ANIMAL SCIENCE AND FOOD TECHNOLOGY

Journal homepage: https://animalscience.com.ua/en
Animal Science and Food Technology, 13(1), 47-56
Received: 20.12.2021 Revised: 17.01.2022 Accepted: 07.02.2022

UDC 637.05
DOI: 10.31548/animal.13(1).2022.47-56

The Effect of Freezing on the Characteristics of Semifinished Products in a Dough Covering Using Non-Conventional Protein-Containing Raw Materials

Vasyl Pasichnyi[1], Yevheniia Shubina[1], Roman Svyatnenko[1], Olena Moroz[2]

[1]National University of Food Technologies
01601, 68 Volodymyrska Str., Kyiv, Ukraine

[2]Lviv Professional College of Food Technology and Business
79039, 30/32 Bortnianskyi Str., Lviv, Ukraine

Abstract. The relevance of this study is conditioned upon the increasing interest in alternative sources of protein, to solve the problem of providing the population with biologically complete food products of a combined composition. The purpose of this study was to investigate the effect of freezing on the stability of the moisture content of semifinished products in the dough covering using several types of meat raw materials, protein, and flour from hemp seed processing products. For the study, eight recipes of minced meat were prepared using beef, pork, red and white meat of broiler chickens with flour and protein from hemp seeds in the amount of 20% to the total mass of minced meat. In the samples, indicators of moisture content, moisture binding, emulsifying ability of products before freezing and after defrosting, and activity of water in defrosted products were determined. In the experimental samples, a substantial difference was found in the stability of the moisture content of semifinished products, depending on the combination of flour and hemp seed protein in the recipes of semifinished products and conventional types of meat raw materials under the influence of freezing. It was found that the best combination of hemp seed flour with beef and pork meat, while protein with broiler chicken meat is the best combination in terms of emulsifying ability. All model samples of minced meat had values above 40%, and all samples, except the combination of hemp protein with pork, were higher than the control. Studies of water activity values in defrosted dumplings were within the normal range of up to 0.970 A_w, and the sample using hemp seed protein and pork had the lowest – at 0.951 A_w. The conducted studies indicate the expediency of selective combination of hemp seed processing products with various types of meat raw materials in the composition of semifinished products in a dough covering. The combination of several types of non-conventional protein-containing raw materials in the composition of frozen semifinished products in the dough covering requires considering their technological compatibility to ensure the possibility of implementing the developed recipes in the production of dumplings in industrial production conditions

Keywords: vegetable proteins, protein, hemp seed flour, frozen semifinished products, moisture content, water activity

Suggested Citation:
Pasichnyi, V., Shubina, Ye., Svyatnenko, R., & Moroz, O. (2022). The effect of freezing on the characteristics of semifinished products in a dough covering using non-conventional protein-containing raw materials. *Animal Science and Food Technology*, 13(1), 47-56.

*Corresponding author

Introduction

One of the common nutritional issues is the lack of nutrients in the human diet due to the low balance of the composition and the dominance of starchy products [1]. The lack of essential nutrients necessary for the healthy functioning of the human body causes excessive food consumption, which can lead to the occurrence of diseases of the cardiovascular system. Among the nutrients important for the functioning of the body, protein plays a significant role, the norm of which for people with a sedentary lifestyle is 0.6 g/kg of body weight, and 1.2-1.7 g/kg of body weight for athletes [2; 3].

It is possible to improve the balance of meat-based products through the combination of animal and vegetable raw materials. Vegetable proteins allow balancing meat-based products in terms of the content of deficient nutrients and increase the biological value of the diet. Partial replacement of the meat-fat fraction with the vegetable fraction leads to a decrease in the amount of cholesterol and saturated fatty acids in the composition of products. Combined meat products in terms of amino acid content are closer to the ideal protein values according to FAO/WHO (Food and Agriculture Organization of the United Nations/World Health Organization) [4], and their fatty acid composition is enriched with polyunsaturated fatty acids, which allows designing functional products [5].

In the same way, the modern rhythm of life forces to increase the share of consumption of fast food. Growth in sales of such products in high-income countries is 1% per year, and in middle-income countries is 10% per year. People would rather not spend time preparing food, and this leads to an increase in the demand for semi-finished products [6]. Insufficient quality composition of such products can cause the problem of deficiency of useful substances. Among meat semifinished products, considerable attention is paid to semifinished products in a dough covering (dumplings, ravioli, khinkali), which are easy to prepare and do not require considerable time to bring to culinary readiness. The combination of meat and protein-containing vegetable raw materials in the recipe composition of dumplings can both satisfy the consumer's need for a high-quality product and improve several functional and technological characteristics of frozen products.

The purpose of this study was to identify the influence of hemp seed processing products on the functional and technological characteristics of frozen semifinished products in a dough covering with different types of meat raw materials using shock freezing.

To achieve the stated objective, the following tasks were set:

– to determine the influence of hemp seed processing products on the moisture content before and after freezing of culinary semifinished products;

– to determine the influence of hemp seed processing products on the change in the moisture-binding capacity of frozen semifinished products;

– to identify the effect of freezing on the emulsifying ability of minced meat for culinary semifinished products using hemp seed processing products;

– to evaluate the activity of water in culinary semifinished products using hemp seed processing products after defrosting.

