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Justification of the technology of sausage products using plant functional ingredients

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Abstract. The search for innovative ways to increase the biological value and optimise the recipes of meat products is an urgent task of food technology. The research was devoted to improving the technology of production of cooked sausage products by introducing a vegetable additive based on carrot puree and mushroom powder to improve their functional and technological properties and increase nutritional value. To obtain experimental data, standard methods for determining the chemical, functional and technological, organoleptic properties of the vegetable additive, model minced meat and finished sausage products were used. The research results were processed by statistical analysis methods. In the course of the research, a recipe composition of a vegetable supplement with an optimal ratio of carrot puree (75%) and mushroom powder (25%) was developed, its nutritional value was established: moisture content – 56.68%, protein – 8.56%, fat – 2.35%, carbohydrates – 36.45%, ash – 6.12%, energy value – 192 kcal/100 g. Functional, technological and organoleptic indicators of boiled sausages with different levels of introduction of the vegetable supplement were analysed. A positive effect of the supplement on the water-binding capacity, consistency and reduction of the energy value of sausages was established. The generalisation of the results showed that the recipe with a 25% replacement of meat raw materials (MP3) provided the best balance between the quality, structure and nutritional value of the finished product. The results can be used in meat processing plants to create cooked sausage products with increased functionality and cost-effectiveness

Keywords: vegetable additive; carrot; oyster mushroom; mushroom powder; functional and technological properties; energy value

Introduction

The state of nutrition is a decisive factor among the main environmental factors affecting the body. This factor directly affects the human body throughout life. Therefore, the problem of improving the structure of nutrition as the basis of human life is one of the most important for both Ukraine and other countries worldwide. As emphasised in the work of L. Bal-Prylypko *et al.* (2023), contemporary food must be functional; it should not only satisfy hunger, but also provide additional physiological benefits for the human body. All food can be considered functional to a certain extent, as it provides energy and essential nutrients required to sustain the vital functions of the human body. However, certain dietary ingredients that are not traditionally classified as nutrients may nonetheless confer positive health benefits. Such ingredients are generally regarded as functional, and food products containing these components are classified as functional foods (Essa *et al.*, 2023). Thus, functional food differs from ordinary food in that it must contain a biologically functional component, the usefulness of which for health has been scientifically proven. Biologically active components of food in the process of metabolism are transformed into components of the body's cells, participating in the formation of their structure and functions. These components play a key role in maintaining physical and mental performance, strengthening the immune system, adaptation to external factors, and also affect the general state of health, life expectancy and level of social activity of a person (Granato *et al.*, 2020).

As noted by L. Pruteanu *et al.* (2023), in the process of developing functional food products, it is advisable to pay special attention to their enrichment with components that contribute to improving the work of the main elements of the body's defence mechanisms, in particular the antioxidant defence system, enzymatic detoxification and cell membrane structures, etc. A promising area for research into the creation of functional products with increased nutritional and biological value is the combination of raw materials of animal and plant origin in accordance with modern requirements of nutritional science. Among animal products, meat and meat products are considered the main components of a healthy and balanced diet. They are concentrated natural sources of complete proteins, as well as other nutrients, such as fats, vitamins and minerals, which are necessary for the processes of growth, development and vital activity of the human body. In addition, meat is rich in biologically active substances and endogenous antioxidants with well-established beneficial properties related to their anti-inflammatory, immunoregulatory and protective activity against oxidative stress. The nutritional profile of meat consists of 75% water, 19% protein, 2.5% fat, 1.2% carbohydrates and 1.65% nitrogen compounds. The quantitative composition of these components is labile and directly correlates with feeding, storage and processing technologies (González-Osuna *et al.*, 2024).

Along with this, a significant amount of meat raw materials with low water-binding capacity are used for the production of meat products, so the use of functional food additives that eliminate this drawback is quite relevant. Modern food additives improve the organoleptic, structural-mechanical and physico-chemical parameters of finished meat products (Hunko *et al.*, 2022). Their application enables the production of goods incorporating substantial amounts of high-fat meat raw materials (Murlykina, 2025). An analysis of contemporary scientific literature indicates an increased interest in the widespread use of non-traditional types of plant raw materials, despite the development of the production of synthetic and refined forms of food additives. In particular, J. Jarnot (2022) established that *Portulaca oleracea* L. is a plant with numerous nutritional and medicinal properties and can be used in sausage production as a food additive to improve nutritional value. According to the researcher, the use of additives may be necessary to extend the shelf life. However, many manufacturers violate the technology and add cheaper substitutes for the main raw material to reduce production costs, while reducing the nutritional value of the product and its quality.

According to literature sources, a complex combination of vegetable and animal proteins is recommended, as meat raw materials contain an excess of essential amino acids, including those that are absent in plant-based raw materials. As noted in the study by V. Vovkotrub *et al.* (2024), in order to enhance the biological value of sausage products, plant-based raw materials play a key role, being considered an inexpensive source of high-quality protein. The most common is the use of soybean proteins, because, unlike animal-derived additives such as powdered milk, casein, egg white and yolk, gelatine, their cost is much lower. In particular, the authors K. Kang *et al.* (2022) developed a model of an emulsion based on soy protein as an alternative to chicken meat for the production of Vienna sausages. This contributed to a significant reduction in their cost. Scientists systematically investigated different levels of meat replacement with soy emulsion and their effect on structural and physicochemical properties. At the same time, this study had limitations in terms of storage, safety, and sensory testing under real consumption conditions, and requires further extensive trials for broader industrial implementation.

Plant raw materials are widely used to increase the nutritional value of sausage products, which are capable of exhibiting complexing and radioprotective properties due to the content of physiologically useful ballast substances, such as cellulose, hemicellulose, pectin, lignin, extensin, cutin, waxes, as well as non-structural polysaccharides such as gums, resins, and alginates. An example of such raw materials is oyster mushrooms. Indeed, in the study by I. Bandura *et al*. (2021), the content of macro- and micronutrients, amino acids, and vitamins in the mushroom species *Calocybe indica* was identified and thoroughly analysed. The authors emphasised the prospect of using this mushroom as a functional ingredient in the food industry. In the work of A. Mazumder *et al.* (2023) an original technological concept of creating a vegetable emulsified sausage-type product using a biopolymer complex of oyster mushroom (*Pleurotus sajor-caju*) and chickpeas. The authors substantiated the effectiveness of combining mushroom and legume raw materials for forming a protein-fibrous matrix with high hydration properties. The study also included microstructural analysis, which enabled accurate interpretation of changes in textural characteristics resulting from the substitution of animal protein. Despite the high quality of the basic experiments, both studies have certain limitations related to the lack of a complete link "from bioraw materials to finished product" and the lack of long-term studies of the functional safety and stability of the resulting systems.

