

Biotechnological Communication

Efficiency of Using Hydrobiont Meal With Different Preparation Technologies in Feeding Rainbow Trout

Dmitry Sergeevich Vasiliev^{1*}, Sergey Petrovich Moskalenko¹, Irina Vasilievna Poddubnaya¹, Alexey Alekseevich Vasiliev¹, Yulia Anatolyevna Guseva¹, Olga Evgenievna Vilutis¹, Rashidya Nazirovna Murtazaeva², and Tatiana Viktorova Daeva²

¹Saratov State Agrarian University N.I. Vavilov, Saratov, Russian Federation

²Volgograd State Agrarian University, Volgograd, Russian Federation

ABSTRACT

The composition of the compound feed for rainbow trout included high-protein feed made from products of processing substandard crayfish in the form of flour. The research was carried out in a closed supply installation. In the course of the experiments, the chemical composition and energy nutritional value of flour from crustaceans of aquatic organisms of various cooking technologies, the chemical composition of muscle tissue, and amino acid score were studied. Studies of the growth and development rates of rainbow trout based on the results of control catches were carried out weekly. At least 10 specimens were weighed on electronic scales. During the experiment, rainbow trout were fed four times a day with pelleted compound feed with a pellet diameter of 6 mm. The composition of the diets differed in several ways. The main component was fish meal and flour made from freshly dried crayfish, and in group 2 from freshly boiled and then dried crayfish. In the experimental groups, the amount of flour studied was 20%. All the changes made in the composition of the feed did not have a significant effect on the energy and protein nutritional value of the feed and the content of fat and phosphorus in them. It was found that the use of crayfish flour in the composition of compound feed for rainbow trout has a positive effect on the increase in live weight of fish, reduces feed costs, does not change the biochemical composition of blood, changes the chemical composition of muscle tissue, and improves the amino acid rate. Due to the relatively low cost compared to fish meal, the use of crayfish meal reduces the cost of compound feed and increases the economic effect of growing rainbow trout.

KEY WORDS: AVERAGE DAILY GAIN, BLOOD, CLOSED WATER SUPPLY INSTALLATION, COMPOUND FEED, CRUSTACEANS.

INTRODUCTION

Currently, fishing in the seas and oceans is the main source of fish products for the population. In some countries, the volume of farmed fish approaches the volume caught from natural reservoirs, and sometimes even exceeds it (Shcherbina & Gamygin 2006; Brug & Ridler 2004). Among the various forms of fish farming, the industrial form has the greatest potential for a rapid increase in production volumes. The success of this form of fish farming largely depends on the balance and quality of the compound feed. Therefore, in recent years in the world, the production of compound feed for fish has been actively developing and there is a constant search for new sources of raw materials (Voronova, 1989,

Perednya, 2002, Guseva et al. 2018a, b; Moskalenko et al, 2020; Poddubnaya2020b).

At present, during the processing of crustaceans to obtain gourmet products, up to 80% of non-food waste is formed, which can be divided into three fractions: chitin-containing, protein-containing, and lipid waste (Trukhin 1992, Shiryaev, 1997). The chitin-containing fraction (mainly represented by shells) serves as a raw material for the production of chitin and chitosan, which have adhesive properties in the composition of compound feed for various types of aquatic organisms (Gamygin & Sazonova 1999; Bakhareva et al., 2019, Moskalenko et al, 2020). Besides, other valuable products can be obtained from crustacean waste, such as crayfish meal, crayfish oil, natural pigments, and others (Trukhin 1992, Shiryaev, 1997). Compared to fish meal, crayfish meal contains slightly less protein, but more calcium and phosphorus. Crayfish can be grown under industrial

Article Information:*Corresponding Author: alekseyvasiliev@yandex.ru

Received 10/07/2021 Accepted after revision 26/09/2021

Published: 30th September 2021 Pp- 1148-1153

This is an open access article under Creative Commons License,

Published by Society for Science & Nature, Bhopal India.

