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ANALYSIS OF THE INFLUENCE OF NON-TRADITIONAL PLANT INGREDIENTS ON THE TECHNOLOGY OF BLOOD SAUSAGE EXTENDED STORAGE

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Abstract

Production of quality and safe products, particularly those with improved chemical composition for extended shelf life using plant-based ingredients, is a current imperative. The aim of this study was to determine the impact of plant-based ingredients on the shelf life extension of blood sausages and their quality parameters. The study investigated the influence of plant-based ingredients on sensory, physicochemical, structural-mechanical properties, and shelf life of blood sausage. It was found that the blood sausage prepared with the addition of green buckwheat and eggplant powder (10 %) had better sensory properties compared to the control. Physicochemical parameters of the developed blood sausage did not differ significantly from the control sample. It was established that incorporating plant-based ingredients into the recipe allows for balancing the protein-to-fat ratio (1 : 1.34), which is closer to the requirements of a balanced diet (1 : 1) compared to the control (1 : 2.02). It was determined that the inclusion of green buckwheat groats and eggplant powder using the developed technology positively affects the system's stability and water-holding capacity. The pH increased from 6.35 (control) to 6.52 (experimental), indicating a decrease in the content of loosely bound moisture from 13.74 % to 5.74 % in the experimental sample. Microbiological parameters met the established requirements, indicating the safety of the product. The research showed that introducing non-traditional raw materials inhibits the growth of microorganisms, allowing for a 24-hour extension of the shelf life of the finished product in natural casing compared to traditional recipes, as confirmed by changes in acidity and peroxide value. The results of the conducted research confirm the effectiveness and technological feasibility of adding eggplant powder and green buckwheat groats to the blood sausage technology, as compared to the control, improving the chemical composition and nutritional value of the products, inhibiting the growth of microorganisms, and extending the shelf life of the finished product by 24 hours compared to the control sample.

Keywords: blood of slaughter animals; eggplant powder; green buckwheat; blood sausage; microbiological indicators safety; quality.

АНАЛІЗ ВПЛИВУ НЕТРАДИЦІЙНИХ РОСЛИНИХ ІНГРЕДІЄНТІВ НА ТЕХНОЛОГІЮ КРОВ'ЯНИХ КОВБАС ПОДОВЖЕНОГО ТЕРМІНУ ЗБЕРІГАННЯ

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Анотація

Метою даного дослідження було визначення впливу рослинних інгредієнтів на подовження терміну зберігання кров'яних ковбас та на їх сенсорні, фізико-хімічні, структурно-механічні властивості. Встановлено, що кров'яна ковбаса за розробленою технологією з додаванням зеленої гречки та порошку баклажанів (10 %) має кращі сенсорні властивості порівняно з контролем. За фізико-хімічними показниками розроблена рецептура кров'яної ковбаси не відрізняється від контрольного зразка. Встановлено, що введення до рецептури рослинних інгредієнтів дозволяє збалансувати співвідношення білків до жирів (1 : 1.34), що наближено до вимог раціонального харчування (1 : 1) порівняно з контролем (1 : 2.02). Визначено, що розроблена технологія позитивно впливає на стабільність системи та здатність утримувати воду. pH збільшується з 6.35 (контроль) до 6.52 (дослід), знижується вміст слабоз'вязаної вологи з 13.74 % до 5.74 % в дослідному зразку. Мікробіологічні показники відповідали встановленим вимогам. Введення нетрадиційної сировини пригнічує розвиток мікроорганізмів, що дозволяє подовжити термін зберігання готового продукту в натуральній оболонці на 24 год порівняно з традиційними рецептурами, що підтверджується змінами кислотного і перекисного числа. Результати проведених досліджень підтверджують ефективність та технологічну доцільність додавання порошків з баклажану та крупи зеленої гречки до технології кровяних ковбас.

Ключові слова: кров забійних тварин, порошок з баклажану, крупа зеленої гречки, кров'яна ковбаса, мікробіологічні показники, безпечність, якість.

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Introduction

The most urgent issue in the world is the production of high-quality and safe food products that satisfy the body's needs for nutrients. However, there are a number of problems associated with the irrational use of available raw resources, in particular animal slaughter products. Most of the animal carcass non-meat portion is biologically and nutritionally suitable for using and may be microbiologically safe for human consumption. The blood of slaughtered animals is cheap and healthy source of protein, and, considering that it is derived from common waste products of the meat industry, its use for the development of environmentally friendly food ingredients can contribute to the reduction of environmental pollution [1].