Additional attention of scientists is also attracted by carrot puree as an affordable source of dietary fibre, β-carotene and mineral elements. Carrots, due to the high content of pectin substances and carotenoids, are able to increase the antioxidant activity of food systems, regulate the texture, moisture retention and colour of sausage products. Specifically, the study by F. Sam *et al*. (2021) demonstrates that the addition of 5-10% carrot paste to frankfurter sausages significantly enhances antioxidant activity and improves sensory attributes, aligning with the concept of functional nutrition. However, the limited period and range of analysed parameters do not allow for a full assessment of the long-term effectiveness and safety of the product. Thus, partial or complete replacement of meat raw materials in sausage products with non-traditional raw materials allows to obtain new and diverse products that can satisfy the needs of people whose consumption choices are limited by cultural conditions, religious beliefs, personal beliefs or health status. However, the introduction of these new ingredients leads to technological problems in production, as well as organoleptic shortcomings in the final products, which must be solved.

The purpose of the research was to substantiate the possibility of improving the technology of cooked sausage products by enriching them with a functional vegetable additive based on mushroom raw materials and carrots. To achieve this goal, the following tasks were formulated: determine the recipe composition of a functional additive made from mushroom raw materials and carrots, determine the effect of a functional plant additive on the physicochemical, functional-technological and organoleptic indicators of model minced cooked sausage products; theoretically justify the recipe amount of a functional additive in the composition of minced sausage.

Materials and Methods

The experimental part of the research was conducted during 2024-2025 on the basis of the laboratory of meat, fish and seafood technology of the Faculty of Faculty of Food Technology and Quality Control of Agricultural Products of the National University of Life and Environmental Sciences of Ukraine. The first stage of the research was to determine the rational amount of ingredients in the composition of the vegetable additive for further use in the technology of cooked sausage products. Carrots of the Chantane variety (manufacturer – LLC "Ahroovoch Ukraine", Zhytomyr region) were used as vegetable raw materials. The root crops were without signs of spoilage, medium in size. After sorting and washing, the carrots were manually peeled, cut into cubes with 10 mm edge length, packed into heat-resistant polymer bags, and vacuum sealed. Heat treatment was carried out using Sous vide technology at a temperature of 80 ± 2°C for 30 ± 5 minutes until softened.

Next, the rubbing was performed in two stages: first on a rubbing machine with sieves with openings of 1.2...1.5 mm, then with sieves with openings of 0.5...0.7 mm. After rubbing, carrot puree was obtained.

The mushroom component of the functional supplement was obtained from the fruiting bodies of the common oyster mushroom (*Pleurotus ostreatus*), grown under controlled conditions at the enterprise LLC "Hrybna Ferma" (Kyiv). Fresh mushrooms were first washed, then sliced to a thickness of 3 mm and dried in a drying oven at 45°C for 12 hours until a residual moisture content of no more than 7% was achieved. The dry raw materials were ground to a powder state in a laboratory crusher and sieved through a sieve with a hole diameter of 1.2...1.5 mm. The resulting mushroom powder had a light brown colour and a pronounced mushroom aroma. The functional vegetable supplement was a mechanically homogenised composition of carrot puree and mushroom powder in various ratios according to the data given in Table 1.

Table 1. *Modelling of the recipe composition of a vegetable additive for the production of cooked sausages*

Ingredients	Proportional composition of ingredients, %				
	MG1	MG2	MG3	MG4	MG5
Carrot puree	90	85	80	75	70
Mushroom powder	10	15	20	25	30

Source: compiled by the authors

The second stage of the study was devoted to the development of a recipe for cooked sausages, taking into account the inclusion of a functional additive. The basis for the new recipe was the minced meat of cooked sausage "Okrema", which included the main ingredients: beef of the 1st grade 60%, semi-fat pork – 25%, pork brisket – 15%, as well as additional ones: table salt 2.5%, coriander 0.1%, fresh garlic 0.3%, sodium nitrite 0.007%, nutmeg 0.05%. The meat raw material was obtained from a certified slaughterhouse (LLC "Miaso Polissia", Zhytomyr region) and met the requirements of DSTU 6030:2008 (2009). Beef – from the front part of the carcass, chilled, without visible defects; Semi-fat pork had a muscle-to-fat ratio of approximately 60:40. A total of five variants of sausage minced meat were produced: one control (traditional, without vegetable additive) and four experimental (MP1-MP4) with a stepwise introduction of vegetable additive in the amount of 15%, 20%, 25% and 30%, respectively (Table 2). The quantity of additional ingredients in the model minced meat formulations was equivalent to that of the selected reference sample. The formulation of the plant-based supplement for incorporation into the model mixtures was determined based on the results of the first stage of the study. The expected product yield was 80% by weight of unsalted raw materials.

Table 2. *Formulation of model minced meat mixtures for the production of cooked sausages*

Component names	Prescription amount of ingredients, %				
	"Okrema"	MP1	MP2	MP3	MP4
Beef, 1st grade	60	60	55	50	45
Pork, semi-fat	25	25	25	25	25
Pork brisket	15	–	–	–	–
Plant-based supplement	–	15	20	25	30
Total	100	100	100	100	100

Source: compiled by the authors

The volume of each batch was 2.5 kg. All samples were prepared according to the same scheme. The production process of the sausage products involved mincing the meat raw materials using a meat grinder with a plate diameter of 3-5 mm, followed by mixing in a bowl cutter with additional ingredients according to the formulation. The functional plant-based supplement, in the form of a homogenate, was added during the mince blending stage (at the second stage of bowl cutting), and the mixture was processed until a uniform consistency was achieved. Then, the minced meat was filled into collagen casings with a diameter of 32 mm using an automatic syringe, and loaves 12...15 cm long were formed. Thermal processing was carried out in a steam-convection oven according to the following regime: roasting at 80°C for 30 minutes, followed by cooking until the internal temperature of the sausage loaf reached 72 ± 1°C (approximately 60 minutes). The sausages were then cooled in a refrigeration chamber to 4°C. Samples were stored for no more than 24 hours before analytical studies.

Standard methods were used to perform analytical studies. determination of chemical, functional and technological properties of the vegetable additive, model minced meats and finished sausage products: water-binding, water-holding, fat-holding, fat-binding capacity, pH value, components of the chemical composition: moisture content, protein, fat, carbohydrates, ash content, organoleptic evaluation. To confirm the reliability of the results obtained, all experimental studies were carried out with three repetitions of each series. For each sample and each indicator (water-binding capacity, fat and water absorption capacity, structural and mechanical characteristics), at least n=5 independent measurements were performed, which provided a sufficient amount of statistical data for further analysis. Statistical processing. The experimental data were analysed using the MS Excel 365 license package with additional add-ins for regression modelling. The significance of differences between mean values was assessed using analysis of variance (ANOVA). When assessing the significance of the results, a standard confidence level of α=0.05 was used.

The hydrogen ion concentration was measured in accordance with DSTU ISO 2917:2001 (2003) using a Testo 205 pH meter. The device provided measurements in the pH range from 0 to 14 units at temperatures from 0 to 60°C, with an accuracy of 0.01 pH units and 0.1°C; the error limit was ±0.02 pH and ±0.4°C. For the analysis, an aqueous extract was prepared at a mince-to-water ratio of 1:10. To this end, 5 g of mince or homogenised sample product was placed in a 250 ml conical flask, followed by the addition of 50 ml of distilled water. Extraction was then carried out for 30 minutes with intermittent stirring. After completion of the process, the extract was filtered and the pH in the filtrate was determined.

