

Meat-containing bread with the use of hemp flour has been devised, with the subsequent assessment of its physical and chemical, sensory properties involving the study into the technological indicators of new products. Three experimental formulations for meat-containing bread were developed, which included semi-fat pork, poultry, mechanically deboned turkey, pumpkin pulp, and 8, 10, 12 % of hemp flour. A meat-containing bread from combined raw materials was adopted as control. All samples were evaluated taking into consideration their physical and chemical, technological, and sensory characteristics.

It has been proven that the addition of hemp flour to the formulation improved the consumer value of products by increasing the content of protein, fat, and minerals. It was found that the protein content in the developed products was 18.03–19.53 g/100 g, which is 3.21–11.80 % higher than that of the analog. The fat content increased by 17.84–56.83 %, which also led to an increase in the calorie content of products.

It has been experimentally confirmed that the introduction of hemp flour into bread's minced meat improves the functional and technological indicators of model meat systems. An increase in water-binding capacity was observed, by 13.46–22.15 %; in water-holding capacity, by 10.34–21.43 %; in fat-holding capacity, by 17.2–26.9 %. The combination of semi-fat pork, poultry, mechanically deboned turkey, and hemp flour increases the ductility of the minced meat while reducing the shear stress, contributes to the good forming properties of the minced meat. The sensory analysis of the prototypes showed their high consumer value. The organoleptic assessment and sensory analysis of the prototypes demonstrated high consumer properties of the manufactured products, which makes it possible to recommend them for inclusion in the diets of various segments of the population

Keywords: *hemp flour, meat-containing bread, pumpkin pulp, technological indicators, physical and chemical properties*

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DETERMINING THE NUTRITIONAL VALUE AND QUALITY INDICATORS OF MEAT-CONTAINING BREAD MADE WITH HEMP SEEDS FLOUR (CANNABIS SATIVA L.)

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1. Introduction

The population's health and well-being are influenced by numerous factors such as the rapid pace of life, age-related changes in the body, bad habits, stressful situations, and, in a view of the recent events, pandemic and severe quarantine.

For various reasons, humanity is consuming less and less biologically full products, with refined and hydrogenated fats more often appearing in our diet. Deficiency of the most important biologically active substances for the human body in modern food encourages the population to

consume excessive food to prevent the deficiency of amino acids, polyunsaturated fatty acids, minerals, and vitamins. Overeating leads to obesity [1]. According to data reported in [2], more than 1.9 billion adults on the planet are overweight, and more than 600 million are obese.

Therefore, one of the relevant tasks in the field of food technology is to find alternative raw material resources that would allow the creation of new products for rational nutrition. This category includes products that provide the human body with essential nutrients, as well as prevent diseases associated with nutrition, and improve physical and psychological state [3, 4].

2. Literature review and problem statement

A new direction has emerged in the food industry, such as the production of functional products based on the use of regional raw food resources, which contain proteins, dietary fiber, essential amino acids, minerals, and vitamins. Functional nutrition is steadily gaining popularity in countries where the state cares about the health of its citizens. This is because the use of functional products can help solve many public health problems. The inclusion of functional products in the diet could help reduce the level of morbidity of the population due to their preventive effect and ensuring a healthy diet for people with insufficient quantity or quality of traditional products. Functional products make it possible to enrich the usual diet of people with vitamins, minerals, and essential substances; increase the mental and physical endurance of employees; help the population in resisting stress, and preventing possible psychological disorders.

Essential to increasing the manufacture of products of this group is to expand the range, as well as improve their quality, and efficient and integrated use of raw materials. In terms of expanding food resources, of traditional interest is the protein-containing raw materials of plant origin, non-traditional for meat products, and, above all, regional. It is obvious that the search for protein-containing plant raw materials of local origin with a high content of essential substances is a relevant issue for the creation of functional foods. The authors of paper [5] offer textured soy proteins, wheat gluten, mucoprotein as an alternative source of vegetable protein. Expanding resources involving the use of regional raw materials for food is the latest European trend, due to the population's adaptation to raw materials and food. Therefore, local products, grown and consumed in the territory of their production, make it possible to solve the problem of reducing the loss of resources in the food chain of consumption of processed animal and vegetable raw materials [6].

