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## Innovative products and environmental aspects of modern fodder production for aquaculture objects

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**Abstract.** The quality of water and fodder components in conditions of industrially developed regions with a high degree of anthropogenic pressure on the territory become especially significant factors. The increasing demand for hydrobionts as a source of food continues to grow annually. This fact is connected not only with the increase in population, but also with the fact that preference is increasingly given to healthy food. To improve the rates of growing aquaculture and expand its species diversity, it is necessary to increase the production of feed, expand their range and develop new technologies for obtaining highly effective feed additives. A feed additive for fish feeds based on secondary raw beekeeping materials is characterized by a complex chemical composition and is a universal source of natural biologically active complexes. The practical absence of heavy metals, radionuclides, pesticides and other harmful substances in the feed additive based on bee products does not pollute the aquaculture of water bodies, and its properties due to a unique composition contribute to the accelerated elimination of toxic substances from the body of fish. The combination of ecological approaches and the introduction of innovative technologies in the production of aquaculture facilities allows to solve such key tasks of social development as ensuring food security and maintaining public health.

### Introduction

In the modern world, the production of fish and fish products is considered an important economic indicator in many countries. The increasing demand for hydrobionts as a source of food continues to grow annually. This fact is connected not only with the increase in population, but also with the fact that preference is increasingly given to healthy food [1], because the fish in its composition contains high-quality proteins, unsaturated fatty acids and other important nutrients necessary for maintaining



human health. It is interesting that the increase in consumption of fish products coincides with the increase in the life expectancy of both men and women [2].

According to FAO data, mankind annually consumes 90 million tons of products produced by aquatic ecosystems, including 13 million tons of aquaculture. In the 21st century, 130 million tons will be needed to meet the nutritional needs of the growing population [3]. The contribution of fish to the diet is more significant from the point of view of proteins of animal origin, since a portion of fish in 150 grams covers about 50-60% of the daily need of an adult in proteins. In 2009, fish accounted for 16.6% of the total content of protein of animal origin consumed by the world's population, and 6.5% of total protein intake [4]. It is also important to have a relatively low cost of growing fish (for comparison, the cost of 1 kg of pond fish is 4-5 times lower than the cost of 1 kg of meat).

In general, the situation is as follows: in the world over the past half century there has been a steady increase in fish consumption - from about 9 kg in 1961 to 18.8 kg in 2011 (per person per year). However, fishing can not continue to meet the growing demand for fish, as its catch has reached a relatively stable limit since the mid-nineties and amounts to approximately 85.0 -90.4 million tons, but not more than 100 million tons per year [3, 5].

To increase the volume of production of commercial fish, it is necessary to ensure the maximum realization of the genetic potential of fish productivity and the growth of its safety, which is possible only with full-fledged feeding, including the use of feed containing a full range of vitally important nutrients - amino acids (irreplaceable and replaceable) - and macronutrients, vitamins, etc. [6].

Along with this, it should be noted that the requirements for the quality of food products are increasing all over the world, including quality of fish. High quality of fish products can be provided only if ecological requirements are met for ecosystems.

On the other hand, there has been a recent increase in interest in the use of beekeeping products, characterized by the absence of harmful side effects on the environment, which is typical for all paleo products [7]. In this regard, they are of interest both in the production of innovative feed additives for mixed fodders for growing fish, and for solving a number of environmental problems in the industry.

## Results and discussion

Ecological aspects of modern fodder production for objects of aquaculture

The Middle Volga region is one of the most industrially developed regions with a high degree of anthropogenic pressure on the territory. The quality of water and feed components under these conditions becomes especially significant factors.

A significant characteristic of feed components is the presence of heavy metals in them. In the muscular tissue of fish, zinc and copper accumulate at the maximum concentrations, while the permissible residual amounts of zinc and copper in the fishery products are 40 and 10 mg / kg for wet weight, respectively [8]. For lead, cadmium and mercury, the permissible residual quantities are 1.0, 0.1 and 0.5 mg / kg of wet weight, respectively, in predatory fish, and 1.0, 0.1 and 0.3 mg / kg of wet weight in non-predatory fish [9]. The permissible standards of toxic metals in fish were developed taking into account the analysis of the current legislation on hygienic regulation in Russia and foreign countries, the international recommendations of FAO / WHO. This took into account the natural content of elements in food products.

The peculiarities of the accumulation of heavy metals in fish from different habitats can be related to the age-specific features, since with the increase in the age of fish the concentration of heavy metals in their organs is influenced by two interrelated trends: accumulation due to an increase in the volume of consumed food and a decrease in the specific content due to an increase in the total body weight of fish. With increasing age of fish, the content of heavy metals in their bodies increases, especially in fish with a lower growth rate. Accumulation of heavy metals in fish is also associated with their entry into the body of fish by chemisorption of ions with mucous membranes; mechanical capture of suspended particles containing heavy metals; absorption by gills during breathing and, of course, with food. In this regard, the use of fish feeds that do not have a negative effect on the biocenosis of aquatic systems becomes important.

In the last period there has been an increase in interest in the use of beekeeping products both in environmental problems [10] and as a feed additive [11].