The fat absorption capacity of the test samples was determined as follows: 3 g of the test sample of the product and 15 ml of oil were mixed in a laboratory mixer for 1 min at a speed of 50 r/60 s, then the suspension was left in a thermostat at a temperature of 90ºC for 20 min. Thereafter, the mixture was centrifuged at 4,000 rpm for 5 minutes. The fugate was drained, its mass F and the content of dry substances in it were determined. The fat absorption capacity was calculated by the formula (1):

$$\mathrm{FAC} = \frac{\mathrm{B}-(\mathrm{F}-m)}{\frac{M\cdot(100-W)}{100}-m}\cdot 100, \%, \quad (1)$$

where B is the amount of oil poured into the centrifuge tube, ml; M is the weight of the product added to the centrifuge tube, g; F is the mass of the fugate, g; W is the moisture content in the product, %; m is the content of dry substances in the fugate, g. m was determined by the formula (2):

$$m = \mathrm{F}\frac{\mathrm{DM^F}}{100}, \quad (2)$$

where $\mathrm{DM^F}$ is the dry matter in the sample taken for determination, g.

Water absorption capacity (WAC) was determined by the above method, but distilled water was used instead of oil. The experiment was repeated three times. The arithmetic mean results of the calculations were presented in the form of graphical images. The method for determining the water-binding capacity (WBC) was based on the principle of water release from 300 mg of the sample during 10-minute pressing with a load weighing 1 kg. The evaluation was carried out based on the area of the stain on filter paper, which formed as a result of the absorption of the released liquid by the paper. The contour of the spot resulting from the pressed minced meat was marked with a pencil. The area of the wet zone was calculated as the difference between the total area of the imprint and the area occupied by the mince itself. The content of bound water was calculated by the formula (3):

$$X = \frac{(A-8{,}4B)\cdot 100}{A}, \qquad (3)$$

where X is the content of bound water (WBC), % of total water; A is the total water content in the sample, mg; B is the area of the wet spot, cm^2.

Determination of water-holding capacity (WHC) and fat-holding capacity was performed in the following order according to generally accepted methods described in the work of T. Szmańko *et al*. (2021). The water content of the samples was determined in accordance with DSTU ISO 1442:2005 (2008) by drying in a thermostated drying oven at a temperature of 130°C. The method was based on the property of the tested material to lose hygroscopic moisture when heated to a specified temperature. The protein content was determined by the Kjeldahl method, which is based on the mineralisation of the sample, distillation of ammonia into a sulfuric acid solution with subsequent titration (DSTU ISO 937:2005, 2007). The mineralisation process was carried out by heating the sample with concentrated sulphuric acid in the presence of a copper-sulphate catalyst. As a result of the reaction, the ammonia formed interacted with an excess of sulfuric acid to form ammonium sulphate (4):

$$2NH_3 + H_2S0_4(k) \rightarrow (NH_4)_2S0_4. \qquad (4)$$

To determine the amount of ammonia, ammonium sulphate was decomposed by concentrated sodium hydroxide (5):

$$(NH_4)_2S0_4 + 2NaOH \rightarrow 2NH_3 + 2H_20 + Na_2S0_4. \qquad (5)$$

The ammonia formed was absorbed by a sulfuric acid solution during titration (6):

$$2NH_3 + H_2S0_{4k} \rightarrow (NH_4)_2S0_4. \qquad (6)$$

The excess sulfuric acid was titrated with sodium hydroxide solution, and the amount of ammonia absorbed, or the corresponding mass of nitrogen, was calculated from the volume of bound acid. The fat content was determined by a method based on repeated extraction of fat from a dried sample using a volatile solvent, followed by removal of the solvent and drying of the extracted thimble to a stable mass (DSTU ISO 1443:2005, 2008). Extraction was carried out in a Soxhlet apparatus using dichloroethane as a solvent. The sample, dried to constant weight, was transferred into a paper thimble, which was weighed and placed into the extractor of a Soxhlet apparatus. The extraction time was 4-6 hours.

The ash content was determined as the mass of mineral substances obtained after ashing of organic substances (DSTU ISO 936:2008, 2008). The combustion of the organic part of the test sample was carried out in a muffle furnace at a temperature of 500...800°C. A 5 g portion of the test sample, weighed to an accuracy of 0.0002 g, was placed into a pre-calcined crucible that had been weighed to constant mass. The crucible with the sample was placed in a muffle furnace. Ashing was started at a low temperature, then continued at a temperature of 500...800°C for 1...2 hours. The crucible was cooled in a desiccator and then weighed.

Carbohydrate content was determined as the sum of sugars, starch, and dietary fibre, which were determined according to standard methods (DSTU ISO 13965:2007, 2009; Bandura *et al.*, 2022). The calculation of the energy value of 100 g of product (kcal) was performed according to the formula (7):

$$EV = (C_p \cdot 4) + (C_c \cdot 3.75) + (C_f \cdot 9), \quad (7)$$

where C_P – protein content, %; C_C – carbohydrate content, %; C_f – fat content, %; 4.0 – coefficient for calculating the energy value for proteins (3.75 – for carbohydrates, 9.0 – for fats, kcal).

Organoleptic evaluation of cooked sausage products was carried out in compliance with ethical and methodological requirements that ensure reproducibility of results and compliance with standards (DSTU 4823.2:2007, 2009). The study was conducted with the involvement of a tasting panel consisting of 12 individuals (7 women and 5 men aged between 24 and 60 years), of whom 8 had professional training in food technology, at least three years of experience in sensory evaluation, and had been certified as internal experts within food industry enterprises. The remaining members of the commission were qualified specialists with knowledge of the consumer properties of meat products. The composition of the panel and participation in the study were carried out on a voluntary basis, following informed consent obtained in writing from all participants after they had been briefed on the aim of the study and the tasting conditions, in accordance with the provisions of the WMA Declaration of Helsinki (2013). The evaluation criteria and their limits were determined in accordance with the requirements of DSTU 4436:2005 (2007), using a five-point scale: 5 points – excellent quality, fully compliant with the requirements of the standard, signs are maximally pronounced, no defects; 4 points – good quality, minor deviations in the severity of signs, do not affect the overall impression; 3 points – satisfactory quality, moderately pronounced defects, but the product is suitable for consumption; 2 points – unsatisfactory quality, noticeable defects; 1 point – product unsuitable for consumption.

