SCIENTIFIC JUSTIFICATION OF HYDROMECHANICAL DISPERGATING IN FOOD PRODUCTION FROM HYDROBIONTS (CYST *ARTEMIA SALINA*)

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Abstract: The problem of raising the level of protein supply in the diet of the population of the Russian Federation is still relevant. To solve this problem it is important to investigate protein food reserves, while priority is given to a combination of vegetable and animal proteins. Fish and non-fish water fishing is paid particular attention as a potential source of protein, because of almost inexhaustible world ocean reserves and the prospects for their use. The aim of the work is the scientific study and practical implementation of preparation and evaluation of the quality of pasty concentrates of aquatic organisms, as well as health food products based on them using hydro-mechanical dispersion. The scientific background of technological aspects of the production of aquatic pasty concentrate from hydrobionts (cyst *Artemia Salina*) using hydro-mechanical dispersion is presented in the article. Consumer characteristics, conditions and terms of the concentrate storage are identified. New data on the effectiveness evaluation of paste concentrate from cyst *Artemia* to increase the body's immune properties are obtained in the experiments with animals. The expediency of development and industrial production of cheese products using pasty concentrates of aquatic organisms is based. Regulated quality parameters, modes and terms of their storage are established.

Keywords: Hydrobionts, hydromechanical dispergation, cheeses, cavitation, foods, quality, safety, pasty concentrates

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INTRODUCTION

The modern concept of creating a sustainable food base comes from the need to search for and use of reserves of agricultural raw materials produced by deep processing of highly effective methods of physical and other kinds of actions [1].

The production of healthy food based on local raw materials is very important. These products are characterized by safety, high nutritional value, corresponding properties, meeting the needs of different population groups in necessary food, biologically active substances and energy [2].

The subject area is one of the priorities in the implementation of international and national programs in the field of diet correction and preservation of health, enshrined at the state level by laws and government regulations [3-7].

Existing technologies for processing are usually material- and energy-consuming, and often do not meet the requirements in terms of quality. Matters of general and function-based food production from pasty concentrates using hydro-mechanical dispersion deserve special attention as part of the discussed problem. The urgency and priority of these studies are shown in the work of scientists in the field of biotechnology – I.A. Rogov, T.K. Kalenik, in the field of hygiene and food biochemistry – V.A. Tutelian, B.P. Sukhanov, V.M. Poznyakovskiy, in the field of commodity science – L.G. Eliseeva, T.N. Ivanova, E.P. Kornena et al.

However, some aspects of this trend remain poorly studied, require scientific justification and practical solutions.

Currently, special attention is given to fish and non-fish water fishing as a potential source of protein, because of almost inexhaustible supply of the world's ocean and prospects for their use [8-11].

Artemia cysts are eggs of saltwater crustacean *Artemia Salina*. Biochemical composition of Artemia cysts (Table 1) indicates the presence of digestive lipids and unsaturated fatty acids in cysts. Artemia cysts are a source of vitamins, contain a set of vital mineral substances (Table 2 and 3). Vitamin E in cysts is 8.8 times more, compared to whole milk powder, B6 and B3 - 15 and 19 times respectively. The content of carotenoid averages 136 mg / 100 g [11].

Table 1. Chemical composition of undecapsulated Artemia cysts, % [11]

Index	Content
Moisture	9.14 ± 0.11
Protein	44.04 ± 1.29
Carbohydrates	30.72 ± 0.76
Lipids	7.22 ± 0.22
Ash	8.88 ± 0.17

Table 2. Mineral composition of undecapusulated Artemia cysts [11]

Index	Content
Macroelements, g/kg	
Calcium	0.24 ± 0.04
Phosphorus	0.46 ± 0.06
Potassium	2.40 ± 0.03
Sodium	8.70 ± 0.14
Magnesium	6.80 ± 0.09
Trace elements, mg/kg	
Iron	375.00 ± 7.93
Copper	17.50 ± 0.13
Zink	97.50 ± 0.68
Manganese	150.30 ± 3.20

Table 3. Vitamin composition of undecapusulated Artemia cysts [11]

Index	Content
Retinol	27.32 ± 0.18
Tocopherol	76.94 ± 2.91
Thiamin	7.69 ± 0.12
Riboflavin	23.08 ± 0.29
Pantothenic acid	38.00 ± 0.32
Pyrodixine	15.39 ± 0.14
Cobalamin	0.08 ± 0.01

Commercial processing of cysts *Artemia Salina* in Russia is practically absent. The main problems of implementation of existing technologies to process them are low efficiency, high cost and complexity of processing equipment.

