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Improvement of the technology of functional pre-made meat products in a dough shell

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Abstract. In modern conditions of increasing globalization and intensifying competition in the food industry in general and in the meat processing industry in particular, there is a need to find new ways to increase the competitiveness of enterprises, guarantee the quality and safety of products, ensure proper working conditions for personnel, and reduce the negative impact on the environment. The research aims to improve the technology of pre-made products in dough shell production and to determine the rational parameters of the production process by introducing new ingredients into the recipe. The content of toxic elements was determined based on the Ukrainian Laboratory of Quality and Safety of Agricultural Products of the National University of Life and Environmental Sciences of Ukraine. The main stages of production of pre-made products in dough shells were analyzed, the technology was improved considering a set of safety and quality studies, risks and critical control points, sources of their occurrence were identified, and preventive actions were developed. The amino acid composition of the protein component and functional and technological quality indicators of the minced meat samples (moisture retention capacity, emulsifying capacity, and stability of meat emulsions) were evaluated. To determine the changes that occurred in the experimental prepared products enriched with vegetable components, a study of changes in their physicochemical properties after freezing and thawing was conducted. The research results showed that in the experimental sample containing the food additive Elamin, the amount of bound moisture in meat systems gradually decreases during storage, but the mass fraction of the concentrate in the amount of 0.3 kg per 100 kg of raw material allows for retaining free moisture. Based on the research results, the technology of functional pre-made meat products in a dough shell was improved, and technical specifications and technological instructions state standard 10.1-00493706-075:2019 “Frozen semi-finished products in a dough shell “Healthy dumplings” were developed for implementation in production

Keywords: minced meat, elamine, wheat fiber, soy protein, recipe, technology, functional product

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Relevance

The progressive deterioration of the environment results in the contamination of traditional food products with unusual pollutants, which traditionally include chemical plant protection products, mineral fertilizers, pesticides, etc. On the other hand, the modern diet lacks essential micronutrients, vitamins, and other biologically active substances, which has led to an increase in the incidence of chronic diseases not only of the gastrointestinal tract but also of cancer and cardiac diseases (Bal-Prylypko, Palamarchuk, and Nikolaenko, 2019; Balogun *et al*., 2018). Given the development of negative trends, the direction of modifying the composition of products with components that help reduce the deficiency of biologically active substances in the human body has become widespread (Bu *et al*., 2020; Cherednichenko *et al*., 2021). Currently, further research on the development of new formulations and improvement of technologies for products known as functional foods, which are intended for systematic consumption by all groups of the healthy population, remains relevant.

Analysis of Recent Research and Publications

The technologies for creating functional foods are based on the modification of traditional foods, which increases the content of useful ingredients in them to a level comparable to the physiological norms of their consumption, which, according to various estimates, is 10-50% of the average daily requirement (Cherednichenko and Bal-Prylypko, 2019).

Ukraine has several deficient substances that need to be included in the daily diet of the population. In particular, most regions of Ukraine, especially Polissia and the Carpathian mountain zone, are characterized by iodine deficiency (Nikolaienko and Bal-Prylypko, 2020; Ren *et al*., 2022). The daily requirement for this micronutrient is highlighted in the World Health Organization (WHO) recommendations (Table 1).

Table 1. *Iodine intake (micrograms per day)*

#	Population group	Norm
1	Children to 5 years	90
2	Children from 6 to 12 years	120
3	Adolescents and adults	150
4	Pregnant women	250

One of the ways to eliminate iodine deficiency is to include seafood in the daily diet, particularly cod liver (iodine content 3700 mcg/kg), salmon (2000 mcg/kg), hake (1600 mcg/kg), tuna (500 mcg/kg) (Dang *et al*., 2020). The current level of consumption of these products remains low, so for the majority of the population, the most affordable way to supplement traditional foods with iodine compounds, namely potassium iodate KJO_3, is the most affordable way recommended by WHO (Cherednichenko & Bal-Prylypko, 2020; Rahmasari & Yemiş, 2022).