Cattle are slaughtered for meat, as a result of which various by-products are formed, including bones, skin, tails, intestines, and blood [2; 3], which are usually used as feed or discarded, despite their nutritional value [4]. However, there are a number of countries that use the blood of cattle, pigs or even-toed ungulates to prepare traditional national dishes [5; 6]. The range of such products is represented by blood sausages and their varieties (blood pudding, ta'bu etc.) [7–9].

It is worth noting that blood sausages are produced and consumed throughout Europe, each region has its own specific traditions. The main raw material for production is the blood of slaughtered animals, which is a source of nutrients and contains a significant amount of proteins, vitamins and essential minerals such as iron, zinc and selenium [10]. The chemical composition of blood differs in a different ratio of dry substances (18...21 %) and water content (79...82 %), that depends on the species and age of animals (cattle, pigs etc.). Comparing the blood of different slaughter animals, scientists [11] found that the hemoglobin content in the blood of pigs is much higher compared to other animals. Accordingly, the content is 28 % higher than in the blood of cattle and 34 % compared to sheep. In addition, the cholesterol content in the blood of pigs (0.11 %) is much lower compared to cattle (0.19 %).

Furthermore, blood is an important source of protein, particularly essential amino acids (lysine) [12], which makes blood an interesting ingredient for the food industry. An important property of proteins is the ability to bind water and fat, which can be compared with other animal proteins, such as egg albumin and whey proteins [13]. In addition, blood provides strong pigmentation and affects the taste properties of finished products when used as an ingredient in food products.

However, in addition to the beneficial properties of blood components, traditional formulations contain a high content of fat and salt. Therefore, issues related to a more detailed selection of ingredients to balance the chemical composition and extend storage remain unresolved.

According to the recipe composition and cooking technology, the storage of blood sausages and puddings can be from 48 hours [14] to 30 days [15] and depends on the ingredient composition and raw materials [16, 17], cooking technology [18; 19], shells [20], packaging materials etc. [15; 21–23].

Most of the scientific works are aimed at researching the impact of packaging materials and conditions for extend storage. It was established that expiration date of blood sausages, wich stored in a vacuum is much higher than under aerobic conditions [15; 22; 23]. However, research that conducted by Korean scientists [24] indicated that vacuum packaging cannot guarantee the prevention of the growth of pathogenic microorganisms and depends on many factors.

Another way of extended storage and minimizing fat oxidation processes is the addition of natural and synthetic antioxidants (ascorbic acid E 300, sodium ascorbate E 301, sodium isoascorbate E 316, sodium citrate E 331) to the composition of blood sausage recipes [25; 26]. Synthetic antioxidants are widely used by the food industry, but the demand for natural antioxidants, especially of plant origin, has increased in recent years due to growing concern among consumers about their potential toxicological effects [26; 27]. Therefore, scientists are considering the possibility of introducing natural ingredients that have antioxidant properties and are sources of essential substances. In the work of Anjos and others [25] studied the antioxidant properties of bee pollen in black pudding (a type of blood sausage). Research results have confirmed that the addition of an apiproduct to the formulation prevents lipid oxidation.

To extend storage of blood sausages [16], the possibility of using pomegranate water infusions as an antioxidant was investigated. [28] However, the results of experimental studies indicated that the addition of pomegranate infusions to the

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composition of sausages is impractical. More promising is the addition of cranberry extract [29], which suppresses the process of lipid hydrolysis during storage.

However, a less studied issue remains the optimization of recipes due to the introduction of natural plant ingredients in order to reduce the content of sodium salt lipids and increase antioxidant properties [30].

However, a less studied issue remains the optimization of recipes due to the introduction of natural plant ingredients in order to reduce the content of sodium salt lipids and increase antioxidant properties [30]. It is known that blood sausages are quite sensitive to microbial contamination due to high moisture content and are favorable environment for the development of pathogenic microorganisms that cause food poisoning and intoxication [31]. Considering this, it is important to carefully select the main recipe components and production technology.

Scientists Cha and others [32] suggest using duck blood in combination with cereals (sorghum, buckwheat, oats, quinoa, amaranth) to prepare blood sausages. It was established that the addition of cereals to the recipes composition improves not only the organoleptic, physicochemical, rheological and microbiotic properties, but also increases the yield of sausages compared to the control.

Kim and others [6] studied the effect of starchy noodles (sweet potato, potato, and tung bean) on properties of Korean blood sausage (Sandae), in particular rehydration. It was determined that the stability of finished products is affected by the type of starch and its pH.

Saun Ken-Jin and others considered the possibility of using pig blood plasma for the physicochemical, antioxidant and antimicrobial properties of emulsion-type pork sausages [33]. It was established that the addition of blood hydrolysates improves the antimicrobial and structural properties of sausages, but the addition of 20 g/kg does not show any antioxidant effect.