The aim of the paper is scientific justification and practical implementation of preparation and evaluation of the quality of aquatic pasty concentrates, as well as health food products based on them using hydro-mechanical dispersion.

To achieve this objective there are the following tasks:

– to formulate scientific and methodological approaches to the formation of consumer properties of healthy food using hydrobionts;

– to substantiate the feasibility of hydro-mechanical dispersion for food raw materials and foodstuffs from the scientific point of view;

– to develop pasty concentrates on the basis of aquatic organisms;

– to evaluate the efficiency and functional orientation of pasty concentrates from Artemia cysts;

– to determine the direction of use of pasty materials from protein-containing concentrates, to develop formulations and technologies of cheese products, to explore their consumer properties;

– to develop and approve technical documentation for new products with pasty concentrates, to carry out their commercial approbation.

The scientific purpose of work is to develop a conceptual model of the system of food production with improved quality, safety and an integrated approach to the development of technologies using hydro-mechanical dispersion.

Scientific novelty. The main directions of improvement of food and biological value of food products are based.

Scientific and methodological approaches to the formation of consumer properties of food raw materials and food products obtained using hydro-mechanical dispersion are formulated.

The data on the nutritional value, functional properties and technological suitability of Artemia cysts, which served as the basis for the development of the technology of pasty concentrates are received.

Technological aspects of the production of pasty concentrates from Artemia cysts using hydromechanical dispersion are scientifically based, and its consumer characteristics, conditions and terms of storage are identified.

Regulated quality parameters, conditions and terms of storage are established.

Practical significance. Technical documentation is developed and approved. The novelty of technical decisions is confirmed by patents of the Russian Federation.

RESULTS AND DISCUSSION

In the first research stage, scientific and methodological approaches to the formation of consumer properties of healthy foods were formulated. To establish such products using plant and aquatic raw materials, a number of mandatory requirements were taken into account: access to raw materials, manufacturability of production, preservation of biologically active substances, storage stability, safety, nutritional value, balanced chemical combinations.

In the product development, along with safety indicators, attention was paid to the content of the feedstock and finished products of vital nutrients such as vitamins, macro- and microelements, fatty acids, and others.

In the second stage a method of hydro-mechanical dispersing for the processing of agricultural raw materials, obtaining pasty concentrates and finished products based on it with improved quality and safety was provided.

A unit based on MAG-50 was developed and tested in working conditions to implement this method. The novelty of the proposed method has a complex effect on the processed product of hydromechanical dispersion, the processes of homogenization, pasteurization and partial deodorization being carried out simultaneously. Rough grinding takes place owing to the stirrer equipped with additional cutting edges, pulverization and homogenization of the components to 6–12 micron are carried out with the working body. Pasteurization temperature is between 50 ... 55°C by ultrasonic cavitation arising during the rotation of body.

To develop paste concentrate (PC) of Artemia cysts, it was necessary to remove cyst chorion. It was found that decapsulation was effectively accomplished with calcium hypochlorite. Before decapsulation cysts are hydrated in fresh water at 25°C for 1 hour, then they are placed in the decapsulating solution where they are suspended. A complete chorion dissolution is confirmed by transition of dark brown color to orange.

Figure 1 shows the effect of the concentration of active chlorine solution, temperature and exposure time on the percentage of decapsulation.

