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SCIENTIFIC RATIONALE OF THE TECHNOLOGY OF PASTES BASED ON FRESHWATER HYDROBIONTS AND ENRICHED WITH SELENIUM

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Abstract. It has been investigated how to use the dietary selenium-protein supplement *Neoselen* to enrich mussel-based pastes with organic selenium. The formulation of the pastes that has been developed involves the use of the soft body of freshwater mussels of the genus *Anodonta*. It has been studied how introduction of different percentages of the supplement *Neoselen* effects on the organoleptic properties of the developed pastes based on freshwater mussels. It has been found that the addition of even more than 5% of *Neoselen* does not spoil the taste and colour of the pastes developed. The moisture content, moisture-holding and fat-holding capacities, and active acidity of the pastes developed have been studied. By determining the values of plastic viscosity and modulus of elasticity, it has been established how adding different quantities of *Neoselen* changes the consistency of pastes based on freshwater mussels. The regularities of the influence of *Neoselen* on the general chemical and mineral composition of pastes based on freshwater mussels have been determined. It has been established that 1%, 3%, or 5% of *Neoselen* added to the paste can enrich it with 34.8, 50.4, and 66.0 mkg of selenium, respectively. The studies have shown that the quantitative contents of protein, minerals, and water prevail in the composition of both the control and the experimental samples of pastes. The more *Neoselen* in the formulation of pastes, the higher their protein and mineral content is. The complex of the qualitative characteristics of the pastes developed has been investigated. Regular features have been found in how the composition effects on the sensory, physicochemical, functional, and technological characteristics of forcemeat systems based on freshwater mussels and the supplement *Neoselen*. It has been established that the optimal quantities of *Neoselen* in the formulation of pastes range within 3–5%.

Keywords: freshwater mussels, functional products, dietary selenium-protein supplement, pastes.

Introduction. Formulation of the problem

In recent years, the demand for physiological food has increased significantly. The concept of healthy, or rather, health-improving nutrition originated in Japan. Foods that have a physiological effect are those containing nutrients or biologically active substances that boost immunity, and improve physiological processes in the human body. These products help prevent diseases and aging of the body [1].

In our country, the consumption of high-grade proteins has decreased significantly, the balance of the lipid composition in foods is far from rational, and there is a noticeable lack of some minerals and vitamins. In 2018, the underconsumption of complete protein in northern regions of Ukraine was 45.5%, in southern regions 34% [2,3]. A possible way of finding alternative sources of protein is developing technologies of food based on freshwater hydrobionts.

Analysis of recent research and publications

The practice of using freshwater hydrobionts in food technologies throughout the world is considerable.

Modern science finds it possible to use the Nile tilapia as the main fish species cultivated around the world, including Brazil. The study focuses on developing a fish snack technology where minced Nile tilapia is used as the main recipe component. Currently, the sensory and physicochemical characteristics of tilapia-based minced meat and fish snacks have been thoroughly described [4].

Since the 1960s, numerous studies have established the possibility of obtaining fish snacks (snacks, burgers) from minced surimi [5].

Russian scientists studied samples of forcemeat made from the freshwater goldfish, which could be put into production to process unprofitable species of the Volga–Caspian basin and obtain culinary products based on it [6].

Indonesian scientists used the parameter “mixing index” to investigate the effectiveness of mixing minced meat. The samples used were *Oreochromis niloticus*, *Walleye pollack surimi*, and a mixture of both [7].

Scientists of the Republic of Korea studied the physicochemical and sensory characteristics of minced meat made with different concentrations of the supplement based on *Astragalus membranaceus* powder [8].

Brazilian scientists investigated the conditions of convective drying of enzymatically modified paste based on fillets of the fish *Engraulis anchoita* [9].

Among local freshwater hydrobionts, there is a group of commercial, but not sufficiently exploited species such as the freshwater mollusc of the genus *Anodonta* (hereinafter referred to as freshwater mussel). Its soft body is the perfect raw material for functional foods. The protein it contains is complete as

there are all essential amino acids in it [10]. Analysis of the fatty acid composition of the freshwater mussel's soft body shows that its lipids contain polyunsaturated fatty acids, including ω -6 and ω -33, as well as eicosapentaenoic, docosapentaenoic, and docosahexaenoic fatty acids [11]. Freshwater mussels have been found to contain valuable micro and macronutrients. Investigations have allowed establishing that by microbiological and safety criteria, freshwater mussels comply with the current regulations [12].