The combination of different types of raw materials, including non-traditional ones, in the technology of meat production, has allowed the development of a wide range of combined foods. The authors of paper [7] devised meat-containing products with a combination of waterfowl and freshwater aquaculture, which have high biological value, high yield; their organoleptic characteristics are not inferior to traditional products, or, as established in [8] have extended shelf life due to the efficient implementation of thermal processes. However, the issue of increasing the nutritional value through inexpensive local protein-containing plant resources remains unresolved.

The authors of work [9], when studying the introduction of lentil flour as a source of vegetable protein in the technology of semi-smoked sausages, found that the criteria for selecting vegetable raw materials with subsequent use in meat technology should include the availability of raw materials, their ability to reproduce quickly; full chemical composition, the content of biologically active components; technological adaptability and safety.

The authors of [10] proved that a promising type of non-traditional protein-containing vegetable raw materials at present is oil-bearing crops, namely hemp, canola, lupine, and sea buckthorn seeds, as well as by-products from the production of vegetable oil. There is a problem of the optimal

ratios of protein sources in the formulations of meat products to increase the nutritional value of products, which can be solved by using raw materials with a high content of biologically active nutrients.

Plant raw materials with a high content of essential substances: vitamins, macro- and micronutrients, polyunsaturated fatty acids (PUFA), as well as dietary fiber, are of practical interest. The use of PUFA sources, the physiological function of which is related to the structural function in cell membranes, the functioning of the nervous, immune, and cardiovascular systems, regulation of cholesterol and triglycerides in human blood, could solve the problem of prevention of nutritional diseases [11]. It is known that the penetration of viruses into the cell of the human body occurs through a weakened membrane, the bilipid layer of which consists mainly of PUFA, so there is a problem of providing the body with these essential substances via food [12].

Dietary fiber is an important texture-forming component of food, which, in the process of passing through the digestive tract, removes toxins, scums, excess fat, and other harmful components. Fiber lowers plasma cholesterol, promotes rapid emptying of the gastrointestinal tract, dietary fiber reduces the transit time of the digestive tract and increases fecal mass, regulating the digestive process, reduces the risk of cardiovascular disease [13]. Therefore, the inclusion of fiber sources as one of the components of plant raw materials solves the problem of gastrointestinal tract diseases prevention.

The problem of increasing the nutritional value of the above biologically active substances by introducing a multi-component ingredient with a high content of protein, PUFA, fiber, etc. into the formulations of meat-containing and meat products remains unsolved. A promising type of such raw material in the technology of combined meat products can be products of hemp seed processing, in particular, hemp flour.

Hemp (*Cannabis Sativa L.*) is a unique plant with a long history. The physical and chemical, technological, and health properties of hemp flour were studied in [14]. The efficiency of using hemp flour in the production of cookies [15], crackers [16] has been proven. The results of the research indicated an increase in the protein content in the finished products. The possibility of using hemp flour to produce new types of meat products was also considered [17]. It was established that when 10 % of beef is replaced with a similar amount of hemp flour in the formulation of chopped meat semi-finished products, the consumer properties of the finished product are preserved while increasing its biological value. It was determined in [18] that by combining pork with protein-containing raw fish and hemp seed protein in meat-rich cooked-smoked sausages, it is possible to produce high-value products with high quality. However, there are no data on the use of hemp processing products in the technology of baked meat-containing products, including traditional types of meat (pork) and products from secondary processing (MPSP).

Traditional cereals contain no more than 13 % of protein while hemp grain has up to 40 % of protein. The content of lysine in the products of hemp seed processing is 2 times higher than that in wheat and 3 times higher than that in corn bulk products. One should also note the lack of gluten in hemp seeds. Therefore, this product can be con-

sumed by people with celiac disease (an allergic disease in which the body cannot absorb products containing gluten), they must not consume oats, wheat, barley, and rye [19]. It was established that hemp seed flour is a unique source of protein, carotenoids, phytosterols, and phospholipids, mineral elements K, Zn, S, and Mg. The flour contains about 38 % of proteins, balanced in the composition of essential amino acids, including lysine, tryptophan, leucine, phenylalanine. Hemp seed processing products are a source of dietary fiber (up to 15 %) [20]. Thus, hemp flour is a multi-component source of nutrients that can enrich meat products.