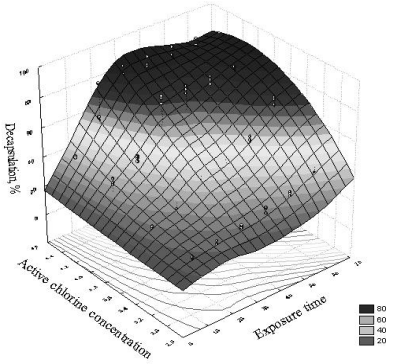

Fig. 1. The effect of the concentration of active chlorine solution, temperature and exposure time on the percentage of decapsulation.

The investigation of decapsulation process made it possible to establish rational parameters that provide the best removal of chorionic Artemia cysts at the lowest energy consumption: the concentration of active chlorine - 4.5%, processing time - 60 minutes, temperature - 35°C.

After decapsulation cysts were washed with decimolar hydrochloric acid, and processed with the hydromechanical dispersing vegetable oil being added in the ratio of 1 : 1. The result is a PC with desired properties.

Studies on the production of dry crushed concentrate from Artemia cysts on a jet mill MPV-1 were carried out. During cyst processing, the product is separated into two fractions: the first one is 90% (particle size up to10 microns), the second - 10% (undecapsulated empty cysts).

Comprehensive analysis of the chemical composition of concentrates was made, the results of which are presented in Table 4.

Table 4. Chemical composition of concentrates from Artemia cysts (n = 9)

Index c	PC from decapsulated Artemia cysts	Crushed concentrate
Moisture, %	20.20 ± 0.20	12.40 ± 0.80
Protein, %	49.60 ± 1.29	43.04 ± 1.29
Carbohydrates, %	23.24 ± 0.95	26.46 ± 1.30
Lipids, %	3.25 ± 0.15	4.90 ± 0.22
Ash, %	3.71 ± 0.21	13.20 ± 1.15
Vitamins, mg/100g:		
Retinol	35.02 ± 2.20	28.62 ± 1.18
Tocopherol	74.30 ± 3.30	74.94 ± 1.90
Thiamin	10.10 ± 0.17	8.89 ± 0.12
Riboflavin	24.42 ± 1.02	23.68 ± 0.19
Pantothenic acid	45.20 ± 1.62	38.43 ± 1.13
Pyridoxine	19.40 ± 0.72	17.09 ± 0.14
Cobalamin	0.09 ± 0.01	0.07 ± 0.01
Macroelements, g/kg:		
Calcium	0.18 ± 0.02	0.26 ± 0.04
Phosphorus	0.57 ± 0.10	0.46 ± 0.08
Potassium	2.21 ± 0.02	2.60 ± 0.03
Natrium	6.23 ± 0.16	8.54 ± 0.18
Magnesium	4.40 ± 0.09	6.45 ± 0.10
Trace elements, mg/kg:		
Iron	128.70 ± 2.40	380.40 ± 7.30
Copper	14.30 ± 0.20	16.20 ± 0.25
Zink	99.60 ± 2.30	94.30 ± 2.80
Manganese	136.21 ± 6.41	125.10 ± 5.30

To evaluate the effectiveness and functional directivity of PC from Artemia cysts laboratory animals - rats of Vistar line were experimentally studied through its inclusion in the diet of animals and investigation of immune system. Lysozyme, phagocytic and bactericidal activity increase, respectively 4–5, 2–4, and 11–13% compared to the animal group receiving common diet was determined. In rats, the test group showed a significant decrease in serum cholesterol levels (Table 5).

Table 5. The cholesterol content in blood serum, mmol / l (n = 5, P <0.01)

Group	Diet	M±m
1 – control	Basic	0.232 ± 0.0116
2 – experimental	Basic +undecapsulated	0.180 ± 0.0071
3 – experimental	Basic +crushed	0.176 ± 0.0092
4 – experimental	Basic +PC from decapsulated Artemia cysts	0.122 ± 0.0038

Laboratory animals treated with traditional vivarium diets have blood cholesterol content at the level of (0.232 mmol / l). When fed by cysts in the native state, the index declined by 28%, when fed by cysts, crushed on a jet mill, by 31% respectively. It is shown that the most efficient of the PCs are decapsulated Artemia cysts produced using hydromehanical dispersion: the introduction of this product to diet reduces cholesterol by 90%.