Each sample was served to the tasters anonymously, under a conditional code, chilled (8...10°C), cut into pieces 1 cm thick and weighing approximately 10 g. All samples were identically prepared, served in disposable tasting dishes, under the same lighting, in a tasting room that meets sanitary and hygienic standards (illumination 600... 800 lux, temperature 20±2°C, neutral interior colours, absence of foreign odours). Between tasting different samples, the tasters were able to neutralise the taste with drinking water and a slice of white bread. The evaluation procedure followed a specific sequence: external appearance was assessed based on structure, density, uniformity of mince filling, and the absence of air pockets or casing defects; cut surface colour was evaluated visually, taking into account homogeneity, intensity, and colour typicality for the respective type of sausage; aroma and taste were assessed through organoleptic analysis after chewing the sample, with attention to the presence or absence of off-flavours or odours, the distinctiveness of the aromatic profile, and saltiness; consistency was evaluated by pressing the sample surface with a finger and during chewing, considering elasticity, firmness, and uniformity. The assessment was carried out individually by filling out tasting questionnaires. All data were summarised in a table and analysed statistically. The reliability of the difference between the estimates for different samples was checked using variance analysis at a significance level of α=0.05.

Based on the results of the questionnaire, a comprehensive evaluation of organoleptic characteristics was carried out. It included determining the total score of model samples S_i and the coefficient of intensity of manifestation of the general impression S_i/S. This coefficient is used for comparative assessment of the quality of food products, in particular – in tasting studies. It is calculated by the formula (8):

$$S_i/_S = \frac{S_i}{S_{max}}, \quad (8)$$

where S_i is the total score obtained by this sample for all organoleptic indicators; S or S_{max} – the maximum possible score. If all 5 indicators are rated 5 points, then:

$$S, S_{max} = 5 \cdot 5 = 25 \text{ points}$$

Based on the results of organoleptic evaluation, conclusions were drawn about the formulation of the tested samples and the quality of the finished product.

Results

Modelling the formulation of a plant-based supplement

The main property of minced meat food systems that affects the quality of finished sausage products is the sorption of water and fat. Water and fat provide key sensory and physiological benefits. Their presence contributes to the formation of taste, texture and appearance of products. From the perspective of consistency, water and fat have a decisive influence on the binding, rheological, and structural properties of meat products and play a crucial role in the formation of meat emulsions within the mince. However, from the standpoint of healthy nutrition, reducing the fat content in food products is considered a promising approach. In turn, a decrease in the fat content in meat products is accompanied by a deterioration in appearance, taste and consistency. Therefore, the most important functional and technological properties were selected as criterion indicators when modelling the recipe quantity of ingredients of a plant-based supplement: water absorption capacity (WAC) and water-holding capacity (WHC), fat absorption capacity (FAC) and fat-holding capacity (FHC) of mixtures. The results of determining these criterion indicators are presented in Figures 1 and 2.

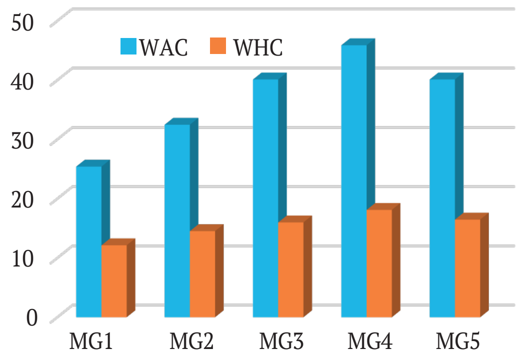

Figure 1. The value of the WAC and WHC of the composite mixtures of the plant-based supplement, %
Source: compiled by the authors

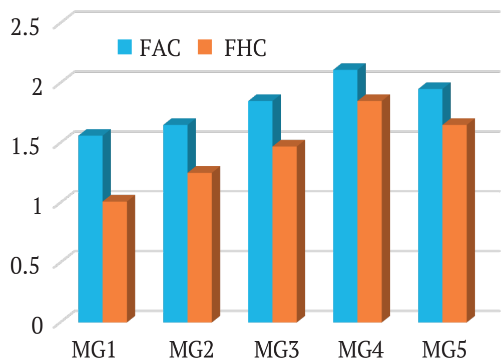

Figure 2. The value of the FAC and FHC of the composite mixtures of the plant-based supplement, g fat/g
Source: compiled by the authors

The obtained results proved that the best functional and technological properties were possessed by the composite mixture of the plant-based supplement MG4, which contained 75% carrot puree and 25% mushroom powder. At the same time, the water absorption and water-holding capacity were 45.89% and 18.11%, respectively, the fat absorption and fat-holding capacity were 2.11 and 1.85 g fat/g, respectively (Figs. 1, 2). A further increase in the mass fraction of mushroom powder in the formulation of the plant-based supplement was accompanied by a decrease in the numerical values of all functional and technological parameters. Such results are associated with the physicochemical structure of plant polysaccharides that dominate in the composition of mushroom powder and are present in carrot puree.

Water-holding capacity is the amount of water that remains bound to the fibre hydrate after the application of external centrifugal force of gravity or compression (Raghavendra *et al.*, 2006). According to known literature data, the dietary fibres of mushroom powder particles have the ability to retain water by adsorption inside the fibre matrix, which will help preserve the structure of future finished sausage products (Grigelmo-Miguel *et al.*, 1999; Lan *et al.*, 2012). Fat-holding capacity is also the most important technological property, which is associated with the chemical structure of plant polysaccharides and depends on the thickness, surface properties, and hydrophobic nature of the fibrous particles (López-Marcos *et al.*, 2015).

An increase in the percentage of mushroom powder in the formulation of the plant-based supplement led to a higher proportion of its insoluble fraction, which adversely affected the functional and technological properties, resulting in their reduction. Correlation-regression analysis confirmed the existence of a close direct correlation between the concentrations of mushroom powder and the functional and technological properties of the plant-based supplement. The pairwise correlation coefficient between the concentration of mushroom powder in the formulation and the WAC of the plant-based supplement was r = 0.85, and the WHC – r = 0.86. The general regression model of the relationship between the concentration of mushroom powder in the formulation of the plant-based supplement and its WAC is described by the graphical dependence and equation presented in Figure 3, and the WHC – in Figure 4.

The pairwise correlation coefficient between the concentration of mushroom powder in the plant-based supplement formulation and the FAC of the supplement was r=0.88, and for the FHC – r=0.90. The general regression model of the relationship between the concentration of mushroom powder in the plant-based supplement formulation and its FAC is described by the graphical dependence and equation presented in Figure 5, and for the FHC – in Figure 6.