Partial replacement of animal proteins for meat products, by cheaper vegetable proteins, can be effective to overcome the protein deficiency in the diet. At the present stage of development of the meat industry, the problem of deficiency of meat protein is solved by the application of proteins of soy, gluten of wheat, the proteins of cotton seeds, etc. [21]. However, replacing meat protein with vegetable protein is predetermined not only by its deficiency. This issue is also related to health or environmentally unfriendly food choices due to inefficient use of land and energy, gas emissions from meat production [22]. The existing issue related to increasing the nutritional value of meat-containing products while reducing the harmful effects on the environment needs to be resolved. One of the ways to address this problem may be to include high-protein hemp seeds in the ingredient composition of meat-containing products.

3. The aim and objectives of the study

The study aims to determine the nutritional value and quality indicators of meat-containing bread when replacing part of the raw meat with hemp flour. This will make it possible to obtain meat-containing bread with a high content of protein, fat, energy value, high quality, and expand the range of meat-containing products in the consumer market.

To achieve this aim, the following tasks were set:

- to investigate the content of basic nutrients and energy value of the samples of meat-containing bread with hemp flour according to the developed model formulations;
- to study the effect of hemp flour share and MPSP from turkey in the formulations of the components of meat-containing bread on the stability of the physical-chemical, functional-technological indicators of minced meat and finished products;
- to determine the impact of using hemp flour and MPSP from turkey on a possibility to ensure the high sensory indicators and consumer value of the developed meat-containing bread.

4. The study materials and methods

Meat-containing bread from the combined raw materials [23] was used as an analog for our research [23]. The formulation consisted of lean duck meat – 30 %, silver carp minced meat – 45 %, lard – 10 %, dry whey powder – 5 %, wheat flour – 2 %. Auxiliary raw materials included the plant-derived fiber Fibra 110 – 2 %, chicken eggs or mélange – 2 %, Aproned (serum albumin) – 2 %, table salt, sodium nitrite, and spices. The ratios of the components in the formulation-analog and model samples are given in Table 1.

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Table 1

Variants of the main raw material for experimental meat-containing bread

Component	Formulation variants			
	Control	1	2	3
Raw material, unsalted, per 100 kg				
Lean pork semi-fat	–	35	30	25
Lean duck meat	30	–	–	–
Silver carp minced meat	45	–	–	–
MPSP (turkey)	–	41	44	47
Lard	10	10	10	10
Whey powder	5	–	–	–
Pumpkin pulp paste	–	3	3	3
Hemp seed flour	–	8	10	12
Wheat flour	2	–	–	–
Chicken eggs or mélange	3	3	3	3
Aproned	2	–	–	–
Vegetable fiber Fibra 110	3	–	–	–

In the developed formulations of meat-containing bread, the duck meat was replaced with traditional lean pork. As an alternative to fish raw materials, MPSP turkey was proposed. Hemp flour was included as a source of vegetable protein; pumpkin pulp paste was added to improve the nutritional value of the product: dietary fiber, minerals.

Duck, fish, and pork were minced in a laboratory meat grinder (Philipps, Germany), and then dry ingredients were added. The hydration of hemp flour was performed with warm (35–40 °C) water for 15 minutes, hydro module – 1:3. Butternut squash paste was made from cleaned pulp using a blender. The crushed components were stirred for 8 minutes. The lard was frozen and crushed into 3×3 mm pieces. After cooking, the minced mass was poured into molds, pre-greased with lard. The baking of bread was performed in three stages with a total process duration of 210–220 minutes until the temperature inside the product reached 70–72 °C. After heat treatment, the loaves were removed from the mold and cooled to a temperature inside the product in the range of 4–8 °C.

Hemp seed flour (*Cannabis Sativa L.*) was used as an ingredient in the development of formulations (TOV Desnaland, Hlukhiv, Ukraine). The properties of the product are given in Table 2.

The samples were examined for nutritional and energy value. The protein content was determined by the Kjeldahl method (ISO 937, 1978). The total fat was determined by the Soxhlet method (ISO 1443, 1973).

