UDC 641.1:641.8:641.52
DOI: 10.15587/1729-4061.2023.291381

DEVELOPING THE QUALITY OF FUNCTIONAL SAUSAGE PRODUCTS WITH THE ADDITION OF LOCAL VEGETABLE RAW MATERIALS

Oksana Dzyundzya
Corresponding author
PhD, Associate Professor*
E-mail: Dzokvaok@gmail.com
Artem Antonenko
PhD, Associate Professor
Department of Standardization and Certification of Agricultural Products
National University of Life and Environmental Sciences of Ukraine
Heroyiv Oborony str., 15, Kyiv, Ukraine, 03041
Olga Gorach
Doctor of Technical Sciences, Associate Professor*
Natalia Novikova
PhD, Associate Professor*
Nina Rezvykh
PhD*
Nataliia Stukalska
PhD, Associate Professor
Department of Technology of Restaurant and Ayurvedic Products
National University of Food Technologies
Volodymyrska str., 68, Kyiv, Ukraine, 01601
Antonina Ratushenko
PhD, Associate Professor
Department of Food Technology
Open International University of Human Development "Ukraine"
Lvivska str., 23, Kyiv, Ukraine, 03115
Oleksandra Biriukova
Postgraduate Student
Department of Management and Innovative Technologies Social and Cultural Activities
Dragomanov Ukrainian State University
Pyrohova str., 9, Kyiv, Ukraine, 01601
Myroslav Kryvoruchko
PhD, Associate Professor
Department of Design and Engineering**
Vitalii Mihailik
PhD, Lecturer
Depatment of Technology and Organization of Restaurant Business**
*Department of Food Technologies
Kherson State Agrarian and Economic University
Sretenskaya str., 23, Kherson, Ukraine, 73006
**State University of Trade and Economics
Kyoto str., 19, Kyiv, Ukraine, 02156

In today's world, the issue of creating complete food products is relevant for the development of food technology. One of these areas is devoted to solving the problem of preventing iron deficiency conditions arising from iron deficiency in the diet.

To enrich the diet with necessary nutrients and reduce the loss of valuable raw materials, it is relevant to justify innovative technologies of sausage products.

The object of the study is the technology of blood sausages with the addition of eggplant powder and green buckwheat.

In the process of modeling the recipe, eggplant powders for blood sausage were added in an amount of 5, 10, 15, 20 % by weight of unsalted raw materials. The optimum concentration was found to be 10 % powder.

It was determined that the introduction of plant additives into the stuffing increases the pH value from 6.35 in the control to 6.52 in the experimental sample of the finished sausage.

The introduction of the additive increases the moisture-retaining capacity of the stuffing proteins in the experimental samples by 6.28–6.87 % compared to the control.

The research found that the introduction of unconventional ingredients positively affects the changes in pH (norm 6.5–6.8), which during 5 days of storage was within 6.5–6.52. The control sample on the day of preparation had a pH of 6.5. During storage, the pH decreased dramatically, which indicates increased acidity, accordingly affects the quality of the finished product and confirms the short storage duration.

As a result of laboratory studies of microbiological safety indicators, only mesophilic aerobic and facultative anaerobic microorganisms were detected in the experimental samples, the number of which does not exceed the standards.

No ochratoxin A (OTA) was found in the studied blood sausage samples, indicating the safety of the developed product

Keywords: blood sausage, ochratoxin A, eggplant powder, green buckwheat, mycotoxins, model compositions

Received date 03.09.2023
Accepted date 13.11.2023
Published date 28.12.2023

***How to Cite**: Dzyundzya, O., Antonenko, A., Gorach, O., Novikova, N., Rezvykh, N., Stukalska, N., Ratushenko, A., Biriukova, O., Kryvoruchko, M., Mihailik, V. (2023). Developing the quality of functional sausage products with the addition of local vegetable raw materials. Eastern-European Journal of Enterprise Technologies, 6 (11 (126)), 16–23. doi: https://doi.org/10.15587/1729-4061.2023.291381*

1. Introduction

In today's world, the issue of creating safe and biologically complete food products is relevant for the development of food technology. One of these areas is devoted to solving the problem of preventing iron deficiency conditions arising from iron deficiency in the diet. Despite the fact that iron is abundant in nature, it is estimated that two billion peo-

ple suffer from its deficiency. The reason for this is the low bioavailability of many iron compounds, ranging from <2 % for some trivalent iron compounds to 40 % for heme iron. In view of this, it is important to enrich food with dietary sources of iron. However, it is worth noting that almost every country in the world has traditional dishes that are a source of heme iron. The most common are sausages, namely blood sausage, which is a popular dish in the national cuisines of many countries around the world [1–3].

Taking into account the demand for healthy food products, food manufacturers are looking for ways to improve existing recipes, considering nutritiology requirements. Technologists revise classic recipes and modernize dishes using ingredients with high nutritional and dietary values. Therefore, it is important to upgrade blood sausages with functional ingredients and explore the possibilities of extending the shelf life. Accordingly, the development of innovative technologies for safe food products is an urgent task for the scientific community.

2. Literature review and problem statement

Food safety and quality are one of the main concerns of producers and consumers around the world. It is worth noting that there is a demand for food products containing biologically active ingredients with a strengthening effect and no food additives [4]. However, for many foods containing animal derivatives, lipid oxidation is an important source of quality degradation, shortening their shelf life and reducing consumption.