It should be noted that quick-frozen food products (fish cutlets, nuggets, and others) are increasingly popular with consumers. All this gives grounds to suggest minced freshwater mussels as a basis for physiological food paste.

One of the promising uses of freshwater mussels is the manufacture of moulded products when various food supplements and components can be added to the forcemeat to improve its sensory, structural, and mechanical qualities and enrich it with essential substances. Among the indispensable nutritional factors necessary to maintain the homeostasis of the human body are mineral compounds. Some of the scarcest are selenium compounds. They are potent anticarcinogens, metabolic regulators, components of most hormones and enzymes [13]. A way of implementing this direction of development can be the enrichment of minced freshwater mussels with the dietary selenium-protein supplement (DSPS) *Neoselen* [14,15]. The technology of the DSPS *Neoselen* containing organic selenium, which is obtained from interaction of selenium salts and globular whey proteins, has been scientifically substantiated [16]. It has been established that the DSPS *Neoselen* has a medical and preventive value. Besides, it is an emulsifier of dispersed polycomponent systems. Its introduction into food recipes does not affect the organoleptic properties, increases the emulsion stability, and enriches the body with organic selenium [17].

The purpose of the research is scientific substantiation of the technology of paste based on freshwater hydrobionts and enriched with the dietary selenium-protein supplement.

To achieve this purpose, it is necessary to solve the following **objectives**:

1. To determine the organoleptic properties of pastes based on freshwater mussels and different concentrations of the DSPS *Neoselen*.
2. To investigate the water-holding capacity (WHC), fat-holding capacity (FHC), and pH of the paste based on freshwater mussels and different concentrations of the DSPS *Neoselen*.
3. To determine the rheological properties of the pastes developed, namely the viscosity and elastic modulus.
4. To determine the total physicochemical and mineral composition of the pastes based on freshwater

mussels and different concentrations of the DSPS *Neoselen*.

5. On the basis of the data received, to substantiate the technology of pastes with the physiological effect.

Research materials and methods

The materials used for the research were freshwater bivalves of the genus *Anodonta*, harvested in the Desna River (the Sumy Region), and the DSPS *Neoselen* TU U (Technical Specifications of Ukraine) 10.8–01566330–329:2018 “Mineral and organic food supplements. Specifications.”

Preparation of the test samples. To prepare freshwater mussel paste, freshwater mussels, after they had been boiled and cooled to $40 \pm 1^\circ\text{C}$, were finely minced for 15 min in a meat cutter with the rate of rotation $2600\text{--}2700\text{ s}^{-1}$. To the resulting paste, we added the DSPS *Neoselen*. Prepared peeled and boiled potatoes and onions, as well as additional flavour components (egg powder, salt, etc.) were added to the total mass of minced freshwater mussels, which was then minced for 5 min

more. The resulting paste mass was packed into 1.5–2 kg polystyrene bags and frozen to -18°C . To make pastes, the following ingredients are required (Table 1).

The following experimental pastes were prepared with the DSPS *Neoselen*:

- control (model paste without supplements);
- sample 1 (paste with 1% of *Neoselen*),
- sample 2 (paste with 3% of *Neoselen*),
- sample 3 (paste with 5% of *Neoselen*).

Besides, when mixing the paste components, 1% of the raw materials was lost, and this was taken into account, too. The process flow chart of making paste based on freshwater mussel and enriched with the DSPS *Neoselen* is presented in Fig. 1 (s-f/p stands for semi-finished product).

The doses of the supplement were calculated taking into account the daily norms of selenium consumption (for men, 70 mcg/day, for women, 55 mcg/day) [18]. Selenium should enter the human body only in organic form. Thus, the risk of poisoning by this trace element is eliminated [19].