Literature Review

Trends in modern nutrition and the shortage of high-quality protein in terms of biological value require the search for alternative protein sources. Such sources for meat products are milk proteins, fish, hydrobionts, insect proteins, cultured meat, protein-containing vegetable raw materials. Milk proteins are widely used in meat products. Whey protein isolate performs well in low-fat products and increases the gel-forming ability [7]. Likewise, fish, as a protein-containing raw material, is used in the technology in the form of fillets, mechanically obtained minced meat. Fish raw materials are rich in polyunsaturated fatty acids and complete proteins, which contributes to the creation of functional products. Waterfowl meat is also rich in useful substances, and the combination of these ingredients in a meat-containing product allows obtaining higher functional and technological indicators [8].

Edible insects are regularly consumed as a staple food or dietary supplement by members of various rural communities in Southeast Asia, the Pacific, Africa, and elsewhere. Insects are rich in protein, and their chemical composition varies depending on the species and place of their cultivation [9; 10].

Cultured meat is a promising area in food technology. This type of product is obtained thanks to the cultivation of meat fibres on a nutrient substrate. The production of this type of product is environmentally safe, and the substrate for its creation can be vegetable raw materials, e.g., algae [11]. However, at this stage of development, cultured meat still differs from natural meat in terms of quality [12].

Modern research proves the rationality of introducing a considerable proportion of vegetable proteins into the human diet, which improve the overall quality of the protein composition of the diet and reduce the consumption of certain nutrients [13]. The results of studies [14] showed that, compared to animal protein, the consumption of vegetable protein can improve the lipid profile in patients with hypercholesterolemia. The creation of products using plant components necessitates the investigation not only of their biological value, but also functional and technological characteristics. The functional and technological characteristics change depending on the type of product and the method of their production [15].

The latest methods of production of healthy products are the creation of analogues of meat fibres based on vegetable raw materials. The main building materials for future products are soy and pea proteins, gluten, polysaccharides, and fibre. Through physicochemical interactions, plant proteins can aggregate particles and anisotropic fibrils to give a meat-like texture and taste in the mouth. Mixtures of vegetable oils and spices are used to change the texture and taste; pigments are added to reproduce the traditional pink colour for meat products; vitamins, minerals, antioxidants, and antimicrobials are included to improve nutrition and increase shelf life. There are opportunities to overcome technological barriers, nutritional, and safety issues to further develop the alternatives market [16].

However, the creation of vegan products based on vegetable proteins causes some discussions. Such raw materials have many advantages in terms of technological characteristics; however, plant proteins are common allergens, and to obtain higher quality products, raw materials require added

processing [17-19]. It was determined that such types of products do not fully satisfy buyers in terms of sensory qualities, and to obtain better quality, raw materials require added processing [20-22]. Such shortcomings can be eliminated by combining non-conventional raw materials with animal protein. A good example of the interaction of plant and animal proteins is the combination of whey proteins of milk and pea or soy proteins, which allow obtaining better emulsion stability and rheological characteristics of products [23; 24].

Meat-vegetable combined products have substantial prospects in the consumer market, thanks to the possibility of effective modelling of their taste-aromatic and functional-technological characteristics and positive impact on the body [25; 26]. Such products are more useful for the body, their use does not force a drastic change in the diet, and according to global surveys, society positively perceives the transition to combining meat and vegetable raw materials [27-29].

A study of the use of plant ingredients in the composition of meat products demonstrates a positive effect on the functional and technological indicators of meat and vegetable products [30]. The rich chemical composition of such raw materials increases the nutritional and biological value of the obtained products and makes them functional [31]. The use of plant ingredients, due to their content of calcium and magnesium, allows solving the issue associated with the use of phosphates in the composition of products and improving their technological properties [32].

The development of recipes using the products of the processing of oil-containing vegetable raw materials considerably affects the quality of sausage products. Thus, the use of mustard powder in several types of sausage products increases product yield and improves the amino acid composition of the product [33]. In the conditions of the development of industrial regional clusters, modern meat technologies are increasingly oriented towards the use of ingredients typical for a certain region for the development of the latest products. Plant extracts that increase the sensory characteristics of products are widely used [34].

Among vegetable protein-containing raw materials, hemp seed processing products are promising for Ukraine. Hemp food products such as flour, fibre, and protein concentrate are produced by grinding the hemp cake and fractionating the resulting mass. The resulting fractions vary in size, with the smallest usually classified by protein content as “hemp protein”. According to research [35], the biological value of hemp seeds and its processing products varies depending on the method of cultivation and processing. However, the amino acid composition of hemp flour and protein contains all essential amino acids at a sufficiently high level.

Studies of the use of hemp seed processing products show high technological efficiency in the composition of meat products. It has been proven that the joint use of turkey meat and hemp flour in meat-rich breads allows producing foods with high nutritional characteristics. Thus, the use of hemp seed flour in the amount of 8-12% allows increasing the protein content by 3.21-11.80% and considerably increases the functional and technological properties of combined meat products [36]. Studies of the rheological properties of minced meat using hemp seed flour show a significant increase in the stability of the meat emulsion and the ultimate shear stress values [37].

The impact of hemp seed processing products on the minced meat system has been understudied. Therefore, the search for ways to expand the use of such protein-containing raw materials in meat products, namely frozen meat semifinished products in a dough covering, needs to be investigated to expand the consumption. The design of recipes for frozen semifinished products faces the problem of functional and technological indicators of minced meat, which can change after defrosting.

It is known that the water content in fresh meat can reach 75% and varies depending on the species, condition, and type of heat treatment. Water in fresh meat is mainly divided into 3 parts: bound water, immobilised water, and free water, in which the ratio of immobilised water and free water directly affects the moisture-binding capacity of meat. Depending on the type of processing, moisture can change from a bound state to a free state, which influences both the organoleptic indicators of the product and its rheological and functional-technological characteristics [38].