According to the literature [12, 15, 19, 32, 34], the main ingredients of sausages produced in different countries are almost the same, mainly blood, sprig, grains and spices. Sausages produced by Ukrainian producers are characterized by a high content of fat and connective tissue. With this in mind, it is important to optimize the formulation by using herbal ingredients. The most common for making sausages are buckwheat and rice groats [34] (Table 1).

Table 1

Chemical composition of cereals [35, 36]

Characteristic	Buckwheat groats	Rice groats	Buckwheat groats (green)
Protein, g	12.6	7.0	13.3
Fat, g	2.6	0.6	3.4
Carbohydrates, g	63.2	71.8	71.5
Mineral substances, mg			
Calcium	17.0	3.0	18.0
Phosphorus	289.0	95.0	347.0
Magnesium	214.0	23.0	231.0
Ferum	2.5	0.8	2.2
Manganese	1.67	1.0	1.3
Copper	0.6	0.1	1.1
Vitamins, mg			
Thiamine	0.34	0.1	0.4
Riboflavin	0.18	0	0.4
Niacin	5.1	1.6	7.0
Tocopherol	6.6	0.45	6.65
β-carotene	0.006	0	0.01
Pantothenic acid	1.2	0.7	1.2

It is worth noting (table 1.) that in terms of chemical composition, buckwheat groats are superior to rice groats. The advantages of buckwheat (kernel) include the fact that all substances in its composition are fully absorbed by the body and it is characterized by a much higher content of minerals and vitamins compared to rice. In addition, buckwheat groats have a high content of fat-soluble vitamin E (tocopherol), which is a natural antioxidant. According to scientists [35], buckwheat groats contain a significant amount of minerals (K, F, Mg, Na, Fe, Ca, Cu, Zn, Mn etc.), which makes buckwheat useful for the human body. It is worth noting that buckwheat contains both saturated and unsaturated amino acids [36], in particular

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methionine and lysine. It is also a source of organic acids (oxalic, malic, citric, folic). However, the chemical composition of buckwheat groats depends on the variety and method of heat treatment. Comparing buckwheat groats with green buckwheat groats, we can observe that thermally untreated groats have better characteristics in terms of nutrient content. According to Dubinina, Trygub and others, the amount of antioxidants (rutin, quercetin, vitexin) in cereals that have not undergone heat treatment is significantly higher [35; 3]. Research of Sitar O.V. confirm these data and indicate that the antioxidant activity in buckwheat sprouts increases by several times compared to groats [38].

So, analyzing the literature data, it was found that green buckwheat groats for the production of blood sausages are not used despite its advantages in chemical composition. Accordingly, the question arises of the possibility and expediency of replacing buckwheat groats with green buckwheat groats, and studying the effect of buckwheat antioxidants on the storage duration of blood sausage.

Another direction in the development of products using blood is optimization of meat products recipes due to the introduction of natural plant ingredients in order to reduce the content of lipids and sodium salts [30]. However, an unsolved problem is the tendency of meat raw materials to spoil. Therefore, it is advisable to develop balanced recipes for blood sausages with the additional introduction of non-traditional plant ingredients, which will affect the extension of finished product storage period and improve the chemical composition of the products.

According to DSTU 4334:2004, cereals (buckwheat, millet, barley, shelled peas, lentils), garlic, onion, wheat flour, potato starch, soy protein, spicy plants are used to prepare blood sausages from plant ingredients. A comparison of the chemical sweetness of buckwheat groats is given in Table 1, which shows that green buckwheat is chemically superior to heat-treated buckwheat. Table 2 shows the chemical composition of the most commonly used additional ingredients for the production of blood sausages and eggplant powder.

Table 2

Chemical composition of plant ingredients for the production of blood sausages [39; 40]

Name of indicators	Eggplant powder	Onion	Garlic	Potato starch	Wheat flour
Protein, g	2.1±0.02	1.4±0.02	6.5±0.02	6.9±0.02	9.7±0.02
Fat, g	0.1±0.01	0.2±0.02	0.5±0.02	0.3±0.02	1.5±0.02
Carbohydrates, g	8.5±0.05	8.2±0.02	29.9±0.02	83.1±0.02	76.2±0.02
Mineral substances, mg /100 g					
Calcium	48.5±2.0	31.0±0.02	180±0.02	65±0.02	20±0.02
Phosphorus	740.4±2.0	175±0.02	260±0.02	1001.0±0.02	149±0.02
Magnesium	1.7±0.5	0.8±0.02	1.5±0.02	1.4±0.02	1.3±0.02
Ferum	98.80±1.5	58±0.02	100±0.02	168±0.02	107±0.02
Manganese	26.18±2.0	14±0.02	30±0.02	65±0.02	25±0.02
Copper	0.5±0.02	0	0.3±0.02	0.2±0.02	0.2±0.02
Vitamins					
B1	0.40±0.01	0.05	0.08±0.02	0.2±0.02	0.2±0.02
B2	0.5±0.06	0.02	0.08±0.02	0.1±0.02	0.1±0.02
PP	5.22±0.10	0.02	1.2±0.02	3.5±0.02	1.2±0.02
Vitamin E	0.4±0.02	0.2	0.3±0.02	0.3±0.02	0.1±0.02

