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Aquaculture: problems and modern perspective on topical solution

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Abstract. In this article describes the current problems of aquaculture. As a new material for feeding fish pond serves biocomposite based on protein hydrolysates and natural polymers. Also disclosed is a method of forming the proposed mother. Studies have been conducted biocomposite molecular weight and amino acid composition of the initial protein products.

Key words: fish feed, biocomposition, protein hydrolysate, aquaculture.

INTRODUCTION

The usage of the North-West region for the cold-water fishing based on the natural lake of the Velino, Samolovskoy region of the Pskovsky district seem quite promising.

The Veline Lake as well as the following lake Dolgoe is located in the Zhelch river Valley are now considered as natural monument of the Pskovsky district. Lakes play an important part in supporting the fish stocks of the Chudskoye water body.

The area of the Velino lake is 1.6 km^2. Maximum depth is identified near the shoreline of the river Zhelch and reaches 16.7 m. In 50 meters away from the water edge continental slope from 4 to 6 meters. The average depth of the water body is 5.7 meters. Velino lake basin is 1,089 km 22 with water exchange from 25 to 26 times a year what causes a volatility of hydro chemical regime and 2–3 times changes of such indicators as pH, mineralization and containment of organic and bioorganic substances, during the year.

The feature of the hydrological regime is in high amounts of oxygen that doesn't fall below 8.6 mg l^{-1} even in the bottom waters of gulf. Salmonid fish farming in the fish tanks located on the Velino Lake is closely linked to the balanced feed production issues. Fish food for salmonids produce from more than 40 components, and consists mainly of protein, fat and carbohydrate fractions. Many manufacturers in accordance with Directive 2000/766/EU, banning the use of 'animal proteins' in the form mix of muscle-connective-bone tissue for animals destined for fattening food production, replacing animal protein in feed on vegetation, usually soybean meal. C.K. Fæste et al. (2015) have shown that since fishmeal produced from marine pelagic fish is an important feed component in the culture of Atlantic salmon and in the poultry industry, it should be considered as a source of potentially allergenic peptides in the final products.

However, in the case of feed based on soybean meal in farming fish - fodder factor has a low figure. Based on the analysis of energies in the structures of collagen on the scientific site of the ITMO University were developed technologies for processing of by-

products from meat-, poultry-, and fish production by chemical hydrolysis in the presence of catalysts of trace. 'Kuprina et al. (2013; 2015) have shown that nowadays little high-quality and feature-rich feedstuffs, which are so necessary today'.

Creation of new protein-containing products generated on the base of collagen containing muscle or their compositions with the necessary structural and mechanical, physic-chemical and technological properties, with a significant content of nanoparticles offers great prospects not only in food but also in feed production. The main technological process for trout farming is feedings in which regular quality control of feed mixtures will help gain the economic benefits for growing trout.

When formulating diets not only the quantitative composition of protein should be taken into account, because of its lack of retards the growth of the fish, and the surplus increases energy metabolism and leads to an inefficient waste of this valuable product, but also its qualitative composition. The ratio of amino acids in the diet that changes due to the stage of fish progress circle which will have high biological value in case if ideal protein is approximated. 'Henry et al. (2015) have shown that the decrease in the availability and the increase in the prices of fishmeal and fish oil have prompted the search for sustainable alternatives for aquaculture feeds'.

To compose feed salmonids used hydrolysates and protein ingredients, received them the following by-products processing industries: collagen tissue of beef, mix of muscle-connective-bone tissue of birds and fish, egg white (a by-product of the production of mayonnaise), egg shells and spongy mushrooms that are not used in the production of high quality of quick-frozen products. 'Eric Leclercq et al. (2015) have shown that the possibility of using collagen tissue of beef'.

Usually hydrolysates are used to create compositions of the salmonids feed and protein ingredients, received from the following by-products processing industries: collagen tissue of beef, mix of muscle-connective-bone tissue of birds and fish, egg white (a by-product of the production of mayonnaise), egg shells and spongy mushrooms that are not used in high quality of quick-frozen products. The holding of the hydrolysis of these products and the compilation of composition of them will make a start, production and feed for feeding early juveniles, and fish producers. Multifunctional fodder mixture includes not only necessary for salmon amino acids-arginine, lysine, phenylalanine (in case of absence of tyrosine), valine, Leucine, isoleucine, threonine, Histidine, methionine (in case of lack of cysteine), tryptophan, but minerals (calcium, phosphorus, sodium). Digestibility protein ingredients ranging from 92 to 98%. 'Mohamed S. Hassaan et al. 2015) have shown that Yeast fermentation increased the protein content by 13.65%, increased the total of hydrolyzed amino acids by 16.27% and decreased phytic acid and tripsin inhibitor'.