It is possible to solve the problem of iodine deficiency by adding sea salt and seaweed to food, which contains a significant amount of iodine in an organically bound form favorable for absorption. The most affordable and economically feasible is the introduction into the formulation of traditional products of the food additive “Elamin”, obtained by processing the brown seaweed *Laminaria*, which is used as a dietary supplement for adults and children (Wang *et al*., 2019; Felici *et al*., 2020). The iodine it contains, due to its organic form, is

absorbed by 90-95%, and to compensate for its lack, it is enough to introduce about 0.1 grams of the drug into the daily diet. In addition to iodine, the supplement contains 0.01-0.02% of minerals (K, Na, Ca, Co, Mg, Fe, Zn, S, N, P, Cl, Cu, Ag, Al, Cr, Mn, B, Br) and vitamins (A, B, D, E). Alginic acid salts, which are part of the "Elamin" dietary supplement, are unique natural sorbents that selectively bind radionuclides, heavy metal salts, and toxic substances and remove them from the body (Stadnyk *et al*., 2020).

The research aims to improve the technology of functional semi-finished meat products in a dough shell by introducing iodine compounds, which are characterized by a deficiency in certain regions of Ukraine, into the recipe, as well as to bring the amino acid composition of the protein component of the product to the WHO-approved standards of ideal protein.

To achieve the aim, the following scientific objectives were defined: based on the analysis of WHO recommendations and current research, to identify promising areas for eliminating iodine deficiency in Ukraine; to develop recipes for minced meat for semi-finished products in a dough shell enriched with iodine compounds; to determine changes in the functional and technological properties of the experimental samples of minced meat compared to the control; to investigate the organoleptic characteristics, chemical composition and biological value of semi-finished products in a dough shell made with minced meat according to new recipes.

Materials and Methods

The research object was liver-based minced meat and pre-made products made from them in a dough shell. Minced meat according to Ukraine state standard 6028:2008 was chosen as a control. The formulation of the test samples included the food additive "Elamin" under technical standard 00382119-02-99, as well as wheat fiber according to technical standard 21586560.001.99 (sample 1) and soy protein according to Ukrainian state standard 4595:2006 (sample 2).

Experimental research was carried out using the methods of physicochemical, organoleptic, chemical, and biochemical research. Functional and technological parameters of minced meat (moisture retention, emulsifying ability, emulsion stability) were determined by centrifugation (Kumar *et al*., 2021; Kim *et al*., 2020). The organoleptic evaluation of semi-finished products was carried out on a five-point scale under Ukraine state standard 4823.2:2007, based on expert evaluation at the Department of Meat, Fish and Seafood Technology of the National University of Life and Environmental Sciences of Ukraine. The mass fraction of ash was determined by the weight method, after mineralization of the product in a muffle furnace at a temperature of 500-600°C based on Ukraine state standard ISO 936:2008. The mass fraction of protein was determined under state standard 25011-81 by the Kjeldahl method. The mass fraction of total fat content was determined by the Soxhlet method, based on the change in sample weight after fat extraction with a solvent under the Ukraine state standard 8380:2015. The amino acid composition of proteins was determined by ion-exchange chromatography, samples were prepared by acid hydrolysis, and free amino acids were extracted with dilute hydrochloric acid, precipitated with sulfosalicylic acid, and separated by filtration.

Results and Discussion

To enrich the pre-made products in the dough casing with iodine, the food additive "Elamin" was introduced into the recipe of the experimental samples. The formulations of minced meat pre-made products in the dough are given in Table 2.