Blood sausages are produced and consumed all over Europe, and each region has its specifics and traditions. The main raw material for the production is the blood of slaughtered animals, mainly pigs. Blood is a source of nutrients and contains a large amount of protein, vitamins (A, B12 and folic acid), essential minerals such as iron, zinc and selenium [5]. It is also an important source of protein and lysine [6]. However, in addition to the beneficial properties of blood components, there are also certain restrictions on the high content of fat and salt in blood-based dishes. Therefore, there are still unresolved issues related to a more detailed selection of ingredients in order to reduce the negative effects on the body.

Depending on the recipe composition and cooking technology, the shelf life of blood sausages and puddings ranges from 48 hours [7] to 30 days [8]. An option to overcome the relevant restrictions is to improve the recipes by introducing ingredients that will affect not only the sensory parameters of the finished products, but also increase the shelf life.

All blood sausages contain antioxidants that minimize the level of lipid oxidation. However, both manufacturers and consumers are looking for products where synthetic antioxidants are replaced with natural ones derived from plants. In [9], the antioxidant properties of bee pollen were studied. It is an important functional ingredient being rich in protein, lipids, free sugars, carbohydrates, minerals, phenolic acids, flavonoids, carotenoids, and vitamins. The presented research results [10] confirm the antioxidant effect on the body and reveal anti-inflammatory, antimutagenic and antimicrobial properties. All this suggests that bee pollen can be used as a natural antioxidant in meat products. However, despite the beneficial properties, there are restrictions for allergy sufferers.

Expanding the range of meat products, technologists improve dishes by enriching them with vegetable ingredients, or reducing the fat or sodium content [11]. But there are still unresolved issues related to the high susceptibility of raw meat to spoilage. These are both oxidative changes and microflora development, as well as further organoleptic changes and the formation of compounds that are dangerous for consumers. Using plant products makes it possible to replace artificial antioxidants with natural ones. It is worth noting that the resulting product is enriched with dietary fiber and omega-3 and omega-6 fatty acids. Therefore, adding plant products rich in natural antioxidants not only extends the shelf life of the product, but also positively affects the consumer health, making the product functional.

In their research, scientists [12] confirm the anti-cancer effect of lycopene from tomatoes in dried fermented meat sausages. The research results indicated good sensory parameters of the proposed products. In order to expand the range of functional meat products, this technology is promising. However, there are still unresolved issues related to the safety indicators and storage duration of these products.

In [13, 14], it was found that adding vegetable oils (oregano, clove, sage) to meat raw materials in sausage production causes antioxidant, antimicrobial, antiviral and antifungal effects. Similar results were obtained when adding green tea extract to sausages [15]. All this gives grounds to assert the prospects of using extracts as natural preservatives to reduce the number of pathogenic bacteria.

Sausages are known to be highly sensitive to microbial contamination due to their high protein content [16]. Blood sausages are a favorable environment for the development of pathogens responsible for product quality (sensory indicators) and causing food poisoning and intoxication [17]. A way to overcome these shortcomings is to carefully select the optimum recipe composition and production technology in order to create high-quality and safe raw materials.

In [3], in the production of Morcilla de Burgos, a methodology of prolonged cooking at temperatures above 90 °C and vacuuming the finished product to extend the shelf life is proposed. It was found that prolonged heat treatment affects both microbiological and structural-mechanical parameters. But there are still unresolved issues related to the quality of sausages during long-term storage in a vacuum, because there is a risk of developing microorganisms in the presence of oxygen. As a result, the organoleptic score decreases, and metabolic compounds accumulate that can cause food poisoning. Therefore, it is worth paying attention to the study of storage conditions and characteristics of packaging materials for this type of sausage.

It should be noted that in their works [18], scientists are concerned about the high content of hemoglobin in blood sausages. The research results indicate the mechanism of oxidation and toxicity of meat and meat products. Lipid, protein and heme iron oxidation products have been shown to be partially cytotoxic (genotoxic). An option to overcome the relevant shortcomings can be to combine the recipe components with plant raw materials. All this gives grounds to assert the feasibility of creating balanced blood sausages in terms of ingredient composition in order to reduce the negative impact on the body.

In sausage production, various food components are used that affect human digestibility and feeling [19]. Many producers practice combining edible animal waste with lean meat to make good sausage and reduce production costs [20].

This approach was used in the work [21], which showed that edible offal such as liver and blood can be used partially or completely in sausage production. Accordingly, such manipulations ensure the balance of the amino acid composition of sausage products, affecting both positively and negatively the taste characteristics. But there are still unresolved issues related to sensory characteristics that need to be improved.

Liver is widely used in many countries [22], but most of the valuable raw materials, like the blood of slaughtered animals, are not used or disposed of. The reason for this may be difficulties associated with exsanguination and storage of raw materials. An option to overcome the corresponding difficulties is industrial processing of blood (freezing, food albumin, etc.) with subsequent use in the food industry.