Ash was measured after mineralization of the samples in a muffle furnace (Germany) at 520 °C.

The energy value was calculated according to the system of the total Atwater coefficient. Mean energy values are expressed as the number of calories per 1 gram of macronutrient. The general system of Atwater factors includes energy values of 4 kcal per gram (kcal·g⁻¹) (17 kJ·g⁻¹) for protein,

4 kcal·g⁻¹ for carbohydrates, and 9 kcal·g⁻¹ (37 kJ·g⁻¹) for fat [24]. The functional-technological properties were determined in the samples of the model minced meat and finished products.

Table 2
Characteristics of the physical and chemical quality indicators of bulk hemp products (TU U 10.41–39224310–002:2017). Certificate number: 10.41–39224310–002:2017

Indicator name	Hemp flour	Hemp protein
Moisture mass fraction, %	6.5 – not exceeding 7.0	6.5–7.0
Protein mass fraction, %	44.01 – not exceeding 40.00	52.14 – not less than 50.00
Oil mass fraction, %	11.65 – not exceeding 16.00	10.62 – not exceeding 12.00
Ash mass fraction, %	9.55 – not exceeding 10.0	8.84 – not exceeding 10.0
Fiber mass fraction, %	5.94 – not exceeding 7.0	13.88 – not exceeding 15.0

Meat pH was determined using the digital pH-meter pH-150MI [25].

PH measurements were performed after 30 min of exposure.

Moisture content was measured by Method (ISO 1442, 1997).

The moisture-binding capacity of minced meat was determined by pressing [25].

The moisture-holding capacity of the minced meat was calculated as the difference between the mass fraction of moisture in the minced meat and the amount of moisture released during heat treatment.

A portion of finely chopped meat weighing 4–6 g was evenly applied with a glass rod to the inner surface of a wide part of the graduated test tube. The tube was tightly closed with a stopper and placed with its narrow end down on a water bath at boiling temperature for 15 minutes. Then the mass of the released moisture was determined by the number of divisions on the scale of the test tube.

The meat moisture-holding capacity (%) was calculated from the following formula:

$$MHC=M-MRA, \quad (2)$$

where M is the total mass fraction of moisture in the sample, %; MRA is the moisture release ability of meat (%). MRA is determined from the following formula:

$$MHC = a \cdot n \cdot m^{-1} \cdot 100, \quad (3)$$

a is a step of divisions of a fat meter; $a=0.01$ cm³; n is the number of divisions of the fat meter scale; m is the weighted portion mass, g

To determine the emulsifying ability (EA), a procedure reported in [25] was used. 7 g of minced meat was ground in 100 cm³ of water in a homogenizer for 60 s at a speed of 66.6 s⁻¹. 100 cm³ of refined sunflower oil were added; the mixture was emulsified in a homogenizer at a speed of 1,500 rpm for 5 minutes. The emulsion was poured into 4 calibrated centrifuge tubes and centrifuged at 500 rpm for 10 minutes. The volume of the emulsified oil was determined. EA was calculated from the following formula, %:

$$EA=V_1/V \times 100, \quad (4)$$

where V_1 is the volume of emulsified oil, cm³; V is the total oil volume, cm³.

The emulsion stability was defined by heating it at a temperature of 80 °C for 30 minutes and cooling it with water for 15 minutes [23]. 4 calibrated centrifuge tubes were filled with the emulsion and centrifuged at 500 s⁻¹ for 5 min. The volume of the emulsified layer was determined. The stability of the emulsion (%) was calculated from the following formula:

$$ES=V_1/V_2 \times 100, \quad (5)$$

where V_1 is the volume of emulsified oil, cm³; V_2 is the total emulsion volume, cm³.

Determining the limit shear stress (LSS) was performed using the Volarovich viscometer RV-8, with a corrugated rotor (a corrugation step is 2 mm). The outer cylinder ($R_s=1.9$ cm) is stationary; the inner cylinder ($R_b=0.605$ cm) is actuated by falling loads. Rotor length $LB=8$ cm. After measurements, charts were constructed and appropriate calculations were performed [26].