The obtained results testify to the effectiveness of Artemia cysts for the increase of immune properties of the body and the functional directivity of their active ingredients.

When developing a PC using hydromechanical dispersion, high keeping quality of nutrients in the feedstock was noted.

In the third stage, the possibility of using pasty concentrates as ingredients in food production was studied. Formulations and technologies of spreadable cheese products with the concentrate of Artemia cysts (PC "Artsalin") obtained using hydromehanical dispersion were developed. Process conditions and food production parameters were defined, consumer properties were investigated, quality regulation rates, time and storage conditions were established.

Rennet cheese with pasty concentrate from Artemia cysts (PC "Artsalin"). To study the qualitative indices of the developed product, the following cheese options were worked out: control; experimental 1 – cheese with 0.5% PC "Artsalin"; experimental 2 – cheese with 1.0% PC "Artsalin."

A method for producing hard rennet cheese comprises curd obtaining, filler introduction, making and pressing the cheese. PC "Artsalin" with the amount of 0.5–1.0% of curd was used as a filler. Components for the preparation of filler were taken in the following proportions, % of weight: raw milk 90–95, filler 0.5–1.0, vegetable oil 0.005–3.0, salt 0.005–2.0. The proposed method for producing solid rennet cheese can increase food value, due to the availability of vitamins, essential amino acids, polyunsaturated fatty acids and mineral substances in PC "Artsalin."

It was found that the number of amino acids including essential ones, both experimental variants differ from the reference sample in a positive way (Table 6).

Table 6. Amino acid composition of experimental hard rennet cheeses, g/100 g (averaged data, n = 7)

Amino acids	Control	Experimental 1	Experimental 2
Essential, including:			
Lysine	0.91	1.17	1.19
Threonine	0.61	0.74	0.82
Valine	1.48	1.89	1.98
Methionine + cystine	0.74	0.80	0.80
Isoleucine	0.20	0.26	0.35
Tyrosine + phenylalanine	1.41	1.44	1.51
Leucine	1.10	1.13	2.19
Total	6.45	7.43	8.84
Replaceable, including:			
Alanine	0.97	0.96	0.97
Arginine	0.75	0.69	0.78
Glycine	0.34	0.67	0.37
Glutamine	4.90	6.00	6.22
Proline	2.86	3.92	3.52
Serine	0.67	0.60	0.67
Total	10.49	12.84	12.53
Total quantity of amino acids	17.94	20.27	21.37

As part of the commodity evaluation, organoleptic characteristics: taste, smell, texture, pattern were investigated. Sample 1 was marked by delicious taste and peculiar smell of caviar, similar dependence was observed for consistency. The pattern did not reveal any significant differences between the experimental and control samples. In terms of integrated organoleptic characteristics, the maximum number of points - 72 is set for the 1st sample. The results show relatively high organoleptic virtues of composed cheeses.

The incorporation of PC "Artsalin" into the curd showed an increase of the amount of lactic microflora in test samples compared to that under control.

It was established that on the 10th day the content of lactic acid microflora in experimental samples increased by 13 and 21%. Subsequently, this pattern remained. After 60 days, marked difference made up 5 and 8.7%, respectively. We can assume that the PC "Artsalin" promotes higher microflora activization and the formation of lactic acid due to PC containing nutraceuticals, the latter being a breeding ground for these microorganisms.

High content of vitamins and minerals in cheeses produced with the addition of PC "Artsalin" compared with a control sample was noted as well.

To determine the biological value of blended cheese proteins, amino acid scores were calculated (Table 7), which indicate that the investigated product with 1.0% PC "Artsalin" does not yield to the reference protein in biological value.