Table 2. *Recipes for minced meat pre-made products in dough, kg*

Raw material	Receipt		
	Control	Sample 1	Sample 2
For minced mead, 100 kg of unsalted material			
Fried liver	65.0	59.7	59.7
Butter	5.0	5.0	5.0
Hydrated wheat fiber	-	5.0	-
Hydrated soy protein	-	-	5.0
Boiled buckwheat	16.0	16.0	16.0
Chicken eggs or egg melange	4.0	4.0	4.0
Fresh chopped onion	10.0	10.0	10.0
Elamine hydrated	-	0.3	0.3
Total	100	100	100
Spices and materials per 100 kg of minced meat			
Rock salt	1.2	-	-
Sea salt	-	1.1	-
Rock salt withlow natrium	-	-	1.1
Ground red pepper	0.05	0.05	0.05
Ground black or white pepper	0.2	0.2	0.2
Ground allspice pepper	0.1	0.1	0.1
Ground coriander	0.2	0.2	0.2

In the experimental samples per 100 kg of minced meat, the liver content was reduced by 5.3 kg compared to the control by adding 0.3 kg of the hydrated food additive "Elamin" to their formulations, and 5.0 kg of hydrated soy protein was added to sample 1, and hydrated wheat fiber to sample 2 (1:2 hydration ratio, without aging). In the formulation of the prototypes, table salt was replaced with sea salt (sample 1) and with table salt with a reduced sodium content (sample 2).

The next step in the research was to study changes in the functional and technological properties of minced meat. The ability of minced meat to retain moisture, its emulsifying ability, and the stability of the resulting emulsions were determined. Replacing meat raw materials with fiber or soy protein leads to a significant increase in the amount of moisture retained by minced meat. This is also facilitated by the replacement of table salt (sodium chloride) used for salting with food-grade salts characterized by a reduced sodium content and enriched with hydrophilic magnesium and potassium chlorides (Fig. 1). Minced meat modified with vegetable additives showed an increased ability to form emulsions (Fig. 2). Emulsified minced meat modified with additives is also characterized by increased stability (Fig. 3).

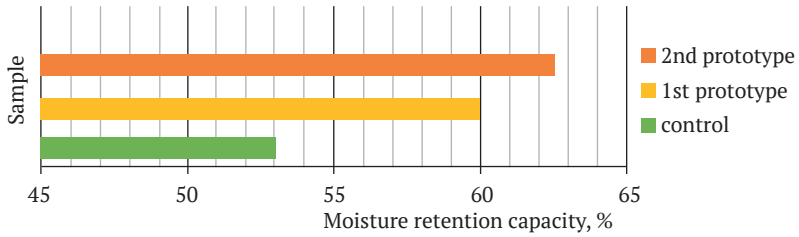

Figure 1. Moisture retention capacity of minced meat

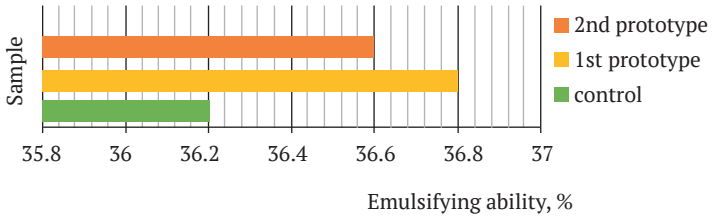

Figure 2. The emulsifying ability of minced meat

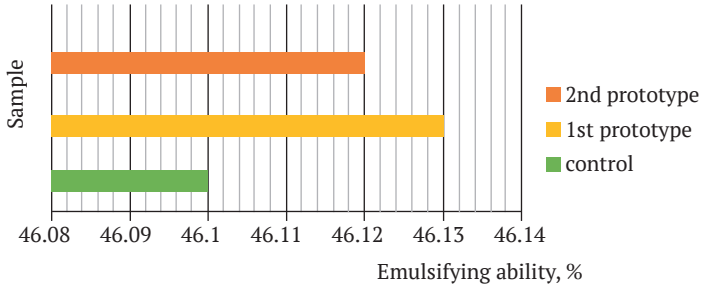

Figure 3. Stability of minced meat emulsions

Based on the studied samples of minced meat, semi-finished products in a dough shell "Healthy dumplings" were made. The study of the organoleptic characteristics of semi-finished products revealed that partial replacement of the liver with additives of plant origin in combination with the use of the food additive "Elamin" and a decrease in the amount of sodium cation leads to an improvement in the consistency of the product and has virtually no effect on the appearance and aroma of the product (Table 3).