Onions and garlic are mainly added to give the blood sausage a distinctive taste, while starch and wheat flour (at least 1 grade) provide structure. According to Table 2, eggplant powder contains a high content of vitamins compared to vegetables and structure-forming components. Also, the powders have a low content of fats (0.1 %) and carbohydrates (8.5 %), represented mainly by dietary fibers. Therefore, it is advisable to study the influence of eggplant powders on the organoleptic and functional-technological properties of blood sausages.

So, analyzing the latest research, it is observed that the main directions and strategy for the development of sausage production are the revision of technological solutions related to production technology and the use of innovative packaging materials and packaging methods. Accordingly, it is important to create technologies that provide an increase in the nutritional and biological value of products, including, due to the

use of non-traditional ingredients that affect on storage period, improve oranoleptic indicators. It was established that the item of blood sausages improving recipes by introducing ingredients that not only affect the sensory properties of the final product, but also extend the expiration date is not sufficiently studied. Accordingly, there is a need to find plant ingredients containing natural antioxidants that can not only extend the storage period, but also have a positive effect on the consumption and functional properties of blood sausages.

The purpose of this study is to determine the effect of herbal ingredients on the expiration date and quality indicators of blood sausages. This will make it possible to obtain a high-quality food product developed from plant raw materials that correspond quality and safety standards.

To achieve the goal, the following tasks were defined:

- to investigate the effect of green buckwheat groats and eggplant powder on the organoleptic, physico-chemical and structural-mechanical parameters of the developed blood sausages.

- to investigate the microbiological parameters of the developed blood sausages.

- to determine the influence of plant ingredients on storage duration of blood sausages.

Research materials and methods

The object of research is the technology of blood sausage with the addition of eggplant powder and green buckwheat groats. The subject of the study is the effect of plant components on the organoleptic and technological properties of blood sausage. "Poliska" blood sausage of the highest grade (TU U 15.1-31806583-005-2002) was chosen as the control sample.

The blood of slaughtered animals (frozen, LLC "Ukrmyasotreyd", Kyiv, Ukraine), buckwheat groats (Ukraine), pork head trimmings (LLC "Ukrmyasotreyd", Kyiv, Ukraine), eggplant powder (Ukraine).

Blood preparation included thawing and grinding. Green buckwheat groats were pre-boiled until the ratio of water to groats was 2 : 1. Raw meat was boiled until ready, chopped in a meat grinder with a diameter of 2...3 mm.

Minced meat for blood sausage was prepared in the following sequence: weighing the ingredients, boiling the raw blood for 2–3 minutes, combining all the components, mixing. The minced meat is thoroughly mixed to obtain a homogeneous mass. Natural shells were filled with ready minced meat. Ready loaves of blood sausage were cooked at 75–85 °C until the temperature in the center of the loaf reached 70±1 °C. Cooking was finished when the temperature in the center of the loaf reached 72 °C and a clear broth flowed out of the loaves when pricked.

pH value. The negative logarithm of the concentration of hydrogen ions in sausages was determined using a pH meter (Edge HI2020, Hanna Instruments, Germany). Measurements were performed immediately after preparation and after the samples reached ambient temperature (20 °C) and all storage period.

Organoleptic evaluation of blood sausages was carried out on a 10-point scale, in accordance with ISO 8586-1 (1993) and ISO 8586-2 (2008); it was evaluated by a commission of 15 people.

Mass change. The change in mass was measured after heat treatment and after one week of storage in the refrigerator, the data were expressed as a percentage of sample initial mass. The yield of the finished product was determined as the fraction of mass after (mass of prepared sausage samples) and mass before heat treatment (mass of raw sausage).

Determining the chemical composition using standard methods. Determination of protein mass fraction using the Kjeldahl method according to DSTU ISO 1871:2003. The fat content was determined using the Soxhlet extraction method, with dichloroethane as the solvent according to GOST 23042-86.

Determination of acid number and peroxide number according to standard methods.

Statistical analysis. The research results were expressed as the average value with a sample size of n=15, the accuracy index (P) of the results is greater than 0.95, and the standard error $\alpha < 0.05$.