Available at: <https://bbrc.in/>

Article DOI: <http://dx.doi.org/10.21786/bbrc/14.3.37>

conditions in artificial reservoirs (Gamygin & Sazonova 1999; Kiyashko et al. 2016a). The organization of full-fledged feeding of rainbow trout using new traditional feed was also studied by many workers, (Guseva et al., 2018a and Guseva et al. 2018b. Moskalenko et al, 2020).

MATERIAL AND METHODS

In 2017-2021 study was carried out to the effectiveness of using high-protein feeds from crustacean processing products in a closed-loop supply unit when feeding rainbow trout. In this experiment, according to the principle of analogs, 150 rainbow trouts with an average weight of 1240-1276 g were selected and placed by 50 in three polypropylene pools with a volume of 5 m³ each. The duration of the experiment was 120 days. The control group received a complete sinking granulated compound feed (OR). Trout from the 1st and 2nd experimental groups received compound feed with crayfish meal from fresh dried crayfish and crayfish meal from boiled dried crayfish (Table 1).

Table 1. The experiment designs

Group	Number of fish	Feeding type
Control	50	OR
1 st experimental	50	OR with crayfish meal from fresh dried crayfish
2 nd experimental	50	OR with crayfish meal from boiled dried crayfish

Table 2. Chemical composition and nutritional value of crayfish meal from crustacean aquatic organisms prepared using different technologies

Indicator	Fresh dried crayfish meal	Boiled crayfish meal
Moisture content, %	9.50	9.70
Dry matter, %	90.50	90.30
Raw protein, %	42.28	42.83
Raw fat, %	2.49	2.20
Raw ash, %	28.10	27.67
Carbohydrates, %	5.00	5.82
Chitin, %	12.63	11.78
Energy, kcal	222.00	225.00
Calcium, %	19.47	19.67
Phosphorus, %	0.71	0.75

A weekly study of the growth and development rates of rainbow trout was carried out based on the results of control catches. At least 10 specimens were weighed on an electronic balance. During the experiment, rainbow trout were fed 4 times a day, with an interval of 4 hours at 7.00, 11.00, 15.00 and 19.00. In feeding, we used granulated compound feed with a pellet diameter of 6 mm, which

corresponds to the weight of the fish. The feed composition and nutritional value corresponded to the period of fish breeding.

RESULTS AND DISCUSSION

The efficiency of fish rearing is determined by the physicochemical properties of water since the course of all vital functions in them depends on the state of the aquatic environment. During the study, the average value of the water temperature was 13.8 °C, and the water exchange in one pool was 12850 l/h. Indicators of dissolved oxygen values, hydrogen index (pH), also corresponded to the requirements. Only with the use of high-quality feed with sufficient concentration of energy and nutrients can fish grow fast. Table 2 provides data on the chemical composition and energy nutritional value of crayfish meal from crustacean aquatic organisms prepared using different technologies.

Table 3. Composition and nutritional value of compound feed

Indicators	1st (control)	Group 2nd experimental	3rd experimental
Wheat flour, %	7	-	
Sunflower cake, %	22.5	20.0	20.0
Yeast, %	6.4	5.0	5.0
Fish meal, %	51.5	42.0	42.0
Vegetable fat, %	5	6.0	6.0
Fish oil, %	4.6	4.0	4.0
Molasses, %	1.0	1.0	1.0
Premix, %	1.0	1.0	1.0
Peltech, %	1.0	1.0	1.0
Raw crayfish meal, %	-	20	-
Boiled crayfish meal, %	-	-	20
Total, %	100	100	100
Energy, kcal	331.0	329.9	328.5
Protein, g	46.0	45.9	46.0
Fat, g	16.0	15.8	15.8
Fiber, g	3.2	2.8	2.8
Calcium, g	2.4	5.9	5.9
Phosphorus, g	1.7	1.5	1.5
Carbohydrates, g	16.6	11.3	11.3
Ash, g	10.1	13.9	13.6
Price	75	66	67

The crayfish meal was made from substandard crayfish. To included crayfish meal in the compound feed, two compound feed formulations were developed, to which crayfish meal was added. In the 1st experimental group, the crayfish meal was made from freshly dried crayfish, and in the 2nd group from freshly boiled and then dried crayfish. The composition and nutritional value of compound feeds are presented in Table 3.