New raw materials for the production of feed additives for aquaculture objects

Bee products - perga (bee bread) and merva are potential raw materials for obtaining feed additives and their use in animal husbandry because they contain a vast complex of vitamins, microelements and amino acids [12]. However, under the influence of external factors - humidity, temperature, ultraviolet irradiation, seeding by various microorganisms - the useful properties of raw beekeeping resources are quickly lost. In order to preserve the composition and properties of these valuable products, technologies have been developed for their processing and obtaining purified substances and feed additives based on them [13,14].

Since the quality of commercial fish depends on the initial components of feeds and their composition, study was conducted on the amino acid, vitamin and macro- and microelement composition of the products obtained - the substance "Perga refined", the substance "Merva" and the fodder additive for fish food "Vinivet F" based on them. The results of the study are shown in Tables 1-3.

A comparative analysis of the chemical composition of bee products and biocomplexes on their basis showed that during the processing of bee perga and merva their original composition is completely preserved.

**Table 1.** The averaged amino acid composition of biologically active substances and fodder additive "Vinivet F".

Index	Substance "Perga refined"	Substance "Merva"	Fodder additive "Vinivet F"
		%	
Alanin	1,84	0,4	0,137
Arginine	0,89	9,3	3,078
Aspartic acid	2,10	16	5,326
Valine	1,10	1,2	0,213
Histidine	0,93	9,1	3,0
Glycine	0,84	18,4	6,073
Glutamine	-	1,4	0,461
Glutamic acid	2,24	5,4	1,80
Isoleucine	0,92	3,6	1,191
Leucine	1,50	2,3	0,80
Lysine	1,00	3,8	1,27
Methionine	0,62		
O-phospho-L-serine	Not detected	12	3,956
Tryptophan	2,11	2,28	2,01
Proline	2,05		
Serin	1,05	9,3	3,07
Tyrosine	0,65		
Threonine	0,97	1,3	0,429
Phenylalanine	0,88	1,2	0,41
Cysteine	2,44	-	0,0008

**Table 2.** The averaged vitamin composition of biologically active substances and fodder additive "Vinivet F".

Index	Substance "Perga refined"	Substance "Merva"	Fodder additive "Vinivet F"
		mg / kg	
A	0,7	Not detected	0,007
B <sub>1</sub>	8	1,5	1,57
B <sub>2</sub>	5,5	3,5	3,5
B <sub>3</sub>	36	Not detected	0,42
B <sub>5</sub> (PP)	51	Not detected	0,51
B <sub>6</sub>	21	Not detected	0,21
B <sub>12</sub>	2	Not detected	0,02
B <sub>c</sub>	1,2	0,8	0,08
C	1080	Not detected	11,2
D <sub>3</sub>	4	Not detected	0,09
E	12	8,7	8,64
H	0,8	Not detected	0,008
K <sub>3</sub>	39,4	7,1	19

**Table 3.** The average chemical composition of biologically active substances and fodder additive "Vinivet F".

Index	Substance "Perga refined"	Substance "Merva"	Fodder additive "Vinivet F"
		%	
Moisture	6,05	8,2	8,2
Crude protein	22,50	33,3	30,1
Raw fiber	2,62	6,1	5,0
M. F. of fat	1,04	2,1	1,9
	Carbohydrates, %		
Glucose	23,7	1,78	2
Fructose	10,52	3,64	3,71
Sucrose	-	-	-
	Macro and microelements, mg / kg		
Iron	47,59	102,83	102,3
Zinc	18,53	59,54	59,1
Manganese	19,84	31,77	31,6
Copper	0,083	0,243	0,241
Cobalt			1,2
Molybdenum			1,2
Phosphorus			4,7 g / kg
Potassium			0,7 g / kg
Calcium			3,2 g / kg

As shown in the composition of the feed additive "Vinivet F", all vitamins are present, both fat and water-soluble; macro- and microelements are widely represented; and the revealed composition of irreplaceable and substitutable amino acids in the supplement surpasses in its balance any artificially created product. The value of the fodder additive "Vinivet F" based on perga and merva is exceptionally high not only in composition, but also in the level of each essential nutritional factor.

Concentrations of micronutrients in the composition of the fodder additive being studied are insignificant, but quite sufficient for the normalization of metabolism and optimization of the physiological and biochemical status of the fish organism. Due to the natural balance of the composition, the risk of overdosing both individual components and the whole complex of nutrients as a whole is eliminated, but also there is an alignment of antagonistic relations between the individual elements. As a consequence, bioavailability and nutrient uptake in the body is increased, which is also an important factor in optimizing nutrition when feeding fish.

So, the feed additive for fish feeds based on secondary sources of raw beekeeping is characterized by a complex chemical composition and is a universal source of natural biologically active complexes. Practical absence of heavy metals, radionuclides, pesticides and other harmful substances does not pollute the aquaculture of water bodies. Moreover, the properties of the Vinivet fodder supplement, due to its unique composition, contribute to the accelerated elimination of toxic substances from the body of fish. In this regard, the quality of commercial fish is improving, what improves the health of people.

Thus, the combination of the use of waste water of energy facilities, ecological approaches and the introduction of innovative technologies in the production of aquaculture objects allows solving such key tasks of social development as ensuring food security and maintaining public health.

## Conclusions

Feed additives based on beekeeping products meet the criteria of ecological safety and improve the quantitative and qualitative characteristics of the composition of fish feeds for amino acids, microelements and vitamins in conditions of highly industrial fish farms at high planting densities and especially in warm water conditions of energy facilities that allow to grow aquaculture objects all year round.

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