Table 1 – Recipes of the pastes developed

Ingredients	Norm, kg per 100 kg of raw material	Technical regulations
Freshwater mussel meat	70	TU U 10.2–3316908299–001:2014
Onions	5	DSTU 3234–95
Black pepper	0.02	DSTU ISO 959–1:2008
Allspice	0.02	DSTU ISO 2254:2008
Table salt <i>Ekstra</i>	2.5	DSTU –3583–97
Powdered eggs	4.0	TU U 15.8–32086437–001:2007
Potatoes	18.0	DSTU 4506:2005
Total	100 kg	

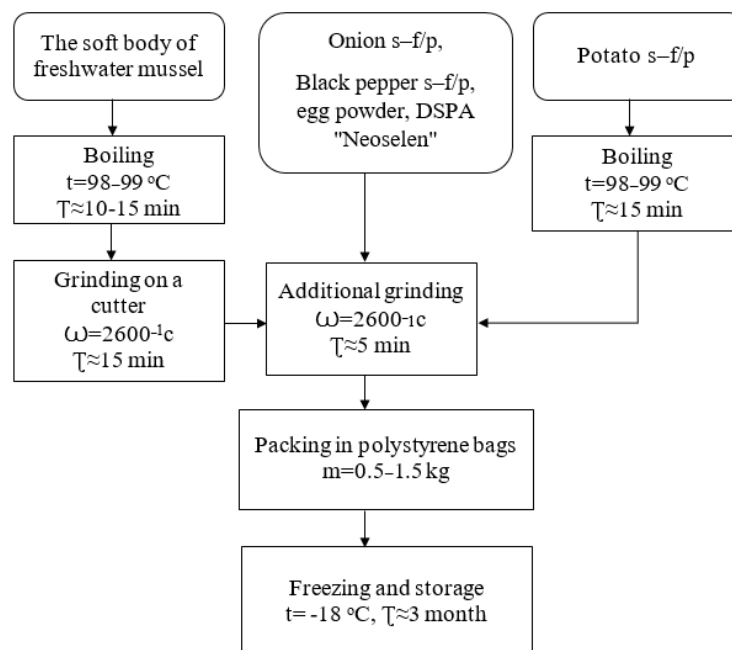


Fig. 1. Process flow chart of the production of paste based on freshwater mussels and enriched with the DSPS *Neoselen*

100 g of *Neoselen* contains $0.78 \pm 0.1 \times 10^{-3}\%$ of elemental selenium (or 0.78 ± 0.1 mg/100 g of the DSPS), which is present in the supplement in combination with whey proteins. That is, 1g of the DSPS contains 7.8 mcg of organic selenium. Thus, by replacing 1%, 3%, or 5% of the forcemeat system with the DSPS, it is possible to enrich it with 14.8, 30.4, and 46.0 mcg of selenium, respectively. The recommended dosage of *Neoselen* per 1 kg of the finished product does not exceed 10 g [20].

Research methods. The sensory parameters were evaluated by the profile method using a 5-point scale to analyse the intensity of certain characteristics: appearance, smell, colour, taste, and consistency (juiciness and density). The results were visualised in the form of profile charts.

The total chemical composition was determined by standard methods according to DSTU (State Standard of Ukraine) 8030:2015. Total nitrogen was determined by a method based on the oxidation of organic matter by burning it in sulphuric acid in the presence of a catalyst in a Kjeldahl flask. The nitrogen content was then determined by titration according to Ukrainian State Standard ISO 5983–2003.

The levels of the main micro and macroelements in the paste (iodine, copper, magnesium, sodium, phosphorus, zinc, iron) were determined by atomic absorption spectrophotometry on an atomic absorption spectrophotometer AAS-30 with the appropriate optical filters ISO 90–1:2004. The potassium content was determined with a photoelectric colorimeter KFC-2 according to DSTU ISO 7485–2003.

The shear stress of the test samples was determined with a rotational viscometer *Reotest-2* (Russia) for 30 s, at 15°C, with the shear gradient 100 s^{-1} , using an S1 spindle. The effective viscosity was calculated by the formula (Oswald and de Waele equation):

$$\eta_{\text{ef}} = \frac{\theta}{\gamma}, \quad (1)$$

where η_{ef} is the effective viscosity, Pa·s;

θ is the shear stress, Pa;

γ is the shear rate, (s^{-1}).

The modulus of elasticity was determined with Kargin and Sogolova's modified scales by studying the compressive deformation of structured systems under the action of a punch with a Teflon attachment.

The modulus of instantaneous elasticity was determined by the formula:

$$E_{\text{el}} = \sigma/\epsilon_0 \quad (2)$$

where E_{el} is the modulus of instantaneous elasticity, Pa;

σ is the strain put on a sample, Pa;

ϵ_0 is the relative conditionally instant deformation.

The mass fraction of moisture was determined in the test samples of pastes with a Chizhov device according to DSTU ISO 6496:2005.