Freezing causes the crystallisation of water molecules and the loss of meat mass, depending on the category of fattening for beef, on average, by 1.58-2.10%, pork – by 1.31-1.60%, lamb – by 1.74-2.20%. The quality of the product is also affected by the speed and temperature of freezing. A low freezing rate can lead to the destruction of the myofibrillar structure and a decrease in the moisture retention capacity [39]. Water activity is a parameter that directly describes the state of hydration of a certain substance and the degree of binding of water in it. Many aspects of food system technology are related to food system hydration, so water activity (A_w) measurements can become widely used in process applications. Water activity monitoring is most widely used for products with a long shelf life to avoid microbiological spoilage [40].

The introduction of plant ingredients into the composition of meat products can considerably affect their functional and technological characteristics and the equilibrium state of moisture in the product, which affects its rheological and technological characteristics, as well as sensory indicators of quality under various conditions of technological influence.

Materials and Methods

Research was conducted in laboratory conditions at the Department of Meat and Meat Products Technology and in the Problem Research Laboratory of the National University of Food Technologies in 2021-2022.

During research, the recipes of minced meat fillings for semifinished products in a dough covering with various meat raw materials and products of hemp seed processing (*Cannabis Sativa* L.) produced by LLC “Desnaland” of the Sumy Oblast were simulated. The “Siberian dumplings” recipe was chosen as the control sample. The recipe composition of experimental samples of dumplings is presented in Table 1.

***Table 1**. Recipe composition of experimental samples of dumplings using protein and flour from hemp seeds*

Raw material	Control	Sample 1 / Sample 5	Sample 2 / Sample 6	Sample 3 / Sample 7	Sample 4 / Sample 8
1	2	3	4	5	6
The composition of the minced meat filling					
Beef of the 1st grade, %	44	37	–	–	–
Fat pork, %	17	–	–	–	–
Semi-fat pork, %	33	37	74	-	-
Red meat of broiler chickens, %	–	–	–	74	-
White meat of broiler chickens, %	–	–	–	–	74
*Hemp seed protein/flour, hydrated 1:2 with water, %	-	20	20	20	20
Onions, %	6	6	6	6	6
Composition of the dough					
Wheat flour, %	58	58	58	58	58
Chicken eggs, %	8	8	8	8	8
Drinking water, %	34	34	34	34	34
Spices for 100 g of minced meat					
Table salt, %	1.7	1.7	1.7	1.7	1.7
Black pepper, %	0.6	0.6	0.6	0.6	0.6

Meat raw materials were ground using a meat grinder (HKN-22SS), minced meat was kneaded on a minced meat mixer (KVL 8470 S. KENWOOD). The dough was mixed using a food processor (KVL 8470 S. KENWOOD). Dumplings were formed manually using a mould.

The semifinished products were frozen using a shock freezing chamber (ASH05K) at -34-35°C until reaching -18°C inside the dumplings.

The moisture content was determined by drying a 5 g sample in a drying cabinet to a constant mass at 105°C. The water-binding capacity to the moisture content (WBCm) and to the weight of the sample (WBCw) was performed by pressing 0.30 g of the minced meat and calculating the ratio of the area of the wet spot to the weight of the minced meat or moisture in the sample [41]. The emulsifying capacity was determined by centrifuging a sample of combined minced meat homogenised with vegetable oil and calculating the ratio of the volume of emulsified oil to the total volume of the sample [41].

Determination of water activity was carried out using the HygroLab 2 device – a water activity analyser for analytical laboratories, with an accuracy of ±0.01 A_w.

Results and Discussion

The content and state of moisture is a factor that directly affects the quality and safety of finished products. The moisture content of products influences their rheological, organoleptic, and technological indicators.

The specific features of the technology of preparing semifinished products in a dough covering, namely the freezing process and the presence of a dough part in the recipe, make it rational to investigate the change in moisture content indicators before and after refrigerating, as well as separately minced meat fillings. Figure 1 shows the change in moisture content in minced meat fillings and dough before and after their shock freezing.

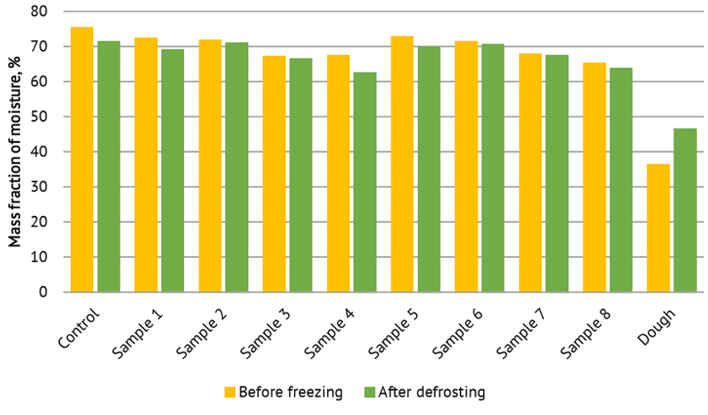

Figure 1. The value of the mass fraction of moisture in the samples of dumplings and dough under study before freezing and after defrosting

As Figure 1 demonstrates, all minced meat samples had sufficiently high moisture content values, ranging from 75.36 to 65.19% before freezing. Samples using protein and hemp seed flour had comparable results with no significant deviations. The comparison of the indicators of minced meat with diverse types of meat shows that the highest value in terms of moisture content was observed in samples based on beef and pork compared to samples based on broiler chicken meat.