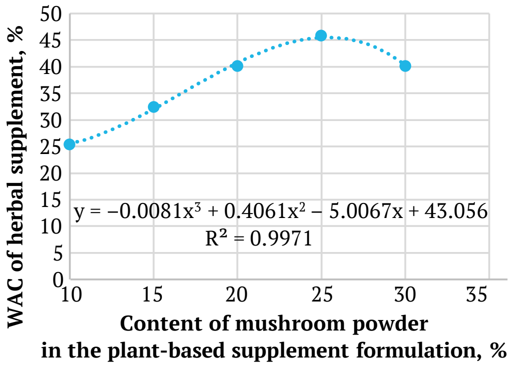

Figure 3. Dependence of the WAC on the content of mushroom powder in the plant-based supplement formulation

Source: compiled by the authors

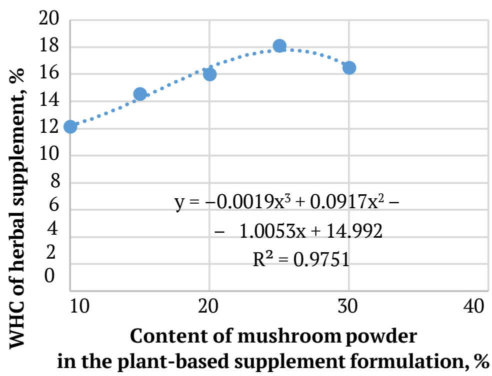

Figure 4. Dependence of WHC on the content of mushroom powder in the plant-based supplement formulation

Source: compiled by the authors

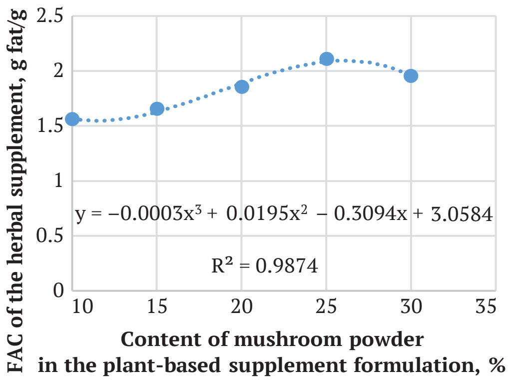

Figure 5. Dependence of FAC on the content of mushroom powder in the plant-based supplement formulation

Source: compiled by the authors

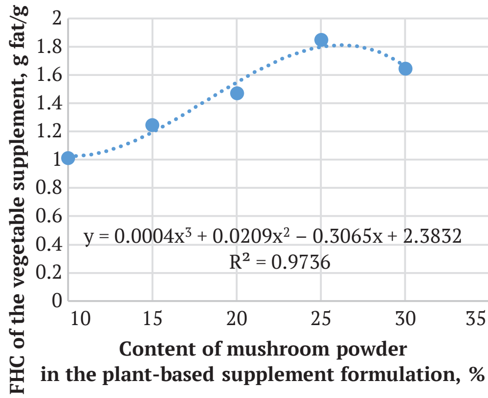

Figure 6. Dependence of FHC on the content of mushroom powder in the plant-based supplement formulation

Source: compiled by the authors

The resulting equations make it possible to predict the key functional and technological properties of the plant-based supplement depending on the mushroom powder content in its formulation. Based on the results obtained, a composite mixture of the plant-based supplement MG4 is recommended for further use, which includes 75% carrot puree and 25% mushroom powder. The chemical composition and calorie content of the developed composite mixture of the plant-based supplement MG4 are given in Table 3.

Table 3. *Chemical composition and caloric value of the composite plant-based supplement mixture MG4*

Chemical composition components	Content, %
Moisture	56.68 ± 0.02
Fat	2.35 ± 0.03
Protein	8.56 ± 0.43
Ash	6.12 ± 0.21
Carbohydrates	36.45 ± 0.14
Caloric value, kcal per 100 g	192.08

Source: compiled by the authors

According to the results of the chemical composition analysis, carbohydrates are the main component. However, it should be noted that the carbohydrate profile of the plant-based supplement consists primarily of so-called complex carbohydrates. The so-called simple carbohydrates, the main representatives of which are sugars, make up a smaller part of them. Their content was 6.56 ± 0.23%. This indicator is generally acceptable, especially for groups of the population suffering from diabetes. In addition, scientists Á. Farkas *et al.* (2020) found that β-carotene, which is contained in carrot puree, inhibits insulin resistance in diabetes. Thus, the developed plant-based supplement demonstrates high technological performance, which may contribute to reducing mass losses of cooked sausage products during thermal processing, promoting the formation of a homogeneous and tender consistency in the final product, and decreasing the number of defective items by minimising moisture and fat release.

Modelling the recipe for cooked sausage products

The formulation modelling of the experimental cooked sausage samples was carried out taking into account the results of organoleptic and physicochemical analyses. The functional and technological properties of the model minced meats are given in Table 4.

Table 4. *Functional and technological properties of model minced cooked sausages with vegetable additive MG4*

Sample name	Moisture content, %	Water-binding capacity, %	Water-holding capacity, %	Fat-holding capacity, g fat/g	pH
"Okrema" (control)	64.0±0.7	81.2±3.5	72.5±2.9	68.5±3.9	5.6±0.1
MP1	66.1±0.24	85.6±2.1	78.2±3.0	74.6±3.3	5.8±0.3
MP2	68.3±1.8	87.7±2.3	81.1±3.7	74.9±3.3	5.9±0.2
MP3	70.1±1.7	90.5±3.6	83.4±2.8	75.2±6.5	6.2±0.1
MP4	72.2±0.9	92.1±2.6	86.1±4.8	75.6±5.8	6.5±0.2

Source: compiled by the authors

The presented research results indicate that the incorporation of the MG4 plant-based supplement – comprising carrot purée and mushroom powder – into model cooked sausage mixtures at levels of 15-30% increases their water-holding capacity by 5.7-13.6% and fat-holding capacity by 6.65-7.58%, which contributes to improved structure in the final products (Table 4). The sensory evaluation of model samples of cooked sausages confirmed that the partial replacement of meat raw materials with a functional vegetable supplement did not worsen their organoleptic indicators. However, increasing the amount of the plant-based supplement to 30% resulted in a pronounced carrot and mushroom flavour and aroma, which is uncharacteristic of cooked sausages and led to a decrease in their sensory evaluation scores (Fig. 7, Table 5).

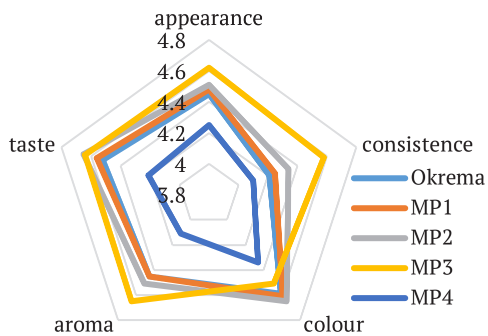

Figure 7. Sensory profile chart of the model cooked sausage samples

Source: compiled by the authors

Table 5. *Results of calculating the areas of the constructed quality profiles of the sausage scoring*

Indicators	"Okrema" (control)	MP1	MP2	MP3	MP4
Consistence	4.21	4.25	4.34	4.58	4.10
Colour	4.59	4.61	4.65	4.51	4.34
Aroma	4.45	4.45	4.51	4.65	4.11
Taste	4.52	4.56	4.65	4.64	4.21
Appearance	4.45	4.48	4.51	4.62	4.25
S	22.22	22.35	22.66	23.0	21.01
S_i/S	0.89	0.89	0.91	0.92	0.84

Note: S – overall score of the experimental samples; S_i/S – coefficient of intensity of manifestation of general impression

Source: compiled by the authors

In particular, the overall score of the experimental samples ranged from 21 to 23 points. The highest total organoleptic score among all samples was recorded for sample MR3 (23.00 points), which contained 25% of the plant-based supplement. This corresponded to a general impression intensity coefficient (S_i/S) of 0.92, indicating the most favourable perception of the sample by the tasting panel. This indicates the best perception of the sample by the tasting panel. Slightly lower values were received by samples MP2 ($S_i/S = 0.91$), MP1 (0.89) and the control sample "Okrema" (0.89), which indicates the preservation or slight improvement of organoleptic properties when including 15...20% of the plant-based supplement in the formulation. In contrast, sample MP4, which contained 30% of the functional composition, had the lowest index (0.84), which confirms the decrease in consumer characteristics with excessive dosage of the plant-based component. In order to provide a comprehensive characterisation of the final sausage products, their chemical composition and energy value were determined (Table 6).