It is worth noting that in food production, especially blood sausages, there are high risks of food poisoning. According to scientists [23], little attention is paid to studying the presence of ochratoxin A (OTA) in blood sausages. Popular Czech and Italian blood sausages have been found to contain OTA, which negatively affects kidney function. The reason for this may be insufficient control over mycotoxins in both raw materials and finished products. Therefore, it is important to study and detect this toxin in foods in order to prevent negative effects on the body.

In order to reduce microbiological contamination and lipid oxidation [24], tamarind paste was added to blood sausage (ta'bu) (2 %, 4 %, 6 %). The research results showed that adding tamarind paste in the preparation of ta'bu affects the reduction of microorganisms and lipid oxidation ($P<0.05$). These studies are important, as they indicate possible ways to improve the microbiological parameters of edible blood dishes. However, there are still unresolved issues related to the ratio of recipe components to meet the physiological needs of the body.

So, according to the literature review, dishes using blood are quite popular. However, the issues of quality assurance and increasing shelf life are still unresolved. No studies were found on the effect of eggplant powders and green buckwheat on the quality of blood sausages. Therefore, all this gives grounds to assert the feasibility of conducting a study on the effect of eggplant powders and green buckwheat on the sensory and microbiological parameters of blood sausages.

3. The aim and objectives of the study

The aim of the study is to determine the effect of plant ingredients on the quality indicators of blood sausage. This will make it possible to obtain a high-quality food product developed from local plant raw materials that meets quality and safety indicators.

To achieve the aim, the following objectives were set:

– to determine the optimum ratio of recipe ingredients and investigate their effect on organoleptic parameters;

– to study the physico-chemical and microbiological parameters of blood sausage samples.

4. Materials and methods

4. 1. Object and hypothesis of the study

The object of the study is the technology of blood sausages with the addition of eggplant powder and green buckwheat. The subject of the study is the effect of plant ingredients on the organoleptic, functional and technological properties of blood sausage. As the control sample, "Poliska" first-grade blood sausage (TU U 15.1-31806583-005-2002) was chosen.

The hypothesis of the study suggests that adding an optimum amount of vegetable raw materials makes it possible to obtain blood sausages with an extended shelf life. It is known that vegetable raw materials (extracts, powders) have the ability to inhibit the oxidative processes of fats, the development of bacteria, fungi, and yeast. Such properties affect the shelf life extension. Increasing the amount of plant ingredients in the recipe can affect the physico-chemical properties of the finished dish. In addition, eggplant powder and green buckwheat have a specific taste. Given these features, it is advisable to study the effect of unconventional ingredients on the sensory parameters and storage duration of blood sausages. The assumptions are the differences in the physico-chemical and organoleptic properties of sausage samples with the addition of eggplant powders and green buckwheat. No simplifications were made in the study.

4. 2. Raw materials

For the technology of blood sausage, the following were used: edible whole blood of slaughtered animals (frozen, Ukrmyastreid LLC (Ukraine, Kyiv)), green buckwheat (Ukraine), pork head trimmings (Ukrmyastreid LLC (Ukraine, Kyiv)), eggplant powder (Ukraine). Blood preparation included defrosting and grinding. Green buckwheat was pre-boiled until ready at a water-buckwheat ratio of 2:1. Meat raw materials were boiled until ready, ground in a meat grinder with a plate hole diameter of 2...3 mm.

4. 3. Program, methodology, equipment

The study was carried out in the laboratories of the Kherson State Agrarian and Economic University, National University of Life and Environmental Sciences of Ukraine, and Kyiv National University of Trade and Economics (Ukraine).

The blood sausage stuffing was prepared according to the following sequence: weighing the ingredients, cutting the raw blood for 2–3 minutes, combining all the components, mixing. The stuffing is thoroughly mixed to obtain a homogeneous mass. Natural casings were filled with the ready stuffing. Ready blood sausage loaves were cooked at 75–85 °C until the center of the loaf reached a temperature of 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. A negative logarithm of the concentration of hydrogen ions in sausages was determined using a pH meter (Edge HI2020, Hanna Instruments, Germany). Measurements were taken immediately after cooking and after the samples reached ambient temperature (20 °C) and the entire storage period.

Organoleptic evaluation of blood sausages was performed on a 10-point scale according to ISO 8586-1 (1993) and ISO 8586-2 (2008) by a commission of 15 people. Statistical analysis was carried out by the surface response method, in each experiment 3 parallel tests were performed, on the basis of which the mathematical prediction and standard deviation were calculated. The effect of the eggplant powder content in the blood sausage recipe on sausage properties was studied using the surface response method. The input

variables were the dosage of plant additives and obtained taste, smell, color, functional and technological properties of the finished dish. The eggplant powder was added in the range from 0 to 20 %, with a step of 5 %. Taking into account that groats (buckwheat or rice) are traditionally added to blood sausage in Ukraine, 100 % of the buckwheat recipe composition was replaced with green buckwheat.

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

To determine OTA, an analytical method of high-performance liquid chromatography in combination with immunofluorescence detection was used.

5. Results of the study of blood sausages with local raw materials

5. 1. Study of the effect of eggplant powders on blood sausage properties

According to the literature data, sausages made in different countries have almost the same main ingredients, mainly blood, lard, cereals, spices.

Sausage products manufactured by the food industry in Ukraine are characterized by a significant content of fat and connective tissue. In view of this, it is important to optimize the recipe composition using unconventional plant raw materials, which will affect not only the taste characteristics, but also extend the shelf life.