After defrosting, the moisture content in the fillings of semifinished products in the dough shell decreased by 4.92-0.26%. The largest weight loss was observed in the sample using white meat of broiler chickens, namely 7.30%, which is 1.88% more than the loss in the control sample.

Research on the moisture content of the dough showed an increase in its moisture content before freezing from 36.36% to 46.49% after defrosting the dumplings, which indicates the redistribution of moisture from the minced meat to the dough covering during the freezing of the dumplings.

Figure 2 shows the averaged values of the moisture content of dumpling samples.

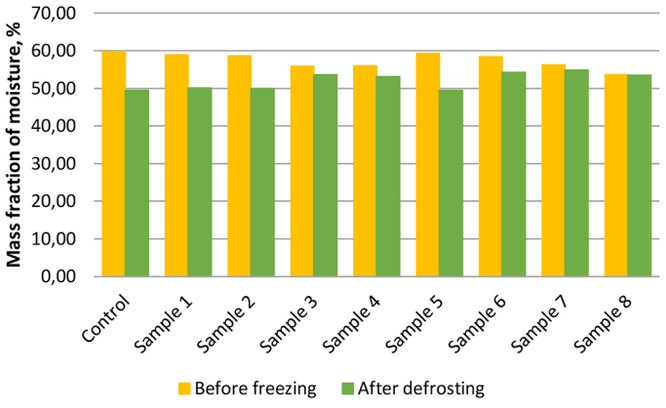

Figure 2. Value of the relative mass of moisture in the samples of dumplings under study before freezing and after defrosting

Studies of the average moisture content of dumpling samples (minced meat in a dough covering) showed that the moisture content of the samples before freezing ranges from 59.76% to 53.66% depending on the type of meat raw material (Fig. 2). The highest values of moisture loss after cryogenic exposure were observed in the control and the first and second samples of semifinished products using beef, fat pork, and semi-fat pork (control and samples No. 1 and No. 2, No. 5, No. 6). For samples with both white and red meat of broiler chickens using protein or hemp seed flour, the change in the moisture content of dumplings during cryogenic exposure changed insignificantly. The samples using white meat from broiler chickens differed the most, where the sample using flour had a 1.34% lower moisture value than the sample with hemp protein.

The moisture content in experimental dumplings after defrosting decreased for all samples and had a value of 54.86-49.52%. At the same time, moisture loss was the largest in the control, and the smallest in dumplings with broiler chicken meat using flour and protein from hemp seeds.

The moisture-binding capacity has a direct impact on the organoleptic and functional-technological properties of the product and is one of the key indicators of the quality of the minced meat emulsion and the product in general.

To investigate the moisture-binding capacity, samples of minced meat were taken before freezing and after defrosting. The obtained experimental data of WBCw are presented in Figure 3.

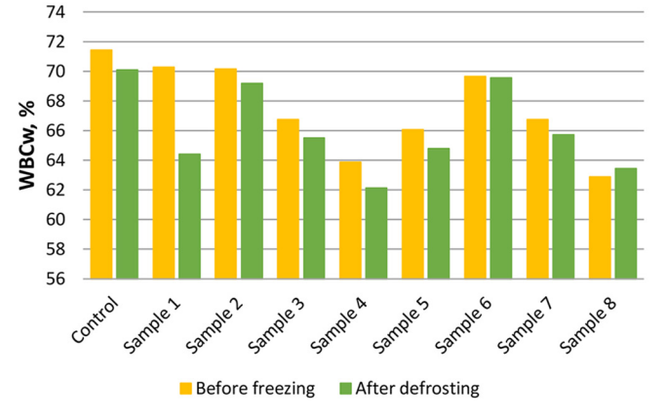

Figure 3. WBCw values in dumplings before freezing and after defrosting

The obtained experimental data of WBCw (Fig. 3) indicate that all samples had indicators at a sufficiently high level, which were corrected with the total moisture content of dumplings. Pork and beef dumpling samples had higher WBCw values compared to broiler chicken meat. At the same time, higher WBCw values were observed in samples with added protein compared to samples with hemp seed flour before freezing.

After defrosting, all minced meat samples decreased in WBCw, except sample No. 8 with hemp seed flour and broiler chicken white meat. Sample No. 1, which combined hemp seed protein with beef and pork, had the largest difference between WBCw values. In this sample, WBCw after defrosting decreased by 8.36% compared to the pre-freezing value. The best indicators were sample No. 6 using pork and hemp seed flour, where both indicators were at the same level – 69.64% and 69.54%.

The results of the WBCm study are presented in Figure 4.

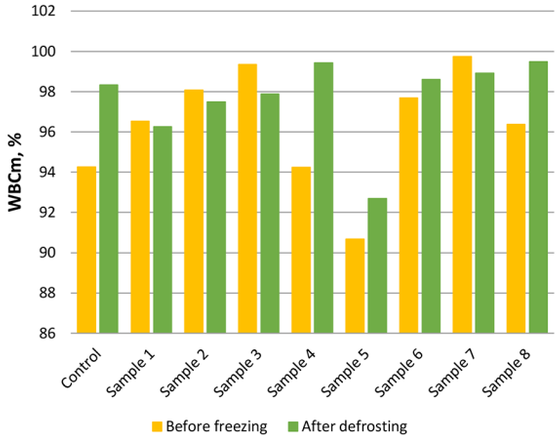

Figure 4. Value of WBCm in dumplings before freezing and after defrosting

The WBCm indicator (Fig. 4) characterises the moisture-binding capacity of minced meat to moisture content. The obtained data indicate sufficiently high values of this indicator for model mincemeats, which for all samples were higher than 90.00%.