The minced meat plasticity is the ability of the minced meat to counteract the static load of the mass reduced to a mass unit (1 kg). The indicator was determined by the area of the stain of minced meat formed under the action of a static load weighing 1 kg for 10 minutes [26] and calculated from the following formula:

$$P=(B_m \times 1000)/m, \quad (6)$$

where P is the minced meat plasticity, cm²·kg/g, B_m is the area of mince spot, cm², 1,000 is the dimensionality conversion coefficient, mg and g to kg.

We determined the bread samples' quality using an organoleptic method [25]. Bread samples were evaluated by 20 tasters; they included students, technicians, and lecturers from the Faculty of Food Technology at Sumy National Agrarian University. They were selected according to inclusion and exclusion criteria from the ages of 18 to 59. Each taster received coded products on a plastic plate. The evaluated quality features were the appearance, texture, juiciness, taste, aroma, and overall acceptability. Sensory analysis was performed on a five-point scale.

Statistical data were treated using Microsoft Excel. All experiments were repeated three times. The absolute measurement error was calculated according to the Student's criteria, the confidence interval $P=0.95$. Data are presented as an average value \pm a standard deviation of the value. The smallest acceptable difference for samples from one prototype was accepted to be 5 %. The reliability value was chosen $p<0.05$.

5. The results of studying the nutritional value, the physical-chemical, and organoleptic indicators of meat-containing bread

5.1. Determining the nutritional and energetic value of the developed samples of meat-containing bread with hemp flour

In meat-containing bread, according to the developed model formulations, the content of the basic nutrients and energy value were investigated. The research results are given in Table 3.

Table 3

Nutritional value of meat-containing bread

Indicator	Analog	Sample		
		1	2	3
Protein content, g/100 g	17.47±0.45	18.03±0.23	18.76±0.52	19.53±0.47
Fat content, g/100 g	19.25±0.19	30.19±0.11	29.33±0.21	28.46±0.58
Mineral substances content, g/100 g	1.09±0.05	1.71±0.03	1.88±0.06	2.06±0.05
Energy value, kJ	1,105	1,439	1,418	1,398

Our analysis of data in Table 3 reveals that the meat-containing combined bread had a high protein content, which ranged from 17.47 to 19.53 g/100 g per product. The amount of protein was higher in the developed products and amounted to 18.03–19.53 g/100 g, which is 3.21–11.80 % higher compared to the analog. In the experimental bread samples, the concentration of fats ranged from 28.46±0.58 to 30.19±0.11 g/100 g. The highest content of mineral residue in the experimental samples amounted to 2.06±0.05 g/100 g, which is 89 % higher compared to the analog.

5. 2. Studying the effect of bread formulation components on the physical and chemical, functional, and technological properties of minced meat and products

Table 4 gives the results characterizing the stability of the functional and technological properties of the model minced meat systems containing pork and turkey MPSP with different hemp flour content.

Data in Table 4 demonstrate that with increasing the share of hemp flour in the formulation of the meat-containing bread not only the stabilization of its functional and technological indicators occurs but also the values of MRA, FRA, MHC increase, compared with control. MRA indicators in the model minced meat range within 82.13–88.46 %. MHC indicators in the model samples ranged from 51.06 % to 56.20 %, which is 10.3 and 21.4 % higher compared to control. It is shown that with the increase of moisture content in the system, the indicators of shear properties tend to decrease. It is noted that increasing the amount of hemp flour in the formulations of model samples led to an increase in the fat retention ability (FRA) to 63.46–68.49 %, which is 17.2–26.9 % higher than that in control. At the same time, there is an increase in mince plasticity and a decrease in GPA values. However, these values are specific to minced meat with a high proportion of vegetable fillers in their formulations [26].

Our analysis of data in Table 5 reveals that the EA in the experimental samples with a high content of hemp flour increases, compared to control, by 5.8–13.9 %, depending on the formulation, and is 91–98 %.

The emulsion stability in the model samples was also higher than that in control, by 12.82–20.6 %.

For minced systems with high fat content, factors that increase the emulsifying ability of minced meat are important. Table 5 gives data from studying the emulsifying prop-

erties of the developed model minced meat in comparison with the control sample.