Table 6. *Chemical composition of finished sausage products*

Model sample	Component content, %					Energy value, kcal
	Moisture	Protein	Fats	Carbohydrates	Ash	
"Okrema" control	64.0 ± 0.7	11.3 ± 1.08	14.94 ± 1.76	0.01 ± 0.01	0.84 ± 0.07	179.32
MP1	66.1 ± 0.24	11.28 ± 1.74	13.02 ± 0.86	1.89 ± 0.09	0.89 ± 0.04	169.43
MP2	68.3 ± 1.8	11.31 ± 1.31	12.11 ± 1.27	1.92 ± 0.16	0.93 ± 0.03	161.43
MP3	70.1 ± 1.7	11.48 ± 1.33	11.08 ± 0.87	1.95 ± 0.28	0.96 ± 0.02	152.36
MP4	72.2 ± 0.9	11.54 ± 1.13	10.22 ± 1.16	1.96 ± 0.12	0.99 ± 0.06	143.79

Source: compiled by the authors

Analysis of the presented data showed that the addition of the plant-based supplement composed of carrot purée and mushroom powder led to an increase in the mass fractions of moisture, protein, carbohydrates, and ash, while simultaneously resulting in a reduction in fat content compared to the control. A noticeable decrease in fat content was accompanied by a decrease in the energy value of finished products. The reduction in fat content and the increase in "beneficial carbohydrates" allow the sausage products with partial substitution of meat raw material by the plant-based supplement to be classified as products with enhanced functional properties.

Discussion

Functional and technological characteristics of minced meat systems are formed under the influence of a complex of physicochemical and sensory factors that determine textural parameters, structural integrity, colour intensity, flavour profile and moisture and fat holding during heat treatment. The results obtained confirmed that the water absorption capacity (WAC) and water-holding capacity (WHC), fat absorption capacity (FAC) and fat-holding capacity (FHC) of the mixtures are the most important technological indicators that determine the quality of cooked sausages. It was found that the composition MG4 (75% carrot puree and 25% mushroom powder) demonstrated the highest values: WAC – 45.89%, WHC – 18.11%, FAC – 2.11 g/g and FHC – 1.85 g/g. With an increase in the proportion of mushroom powder, all indicators declined, which can be attributed to the growing amount of the insoluble fraction, which is less effective in liquid binding. These results are consistent with the findings of L. Korets (2019) and Y. Xu *et al.* (2022), who demonstrated that the incorporation of dietary fibres into meat products significantly improves the water-holding capacity of meat mince. Similarly, in the work of S. Lee *et al.* (2023) found that the fibrous structure provides stability to emulsions by forming bonds with fat globules, which maintains the structure of the minced meat and reduces moisture loss. J. Feng *et al.* (2025) found that fat-holding capacity correlates with the hydrophobic properties of the fibres – a high proportion of mushroom powder, which is rich in insoluble fibres, can worsen the HFCS, which is also reflected in the indicators for MG5 compositions in the current study. The data obtained in this study also resonate with the results of A. Mazumder *et al.* (2023), in which a significant decrease in HFCS and HFCS was recorded when a high concentration of mushroom powder was added to sausages – similar to observations for MG5.

Particular attention should be given to the role of carrot purée: in the study by J. Richards *et al.* (2024), the addition of 3-4% carrot purée to meat mince improved the water-binding capacity by 8.5-15.7% and increased the yield of the final product by 13.9-22.8%. This indicates a synergistic effect of carrot-mushroom powder, which the authors of the current study confirmed, obtaining the maximum indicators for the MG4 composition. Moreover, S. Yadav *et al*. (2018) found that the addition of dried carrot pomace in combination with wheat bran improves the technological properties of chicken sausages without compromising their sensory qualities.

Correlation-regression analysis of the conducted study confirmed the high statistical significance of the relationship between the concentration of mushroom powder and functional indicators ($r = 0.85$-0.90). This coincides with the studies of B. Mishra *et al.* (2023), which revealed the dependence of WHC and FHC on the proportion of fibre compounds in sausage systems. Thus, the synergistic combination of carrot fibre and mushroom powder provides a technological compromise between texture, emulsion stability, and juice retention, which is optimised at a ratio of 75:25. Adding 15-30% of the plant-based supplement MG4 to the minced meat of cooked sausages contributed to a significant increase in water-holding capacity (by 5.7…13.6%) and fat-holding capacity (by 6.65…7.58%) compared to the control, which is consistent with the conclusions of X. Li *et al.* (2024). The observed positive effect is attributed to the fact that the dietary fibres in mushroom powder and carrot purée have a low gelatinisation temperature, which is close to the denaturation temperature of meat proteins. Upon reaching this temperature, moisture is released and subsequently absorbed by the protein-carbohydrate complex introduced with the carrot-mushroom supplement.

According to DSTU 4436:2005 (2007), no more than 75% moisture is allowed in cooked sausage products. Adding a vegetable additive contributed to an increase in the moisture content in the products. However, the moisture content of the model samples produced using the classical formulation (control) and the MP1, MP2, and MP3 formulations complied with the requirements for the highest commercial grade, whereas the MP4 formulation corresponded to the standards for first and second commercial grades. The organoleptic evaluation confirmed a consistently high level of consumer properties for samples with 15-25% of the additive, while 30% caused the appearance of a pronounced carrot-mushroom taste and aroma and a decrease in the S_i/S coefficient to 0.84. The results of the correlation analysis confirmed the obtained results. A strong inverse correlation was established between the content of the plant-based supplement and the fat content in the finished sausage products, with a correlation coefficient of $r = -0.99$. In contrast, strong direct correlations were observed with all other chemical composition parameters: with protein content ($r = 0.70$), carbohydrate content ($r = 0.89$), and ash content ($r = 0.98$). Based on a comprehensive assessment of the functional and technological properties and organoleptic indicators of finished sausage products, the optimal recipe composition was determined to be the composition of MP3, which provides for the introduction of 25% of the vegetable additive.

Conclusions

In the course of the study, a novel solution was proposed to a relevant scientific and applied problem, namely the improvement of the functional, technological, and consumer properties of cooked sausages through the addition of a plant-based supplement formulated from carrot purée and oyster mushroom powder. Taking into account the functional and technological indicators, the optimal recipe composition of the vegetable supplement was substantiated. Its composition includes 75% carrot puree and 25% mushroom powder. The nutritional value of the vegetable supplement was established: moisture content – 56.68%, fat – 2.35%, protein – 8.56%, carbohydrates – 36.45%, ash – 6.12%, energy value – 192 kcal per 100 g. The investigation of organoleptic indicators and functional properties of the finished sausage products confirmed the feasibility of partially replacing meat raw materials with a functional plant-based supplement. Based on experimental studies, it was established that the optimal recipe composition is the MP3 composition, which provides for the introduction of 25% of the vegetable supplement.