Table 7. Amino acid score of hard rennet cheese with PC "Artsalin" (averaged data, n = 7)

Amino acid	Control		Experimental 1		Experimental 2		Ideal protein g/100g FAO/ WHO
	g/100g of protein	% to protein FAO/ WHO	g/100g of protein	% to protein FAO/ WHO	g/100g of protein	% to protein FAO/ WHO	
Lysine	5.1	93.0	5.4	97.5	5.4	98.7	5.5
Threonine	3.7	93.0	3.7	92.5	3.7	93.5	4.0
Valine	8.6	172.6	8.7	173.2	9.1	180.6	5.0
Methionine + cystin	3.4	97.1	3.7	104.6	3.7	104.3	3.5
Isoleucine	0.9	23.0	1.2	29.8	1.6	40.0	4.0
Phenylalanin	6.5	107.8	6.6	110.0	6.9	114.8	6.0
Total	28.2	100.8	29.2	104.2	30.3	108.4	28/100

Melted cheese with PC "Artsalin". The process of melted cheese production consists of the following main stages: selection and processing of raw materials, the removal of paraffin away from cheese crust, soaking and scraping, crushing and grinding of raw materials, mixture composition, incorporation of melting salts, mixture maturation, cheese-mass melting, PC "Artsalin" introduction, melted cheese prepacking and cooling, packaging of finished products.

To study the amino acid composition of the product under development experimental working out on options was carried out: experimental 1 – combined, 1.0% PC "Artsalin"; experimental 2 - combined, 0.5% PC "Artsalin."

The content of the water- and fat-soluble vitamins and minerals in cheeses with PC "Artsalin" was higher than that of the control sample.

Results comparing the amino acid composition of cheeses combined with optimal ideal protein composition give reason to believe that the products offered have a high biological value, especially leucine, phenylalanine and isoleucine (Table 8).

Table 8. Amino-acid score of melted cheese with PC "Artsalin" (averaged data, n = 5)

Amino acid	Control		Experimental 1		Experimental 2		Ideal protein g/100g FAO/ WHO
	g/100g of protein	% to protein FAO/ WHO	g/100g of protein	% to protein FAO/ WHO	g/100g of protein	% to protein FAO/ WHO	
Leucic	7.5	107.1	14.8	211.4	7.8	111.4	7.0
Lysin	10.1	183.6	10.8	196.4	10.7	194.5	5.5
Threonine	8.1	202.5	7.07	176.7	7.48	187.0	4.0
Valine	8.23	164.6	3.6	72.0	10.6	212.0	5.0
Methionine + cystin	3.4	97.1	4.2	120.0	3.5	100.0	35
Isoleucine	5.3	135.0	9.2	230.0	4.6	115.0	4.0
Phenylalanine	6.2	103.3	8.09	134.8	8.8	146.6	6.0
Total	48.83	139.5	57.76	165.02	53.48	152.8	35/100

As a result, sanitary and microbiological studies have shown that the introduction of PC "Artsalin" into cheese mass improves the quality of the experimental hard rennet and melted cheeses in storage in terms of safety. After 3 months of storage in the control samples of hard rennet and 1 month in melted cheese there were detected coliform bacteria; these microorganisms have not been identified in the test specimens. Antibacterial effect is due, apparently, to the PC "Artsalin" containing vitamin E which has an inhibitory effect on the development of coliforms.

There were no differences in the content of Salmonella, S. aureus, yeast and molds between the control and test samples of cheese.

CONCLUSIONS

1. The possibility of using hydro-mechanical dispersion for the production of food raw materials, semi-finished and pasty products with their application was based. Simultaneous use of cavitation effect and mechanical crushing makes it possible to obtain products with new quality characteristics and consumer properties. The results obtained were tested using apparatus with interrupting of the flow of treated medium, developed with mechanic-acoustic homogeneizator MAG-50.

3. The complex commodity assessment of Artemia cysts on physicochemical, microbiological indices, and other safety criteria were carried out. The data obtained served as the basis for their use in food production as a source of complete protein, polyunsaturated fatty acids, vitamins, minerals, whose presence enhances the nutritional value and determines the functional directivity of food.

4. The technologies for the production of pasty concentrates were developed. The dependence of the effect of temperature and time of treatment on quality of raw materials was defined. The features of the

chemical composition and consumer properties of concentrates of Artemia cysts were revealed. The conditions and terms of storage, nutritional value and safety factors were established.

5. A new range of cheese products with pasty concentrates has been developed and tested in the production environment. Dosages and methods of their application were defined. Regulated quality indices, nutritional value, terms and conditions of storage were established.

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