The main goal was to model the blood sausage recipe so that the product was balanced in basic food and biologically active substances.

However, taking into account national culinary preferences and to increase the nutritional value and digestibility of sausages, the following was added to the recipe:

– eggplant powder as a source of fiber, vitamins B, PP, carotenoids and minerals;

– green buckwheat as a source of carbohydrates, vitamins and minerals.

When developing recipes and technologies for new types of blood sausage, edible blood, fat pork (pork head trimmings), green buckwheat and eggplant powder were used. The ratio of ingredients was selected in such a way that the finished product had high organoleptic parameters, corresponded to the formula of balanced and rational nutrition, and the finished products were effective in preventing iron deficiency anemia.

As a result of experiments, tests were made to produce blood sausages with additives to identify restrictions on their amount. Preliminary studies have shown that the complete replacement of buckwheat with green buckwheat does not significantly affect organoleptic parameters. In view of the data obtained, the next step was to introduce eggplant powders, which for blood sausage was 5, 10, 15, 20 % by weight of unsalted raw materials. The choice of this additive amount is explained by the need to set limits on their maximum and minimum use in order to preserve all organoleptic parameters.

Analysis of changes in the organoleptic score of blood sausages with eggplant powder and green buckwheat revealed a certain pattern (Fig. 1). So, initially, when introducing additives, the organoleptic score of the finished products almost does not change and is 9.2 points. Moreover, there comes a time when the organoleptic score, reaching its maximum at a certain additive concentration (10 % powder), begins to decrease. This effect can be explained by the fact that the introduction of any additive in a certain (critical) concentration to the recipes of sausage products leads to a deterioration in the quality of the finished products.

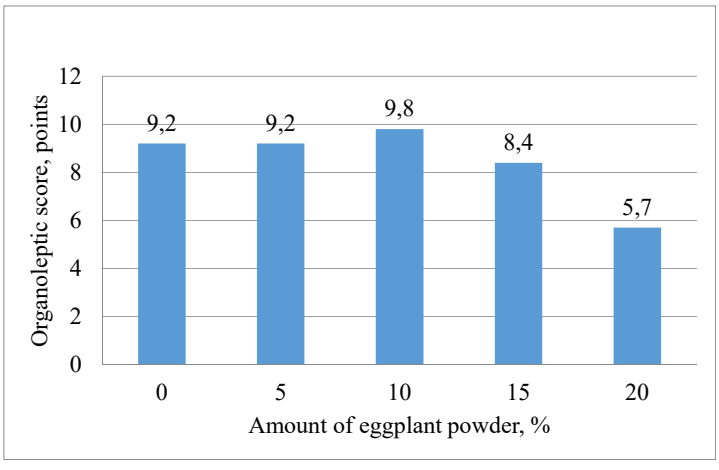
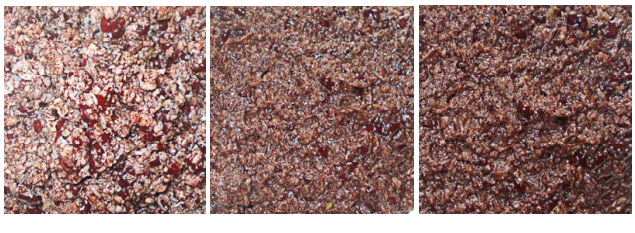


Fig. 1. Changes in the organoleptic score depending on the amount of eggplant powder added

The appearance of the stuffing, namely, control and experimental samples with different amounts of food powders and green buckwheat, is shown in Fig. 2.



a *b* *c*

Fig. 2. Appearance of the stuffing: *a* – control; *b* – 10 % eggplant powder; *c* – 20 % eggplant powder

The introduction of eggplant powder affects the appearance and consistency of the stuffing (Fig. 2). It was found that the most optimum addition is 10 % (Fig. 2, b), with increasing dosage of powders, the stuffing had a dense structure.

Studies of cooked sausage samples confirm that when the dosage of powders is increased by more than 10 %, the taste of the finished products, consistency and color on the cut deteriorate. So, the optimum ratio of ingredients was determined: edible blood – 35 %, boiled green buckwheat – 25 %, boiled meat raw materials – 30 %, eggplant powder – 10 %.

As a positive point, tasters noted that with the introduction of biologically active components to the blood sausage recipe, the stuffing remains tender. The highest score for appearance, stuffing appearance on the cut, taste, smell and consistency is shown by blood sausage (10 %) with an average organoleptic score of 9.8 points, while the control sample had 8.8 points.

The introduction of additives to the recipe has a positive effect on the moisture-retaining capacity and consistency of the finished sausage stuffing.

So, the water-retaining capacity of stuffing depends on the degree of its grinding. With less grinding, accompanied by significant destruction of muscle fibers, muscle tissue has a high water-retaining capacity and vice versa.

In order to increase the water-retaining capacity of stuffing, various food components of plant and animal origin are used in blood sausage production: flour, starch, etc. A great influence on the moisture-retaining capacity of stuffing is caused by the introduction of plant raw materials.

The introduction of plant additives to the experimental samples of stuffing increases the pH value from 6.35 in the control to 6.52 in the blood sausage (Table 1).

There is a regular decrease in moisture amount in the experimental samples of blood sausage.