The moisture-holding capacity (MHC) of paste was determined by the gravimetric method. It consists in determining the quantity of water released from the

product by light pressing and absorbed by filter paper. The MHC was calculated by the formula:

$$\text{MHC} = 100 - (b - c) \times 100 / (a \times M) \times 100 \quad (3)$$

where MHC is the moisture-holding capacity, %;

a is the mass of a sample, g;

b is the mass of the filter paper after pressing and removing the sample portion from it, g;

c is the mass of the filter paper after pressing, removing the sample portion, and drying, g;

M is the mass fraction of moisture in the sample, %.

To determine the fat-holding capacity of the pastes (FHC), 5 g portions of the paste was quantitatively transferred to centrifuge tubes, where 30 cm^3 of refined sunflower oil was added, stirred for 1 min at the speed of the stirrer 1000 s^{-1} , and rested for 30 min. After resting, the tubes with the mixture were centrifuged for 25 min at 3200 s^{-1} , weighed, and drained of the oil above the paste sediment. The tubes were tilted to remove excess fat, and rested for 10 minutes. The test-tubes with the sediment were weighed, and the FHC was calculated by the formula:

$$\text{FHC} = 100 - (b - c) \times 100 / (a \times b) \times 100 \quad (4)$$

where FHC is fat-holding capacity, %;

a is the weight of the tube with protein and bound oil, g;

b is the weight of the test-tube with paste, g;

c is a weighed sample portion of paste, g.

The active acidity of the paste was determined by the potentiometric method on a pH-meter *pH-410*. A 1g portion of paste was dissolved in 100 ml of distilled water, and 0.1 g of the 0.1-n sodium thiosulphate solution was added.

The standard error and mean values were determined using multiple regression (descriptive statistics in MS Office Excel).

Results of the research and their discussion

Organoleptic studies of the samples of the pastes developed have been carried out. The parameters considered were the taste, smell, colour, and consistency. The profiles of the organoleptic evaluation of the paste are shown in Fig. 2.

The results of the tasting evaluation have shown that the addition of 1% of *Neoselen* (sample 1) has almost no effect on the sensory characteristics of the pastes. Sample 3 with 5% of *Neoselen* added has a slight taste of selenium. The freshwater mussel present in the paste in combination with organic flavouring substances of other components results in the formation of original taste sensations. Summarising the results of the tasting, it can be stated that the paste has a delicate smell (characteristic of freshwater fish), taste, colour, and appearance.

The main requirement of the technology of minced meat products is the dispersed state of paste components and the bound state of moisture and fat. So, the moisture content, MHC, and FHC belong to the most important parameters in the paste technology. These functional and technological parameters are presented in Table 2.