Table 3. *Organoleptic evaluation of quality indicators of meat semi-finished products in the dough shell "Healthy dumplings"*

Samples	Appearance	Appearance and color, cut	Aroma	Taste	Consistency	Moisture	Overall marks	Overall mark
Control	4.9	4.9	5	4.8	4	4.7	28.3	Very good
1-prototype	4.9	4.9	4.9	4.5	4.9	4.9	29	Very good
2-prototype	5	5	5	4.7	4.9	4.9	29.5	Excellent

The highest overall score of organoleptic quality indicators on a 5-point scale was obtained for minced meat with the replacement of 5% liver with hydrated soy protein – the 2nd experimental sample (Fig. 4).

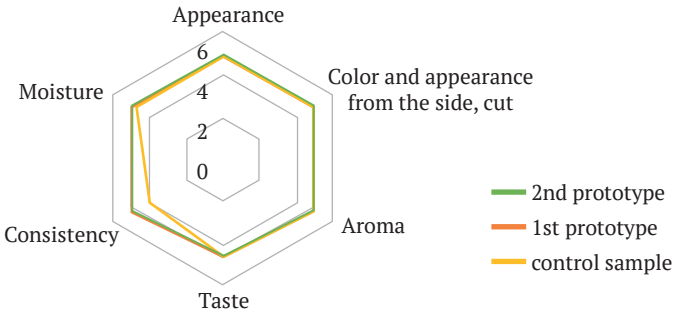

Figure 4. Diagram of quality indicators of pre-made products in dough shell "Healthy dumplings"

In the development of new types of functional meat products, the chemical composition of the experimental samples and their comparison with the control samples is of key importance. The results of studying the general chemical composition of minced meat for pre-made products in a dough shell are shown in Table 4.

Table 4. *Chemical composition of minced meat, %*

Component	Samples		
	Control	1-prototype	2-prototype
Moisture	55.00±2.44	58.21±3.12	59.15±3.44
Protein	10.90±1.02	11.34±2.12	11.63±2.17
Fat	26.51±2.78	24.82±1.98	24.5±2.04
Ash	2.20±0.24	3.16±0.44	3.08±0.41

According to the results of chemical composition studies, an increase in the content of minerals in the experimental samples was noted, and their mass fraction increased by 1.3-1.5 times compared to the control. This fact is explained by the higher content of micro- and macroelements in the used additives compared to meat raw materials.

The results of the study of the amino acid composition of proteins of the control and experimental samples of pre-made products in the dough shell are shown in Table 5.

Table 5. *Amino acid composition of proteins, mg/100 g of product*

Attributes	Samples		
	control	1-prototype	2-prototype
Essential amino acids:			
Isoleucine	518.63	492.18	522.71
Leucine	892.48	891.56	902.08
Sum of methionine and cysteine	412.83	409.51	446.37
Lysine	780.12	741.05	805.7
Sum of phenylalanine and tyrosine	874.86	878.63	940.78
Threonine	458.12	431.45	466.71
Tryptophan	143.33	128.58	139.64
Valine	670.54	647.96	698.66
Nonessential amino acids:			
Alanine	556.28	544.44	579.76
Arginine	677.86	678.57	717.64

Table 5. Continued

Attributes	Samples		
	control	1-prototype	2-prototype
Aspartic acid	776.51	763.77	806.93
Histidine	427.15	422.75	456.42
Glycine	486.58	770.63	514.36
Glutamic acid	1198.87	1171.19	1169.53
Proline	551.73	514.8	549.86
Serine	409.1	397.53	417.71
The total amount of amino acids	9834.9	9584.6	10134.86

The data obtained demonstrate that the qualitative composition of protein substances changes significantly in the experimental dumplings samples compared to the control sample. This indicates that the replacement of the main raw material (liver) with soy protein (2nd experimental sample) contributes to an increase in the number of amino acids in semi-finished products. An important indicator that characterizes the biological value of a protein is its compliance with the ideal protein. The correspondence of the amino acid content to the ideal protein is shown in Table 6.