Table 1

Physico-chemical indicators of blood sausages

Indicator	Control	"Pivdenna"
pH	6.35±0.04	6.52±0.05
Water, %	44.11±0.28	42.94±0.27
Bound moisture, % by product weight	30.32±0.84	37.6±0.24
Weakly bound moisture, % by product weight	13.79±0.23	5.74±0.11
Plastic deformation value, %	33.6±0.13	31.2±0.17
Compression stress, 104 Pa	4.6±0.05	4.7±0.07
Shear stress, 104 Pa	5.61±0.08	5.52±0.06
Effective viscosity, Pa·s\12 s	5,053±53	4,787±72
Loss, % by the initial weight	19±0.5	14±0.3
Yield, % by weight of the main raw material	80±2.1	86±2.3

With the addition of plant additives to blood sausage stuffing, the amount of soluble proteins with high hydrophilic and emulsifying properties increases, thereby increasing the moisture-retaining capacity. With an increase in the amount of protein components in the blood sausage recipe, the content of bound moisture increases, although not proportionally, but in a natural dependence. This decreases losses during heat treatment, which is confirmed by experimental data (Table 1).

Thus, the moisture-retaining capacity of the stuffing proteins in the experimental samples is increased by 6.28–6.87 % compared to the control.

A relationship between the pH value and the moisture-retaining capacity of stuffing is undoubtedly proved: with an increase in the reaction of the medium (to certain limits), the moisture-retaining capacity of the stuffing increases. Fig. 3 shows changes in pH during storage of the experimental and control samples.

The study found (Fig. 3) that the introduction of unconventional ingredients positively affects the changes in pH (norm 6.5–6.8), which during 5 days of storage was within 6.5–6.52. The control sample on the day of preparation had a pH of 6.5. During storage, the pH decreased dramatically, which indicates increased acidity, accordingly affects the quality of the finished product and confirms the short storage duration.

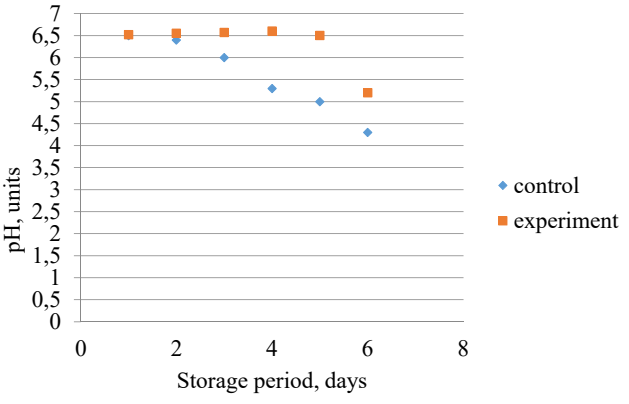


Fig. 3. Changes in pH during storage of blood sausage

5. 2. Results of the study of microbiological safety of blood sausage

An important stage of the study was to detect microbiological contamination. The results of the study are shown in Fig. 4.

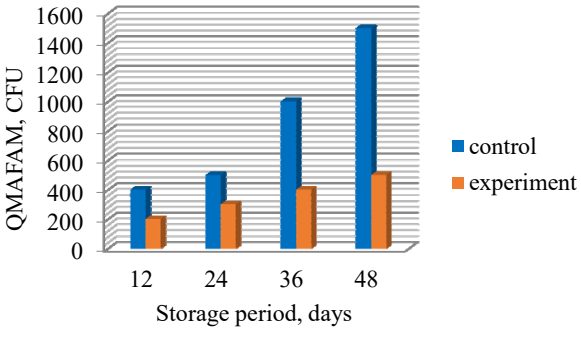


Fig. 4. Study of microbiological contamination of blood sausage samples

As a result of laboratory tests, only mesophilic aerobic and facultative anaerobic microorganisms were found in the experimental samples (Fig. 4). The presence of pathogenic, mold and yeast cultures is not allowed.

6. Discussion of the results of the study of blood sausage from local raw materials

The organoleptic score of blood sausages with the addition of unconventional ingredients is shown in Fig. 1, and Fig. 2 shows the appearance of stuffing samples. It is determined that the maximum permissible concentration of eggplant powder in the recipe is 10 %. Therefore, the addition of dietary fiber affects the binding and retention of moisture, which improve the consistency of products by forming a three-dimensional network that can change the rheological properties. The findings are consistent with the results of researchers [25, 26] who studied the effect of dietary fiber on the sensory properties of meat products.

Physico-chemical parameters of blood sausages are given in Table 1. According to the obtained data, the introduction of eggplant powders and green buckwheat made it possible to improve not only the organoleptic, but also the physico-chemical properties of the finished prod-

uct. The level of hydrophilicity and moisture retention capacity is important for meat systems [27], as it serves as the final indicator of finished products, affecting the yield and quality. The obtained results are confirmed by the studies [11, 25, 27] that the properties of stuffing systems are closely related to the presence of proteins, and their solubility determines the quality of emulsions. According to the data (Table 1), adding plant ingredients with a high ability not only to bind, but also to retain moisture affects the formation of the stuffing structure.