This indicator was the lowest in the sample using pork and beef meat and hemp seed flour. The change of this indicator after defrosting occurred unevenly: in samples using protein, WBCm values decreased, except for the recipe with white meat of broiler chickens, and for samples using flour, after defrosting, WBCm values increased, except for sample No. 7.

Therewith, the highest WBCm values were observed in samples using broiler chicken meat.

Emulsifying ability is an indicator that directly characterises the functional and technological combined minced meat. The qualitative composition of proteins and the quantitative ratio of protein moisture and fat in the composition of minced meat contribute to the formation of a stable emulsion structure. The emulsifying ability of minced meat for semifinished products in the dough covering was investigated after defrosting (Fig. 5).

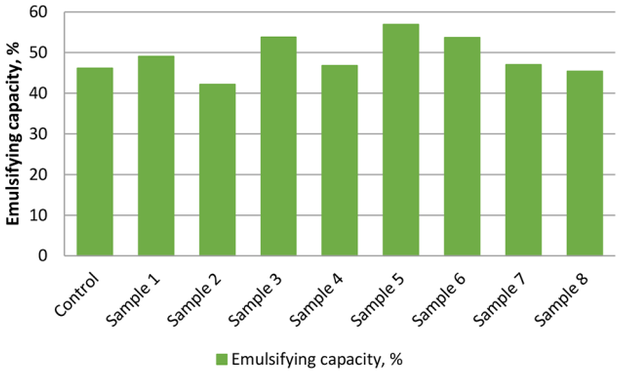

Figure 5. The value of the emulsifying ability in the minced meat of semifinished products in the dough covering

According to the results of the emulsifying capacity obtained (Figure 5), all experimental samples using hemp seed processing products have higher values than the control, except for sample No. 2, the recipe of which included pork and vegetable protein. The most important was sample No. 5 with beef, pork, and hemp seed flour, which was 56.97%. In experimental samples using hemp seed protein, the best combination was with red meat broiler chickens.

The "water activity" indicator is an essential indicator that shows the state of moisture in the food product

and the direction of moisture-mass exchange. This indicator characterises the presence of water in a state that can be involved in biochemical reactions and can be used by microorganisms for their vital activities.

The water activity (A_w) in dumpling samples was investigated after their defrosting, which allowed assessing the state of moisture in the product after freezing. The values of water activity are presented in the diagram in Figure 6.

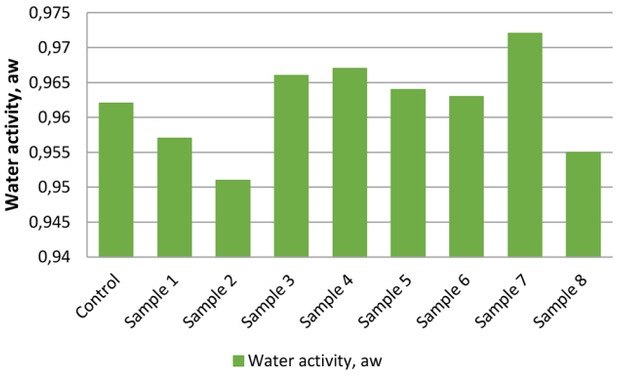

Figure 6. Value of water activity in samples of defrosted dumplings

All the samples of dumplings under study showed acceptable values for meat products of this assortment group in the range of 0.951-0.967 A_w, except for sample No. 7 using hemp seed flour and red meat of broiler chickens, where the value was at the level of 0.972 A_w.

The water activity value of the control sample was at the level of 0.962 A_w, the lowest water activity values were shown by samples using beef and pork with protein from hemp seeds at the level of 0.957 A_w and 0.951 A_w, which is a good indicator for the microbiological safety of this group of products. The lowest water activity of the samples using hemp seed flour was the sample containing the white meat of broiler chickens.

Based on a review of literary sources, it is possible to conclude on the relevance of developing products with a combined composition. Considering the prospects of non-conventional protein-containing raw materials in Ukraine, products processed from hemp seeds are of particular interest.

The study [36] of the effect of hemp seed flour on the functional and technological properties of meat-rich breads from the mechanically separated poultry meat of turkey showed their increase compared to the analogue, the recipe of which included wheat flour. The moisture content in the experimental samples increased and amounted to 70.03-77.13%, and the moisture binding and emulsifying capacity increased by 15-20% on average.

According to research [42], the use of 5% hemp seed processing products in the composition of pork loaves, the moisture content in recipes using flour and protein were at the level of 63.04% and 62.96%, respectively.

The data were obtained by researchers [36; 42] testify to the high efficiency of hemp seed processing products in the composition of meat and meat-containing products. However, the comparison of the values of the functional and technological indicators of minced meat based on diverse types of meat raw materials and their change during the freezing process is still under studied.

The freezing process directly affects the moisture in the meat, and according to research [43], it varies for diverse types of meat depending on the morphological composition of the raw material.

The obtained results of research on minced meat for dumplings before freezing confirm the data obtained by other researchers [36; 42]. Products processed from hemp seeds with meat raw materials of different origins did not significantly differ in moisture content from the control sample and had values higher than 65.0%. Moisture change after defrosting shows a considerable decrease in the samples using white broiler chicken meat and hemp seed protein, but all other plant-based samples showed better values than the control. Such results indicate better binding of moisture by plant protein-containing raw materials and reduction of its freezing.