Results and their discussion

The main goal of the study is to determine the influence of plant ingredients on the formation of blood sausage quality indicators. Accordingly, there is a need to model the recipe of blood sausage to ensure the balance of the product in terms of the main nutritional and biologically active substances due to the introduction of non-traditional ingredients. Taking into account national culinary preferences, the following ingredients were added to the recipe to increase the biological value and digestibility of sausages.

- Eggplant powder is a source of dietary fiber, carotenoids, zinc complexes, iron, phosphorus, calcium and B vitamins (B_1, B_2, B_3 and B_6).

- Green buckwheat groats are a source of carbohydrates, vitamins and minerals. The content of proteins and amino acids (tryptophan, lysine, methionine, valine, threonine, leucine, isoleucine, phenylalanine) is especially valuable.

During developing the recipe and technology of the improved blood sausage, we used the blood of slaughtered animals, pig heads, green buckwheat groats and eggplant powder. Recipes of blood sausages experimental samples are presented in Table 3.

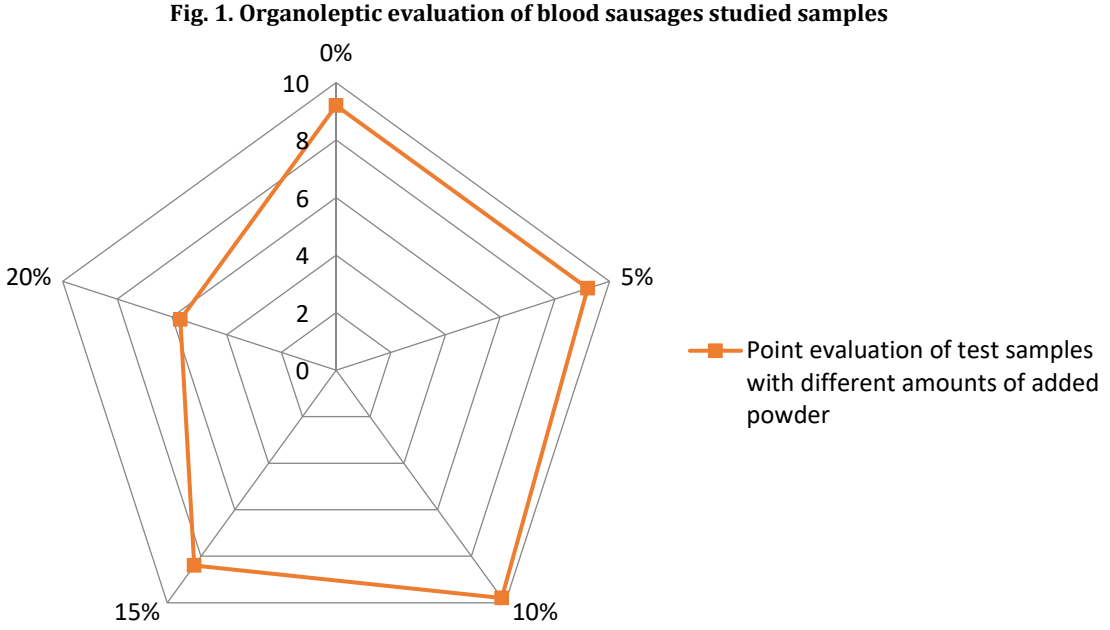
Table 3

Recipe composition of blood sausage experimental samples

The name of the raw material	Recipe ratio of components, %				
	Control (TU U 15.1-31806583-005-2002)	Experiment 1	Experiment 2	Experiment 3	Experiment 4
Blanched buckwheat groats	25	-	-	-	-
Green buckwheat groats blanched	-	25	25	25	25
Boiled meat of pig's heads	45	35	30	25	20
Boiled pork skin	5	-	-	-	-
Food blood	35	35	35	35	35
Eggplant powder	-	5	10	15	20
Total	100	100	100	100	100

The ratio of ingredients was selected in such way that the finished product had good sensory properties. The profilegram (Figure 1) shows the average value of the sensory evaluation of the tested samples of blood sausages, which was determined based on main indicators (taste, smell, consistency, appearance, cross-section view).

Fig. 1. Organoleptic evaluation of blood sausages studied samples



According to the results of sensory evaluation of blood sausages investigated samples, the addition of 10 % turned out to be the most optimal (Fig. 1). Tasters noted that with an increase in the amount of added powder, the products had a denser structure and the taste worsened.

In the course of experiments to improve the recipe of blood sausage, it was found that the replacement of buckwheat groats with groats from raw (green) buckwheat does not significantly affect the structural, mechanical and sensory properties of experimental sausage samples (Table 4).