Fig. 3 shows the pH values obtained for the samples during storage. There were no significant differences in the pH values of the sample with eggplant powder and green buckwheat. The average initial pH of blood sausage was 6.52, and changes during storage were consistent with the results of sausage studies [26, 27]. The shift in the pH of the stuffing of experimental blood sausage samples to an alkaline environment positively affects the formation of its structure, based on the appearance of a spatial fibrous framework. The appearance of the framework occurs due to the mutual approximation of dispersed particles by molecular forces and the interaction of molecules with the part of proteins that is in the dispersed medium of sausage stuffing. Due to this, protein hydration increases, and the number of carboxyl groups increases, which is confirmed by experimental studies.

The ingredient composition and characteristics of raw materials affect not only the physico-chemical, but also the microbiological parameters of the finished product, contributing significantly to determining the sensory properties and safety of the product [28]. It should be noted that the technological process creates conditions for the development of microorganisms. Therefore, the microbiological safety of sausages depends on the parameters of the production process, the characteristics of the ingredients and the environment. It is known that different types of dietary fiber are successfully used for the production of meat and meat-containing products [24, 29] and unfermented dried meat products [30]. The introduction of plant ingredients, including pectin-containing ones [31], does not reduce the stability of cooked sausages during storage and confirms the results of studies and positively affects the microbiological parameters (Fig. 4). The chemical compounds present in eggplant powders (phytoncides, pectin polyphenols, anthocyanins, chlorogenic acid) [32, 33] have antioxidant properties and inhibit the development of bacteria and fungi, which is confirmed by the studies. Also, an increase in solids in the emulsion increases the osmotic pressure in the system, which inhibits the growth of microorganisms and their metabolic processes. QMAFAM activity data (Fig. 4) confirm the effect of plant antioxidants, respectively reducing the activity of microorganisms.

Blood sausages without the addition of plant raw materials have a high moisture content (55–75 %) compared to samples containing buckwheat (control – 44.11 %). It is known that moisture affects the development of microflora and causes a decrease in product quality during storage. The total number of aerobic microorganisms indicates the level of microorganisms in the product and represents the hygienic status of foods according to AOAC 966.23.

Determination of microorganisms allows you to predict and determine the shelf life of food products. According to DSTU, first-grade blood sausages are stored for 24 hours from the end of the technological process (t=2–6 °C). Samples of freshly prepared sausage and after 12, 24, 36, 48 hours of storage (t=2–6 °C) were examined. E. coli, Staph. aureus bacteria, pathogenic microorganisms, including salmonella bacteria, sulfite-reducing clostridia were not detected in any of the samples. This indicates the positive effect of plant ingredients.

As a result of studies, ochratoxin A (OTA) was not found in blood sausage samples, indicating the safety of the developed product. However, considering the research of scientists [23], in Europe there are cases of mycotoxins in blood sausages from different manufacturers, so there is a need for constant monitoring. In Ukraine [7], the maximum content of certain pollutants in food products is established by law, which is harmonized with the European Union Commission Regulation. The problem of mycotoxins in food is relevant in the world, because the presence of ochratoxin A in blood sausage is a serious threat to human safety, so there is a need for constant monitoring.

The possibility of creating blood sausages with a longer shelf life and high organoleptic parameters has been confirmed. The range of dishes aimed at preventing iron deficiency conditions has been expanded. The developed technology allows the optimum use of existing raw materials.

The proposed solutions and recommendations will expand the ways of effective use of eggplant powders and green buckwheat in food technology.

The results given in the paper have limitations related to the properties of eggplant powders used for blood sausage production. Adding more powders to the recipes negatively affects the structural and mechanical properties and sensory indicators of finished sausages. To obtain identical results in production, it is necessary to use eggplant powders (Almaz variety) and green buckwheat (Deya variety).

Further research will focus on studying the biological value of blood sausage and the possibility of using other cereals (millet, rice, barley) in this technology.

7. Conclusions

1. The optimum recipe ratio of ingredients and their effect on organoleptic parameters are determined. It was found that it is rational to add 10 % eggplant powder to the recipe. The results of studies show that blood sausage with green buckwheat (100 %) and eggplant powder (10 %) can have excellent organoleptic characteristics compared to the control.

2. It was found that in basic physico-chemical parameters, the developed blood sausage recipe does not differ from the control sample. Replacing buckwheat with green buckwheat in combination with eggplant powder makes it possible to enrich the product with macro and microelements. The study of microbiological indicators showed compliance with the established standards and indicates product safety. The introduction of unconventional ingredients inhibits the development of microorganisms, so the storage duration of the finished product can be increased compared to the traditional recipe. No ochratoxin A has been found, but there is a need for con-

stant monitoring due to possible mycotic lesions of raw materials.

Conflict of interest

The authors declare that they have no conflict of interest regarding this research, whether financial, personal, authorship or otherwise, that could affect the research and its results presented in this paper.

Financing

The study was conducted without financial support.

Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies when creating the presented work.