The improved technology of cooked sausage products, which involves the use of 25% vegetable supplement of mushroom powder and carrot puree, has advantages over traditional technology – rational use of meat raw materials, the ability to regulate functional and technological properties, effective impact on the energy value of finished products. The prospects of the conducted research are significant for both science and the food industry. The scientific value lies in the introduction of a composite plant-based supplement, based on carrot purée and oyster mushroom powder, as a functional ingredient that enhances the water- and fat-holding capacities of minced meat systems and enriches the product with biologically active compounds. The results obtained create a basis for further research into interfacial interactions in protein-carbohydrate systems and the study of the physiological impact of bioactive components on human health. From a practical perspective, the proposed formulation allows for partial replacement of meat raw materials, reduction of fat content, enhancement of nutritional value, and alignment with current trends in healthy and functional nutrition, making it a promising option for industrial implementation.

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Conflict of Interest

None.

References

[1] Bal-Prylypko, L., Nikolaenko, M., Volkhova, T., Holembovska, N., Tyshchenko, L., Ivaniuta, A., Israelian, V., Menchynska, A., Shynkaruk, O., & Melnik, V. (2023). The study of functional and technological properties of vegetarian ice cream. *Potravinarstvo Slovak Journal of Food Sciences*, 17, 110-121. doi: 10.5219/1798.

[2] Bandura, I., *et al*. (2021). Biology and nutritional contents in the culinary-medicinal milky white mushroom, *Calocybe indica* (Agaricomycetes), during cultivation involving casing and scratching treatments. *International Journal of Medicinal Mushrooms*, 23(12), 53-63. doi: 10.1615/IntJMedMushrooms.2021040535.

[3] Bandura, I., *et al*. (2022). Effect of different grain spawn materials on *Pleurotus ostreatus* (Jacq.) P. Kumm. mushroom cultivation under unregulated and regulated fruiting conditions. *Acta Agriculturae Slovenica*, 118(1), 1-13. doi: 10.14720/aas.2022.118.1.1862.

[4] DSTU 4436:2005. (2007). *Boiled sausages, frankfurters, sardellas, meat loaves general specifications*. Retrieved from https://online.budstandart.com/ua/catalog/doc-page.html?id_doc=77099.

[5] DSTU 4823.2:2007. (2009). *Meat products. Organoleptic evaluation of quality indicators. Part 2. General requirements*. Retrieved from https://surl.li/mjuyns.
[6] DSTU 6030:2008. (2009). *Meat beef and veal in carcasses, semi-carcasses and quarters. Specifications*. Retrieved from https://surl.li/dfidot.
[7] DSTU ISO 13965:2007. (2009). *Meat and meat products. Determination of the mass fraction of starch and glucose by enzymatic method (ISO 13965:1998, IDT)*. Retrieved from https://online.budstandart.com/ua/catalog/doc-page.html?id_doc=89536.
[8] DSTU ISO 1442:2005. (2008). *Meat and meat products. Method for determining the moisture content (control method) (ISO 1442:1997, IDT)*. Retrieved from https://surli.cc/eaywkh.
[9] DSTU ISO 1443:2005. (2008). *Meat and meat products. Method for determining total fat content (ISO 1443:1973, IDT)*. Retrieved from https://surl.li/jpazkq.
[10] DSTU ISO 2917:2001. (2003). *Meat and meat products. Determination of pH (control method) (ISO 2917:1974, ID)*. Retrieved from https://surl.li/mqcder.
[11] DSTU ISO 936:2008. (2008). *Meat and meat products. Determination of total ash (ISO 936:1998, IDT)*. Retrieved from https://online.budstandart.com/ua/catalog/doc-page?id_doc=89525.
[12] DSTU ISO 937:2005. (2007). *Meat and meat products. Determination of nitrogen content (control method) (ISO 937-1978, IDT)*. Retrieved from https://surli.cc/lnmtue.
[13] Essa, M.M., Bishir, M., Bhat, A., Chidambaram, S.B., Al-Balushi, B., Hamdan, H., Govindarajan, N., Freidland, R.P., & Qoronfleh, M.W. (2023). Functional foods and their impact on health. *Journal of Food Science and Technology*, 60, 820-834. doi: 10.1007/s13197-021-05193-3.
[14] Farkas, Á., Bencsik, T., & Deli, J. (2020). Carotenoids as food additives. In E. Jacob-Lopes, M.I. Queiroz & L. Queiroz Zepka (Eds.), *Pigments from microalgae handbook* (pp. 421-447). Cham: Springer. doi: 10.1007/978-3-030-50971-2_17.
[15] Feng, J., Chen, J., Zhai, J., Zhang, P., & Peng, L. (2025). Reduced fat content of fried batter-breaded fish nuggets by adding dietary fibers: Insight into wheat starch and gluten conformations, fiber properties and anti-fat absorption capacities. *Food Chemistry*, 463(2), article number 141251. doi: 10.1016/j.foodchem.2024.141251.
[16] González-Osuna, M.F., Bernal-Mercado, A.T., Wong-Corral, F.J., Ezquerra-Brauer, J.M., Soto-Valdez, H., Castillo, A., Rodríguez-Figueroa, J.C., & Del-Toro-Sánchez, C.L. (2024). *ACS Food Science & Technology*, 4(5), 1003-1016. doi: 10.1021/acsfoodscitech.3c00605.
[17] Granato, D., Barba, F.J., Bursać Kovačević, D., Lorenzo, J.M., Cruz, A.G., & Putnik, P. (2020). Functional foods: Product development, technological trends, efficacy testing, and safety. *Annual Review of Food Science and Technology*, 11(1), 93-118. doi: 10.1146/annurev-food-032519-051708.
[18] Grigelmo-Miguel, N., Abadías-Serós, M.I., & Martín-Belloso, O. (1999). Characterisation of low-fat high-dietary fibre frankfurters. *Meat Science*, 52(3), 247-256. doi: 10.1016/S0309-1740(98)00173-9.
[19] Hunko, Y., Holiachuk, S., & Fedorus, Y. (2022). Proofs os summer sausage produced using an advanced technology. *Commodity Bulletin*, 15(2), 38-48. doi: 10.36910/6775-2310-5283-2022-16-3.
[20] Jarnot, J. (2022). Analysis of food additives in the production of sausages. *Annals of the University of Craiova-Agriculture Montanology Cadastre Series*, 52(1), 218-223. doi: 10.52846/aamc.v52i1.1336.
[21] Kang, K.M., Lee, S.H., & Kim, H.Y. (2022). Effects of using soybean protein emulsion as a meat substitute for chicken breast on physicochemical properties of Vienna sausage. *Food Science of Animal Resources*, 42(1), 73-83. doi: 10.5851/kosfa.2021.e63.