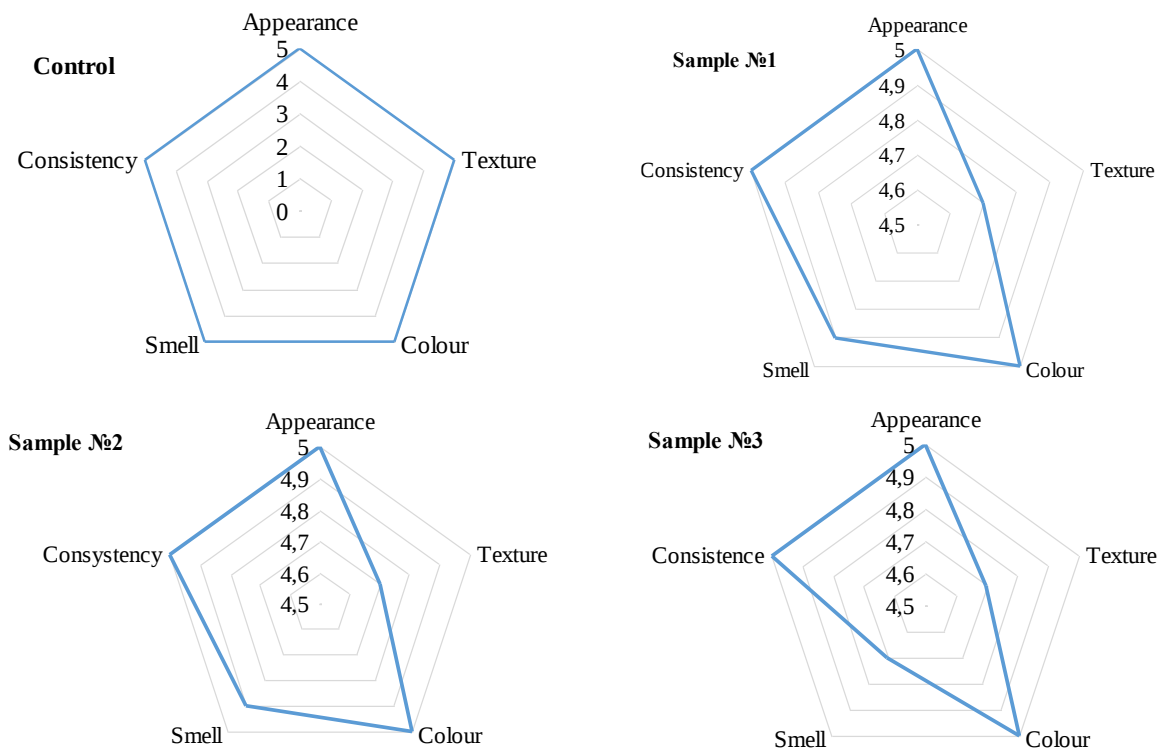


Fig. 2. Profiles of the organoleptic evaluation of the paste based on freshwater mussels and enriched with the DSPS *Neoselen*

Table 2 – Functional and technological properties of pastes (n=5, P≥0.95)

Sample	WHC, %	FHC, %	Moisture, %	Active acidity, pH
Control	70.6	72.0	70.9	6.2
Sample 1	72.3	72.2	72.1	6.3
Sample 2	73.9	72.7	72.9	6.3
Sample 3	75.4	72.9	72.7	6.2

The addition of the DSPS *Neoselen* helps to stabilise forcemeat systems. The studies of model samples of pastes with different concentrations of *Neoselen* have shown that adding 5% of it has a positive effect on the organoleptic, functional, and technological properties of minced meat. This is evidenced by the highest values of MHC and FHC in sample 3.

The developed pastes based on freshwater mussel and enriched with *Neoselen* are a plasto-viscous system. Its parameters are the plastic viscosity index and the modulus of elasticity. The consistency of the finished paste depends directly on the overall chemical composition and the degree of mincing. For each sample, the value of plastic viscosity has been obtained, and the modulus of elasticity calculated (Table 3).

Samples 1 and 2 have about the same plastic viscosity. The differences in the values of the modulus of elasticity in different minced meat samples can be explained by different contents of *Neoselen*. The quantitative index of viscosity in all samples shows the rate of the breakdown of the structure: its smallest value in sample 3 indicates that the structure of the

sample is least likely to be destroyed, and the most likely is that of sample 1.

Table 3 – Values of structural and mechanical parameters of the pastes (n=5, P≥0.95)

Parameter	Control	Number of the sample		
		1	2	3
Plastic viscosity, Pa·s	0.8	0.04	0.038	0.037
Modulus of elasticity, 10 ⁻³ , Pa·s	0.2	0.2	0.19	0.17

To study the nutritional value of pastes based on freshwater mussels and enriched with *Neoselen*, their chemical composition has been analysed. The chemical composition of pastes determines their nutritional and biological value. The general chemical composition of the *Neoselen*-enriched paste and of the control samples has been studied. The results are presented in Table 4.

The studies have shown that in the composition of both the control and experimental samples of pastes, the largest are the quantities of protein, minerals, and water. The content of protein and mineral substances increases with the increase of the content of the DSPS *Neoselen* in the paste formulation.

Table 4 – Chemical composition of the pastes (n=5, P≥0.95)

Parameter	Control	Number of the sample		
		1	2	3
Mass fraction of, %:				
water	79.9	78.6	79.1	79.5
minerals	2.3	2.5	3.1	3.4
raw fat	1.1	1.15	1.15	1.15
total protein	11.3	11.4	11.7	11.8
crude fibre	0.1	0.2	0.2	0.2
nitrogen-free extractives	5.2	6.15	4.75	3.95

Mineral substances are especially important for the proper functioning of the body, so it was necessary to determine their content in the composition of *Neoselen*-enriched pastes based on freshwater mussels (Table 5).