The change in moisture during freezing also influences the moisture-binding capacity of minced meat. WBCw when using beef and pork with hemp seed protein was higher than the control and a similar sample with flour, but the loss of this indicator after defrosting was the highest. A sample using pork and hemp seed flour revealed no changes in WBCw.

The moisture-binding capacity to the mass of moisture in the sample after defrosting showed uneven changes. According to the results of the study, the combination of broiler chicken meat with hemp seed processing products gives the highest values. This is explained by the higher content of fibre and carbohydrates in flour.

The redistribution of moisture during the freezing process can cause changes and affect the formation of a stable meat emulsion. Comparing the combination of meat raw materials with vegetable protein-containing raw materials, the best emulsifying ability with flour is given by beef and pork, and with protein by broiler chicken meat.

The state of moisture after defrosting influences the chemical processes occurring in the raw meat and the development of microorganisms. All samples developed had values in the range suitable for meat products – 0.967 Aw, except for the sample with red broiler chicken meat and hemp seed meal.

According to the results, semifinished products in a dough shell using hemp seed processing products give stable indicators after freezing, which proves the relevance of further research.

Conclusions

The data obtained from the analysis of literary sources indicate a considerable amount of scientific research on the development of combined meat-vegetable products using vegetable proteins. The presented results of studies on the use of hemp seed processing products for frozen semifinished products in the dough covering testify to the high cryostability of the minced dumpling base when hemp seed flour is used in the minced meat.

Studies of water activity have shown that the addition of vegetable protein-containing preparations based on hemp seed processing products to the composition of the formulation allows reducing the Aw value by 0.005-0.011 Aw in samples using beef and pork compared to the control, and to ensure high values of the functional and technological indicators of the minced meat filling.

The study of the effect of freezing on model samples of minced meat filling and dumplings showed that in the process of cryogenic influence, there is a redistribution of moisture content in minced meat fillings and dumpling dough and a partial decrease of the WBCw indicator by 0.09-5.68%, except for the sample using white chicken meat – broilers and hemp seed flour. At the same time, it was proven that the selective combination of flour and protein from hemp seeds allows increasing the effectiveness of such a combination to stabilise the functional and technological indicators of semifinished products in the dough covering.

Further research will be aimed at developing frozen semifinished products in a dough covering of a combined composition using hemp seed processing products to ensure a high balance of protein and fatty acid composition of semifinished products in a dough covering.

References

[1] Adesogan, A.T., Havelaar, A.H., McKune, S.L., Eilittä, M., & Dahl, G.E. (2020). Animal source foods: Sustainability problem or malnutrition and sustainability solution? Perspective matters. *Global Food Security,* 25, article number 100325.

[2] Suardi, C., Cazzaniga, E., Graci, S., Dongo, D., & Palestini, P. (2021). Link between viral infections, immune system, inflammation and diet. *International Journal of Environmental Research and Public Health*, 18(5), article number 2455.

[3] Brestenský, M., Nitrayová, S., Patráš, P., & Nitray, J. (2019). Dietary requirements for proteins and amino acids in human nutrition. *Current Nutrition & Food Science*, 15(7), 638-645.

[4] Kotecka-Majchrzak, K., Sumara, A., Fornal, E., & Montowska, M. (2020). Oilseed proteins – Properties and application as a food ingredient. *Trends in Food Science & Technology*, 106, 160-170.

[5] Novello, D., Schiessel, D.L., Santos, E.F., & Pollonio, M.A.R. (2019). The effect of golden flaxseed and by-product addition in beef patties: Physicochemical properties and sensory acceptance. *International Food Research Journal*, 26(4), 1237-1248.

[6] Monteiro, C.A., Cannon, G., Levy, R.B., Moubarac, J.C., Louzada, M.L., Rauber, F., Khandpur, N., Cediel, G., Neri, D., Martinez-Steele, E., Baraldi, L.G., & Jaime, P.C. (2019). Ultra-processed foods: What they are and how to identify them. *Public Health Nutrition*, 22(5), 936-941.

[7] Kwon, H.C., Shin, D.M., Yune, J.H., Jeong, C.H., & Han, S.G. (2021). Evaluation of gels formulated with whey proteins and sodium dodecyl sulfate as a fat replacer in low-fat sausage. *Food Chemistry*, 337, 127682.

[8] Bozhko, N., Tischenko, V., Pasichnyi, V., Shubina, Y., Kyselov, O., Marynin, A., & Strashynskyi, I. (2021). The quality characteristics of sausage prepared from different ratios of fish and duck meat. *Potravinarstvo Slovak Journal of Food Sciences*, 15, 26-32.

[9] Gahukar, R.T. (2020). Edible insects collected from forests for family livelihood and wellness of rural communities: A review. *Global Food Security*, 25, article number 100348.

[10] Meyer-Rochow, V.B., Gahukar, R.T., Ghosh, S., & Jung, C. (2021). Chemical composition, nutrient quality and acceptability of edible insects are affected by species, developmental stage, gender, diet, and processing method. *Foods*, 10(5), article number 1036.

[11] Caporgno, M.P., Böcker, L., Müssner, C., Stirnemann, E., Haberkorn, I., Adelmann, H., Handschin S., Windhab E.J., & Mathys, A. (2020). Extruded meat analogues based on yellow, heterotrophically cultivated *Auxenochlorella protothecoides* microalgae. *Innovative Food Science & Emerging Technologies*, 59, article number 102275.