Table 4

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Research of organoleptic and structural-mechanical indicators of blood sausage

Characteristic	Blood sausage	
	Control (TU U 15.1-31806583-005-2002)	Experiment (from green buckwheat)
Organoleptic evaluation, score	9.2± 0.1	9.3± 0.1
Amount of plastic deformation, %	33.6± 0.13	34.1± 0.10
Compression stress,		
10^4 Pa	4.6± 0.05	4.6± 0.04
Shear stress, 104 Pa	5.61± 0.08	5.68± 0.04

According to Table 4, the indicators in the experimental sample remained at the control level. However, buckwheat groats contain starch, which is used as a food stabilizer, thickener, and as a substance to increase stickiness [41; 42]. In thermally processed buckwheat, the starch is partially gelatinized, whereas in green buckwheat, it is in its native form, thus stabilizing the properties of buckwheat grains even more.

When adding eggplant powders to the mass of minced meat, the consistency and structure of the minced meat changes. After all, dehydrated raw materials have a large specific surface and are characterized by high water absorption capacity, which mainly depends on the hydrophilicity of pectin, fiber, cellulose, their swelling ability and structure formation [43]. Taking all this into account, the amount of eggplant powder used for blood sausage was 5, 10, 15, 20 % to the mass of unsalted raw materials (Table 3). The choice of this amount is explained by the need to establish the limits of maximum and minimum use in order to preserve all sensory characteristics.

The addition of vegetable ingredients (green buckwheat, eggplant powder) to the composition of blood sausage increases the amount of hydrophilic and emulsifying soluble protein, which, in turn, increases the moisture-holding capacity of the finished product.

Table 5

Functional and technological indicators of blood sausages

P ≥ 0.95; n = 15

Characteristic	Control	Experiment 2
Moisture retention capacity, %	74.5	77.1
Bound moisture, % by weight of the product	30.32± 0.84	37.6± 0.24
Plasticity cm^3, g	18.1±0.1	19.8±0.1
pH	6.35±0.04	6.52±0.05
Water, %	44.11±0.28	42.94±0.27
Bound moisture, % by weight of the product	30.32± 0.84	37.6± 0.24
Weakly bound moisture, % by weight of the product	13.79± 0.23	5.74± 0.11
Amount of plastic deformation, %	33.6± 0.13	31.2± 0.17
Compression stress Напруження тиснення, 10^4 Pa	4.6± 0.05	4.7±0.07
Effective viscosity, Pa·s \ 12 s	5053±53	4787±72
Losses, % to the initial mass	19±0.5	14±0.3
Yield, % to the mass of the main raw material	80±2.1	86±2.3

Therefore, with increasing of protein and carbohydrate components in recipe, the level of bound moisture is growing, which leads to decreasing losses during heat treatment, that is confirmed by experimental data (Table 5).

The introduction of plant additives to the recipe has a positive effect on the physicochemical parameters (Table 5) of the developed sausages compared to the control sample. The pH value increases from 6.35 in control to 6.52 in blood sausage (experiment). A natural decrease in the content of weakly bound moisture from 13.74 % to 5.74 % in the experimental sample is observed. The obtained results confirm the studies [40] that the properties of minced meat systems are closely related to the presence of protein, and its solubility determines and affects the quality of the emulsion. Carbohydrates present in plant raw materials (such as starches, fibers, etc.) also affect the moisture-holding and moisture-binding properties. Accordingly, the functional-technological indicators of blood sausages (the study) with the addition of unconventional plant ingredients containing an increased carbohydrate content will differ from the control sample (Table 5).

Accordingly, the introduction of vegetable proteins and carbohydrates increases the binding and moisture-retaining capacity, which positively affects to formation of finished product structure and juiciness.

Studies of structural and mechanical properties make it possible to determine the

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behavior of minced sausage under the influence of pressure and allow to link such characteristics as tension, deformation and deformation rate. Accordingly, the introduction of new formulation components affects changes in the structural and mechanical properties of products. This is explained by the different chemical composition of the ingredients, in particular the characteristics of proteins and carbohydrates in green buckwheat and eggplant powders, which had a positive effect on the plasticization of the minced meat. It is worth noting that comparing the data of significant changes in the main structural and mechanical properties (Table 5), the main values (plastic deformation, compression stress, shear stress) do not occur, they remain at the level of the control sample. Also, during heat treatment, the water-holding capacity of minced meat decreases, but the addition of groats and powder affects the stability of the system and the water-holding capacity. Accordingly, the yield of the finished product (experiment) is higher compared to the control sample by 7 %, and the developed blood sausage has a denser structure.

Thus, the obtained data are consistent with the results [39], which confirm the positive effect of dietary fibers on the structural-mechanical and organoleptic properties of meat-containing products.

In addition to good sensory and structural-mechanical properties, the addition of green buckwheat groats and eggplant powder has a positive effect on the chemical composition of the finished product.