Feature of fish feed is high value proteins and fats, which account for 46 and 20%, respectively. Technology of obtaining protein ingredients allows you to get fat from mix of muscle-connective-bone tissue of trout, including Omega-3 fatty acids: linolenic acid, arachidonic acid and also eicosapentaenoic acid and Docosahexaenoic acid (DHA). Creating a feed for salmonids is considered one of the most complicated processes in the industrial relation throughout the livestock sector due to the high fat content. We have developed polymer biocomposites with different content of pectin's that that allows you to retain fat in finished food to Trout Pellet. Thus, protein-containing composites from new products and developed technology of encapsulation allowed to create a perspective on the composition and the form feed for growing salmonids.

Artificial cultivation of fish in terms of unique flow reservoir ice age Lake Velino appears to be rational in terms of geographical location, the hydrological regime and the characteristic of the coastal zone rich in water plants, working as a spawning substrate for spring-spawning fish phytophilous fish. It should also be noted the great importance of Lakes Velino and long in maintaining fish stocks of Chuskogo reservoir.

Due to the reduction of natural catch fish the development of aquaculture may be associated with modern solutions to the tasks in creating compositions of the starting feeds. One of the strategic action lines in the field of artificial fish breeding is to create new kinds of forages on the basis of protein containing components of by-products from organic raw materials.

Freshwater trout in cages in the conditions of Northwest of Russian Federation appears to be cost effective in the case of the introduction at enterprises of the region integrated processing of various types of by-products of animal and vegetable origin for the creation, including animal feed, high quality. Expansion of assortment policy in the segment of balanced composition of protein, fats, carbohydrates, vitamins, macro-and microelements feed at the moment is not possible without the development of resource-saving technologies.

Traditionally, the main raw material in the production of animal feed was the flour reached from animal products. However, modern requirements for the composition of the ingredients of all types of animal feed, including aquaculture production, involve the development of technologies for producing insoluble (protein products) or functional properties of hydrolysates defined by their molecular mass (MM) 'Kutsakova et al. (2009) have shown that hydrolyzate properties depend on catalyst concentration'.

Creating technology of hydrolysis collagen containing raw materials by chemical hydrolysis to obtain protein products with desired pre-defined properties is related to the need to reduce the activation energy of the process and an increase in the energy system.

These conditions can be fulfilled through the action of catalysts (often HCl, NaOH) and temperature growth. Given the strong covalent bond in primary and quaternary, and, consequently, weak hydrogen and ionic bonds in the secondary and tertiary structures of collagen, as well as certain combinations of modal parameters of the process, it is possible to obtain the hydrolyzed product with the desired molecular weight, which provides specific properties 'Kuprina et al. (2002; 2003), Nyanikova et al. (2002; 2003), have shown hydrolysis method of protein'.

MATERIALS AND METHODS

In process of creating of biopolymerical material were used various protein. materials such as mix of muscle-connective-bone tissue of trout, egg white, mushroom mixture, pork skin, collagen tissue of beef. 'Kuprina et al. (2002), Sáez et al. (2015), have shown that Encapsulation efficiency of protein in alginate or a combination of alginate and chitosan hydrogels was studied with the aim of ascertaining the adequacy of these carriers to deliver exogenous protein to fish orally'. When conducting the hydrolysis of the basic materials used were sodium hydroxide and hydrochloric acid. Research on distribution function of molecular mass protein products and hydrolyzed proteins derived from collagen tissue of beef of cattle hides at temperatures of 92–95 and 130 °C respectively, in the presence of chemical catalysts, concentration from 0.05 to 3% it have been conducted with method of gel chromatography. Columns filled with

gels sefadeks G–50 (mm = 1–30 kDa), G-75 (mm = 3–70 kDa) and G–200 (mm = 5–800 kDa). 0.15 M. NaCl solution was used as the eluent, elution speed was 20 ml h^{-1} detection conducted by the Spectrophotometric method with 230 nm wavelength. To determine MM took 5 mg of the substance in 1 ml of 0.15 m NaCl solution. All chemicals were analytical grade.

Dynamic viscosity is defined with Ostwald viscometer while the modulus of elasticity- is defined with consistometr.

During the process of organization of the feed production and transportation of the protein products for the implement over long distances, it is advisable to conduct their drying. Drying is conducted in the laboratory of the ITMO University in semi-industrial unit with back-to-back twirled air flow and the temperature of drying agent at the inlet to the unit equal 140 °C while the temperature of leaving the unit is 90 °C. Industrial production of the drying unit carries out the company Poly NOM. Study of dry protein products were held jointly with Leningrad interregional veterinary laboratory.