References

1. Fonseca, S., Cachaldora, A., Gómez, M., Franco, I., Carballo, J. (2013). Monitoring the bacterial population dynamics during the ripening of Galician chorizo, a traditional dry fermented Spanish sausage. Food Microbiology, 33 (1), 77–84. doi: https://doi.org/10.1016/j.fm.2012.08.015
2. Iacumin, L., Manzano, M., Stella, S., Comi, G. (2017). Fate of the microbial population and the physico-chemical parameters of "Sanganel" a typical blood sausages of the Friuli, a north-east region of Italy. Food Microbiology, 63, 84–91. doi: https://doi.org/10.1016/j.fm.2016.10.034
3. Pereira, J. A., Ferreira-Dias, S., Dionísio, L., Patarata, L., Matos, T. J. S. (2016). Application of Unsteady-State Heat Transfer Equations to Thermal Process of Morcela de arroz from Monchique Region, a Portuguese Traditional Blood Sausage. Journal of Food Processing and Preservation, 41 (2), e12870. doi: https://doi.org/10.1111/jfpp.12870
4. Shah, M. A., Bosco, S. J. D., Mir, S. A. (2014). Plant extracts as natural antioxidants in meat and meat products. Meat Science, 98 (1), 21–33. doi: https://doi.org/10.1016/j.meatsci.2014.03.020
5. Fellendorf, S., O'Sullivan, M. G., Kerry, J. P. (2016). Impact of ingredient replacers on the physicochemical properties and sensory quality of reduced salt and fat black puddings. Meat Science, 113, 17–25. doi: https://doi.org/10.1016/j.meatsci.2015.11.006
6. Fellendorf, S., O'Sullivan, M. G., Kerry, J. P. (2016). Effect of different salt and fat levels on the physicochemical properties and sensory quality of black pudding. Food Science & Nutrition, 5 (2), 273–284. doi: https://doi.org/10.1002/fsn3.390
7. Reshetylo, L. I. (2020). Microbiological safety of foodstuffs: risks of poisoning by mold fungi toxins. Herald of LUTE. Technical sciences, 24, 58–65. doi: https://doi.org/10.36477/2522-1221-2020-24-08
8. Silva, F. A. P., Amaral, D. S., Guerra, I. C. D., Arcanjo, N. M. O., Bezerra, T. K. A., Ferreira, V. C. S. et al. (2014). Shelf life of cooked goat blood sausage prepared with the addition of heart and kidney. Meat Science, 97 (4), 529–533. doi: https://doi.org/10.1016/j.meatsci.2014.03.018
9. Anjos, O., Fernandes, R., Cardoso, S. M., Delgado, T., Farinha, N., Paula, V. et al. (2019). Bee pollen as a natural antioxidant source to prevent lipid oxidation in black pudding. LWT, 111, 869–875. doi: https://doi.org/10.1016/j.lwt.2019.05.105
10. Tohamy, A. A., Abdella, E. M., Ahmed, R. R., Ahmed, Y. K. (2013). Assessment of anti-mutagenic, anti-histopathologic and antioxidant capacities of Egyptian bee pollen and propolis extracts. Cytotechnology, 66 (2), 283–297. doi: https://doi.org/10.1007/s10616-013-9568-0
11. Hygreeva, D., Pandey, M. C., Radhakrishna, K. (2014). Potential applications of plant based derivatives as fat replacers, antioxidants and antimicrobials in fresh and processed meat products. Meat Science, 98 (1), 47–57. doi: https://doi.org/10.1016/j.meatsci.2014.04.006
12. Siepko, N., Chwastowska-Siwiecka, I., Kondratowicz, J. (2015). Properties of lycopene and utilizing it to produce functional foods. Zywnosc.Nauka.Technologia.Jakosc/Food.Science.Technology.Quality. doi: https://doi.org/10.15193/zntj/2015/103/084
13. Shan, B., Cai, Y., Brooks, J. D., Corke, H. (2009). Antibacterial and antioxidant effects of five spice and herb extracts as natural preservatives of raw pork. Journal of the Science of Food and Agriculture, 89 (11), 1879–1885. doi: https://doi.org/10.1002/jsfa.3667
14. Fasseas, M. K., Mountzouris, K. C., Tarantilis, P. A., Polissiou, M., Zervas, G. (2008). Antioxidant activity in meat treated with oregano and sage essential oils. Food Chemistry, 106 (3), 1188–1194. doi: https://doi.org/10.1016/j.foodchem.2007.07.060
15. Salejda, A. M., Krasnowska, G., Tril, U. (2011). Attempt to utilize antioxidant properties of green tea extract in the production of model meat products. Zywnosc.Nauka.Technologia.Jakosc/Food.Science.Technology.Quality. doi: https://doi.org/10.15193/zntj/2011/78/107-118
16. Fursik, O., Strashynskiy, I., Pasichny, V., Kochubei-Lytvynenko, O. (2018). Quality assessment of proteins in cooked sausages with food compositions. Food Science and Technology, 12 (2). doi: https://doi.org/10.15673/fst.v12i2.936
17. Delgado, J., Rondán, J. J., Núñez, F., Rodríguez, A. (2021). Influence of an industrial dry-fermented sausage processing on ochratoxin A production by Penicillium nordicum. International Journal of Food Microbiology, 339, 109016. doi: https://doi.org/10.1016/j.ijfoodmicro.2020.109016
18. Papuc, C., Goran, G. V., Predescu, C. N., Nicorescu, V. (2016). Mechanisms of Oxidative Processes in Meat and Toxicity Induced by Postprandial Degradation Products: A Review. Comprehensive Reviews in Food Science and Food Safety, 16 (1), 96–123. doi: https://doi.org/10.1111/1541-4337.12241