Table 6

Changes in the chemical composition of blood sausages

P ≥ 0.95; n = 15

Characteristic	Control	Experiment 2
Protein, %	14.64±0.51	13.48±0.42
Fat, %	29.63±0.12	15.31±0.11
Carbohydrates, %	2.4±0.05	4.9±0.05
including fiber, %	0	1.3±0.02
Energy value, kcal	334.83	211.31

The addition of grits and eggplant powder causes a significant decrease in fat content by almost 2 times compared to the control, and the amount of carbohydrates, on the contrary, increases by two times. It is worth noting that the introduction of plant ingredients enriches the blood sausage with fiber, which positively affects the motility of the stomach and metabolism. The ratio of proteins to fats in the test sample is 1 : 1.34, in contrast to the control 1 : 2.02, which is closer to the requirements of rational nutrition (1 : 1). Therefore, analyzing the chemical composition (Table 6), we observe significant positive changes that indicate balance and compliance with the principles of rational nutrition.

Microbiological studies of blood sausages test samples (Fig. 2.) indicated the advantages of proposed formulation compared to classical technology.

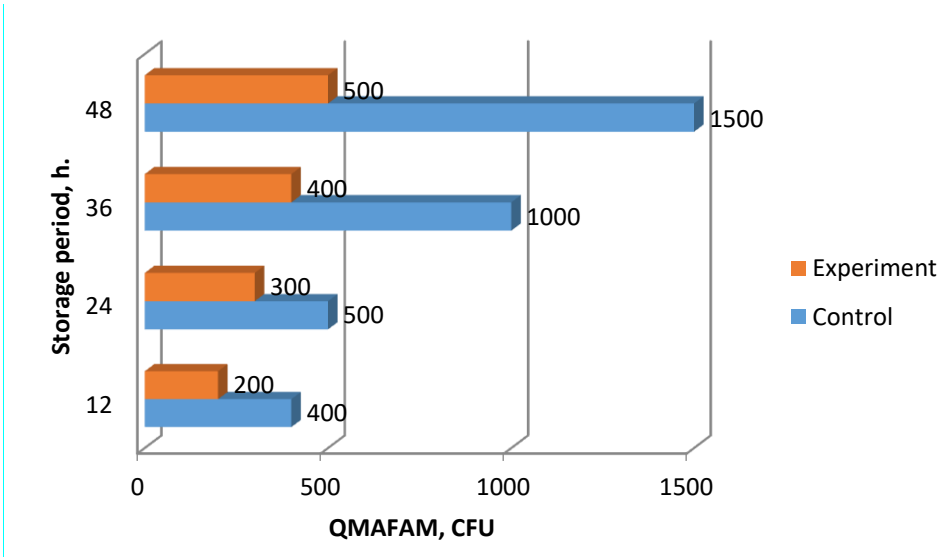

Fig. 2. Study of microbiological contamination of samples of blood sausages in natural casing

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Only aerobic and facultatively anaerobic microorganisms were detected in the studied samples (control, experiment) (Fig. 2). The presence of pathogenic, mold and yeast cultures was not detected. The obtained results meet the requirements of DSTU 4334:2004 (MAFAM standard, CU from $1 \bullet 10^3$ to $2.0 \bullet 10^3$). Vegetable ingredients (green buckwheat, eggplant powder) increased the microbiological stability of ready-made sausages due to phytoncides, pectin polyphenols, and anthocyanins present in them. That is, evident chemical compounds in plants inhibit the development of bacteria and fungi, which is confirmed by conducted researches (Fig. 2, Table 7).

Table 7

Changes in the peroxide and acid number of blood sausages during the storage period that established by DSTU

P ≥ 0.95; n = 15

Characteristic	Duration of storage (t=0...6°C), h				
	0	12	24	36	48
Fat peroxide number, % I					
Control	0,01±0,0001	0,01±0,0001	0,011±0,0001	0,012±0,0001	0,02±0,0001
Experiment	0,01±0,0001	0,01±0,0001	0,01±0,0001	0,01±0,0001	0,01±0,0001
Acid number, mg KOH					
Control	0,7±0,01	0,73±0,01	0,75±0,01	0,78±0,01	0,8±0,01
Experiment	0,6±0,01	0,6±0,01	0,62±0,01	0,64±0,01	0,68±0,01

Accordingly, microbiological studies confirm the positive effect of plant ingredients on the biological safety of sausage products, extending the expiration date. During the storage of blood sausages, various biochemical processes occur that affect on quality and safety of the products. Studies of peroxide and acid number allow to determine changes in fats and proteins that reduce the quality of sausages.