Amino acid composition of modified protein products were determined by the method of ion exchange chromatography on the automatic amino acid Analyzer (Japan). The research results are presented in the Table 1.

Polymer biocomposites consisting of insoluble protein (46%) and the fat fraction (20%), and granulation molding method for making synthesized material specified dimensions used acrylic leaf shape with a specified thickness and diameters of the holes corresponding to the desirable size of the pellets. A mixture of bio-polymers such as gelatin and pectin is used as a binder. 'De Cruz et al. (2015) have shown that significant effects on the physical properties of the extruded pellets during the increase of die temperature and also change of starch source from taro to broken rice'. Polymerization of finished material was carried out from the aquatic environment granulation molding method methodology includes the following phases: preparation of primary nutrient material cooking the binder, mixing aqueous biopolymer composites and binder, molding pellets, polymerization received composition and its drying. Formation of liquid feed pellets is the final step in creating a feed of polymeric bio compositions. Preparation of the primary nutrient material was deleting the water parts of polymeric biocomposites at temperatures temperature 60 °C for 180 minutes. Preparation of binder is based on getting the dry mixes biopolymers with content (50–60–70–80–90–100) % pectin, which were flooded with water when liquid ratio equal to 3, and maintained for the swelling within 120 minutes.

Mixing prepared biopolymer composites and binder were conducted dosed at constant hashing with at least 700 rpm and temperature 60 °C before reception of homogeneous weight. Molding pellets from mixed solution biocompositions conducted in previously chilled to a temperature of 4 °C cleaning method sheets (you can use as a method of granulating extrusion mechanism). Polymerization of granules were done in oven with forced convection at a temperature of 40 °C, after which they removed from the forming of sheets and dried at a temperature of 60 °C to specified moisture content.

Table 1. Amino acid composition of modified products of animal and vegetable origin

Name of amino acids	The content of amino acid in 100 g protein, %						
	recommended for starting trout feed	mix of muscle-connective-bone tissue of trout	egg protein	fungi Boletus edulis+ Leccinum scabrum= 1 : 1	mix of muscle-connective-bone tissue of bird	pork skin	collagen tissue of beef
valine	9.4	9.5	7.4	7.55	3.89	1.83	2.36
isoleucine	7.4	7.8	6.3	11.83	3.42	0.97	2.01
lecithine	15.8	14.9	9.2		6.60	2.30	3.99
lysine	14.7	15.8	6.8	7.43	6.35	2.60	3.52
methionin*	4.9	5.5	4.1	2.79	2.23	0.61	0.80
threonin	8.9	9.1	4.8		5.28	1.25	2.06
tryptophan	1.6	1.6	1.7	1.12			0.50
phenylalanine**	8.9	8.1	6.7	4.67	4.48	1.54	1.75
arginine	11.5	12.2	6.2	10.22	18.24	5.67	4.19
histidine	7.5	5.9	2.5	4.82	10.28	0.76	0.81
glutamic acid		31	15.1	12.12	15.58	6.42	8.09
proline			4.0		21.26	8.49	9.89
tyrosine	6.8	6.5		3.00	1.77	0.83	0.98
cysteine			2.8	1.42		0.43	0.82
cystine	2.8	3.1			0.33		
alanine		14	6.9	8.39	16.58	5.37	10.35
aspartic acid		20	10.1	10.37	9.95	3.93	5.62
asparagine					2.18		
glycine		9.5	3.9	5.33		14.06	31.87
serin			7.6	4.35		2.28	3.44
oxyproline						7.24	1.93
ornithine				1.20			0.59

* in the absence of cysteine
** in the absence of tyrosine

RESULTS AND DISCUSSION

NaCl solution was used as the eluent, elution speed was 20 ml h^{-1} detection conducted by the Spectrophotometric method with 230 nm wavelength. To determine MM took 5 mg of the substance in 1 ml of 0.15 m NaCl solution. Chromatograms, reflecting the values of the distribution functions of molecular masses collagen containing insoluble hydrolysates obtained in the presence of a chemical catalyst concentration of 0.05, 0.3 and 3% are presented in Figs 1, 2 and 3.