[12] Fraeye, I., Kratka, M., Vandenburgh, H., & Thorrez, L. (2020). Sensorial and nutritional aspects of cultured meat in comparison to traditional meat: Much to be inferred. *Frontiers in Nutrition*, 7, 35.

[13] Salomé, M., de Gavelle, E., Dufour, A., Dubuisson, C., Volatier, J.L., Fouillet, H., Huneau, J.-F., & Mariotti, F. (2020). Plant-protein diversity is critical to ensuring the nutritional adequacy of diets when replacing animal with plant protein: observed and modeled diets of French adults (INCA3). *The Journal of Nutrition*, 150(3), 536-545.

[14] Zhao, H., Song, A., Zheng, C., Wang, M., & Song, G. (2020). Effects of plant protein and animal protein on lipid profile, body weight and body mass index on patients with hypercholesterolemia: A systematic review and meta-analysis. *Acta Diabetologica*, 57(10), 1169-1180.

[15] Sim, S.Y.J., Srv, A., Chiang, J.H., & Henry, C.J. (2021). Plant proteins for future foods: A roadmap. *Foods*, 10(8), 1967.

[16] Sha, L., & Xiong, Y.L. (2020). Plant protein-based alternatives of reconstructed meat: Science, technology, and challenges. *Trends in Food Science & Technology*, 102, 51-61.

[17] Tan, M., Nawaz, M. A., & Buckow, R. (2021). Functional and food application of plant proteins – a review. *Food Reviews International*, 1-29.

[18] Langyan, S., Yadava, P., Khan, F.N., Dar, Z.A., Singh, R., & Kumar, A. (2021). Sustaining protein nutrition through plant-based foods. *Frontiers in Nutrition*, 8.

[19] Nasrabadi, M.N., Doost, A.S., & Mezzenga, R. (2021). Modification approaches of plant-based proteins to improve their techno-functionality and use in food products. *Food Hydrocolloids*, 118, article number 106789.
[20] Cordelle, S., Redl, A., & Schlich, P. (2022). Sensory acceptability of new plant protein meat substitutes. *Food Quality and Preference*, article number 104508.
[21] Boukid, F. (2021). Plant-based meat analogues: From niche to mainstream. *European Food Research and Technology*, 247(2), 297-308.
[22] Schreuders, F.K., Sagis, L.M., Bodnár, I., Erni, P., Boom, R.M., & van der Goot, A.J. (2021). Mapping the texture of plant protein blends for meat analogues. *Food Hydrocolloids*, 118, article number 106753.
[23] Hinderink, E.B., Berton-Carabin, C.C., Schroën, K., Riaublanc, A., Houinsou-Houssou, B., Boire, A., & Genot, C. (2021). Conformational changes of whey and pea proteins upon emulsification approached by front-surface fluorescence. *Journal of Agricultural and Food Chemistry*, 69(23), 6601-6612.
[24] Zhang, X., Zhang, S., Xie, F., Han, L., Li, L., Jiang, L., Jiang, L., Qi, B., & Li, Y. (2021). Soy/whey protein isolates: Interfacial properties and effects on the stability of oil-in-water emulsions. *Journal of the Science of Food and Agriculture*, 101(1), 262-271.
[25] Tarrega, A., Rizo, A., Murciano, A., Laguna, L., & Fiszman, S. (2020). Are mixed meat and vegetable protein products good alternatives for reducing meat consumption? A case study with burgers. *Current Research in Food Science*, 3, 30-40.
[26] De Boer, J., & Aiking, H. (2021). Favoring plant instead of animal protein sources: Legitimation by authority, morality, rationality and story logic. *Food Quality and Preference*, 88, article number 104098.
[27] Lang, M. (2020). Consumer acceptance of blending plant-based ingredients into traditional meat-based foods: Evidence from the meat-mushroom blend. *Food Quality and Preference*, 79, article number 103758.
[28] Spencer, M., Rowe, S., Bonnell, C., & Dalton, P. (2021). Consumer acceptance of plant-forward recipes in a natural consumption setting. *Food Quality and Preference*, 88, article number 104080.
[29] Sogari, G., Li, J., Wang, Q., Lefebvre, M., Gómez, M. I., & Mora, C. (2021). Factors influencing the intention to purchase meat-mushroom blended burgers among college students. *Food Quality and Preference*, 90, article number 104169.
[30] Hleap-Zapata, J.I., Cruz-Rosero, J.D., Durán-Rojas, L.T., Hernández-Trujillo, D., Reina-Aguirre, L.D., & Tilano-Pemberthy, N. (2020). Evaluation of pumpkin flour (*Cucurbita moschata* Duch.) added as a meat extender in Frankfurt-type sausages. *Revista de la Facultad de Ciencias Agrarias. Universidad Nacional de Cuyo*, 52(2), 395-404.
[31] Sirini, N., Roldán, A., Lucas-González, R., Fernández-López, J., Viuda-Martos, M., Pérez-Álvarez, J. A., Frizzo, L.S., & Rosmini, M.R. (2020). Effect of chestnut flour and probiotic microorganism on the functionality of dry-cured meat sausages. *LWT*, 134, article number 110197.
[32] Goemaere, O., Glorieux, S., Govaert, M., Steen, L., & Fraeye, I. (2021). Phosphate elimination in emulsified meat products: Impact of protein-based ingredients on quality characteristics. *Foods*, 10(4), 882.
[33] Gorlov, I.F., Bozhkova, S.E., Danilov, Y.D., Anisimova, E.Y., Mosolova, N.I., & Starodubova, J.V. (2020). Analysis of efficiency of production of sausage products using non-traditional vegetable raw materials. *IOP Conference Series: Earth and Environmental Science*, 548, 8, article number 082032.
[34] Zheleuova, Z.S., Uzakov, Y.M., Shingisov, A.U., Alibekov, R.S., & Khamitova, B.M. (2021). Development of halal cooked smoked beef and turkey sausage using a combined plant extracts. *Journal of Food Processing and Preservation*, 45(1), article number 15028.
[35] Oseyko, M., Sova, N., & Chornei, K. (2021). Substantiation of hemp seeds storage and processing technologies for functional, dietary and specialty products. Review. *Ukrainian Food Journal*, 10(3), 427-458.
[36] Bozhko, N., Pasichnyi, V., Tischenko, V., Marynin, A., Shubina, Y., & Strashynskyi, I. (2021). Determining the nutritional value and quality indicators of meat-containing bread made with hemp seeds flour (*Cannabis sativa* L.). *Eastern-European Journal of Enterprise Technologies*, 4(11), 112.
[37] Merenkova, S.P., Zinina, O.V., Khayrullin, M.F., Bychkova, T.S., & Moskvina, L.A. (2020). Study of the rheological properties of meat-vegetable minces. *IOP Conference Series: Earth and Environmental Science*, 613(1), article number 012078.
[38] Aboagye, G., Zappaterra, M., Laghi, L., Dall'Olio, S., Petracci, M., & Costa, L. N. (2020). Water status in meat from pig breeds strongly differing in growth performances. *Food Chemistry*, 305, article number 125445.
[39] Dang, D.S., Bastarrachea, L.J., Martini, S., & Matarneh, S.K. (2021). Crystallization behavior and quality of frozen meat. *Foods*, 10(11), 2707.
[40] Vu, T.P., He, L., McClements, D.J., & Decker, E.A. (2020). Effects of water activity, sugars, and proteins on lipid oxidative stability of low moisture model crackers. *Food Research International*, 130, article number 108844.
[41] Bozhko, N., Tischenko, V., Pasichnyi, V., & Matsuk, Y. (2020). Analysis of the possibility of fish and meat raw materials combination in products. *Potravinarstvo Slovak Journal of Food Sciences*, 14(1), 647-655.
[42] Zając, M., Guzik, P., Kulawik, P., Tkaczewska, J., Florkiewicz, A., & Migdał, W. (2019). The quality of pork loaves with the addition of hemp seeds, de-hulled hemp seeds, hemp protein and hemp flour. *LWT*, 105, 190-199.
[43] Dromenko, O., Potapov, V., Yancheva, M., Onishchenko, V., Bolshakova, V., & Inzhyyants, A. (2021). Research into the thermophysical characteristics of muscle and adipose tissues in the freezing–thawing process. *Food Science and Technology*, 15(3), 40-51.