19. Alao, B. O., Falowo, A. B., Aladejana, E. B. (2021). Effect of Cooking Oil on the Fatty Acid Profile of Beef Sausage Fortified with Edible Deboned Meat Waste. International Journal of Food Science, 2021, 1–8. doi: https://doi.org/10.1155/2021/5592554
20. Alao, B., Falowo, A., Chulayo, A., Muchenje, V. (2017). The Potential of Animal By-Products in Food Systems: Production, Prospects and Challenges. Sustainability, 9 (7), 1089. doi: https://doi.org/10.3390/su9071089
21. Silva, F. A. P., Amaral, D. S., Guerra, I. C. D., Dalmás, P. S., Arcanjo, N. M. O., Bezerra, T. K. A. et al. (2013). The chemical and sensory qualities of smoked blood sausage made with the edible by-products of goat slaughter. Meat Science, 94 (1), 34–38. doi: https://doi.org/10.1016/j.meatsci.2013.01.004
22. Pérez-Palacios, T., Estévez, M. (2022). Lipid Oxidation in Meat Systems: Updated Means of Detection and Innovative Antioxidant Strategies. Lipid Oxidation in Food and Biological Systems, 93–111. doi: https://doi.org/10.1007/978-3-030-87222-9_4
23. Pickova, D., Toman, J., Mikyskova, P., Ostry, V., Malir, F. (2022). Investigation of ochratoxin a in blood sausages in the Czech Republic: Comparison with data over Europe. Food Research International, 157, 111473. doi: https://doi.org/10.1016/j.foodres.2022.111473
24. Gomes, N. E. E., Malelak, G. E. M., Armadianto, H., Oematan, G. (2022). Nilai mikrobiologis dan oksidasi lemak sosis darah (ta'bu) yang diberi tambahan pasta asam (Tamarindus indica) (Microbiological and lipid oxidation value of blood sausage (ta'bu) which is additional with acid paste (tamarindus indica). Jurnal Nukleus Peternakan, 9 (1), 101–106. doi: https://doi.org/10.35508/nukleus.v9i1.6727
25. Dzyundzya, O., Burak, V., Ryapolova, I., Voievoda, N., Shinkaruk, M., Antonenko, A. et al. (2019). Establishing the effect of eggplant powders on the rheological characteristics of a semi-finished product made from liver pate masses. Eastern-European Journal of Enterprise Technologies, 4 (11 (100)), 56–63. doi: https://doi.org/10.15587/1729-4061.2019.174234
26. Santos, E. M., González-Fernández, C., Jaime, I., Rovira, J. (2003). Physicochemical and sensory characterisation of Morcilla de Burgos, a traditional Spanish blood sausage. Meat Science, 65 (2), 893–898. doi: https://doi.org/10.1016/s0309-1740(02)00296-6
27. Choi, Y.-S., Choi, J.-H., Han, D.-J., Kim, H.-Y., Lee, M.-A., Kim, H.-W. et al. (2009). Physicochemical and Sensory Characterization of Korean Blood Sausage with Added Rice Bran Fiber. Korean Journal for Food Science of Animal Resources, 29 (2), 260–268. doi: https://doi.org/10.5851/kosfa.2009.29.2.260
28. Belleggia, L., Ferrocino, I., Reale, A., Boscaino, F., Di Renzo, T., Corvaglia, M. R. et al. (2020). Portuguese cacholeira blood sausage: A first taste of its microbiota and volatile organic compounds. Food Research International, 136, 109567. doi: https://doi.org/10.1016/j.foodres.2020.109567
29. Gbaguidi, M. D. D., Degnon, R. G., Konfo, T. R. C., Kpatinvoh, B., Baba-Moussa, F. (2020). Improvement in sausage manufacturing process and potential use of selected aromatic plants as their bio preservatives in Benin. GSC Biological and Pharmaceutical Sciences, 11 (3), 166–176. doi: https://doi.org/10.30574/gscbps.2020.11.3.0180
30. Comi, G., Muzzin, A., Corazzin, M., Iacumin, L. (2020). Lactic Acid Bacteria: Variability Due to Different Pork Breeds, Breeding Systems and Fermented Sausage Production Technology. Foods, 9 (3), 338. doi: https://doi.org/10.3390/foods9030338
31. Sukhenko, Y., Korets, L., Dudchenko, V., Kos, T. (2019). New boiled sausages with wheat cell enriched with pumpkin pectin. Food resources, 7 (13), 190–198. Available at: https://iprjournal.kyiv.ua/index.php/pr/article/view/92
32. Jing, P., Zhao, S., Ruan, S., Sui, Z., Chen, L., Jiang, L., Qian, B. (2014). Quantitative studies on structure–ORAC relationships of anthocyanins from eggplant and radish using 3D-QSAR. Food Chemistry, 145, 365–371. doi: https://doi.org/10.1016/j.foodchem.2013.08.082
33. Dzyundzya, O., Antonenko, A., Brovenko, T., Tolok, G., Kryvoruchko, M., Bozhko, T. et al. (2022). Research of medical and biological indicators of eggplant powder. EUREKA: Life Sciences, 3, 3–8. doi: https://doi.org/10.21303/2504-5695.2022.002605