D. 2,* *D. 4,* *D. 6* is reduced by 5, 13, 16 % (respectively) compared with the control and by 1, 3, 2 % compared with samples *D. 1,* *D. 3,* *D. 5*, in Table 3.

The obtained results of the study can be explained by changes in the chemical composition of the meat system. The increase in protein is due to an increase in the proportion of flour replacement of germinated legumes, which are carriers of protein. The decrease in the mass fraction of fat is due to a decrease in the amount of lard, as an ingredient that is a carrier of fat. Samples of cooked and smoked sausages (*D. 2,* *D. 4,* *D. 6*), which used germinated bean flour in solutions of mineral salts, contain 13, 26, 39 and 12.5, 25, 37.5 μg , iodine and selenium (respectively), due to the use in the recipe of fortified flour. This solves the problem of insufficient consumption of deficient microelements – iodine and

selenium deficiency which is found in many people in different countries. Analyzing the obtained dependences, it was found that it is rational to use soy and chickpeas flour with a share of up to 10 % by weight of raw meat. Consumption of 200 grams of cooked-smoked sausage provides 1/3 % of the daily requirement for iodine and selenium.

It was found that the samples where the flour germinated in mineral solutions was used have a quantitative benefit. In samples *D. 2,* *D. 4,* *D. 6*, the total content of essential amino acids increases by 1.609, 2.756, 4,012 mg/100 g compared to samples *D. 1,* *D. 3,* *D. 5.*, and by 2.134, 5.594, 8.468 mg/100 g compared to the control sample (Table 5). The total content of substituted amino acids in samples *D. 2,* *D. 4,* *D. 6*, increases by 1.054, 2.100, 3.150 mg/100 g with samples *D. 1,* *D. 3,* *D. 5* and 3.128, 6.254, 9.380 mg/100 g compared to the control sample (Table 6). The germination process leads to an increase in the number of amino acids, and solutions of mineral salts enhance these reactions. The obtained results can be explained by the fact that a nutrient medium with the increased content of biologically active substances is created, biochemical reactions are started, aimed at the growth of shoots and roots.

Studies [35, 36] have shown that grain germination causes enzymatic transformations and cleavage of phytic acid due to phytase activation. In turn, activated phytase enzymatically breaks down phytic acid, which reduces its anti-nutritional effect. Therefore, the process of germination in addition to enriching products with amino acids will reduce the anti-nutritional effect due to the breakdown of phytic acid, the study of the content of which is a prospect for further research.

7. Conclusions

1. Examining the change in structural and rheological parameters of minced meat, it was found that samples where raw meat was replaced by 5, 10, 15 % of legume flour germinated in solutions of mineral salts, have a pH of 0.2, 0.4, 0.7 units less than control and other samples. An increase in inbound moisture content, shear stress, emulsion stability, emulsifying ability, and ductility was observed in all test specimens using legume germinated in different media. Analyzing the obtained dependences, it was found that the rational range of use of germinated legume flour to improve the structural and rheological characteristics of minced cooked- smoked sausages in the amount of 5...15 % by weight of raw meat.

2. After studying the change in organoleptic, physical-chemical parameters of cooked and smoked sausages, the dependences according to which it is rational to replace raw meat up to 10 %. When the proportion of substitution is increased to 15 %, there is a pronounced taste of legumes, the color of cooked-smoked sausages deteriorates, which acquires a yellow-gray color. The change and intensity of color depending on the increase in the percentage of replacement of raw meat with legume flour. The germination medium (water or mineral salt solutions) does not affect the color change of cooked-smoked sausages. Consumption of 200 grams of cooked-smoked sausage provides 1/3 % of the daily requirement for iodine and selenium.

3. A study of the dependence of changes in the amino acid composition of cooked-smoked sausages found that the germination process affects the increase in amino acid

composition. Quantitative preference has those samples where flour germinated in a solution of mineral salts were used. Analyzing the obtained dependences, it was found that

the rational range of use of germinated legume flour for the enrichment of cooked-smoked sausages with amino acids is 5...15 % by the weight of raw meat.

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