[22] Korets, L. (2019). Investigation of functional properties of varnish sausage with addition of wheat cloth with pectin pumpkin. *Commodity Bulletin*, 12(1), 18-28. doi: 10.36910/6775-2310-5283-2019-12-02.

[23] Lan, G., Chen, H., Chen, S., & Tian, J. (2012). Chemical composition and physicochemical properties of dietary fiber from *Polygonatum odoratum* as affected by different processing methods. *Food Research International*, 49(1), 406-410. doi: 10.1016/j.foodres.2012.07.047.

[24] Lee, S., Jo, K., Jeong, S.K.C., Jeon, H., Choi, Y.S., & Jung, S. (2023). Recent strategies for improving the quality of meat products. *Journal of Animal Science and Technology*, 65(5), 895-911. doi: 10.5187/jast.2023.e94.

[25] Li, X., Wang, L., Tan, B., & Li, R. (2024). Effect of structural characteristics on the physicochemical properties and functional activities of dietary fiber: A review of structure-activity relationship. *International Journal of Biological Macromolecules*, 269(2), article number 132214. doi: 10.1016/j.ijbiomac.2024.132214.

[26] López-Marcos, M.C., Bailina, C., Viuda-Martos, M., Pérez-Alvarez, J.A., & Fernández-López, J. (2015). Properties of dietary fibers from agroindustrial coproducts as source for fiber-enriched foods. *Food and Bioprocess Technology*, 8, 2400-2408. doi: 10.1007/s11947-015-1591-z.

[27] Mazumder, A.R., Sujintonniti, N., Chaum, P., Ketnawa, S., & Rawdkuen, S. (2023). Developments of plant-based emulsion-type sausage by using grey oyster mushrooms and chickpeas. *Foods*, 12(8), article number 1564. doi: 10.3390/foods12081564.

[28] Mishra, B.P., Mishra, J., Paital, B., Rath, P.K., Jena, M.K., Reddy, B.V.V., Pati, P.K., Panda, S.K., & Sahoo, D.K. (2023). Properties and physiological effects of dietary fiber-enriched meat products: A review. *Frontiers in Nutrition*, 10, article number 1275341. doi: 10.3389/fnut.2023.1275341.

[29] Murlykina, N. (2025). Determination of properties of meat products with plant supplements. *Engineering Proceedings*, 87(1), article number 28. doi: 10.3390/engproc2025087028.

[30] Pruteanu, L.L., Bailey, D.S., Grădinaru, A.C., & Jäntschi, L. (2023). The biochemistry and effectiveness of antioxidants in food, fruits, and marine algae. *Antioxidants*, 12(4), article number 860. doi: 10.3390/antiox12040860.

[31] Raghavendra, S.N., Swamy, S.R., Rastogi, N.K., Raghavarao, K.S.M.S., Kumar, S., & Tharanathan, R.N. (2006). Grinding characteristics and hydration properties of coconut residue: A source of dietary fiber. *Journal of Food Engineering*, 72(3), 281-286. doi: 10.1016/j.jfoodeng.2004.12.008.

[32] Richards, J., Lammert, A., Madden, J., Cahn, A., Kang, I., & Amin, S. (2024). Addition of carrot pomace to enhance the physical, sensory, and functional properties of beef patties. *Foods*, 13(23), article number 3910. doi: 10.3390/foods13233910.

[33] Sam, F.E., Ma, T.Z., Atuna, R.A., Salifu, R., Nubalanaan, B.A., Amagloh, F.K., & Han, S.Y. (2021). Physicochemical, oxidative stability and sensory properties of Frankfurter-type sausage as influenced by the addition of carrot (*Daucus carota*) paste. *Foods*, 10(12), article number 3032. doi: 10.3390/foods10123032.

[34] Szmańko, T., Lesiów, T., & Górecka, J. (2021). The water-holding capacity of meat: A reference analytical method. *Food Chemistry*, 357, article number 129727. doi: 10.1016/j.foodchem.2021.129727.

[35] Vovkotrub, V., Iakubchak, O., Vovkotrub, N., Shevchenko, L., Lebedenko, T., Holembovska, N., Pylypchuk, O., & Omelian, A. (2024). Quality and safety of pork meat after cooling and treatment with lactic starters. *Potravinarstvo Slovak Journal of Food Sciences*, 18, 439-452. doi: 10.5219/1954.

[36] WMA Declaration of Helsinki – Ethical Principles for Medical Research Involving Human Participants. (2013). Retrieved from https://surl.li/hlhux.

[37] Xu, Y., Yan, H., Xu, W., Jia, C., Peng, Y., Zhuang, X., Qi, J., Xiong, G., Mei, L., & Xu, X. (2022). The effect of water-insoluble dietary fiber from star anise on water retention of minced meat gels. *Food Research International*, 157, article number 111425. doi: 10.1016/j.foodres.2022.111425.

[38] Yadav, S., Pathera, A.K., Ul Islam, R., Malik, A.K., & Sharma, D.P. (2018). Effect of wheat bran and dried carrot pomace addition on quality characteristics of chicken sausage. *Asian-Australasian Journal of Animal Sciences (AJAS)*, 31(5), 729-737. doi: 10.5713/ajas.17.0214.

Обґрунтування технології ковбасних виробів з використанням рослинних функціональних інгредієнтів

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Анотація. Пошук інноваційних шляхів підвищення біологічної цінності та оптимізації рецептур м'ясних продуктів є актуальним завданням харчових технологій. Дослідження було присвячено удосконаленню технології виробництва варених ковбасних виробів шляхом введення рослинної добавки на основі морквяного пюре та грибного порошку для покращення їхніх функціонально-технологічних властивостей і підвищення харчової цінності. Для отримання експериментальних даних використані стандартні методи визначення хімічних, функціонально-технологічних, органолептичних властивостей рослинної добавки, модельних фаршів та готових ковбасних виробів. Результати досліджень оброблено методами статистичного аналізу. У процесі дослідження розроблено рецептурну композицію рослинної добавки з оптимальним співвідношенням морквяного пюре (75 %) та грибного порошку (25 %), встановлено її харчову цінність: вміст вологи – 56,68 %, білка – 8,56 %, жиру – 2,35 %, вуглеводів – 36,45 %, золи – 6,12 %, енергетична цінність – 192 ккал/100 г. Було проаналізовано функціонально-технологічні та органолептичні показники варених ковбас із різним рівнем введення рослинної добавки. Встановлено позитивний вплив добавки на вологозв’язувальну здатність, консистенцію та зниження енергетичної цінності ковбас. Узагальнення результатів показало, що рецептура з 25 %-вою заміною м’ясної сировини (МР3) забезпечувала найкращий баланс між якістю, структурою та харчовою цінністю готового продукту. Результати можуть бути використані на підприємствах м’ясної промисловості для створення варених ковбасних виробів із підвищеною функціональністю та економічною ефективністю

Ключові слова: рослинна добавка; морква; глива; грибний порошок; функціонально-технологічні властивості; енергетична цінність