Table 4

The physical-chemical, structural-mechanical indicators of the model mince for meat-containing bread

Indicator	Control	Sample 1	Sample 2	Sample 3
Moisture content, %	69.27±3.73	77.13±0.40	77.03±2.54	74.31 ±1.77
MRA, %	72.39±0.75	82.13±0.05	88.43±0.35	87.21 ±0.45
MHC, %	46.28±7.00	51.06±0.01	56.20±0.01	51.37 ±0.01
FRA, %	54.11±0.23	63.46±0.31	68.40±0.17	68.49 ±0.79
pH	5.91±0.015	6.27 ±0.03	6.39±0.015	6.38 ±0.085
Plasticity, cm ² /g	9.23±0.11	11.35±0.17	11.28±0.85	11.57 ±0.13
GPA, Pa	651.31±1.41	589.37±1.61	576.09±2.03	574.31 ±1.72

Table 5

The emulsifying properties of model mince for meat-containing bread

Indicator	Control	Sample 1	Sample 2	Sample 3
Emulsifying ability, %	86.00±0.65	91.00±1.41	98.00±0.13	97.21±0.41
Emulsion stability, %	55.14±1.08	62.21±0.70	66.50±1.54	63.71±0.11

The technological and physical-chemical parameters of finished products are relevant in the production of baked goods. The study results are given in Table 6.

The yield of the finished product and its consumer properties demonstrate the stability of the quality characteristics of meat-containing bread with the introduction of hemp flour in the amount of 10–12 % as one of the basic components of the model minced meat-containing bread.

Table 6

Technological, physical, and chemical indicators in baked bread

Formulation	Moisture content, %	Yield, %	pH
Control	68.36±0.17	109.3±0.37	6.17±0.06
Sample 1	71.20±0.13	120.9±0.31	6.22±0.02
Sample 2	72.63±0.22	122.1±0.57	6.21±0.03
Sample 3	71.01±0.53	120.3±0.36	6.29±0.03

5. 3. Analyzing the sensor evaluation and consumer value of the developed meat-containing bread with hemp flour

When devising new types of combined meat products, suggesting a partial replacement of raw meat with non-meat ingredients, it is necessary to achieve organoleptic characteristics that correspond to traditional products. The results of studying the organoleptic parameters of experimental samples and control are shown in Fig. 1.

Fig. 1 shows that the consistency and juiciness of the developed bread samples were better than those in the con-

control sample. However, in terms of other indicators, namely appearance, color, and aroma, only samples 1 and 2 exceeded the control sample. Based on the results of our research, it has been determined that it is the most rational to use 10 % of hemp flour in the meat-containing bread formulation.

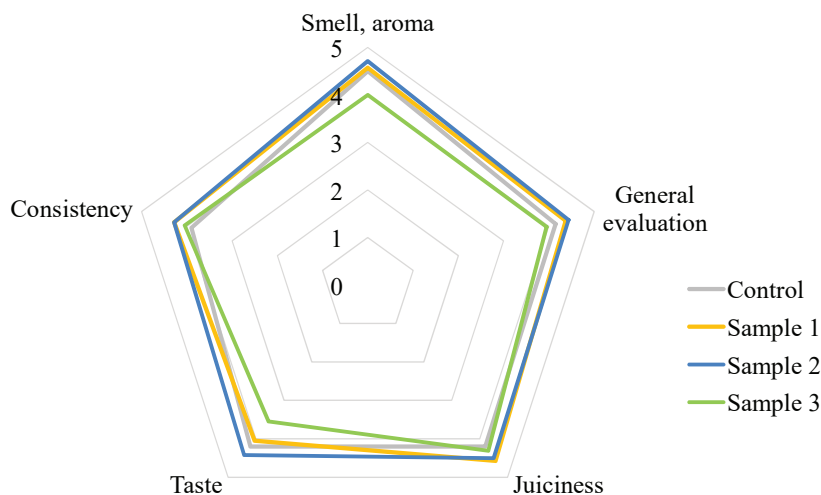


Fig. 1. Results of sensor evaluation of the combined meat-containing bread

6. Discussion of results of studying the nutritional value, the physical-chemical, and organoleptic properties of meat-containing bread

The study of protein content in the experimental samples showed that, compared to the analog, the protein concentration in the developed products increased by 3.21–11.80 %. That was achieved through the inclusion of high-protein ingredients in the formulation, such as pork, turkey MPSP, and hemp flour. The protein content of hemp seeds can range from 20 to 25 % [27] depending on the variety and environmental factors. This figure may increase under the conditions of additional hemp seeds processing. Cleaning the seeds and obtaining meals after extracting the oil fraction make it possible to increase the percentage of protein in the products of hemp seeds processing.