Вплив заморожування на характеристики напівфабрикатів у тістовій оболонці з використанням нетрадиційної білокумісної сировини

Василь Миколайович Пасічний[1], Євгенія Андріївна Шубіна[1], Роман Сергійович Святненко[1], Олена Олексіївна Мороз[2]

[1]Національний університет харчових технологій
01601, вул. Володимирська, 68, м. Київ, Україна

[2]Львівський фаховий коледж харчових технологій та бізнесу
79039, вул. Бортнянського, 30/32, м. Львів, Україна

Анотація. Актуальність дослідження зумовлена збільшенням зацікавлення альтернативними джерелами білка, для вирішення проблеми забезпечення населення біологічно повноцінними продуктами харчування комбінованого складу. Метою роботи є дослідження впливу заморожування на стабільність вологовмісту напівфабрикатів у тістовій оболонці з використанням різних видів м'ясної сировини, протеїну й борошна з продуктів переробки насіння конопель. Для дослідження було складено вісім рецептур фаршів із використанням яловичини, свинини, червоного та білого м'яса курчат-бройлерів із борошном та протеїном із насіння коноплі в кількості 20 % до загальної маси фаршу. У зразках визначались показники вмісту вологи, вологозв'язуюча, емульгуюча здатність виробів до заморожування та після розморожування та активність води в розморожених виробах. В дослідних зразках виявлено суттєву різницю в стабільності вологовмісту напівфабрикатів, залежно від поєднання в рецептурах напівфабрикатів борошна і протеїну насіння конопель і традиційних видів м'ясної сировини під впливом заморожування. Визначено, що за показниками емульгуючої здатності краще поєднання має борошно з насіння конопель із м'ясом яловичини та свинини, а протеїн з м'ясом курчат-бройлерів. Усі модельні зразки фаршів мали значення вищі за 40 %, а всі зразки окрім поєднання протеїну конопель зі свининою, були вищими за контрольний. Дослідження значень активності води в розморожених пельменях були в межах норми до 0,970 Aw, а зразок із використанням протеїну з насіння коноплі та свинини мав найнижчий показник у 0,951 Aw. Проведені дослідження свідчать про доцільність селективного комбінування продуктів переробки насіння конопель із різними видами м'ясної сировини в складі напівфабрикатів у тістовій оболонці. Поєднання різних видів нетрадиційної білокумісної сировини в складі заморожених напівфабрикатів у тістовій оболонці потребує врахування їхньої технологічної сумісності для забезпечення можливості реалізації розроблених рецептур при виробництві пельменів в умовах промислового виробництва

Ключові слова: рослинні білки, протеїн, борошно з насіння коноплі, заморожені напівфабрикати, вологовміст, активність води