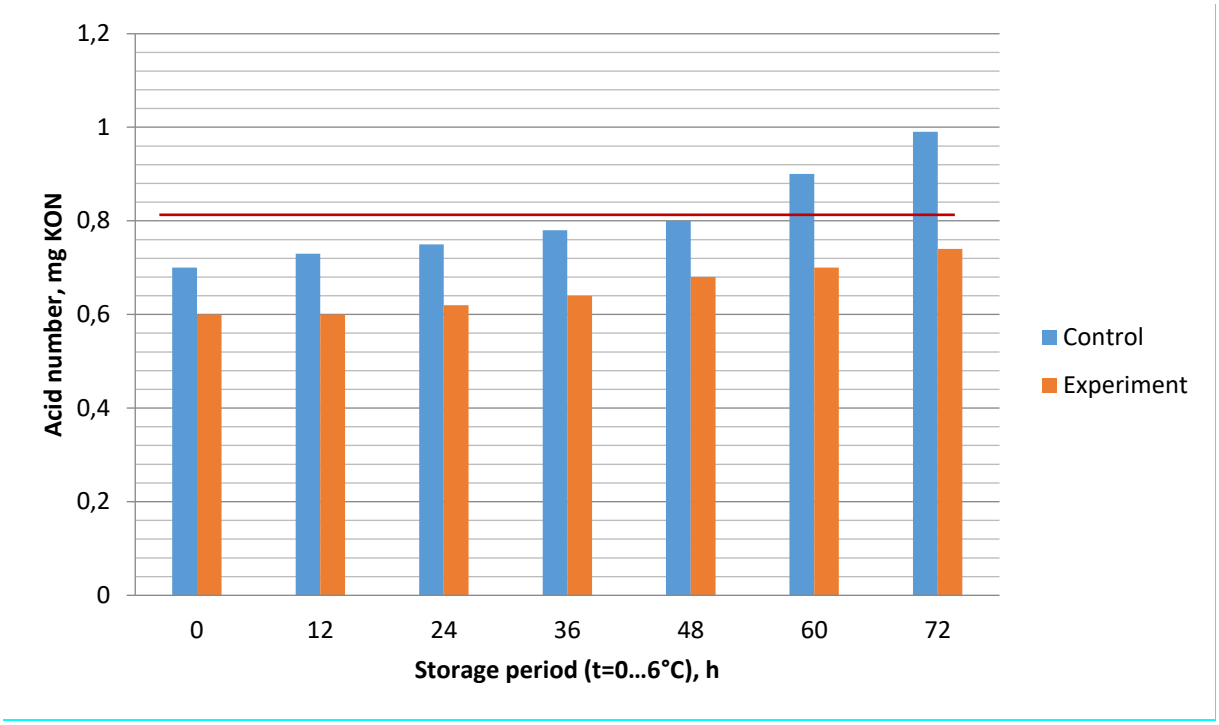

Fig. 3. Study of changes in the acid number of blood sausages in their natural casing during the entire storage period

Approprietely to Fig. 3, according to the data of the acid number study, the storage period of the test sample of blood sausages in the natural casing is extended by 24 hours and meets the requirements of regulatory documentation. At the same time, the control sample reached the red line after 48 hours of storage, which indicates an increase in the content of volatile fatty acids and the beginning of product deterioration.

So, according to the results of research, it was found that the introduction of green buckwheat groats and eggplant powder into the composition of the recipe affects the sensory characteristics and prolongation of expiration date.

Conclusions

Analyzed the impact of green buckwheat groats and eggplant powder on the shelf life, organoleptic, physicochemical, and structural-mechanical properties of blood sausages. It was found that the blood sausage developed using the technology with the addition of green buckwheat groats and eggplant powder (10 %) has better sensory properties compared to the control. In terms of physicochemical and structural-mechanical indicators, the recipe of the blood sausage developed does not differ from the control sample. However, the pH value increases from 6.35 (control) to 6.52 (experimental), and there is a consistent decrease in the content of loosely bound moisture from 13.74 % to 5.74 % in the experimental sample. It has been established that the addition of green buckwheat groats and eggplant powder positively affects the stability of the system and its ability to retain water. Consequently, the output of the finished product (experimental) is higher compared to the control sample by 7 %, and the developed blood sausage has a denser structure. It has been found that incorporating plant ingredients into the formulation allows for balancing the ratio of proteins to fats (experimental 1 : 1.34, control 1 : 2.02), which is closer to the requirements of rational nutrition (1 : 1). Microbiological indicators met the established criteria, and the antioxidants present in plant ingredients increased the microbiological stability of the finished sausages. Research has shown that using non-traditional raw materials suppresses the growth of microorganisms, allowing for an extended shelf life of the finished product by 24 hours compared to the control sample.

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