Table 6. *Compliance with the ideal protein amino acid composition of the protein component of functional meat pre-made products*

Names of essential amino acids	The amino acid content in the protein component of minced meat, g/100 g of protein			
	ideal protein	control	1-prototype	2-prototype
Valine	5.0	5.91	5.57	6.41
Isoleucine	4.0	4.57	4.23	4.80
Leucine	7.0	7.87	7.67	8.28
Lysine	5.5	6.88	6.37	7.39
Methionine + cystine	3.5	3.64	3.52	4.10
Threonine	4.0	4.04	3.71	4.28
Tryptophan	1.0	1.26	1.11	1.28
Phenylalanine + tyrosine	6.0	7.72	7.55	8.63
Amount of amino acids	36	41.89	39.73	45.17

The table shows that the content of each essential acid and their total amount in the control, 1st experimental, and 2nd experimental samples exceeds their amount in the ideal protein and is 41.89 g/100 g of protein, 39.73 g/100 g of protein and 45.17 g/100 g of protein, respectively. The results obtained indicate the absence of limiting amino acids and the high biological value of the product.

Conclusions and Perspectives

Based on the results of complex research, the technology of functional pre-made meat products in a dough shell has been improved. It has been shown that the prototype of minced meat No. 2 enriched with the food additive Elamin and soy protein is characterized by improved functional, technological, and organoleptic properties, an increase in the mass fraction of protein, and compliance with its amino acid composition with the ideal protein. Technical specifications and technological instructions 10.1-00493706-075:2019 "Frozen semi-finished products in a dough shell "Healthy dumplings" were developed for implementation in production. Further research will be aimed at determining the mineral composition of the dumplings to recommend them as a functional food for the prevention of iodine deficiency.

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Удосконалення технології м'ясних напівфабрикатів функціонального призначення у тістовій оболонці

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Анотація. В сучасних умовах посилення процесів глобалізації та загострення конкуренції в харчовій промисловості загалом та у м'ясопереробній зокрема виникає необхідність пошуку нових шляхів підвищення конкурентоспроможності підприємств, гарантування якості та безпечності продукції, забезпечення належних умов праці персоналу, зменшення негативного впливу на навколишнє середовище. Метою досліджень є удосконалення технології виробництва напівфабрикатів у тістовій оболонці та визначення раціональних параметрів технологічного процесу виробництва, за рахунок введення у рецептуру нових складових. Визначення вмісту токсичних елементів проводили на базі Української лабораторії якості і безпеки продукції агропромислового комплексу Національного університету біоресурсів і природокористування України. Проаналізовано основні етапи виробництва напівфабрикатів у тістовій оболонці, удосконалено технологію з урахуванням комплексу досліджень безпечності та якості, визначено ризики та критичні контрольні точки, джерела їх виникнення та розроблено попереджувальні дії. Проведена оцінка амінокислотного складу білкової компоненти та функціонально-технологічних показників якості дослідних зразків м'ясного фаршу (здатність до утримання вологи, емульгувальна здатність, стабільність м'ясних емульсій). Для визначення змін, що відбувалися з дослідними напівфабрикатами збагаченими рослинними компонентами, було проведено дослідження зміни їх фізико-хімічних властивостей після їх заморожування-розморожування. Результати досліджень показали, що у дослідному зразку з вмістом харчової добавки «Еламін», кількість зв'язаної вологи у м'ясних системах протягом зберігання поступово зменшується, але масова частка концентрату у кількості 0,3 кг на 100 кг сировини дозволяє утримати вільну вологу. На основі результатів досліджень удосконалена технологія м'ясних напівфабрикатів функціонального призначення у тістовій оболонці, а для впровадження у виробництво розроблені технічні умови і технологічна інструкція ТУ У і ТІ У 10.1-00493706-075:2019 «Напівфабрикати у тістовій оболонці заморожені «Вареники оздоровчі»

Ключові слова: м'ясний фарш, еламін, пшенична клітковина, соєвий білок, рецептура, технологія, функціональний продукт