However, despite the use of protein components, the fat content increased significantly. The developed samples of combined bread exceeded the analog in terms of this indicator by 47.84–56.83 %, which predetermined the high caloric content of the obtained products. Due to the use of MPSP turkey in the developed products, not only the energy value increased but also the total amount of minerals. The developed samples of meat-containing bread contained a total amount of minerals of 1.71–2.06 g/100 g of product. Compared with the control sample, the content of mineral residue in the experimental bread was higher by 56.88–88.99 %. This is due to the presence of turkey MPSP in the formulations. Mechanically deboned poultry meat is often used in minced meat products due to its fine consistency and relatively low cost [28]. In some countries, MPSP are often used in emulsified, minced meat products (sausages and frankfurters), it can be added to sausages up to 60 % by weight of the raw materials [29]. On the other hand, protein-energy malnutrition is one of the most important health problems in many countries around the world and causes half of all child mortality, negatively affecting the development of children who do not have compensatory mechanisms [30]. The inclusion of high-protein and

high-calorie foods in the diet can eliminate the lack of protein and energy in the human diet.

The increase in the values of MRA and MHC in the samples can be explained by the introduction into the meat system of a certain proportion of hemp flour (8.0–12.0 %), which contributed to an increase in the mass fraction of substances capable of swelling. The better structural properties of minced specimens of the experimental samples are also due to the significant content of salt-soluble fractions of proteins in hemp flour. The increase in the amount of hemp flour in the formulations causes an increase in fat retention ability to 63.46–68.49 %, which is 17.2–26.9 % higher than that of control. The increase in the mass fraction of proteins, which play an important role in the formation of the protein-fat matrix, predetermines the strength of the protein-hydrate shells around the droplets of the fat fraction [31]. The retention of fat in the emulsion state due to protein-fat conglomerates stabilizes the formed dispersed system. This is confirmed by the values of emulsion stability in the model samples, which increased by

12.82–20.6 % compared to control. In addition to hemp flour, poultry and pork in meat-containing bread have high emulsifying properties [32, 33], which are enhanced by the addition of hemp flour.

In this research, we did not study the amino acid and fatty acid composition of the products obtained, which is necessary to characterize the biological value of the product. The prospect of further research is to determine the completeness of protein and the biological effectiveness of the fat fraction of meat-containing bread.

7. Conclusions

1. Based on the developed formulations for meat-containing bread using hemp flour, it has been proven that the use of different types of meat and plant-derived raw materials in the composition of meat-containing bread using 8–12 % of hemp flour makes it possible to achieve acceptable consumer and technological characteristics of meat-containing bread. It has been established that the use of pork, turkey MPSP, and hemp flour in the formulations makes it possible to improve the consumer value of products by increasing the protein content by 3.21–11.80 %, fat – by 47.84–56.83 %. The content of mineral substances increased by 56.88–88.99 %.

2. Due to the increase in the share of protein in meat-containing bread, the functional and technological indicators of the model minced meat are improved, which is manifested by an increase in MRA, by 13.46–22.15 %, MHC – by 10.34–21.43 %, FRA – by 17.2–26.9 %. Combining in the formulations of meat-containing bread the turkey and pork MPSP and hemp flour increases the plasticity of minced meat while reducing the shear stress, which gives the minced meat good molding properties.

3. It has been determined that the use of hemp flour in the amount of 8–12 % and turkey MPSP in the amount of 41–47 %, when replacing waterfowl and silver carp meat

with them, improves the organoleptic and consumer indicators of meat-containing bread, which allows us to recommend these types of raw materials for the composition of meat-containing products.

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