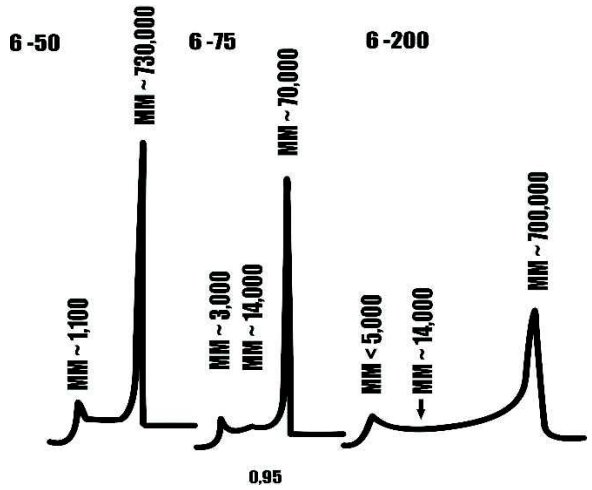

Figure 1. Chromatogram of distribution function of molecular masses of collagen hydrolysate obtained in the presence of a catalyst, a concentration of 0.05%.

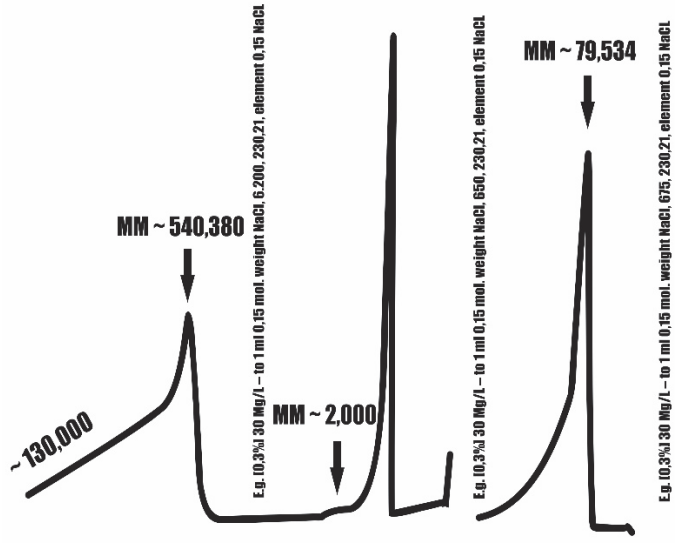

Figure 2. Chromatogram of distribution function of molecular masses of collagen hydrolysate obtained in the presence of a catalyst, a concentration of 0.3%.

From the analysis of the distribution functions of molecular masses and structurally-mechanical properties of protein products for border concentration we can match the following: The mean values of the molecular masses of protein products obtained in the presence of catalyst concentration from 0.05 to 0.3%, are identical (Fig. 1) and were 700 kDa.

The obtained substances have high values of viscosity (of 3086.9 to 10^{-6} • 56281 Pa •) and strength (modulus of elasticity of the gel at a temperature of t = 4 °C is E = 29.54-51.06 kPa). The results of processing the chromatograms, presented in Fig. 2 showed that 40% of the substance has the molecular mass of 540, and 60%–130 kDa. The average value of such a product will be protein MM 300 kDa.

Functional and technological properties of the protein product hydrolyzed in the presence of 0.3% chemical catalyst protein product are completely different. Viscosity was 1109.2 • 10^{-6} Pa • and protein product had the consistency of weak jelly, which elasticity is impossible to determine.

The average value of the molecular masses of protein product obtained when processing catalyst 3% concentration (Fig. 3) stood at 6.7 kDa. Protein collagen containing product is a combination of amino acids, with a maximum content of glycine. Using similar modal parameters modificates and hydrolysates of the by-products of meat, poultry and fish processing equipment-pork skins, mix of muscle-connective-bone tissue of birds and fish, egg whites, as well as raw materials of mushroom were obtained. 'Pat. 2303881 (2006) showed the use of this method'. In order to obtain the protein product from muscle tissue meat and bone remnants of raw, processing raw materials carried out in the presence of catalyst concentration 0.4%. 'Kutsakova et al. (2013) have shown that way catalyst concentration was chosen'.

Functional and technological properties of powders has high water-binding capability (1:18 the best for mince systems), solubility of not less than 95% and digestibility 96.9% minimum (pork skin).