Table 5 – Mineral composition of the pastes (n=5, P≥0.95)

Parameter	Control	Number of the sample		
		1	2	3
Calcium, mg/100 g	110	190	190	185
Phosphorus, mg/100 g	240	350	346	335
Potassium, mg/100 g	290	260	256	249
Sodium, mg/100 g	155	130	134	122
Magnesium, mg/100 g	186	170	150	178
Copper, mcg/100 g	39	35	33	333
Manganese, mg/100 g	2.88	3.41	3.41	3.41
Zinc, mg/100 g	1.90	0.63	0.53	0.59
Iron, mg/100 g	2.3	3.15	3.67	3.55
Selenium, mcg/100 g	7	14.8	30.4	46.0
Iodine, mcg/100 g	57	55	59	67

The data obtained show that the control samples of *Neoselen*-enriched pastes based on freshwater mussels contain all the basic macro- and microelements, such as calcium, phosphorus, potassium, sodium, magnesium, iron, and selenium. The selenium content

in the control samples is 7 mcg/100 g, which satisfies an adult's daily need for it by almost 10%. And in test sample 3, its content is as high as 46.0 mcg/100 g, which is almost 60% of the recommended daily intake. The data obtained indicate that pastes *Neoselen*-enriched pastes based on freshwater mussels can be regarded as a product of high biological value.

Conclusion

Thus, the experimental studies confirm the possibility of producing pastes based on freshwater mussel with the addition of the DSPS *Neoselen* as a product that has a physiological effect. It has been studied how introduction of different percentages of *Neoselen* effects on the organoleptic properties of the developed pastes based on freshwater mussels. It has been established that the optimum amount of *Neoselen* in the recipe of pastes is 3% to 5%.

Based on the organoleptic analysis, it has been determined that the paste has a delicate smell (characteristic of freshwater fish), taste, colour, and appearance. The addition of even more than 5% of *Neoselen* does not spoil the organoleptic properties.

Adding the DSPS *Neoselen* helps to stabilise forcemeat systems. The studies of model samples of pastes with different concentrations of *Neoselen* have shown that adding 3% to 5% of it has a positive effect on the functional and technological properties of minced meat. This is evidenced by the increase in MHC and FHC in samples 1 and 3.

With 5% of the DSPS *Neoselen* in the paste formulation, the system has the best adhesive properties: the viscosity of the paste increases due to an increase in the concentration of solids.

The data obtained make it possible to give scientific reasons for the technology of physiological-action paste based on freshwater mussels and enriched with the DSPS *Neoselen*.

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НАУКОВЕ ОБГРУНТУВАННЯ ТЕХНОЛОГІЇ ПАСТ НА ОСНОВІ ПРІСНОВОДНИХ ГІДРОБІОНТІВ, ЗБАГАЧЕНИХ НА СЕЛЕН

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Анотація. Досліджено можливість використання добавки дієтичної селен-білкової «Неоселен» для збагачення паст на основі гідробіонтів органічним селеном. Розроблено рецептуру паст передбачала використання м'якого тіла прісноводного молюска роду Anodonta. Досліджено вплив внесення різної відсоткової кількості добавки «Неоселен» на органолептичні властивості розроблених паст на основі прісноводних молюсків. Встановлено, що додавання добавки «Неоселен» навіть понад 5% не погіршує смак та колір розроблених паст. Досліджено вміст вологи, вологоутримуючу, жирутримуючу здатність та активну кислотність розроблених паст. Досліджено відмінність консистенції паст на основі молюска прісноводного з різним процентним внесенням добавки «Неоселен», шляхом визначення значень пластичної в'язкості та модуля пружності. Встановлено закономірності впливу добавки «Неоселен» на загальний хімічний та мінеральний склад паст на основі прісноводних гідробіонтів. Встановлено, що внесення до складу паст добавки «Неоселен» у кількості 1%, 3% або 5% вдається збагатити її на 14.8, 30.4 та 46.0 мкг селену відповідно. Дослідження показали, що у складі, як контрольного так і дослідних зразків паст по кількості переважає вміст білка, мінеральних речовин та води. Зі збільшенням вмісту «Неоселен» у рецептурі паст вміст білка та мінеральних речовин підвищується. Досліджено комплекс якісних характеристик розроблених паст. Встановлено закономірності впливу компонентного складу на органолептичні та фізико-хімічні та функціонально-технологічні характеристики фаршевих систем на основі прісноводних гідробіонтів та добавки «Неоселен». Встановлено, що оптимальні дози використання добавки «Неоселен» у рецептурі паст коливаються в межах 3–5%.

Ключові слова: прісноводні молюски, функціональні продукти, добавка дієтична селен-білкова, пасти.

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