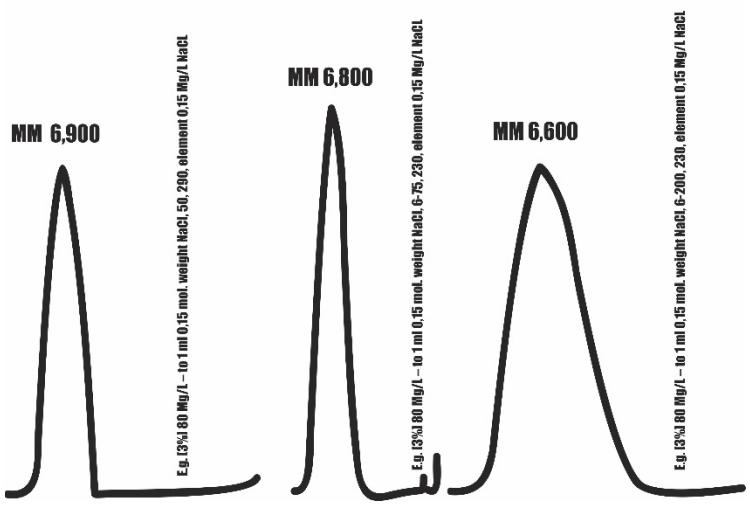

Figure 3. Distribution function of molecular masses of collagen hydrolysate obtained in the presence of a catalyst, with a concentration of 3%.

As it is clear from the presented data, amino acid composition of new modified products allows you to create a wide range of balanced feed for the desired protein composition variation.

In fish cultivation wet forage is also used. For small farmers that organize production for their own needs, the use of drying is quite expensive. Studies have shown that cold storage jelly modificates at a temperature 4 °C enables you to use the product within 14 days of elaborate, without altering the physico-chemical and microbiological indicators.

The Starter feed feature is regulation not only protein content (46%) but also fat (up to 20%). Developed technologies include the generation and collection of fat by-products that allows almost completely compensate for feeding component through the processing of by-products from meat bone residue and pig skins.

When creating a moist feed from the proposed modified protein the development of additional products such as glue from cover or bone tissues is not required. Since the rheological characteristics of protein products are high, their introduction to recipes as moisture binding component will have a positive impact and on the structure of the feed.

Introduction to compounding forage mushroom modification draws an attention, from the point of view that the presence of chitin-glucan complex in the cell wall of fungi can be regarded as a substitute for expensive chitin component of crustaceans, used to improve the process during the period osmosis regulation smoltification of salmon and enhance the sustainability of the fish to skin diseases and stressful situations. Toxicological characteristics of fungal product conducted with express-method using infusoria Tetrahymena pyriformis.

The conducted contents of toxic elements and residual pesticides are (mg kg^{-1}): lead (15.8), cadmium (2.15), copper (90.0), zinc (335.0), mercury (0.15), arsenic (less than 0.2), aldrin (not detected), heptachlor (not detected), hexachlorocyclohexane (total isomers of less than 0.001), DDT and its metabolites (less than 0.002).

CONCLUSIONS

Thus, expanding the range of supply trout fish species can be achieved by solving the problem of aquaculture, including in the field of creation of forages during artificial cultivation.

Thus, expanding the range of trout fish nutrition can be achieved through the introduction of advanced new solutions to the problem of aquaculture in creating quality forages during artificial rearing of fish. 'Mukhina & Pestrikova (2012), James et al. (2013) have shown prospects of Aquaculture development'. Organization and implementation of resource-saving technologies of the by-products of animal and vegetable origin can produce with minimal competitive feed polymer bio composition.

The usage of 'animal proteins' is limited by the rules of the European Union which leads to the development of a new protein containing products used in the fattening of livestock. One of the directions for obtaining such products may be a hydrolysis of the collagen containing by-product in the presence of chemical catalysts micro concentration. Through this process it is possible to gain trace ingredients with specified composition and properties.

Analysis of the binding energy in collagen structures revealed that the hydrolysis process required energy can be transferred to the system either by increasing the kinetic

energy associated with an increase in temperature or by lowering the activation energy by the action of catalysts. Depending on the required properties of the obtained ingredients defined by molecular weight (from 6.7 to 700 kDa) modal parameters of hydrolysis are specified. Analysis of the collagen hydrolysis mechanism allows predicting the process parameters of hydrolysis and concentration of catalyst, providing the relevant mechanical and technological properties of functional protein ingredients.

Amino acid composition of all the studied protein ingredients recommended for compiling starting feed salmonids recipes, allows noticing the high quality of the designed product.

Addition of non-toxic chitin glucan complexes made of the plant component to the feed formula will not only advantageously replace the expensive equivalent, derived from crustaceans but can be used to regulate critical physiological and biochemical processes of restructuring the body of salmonids, preceding and accompanying migration from the freshwater reservoirs.

The recommended granulation method for molding forage caps with bio-composite material composed of protein and fat ingredient faction, allowed to keep such a complex system with a combination of acrylic sheet forms and bounded gelatin-pectin mixtures.

These drying modes in aggregates with back-to-back twirled the air flows also allows to receive powdered protein ingredients with preservation of functionally-technological properties in organizing large productions.

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