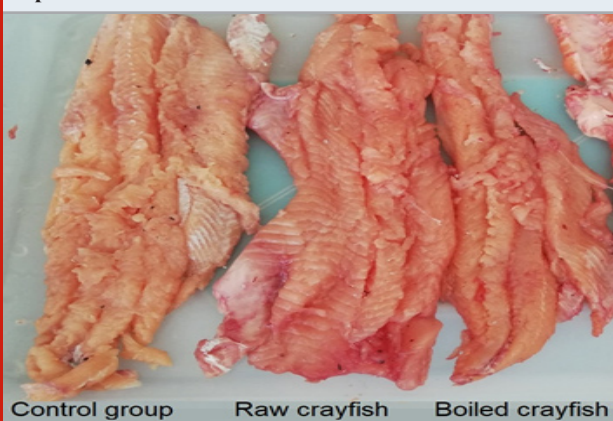
The composition of the diets differs in several ways. The main component is fish meal and crayfish meal made from freshly dried crayfish, and in group 2 from freshly boiled and then dried crayfish. In the experimental groups, the amount of fish or crayfish meal studied was 20%. All the changes made in the composition of the compound feed did not have a significant effect on the energy and protein nutritional value of the compound feed or the content of fat and phosphorus in them. The largest changes were observed

in the level of calcium and carbohydrates. At the same time, the technology itself practically did not affect the chemical composition and nutritional value of the compound feed used. Crayfish meal is much cheaper than fish meal, which is reflected in the cost of compound feed. Evaluation of the effectiveness of the use of crayfish meal in the composition of compound feed was carried out based on the rate of ichthyomass gain, as an indicator of paramount importance for the development of fish (Table 4).

Table 4. Growth rates of hydrobionts

Indicator	Group		
	1st (control)	2nd experimental	3rd experimental
Livestock heads	50	50	50
Total weight of fish at the beginning of the experiment, kg	62.4	62.05	61.3
Average live weight of 1 fish, g	1,248±14.2	12,41±6.3	1,226±11.0
Total weight of fish at the end of the experiment, kg	95.3	98.6	97.55
Average live weight of 1 fish, g	1,906±12.8	1,972±29.0*	1,951±24.4
Weight gain per 1 fish, kg	0.658	0.731	0.725
Average daily gain per 1 fish, g	5.48	6.09	6.04

Figure 1: Muscle tissue of a trout participating in the experiment



The results of the conducted studies show that the total and average live weight of 1 head at the beginning of the experiment in all experimental groups did not differ significantly ($P > 0.05$). At the end of the study, the fish stock of the second group had a larger ichthyomass and an average live weight of 1 head, 98.6 kg, and 1972 g respectively, versus 95.3 kg and 1906 g in the control group, and 97.55 and 1951 g in the third group. In terms of the average daily gain, the fish of the first group were ahead of their counterparts from the control group by 0.61 g, and from the third group by 0.05 g. The use of raw materials with different technologies for the preparation of crayfish meal did not affect the safety of the fish. The morphological and biochemical composition of blood quickly reacts to the level and quality of nutrients and other substances coming from outside. Therefore, monitoring changes in its indicators can quickly establish irregularities in the organization of fish feeding or the presence of various diseases.

Table 5. Chemical composition of the muscle tissue of rainbow trout, %

\Indicator	Group		
	control	1st experimental	2nd experimental
Initial moisture	72.22 ± 0.45	73.45 ± 0.37	70.53 ± 0.83
Dry matter	26.69 ± 0.43	25.47 ± 0.35	28.22 ± 0.86
Protein	19.87 ± 1.44	20.81 ± 1.62	22.00 ± 0.62
Fat	5.35 ± 0.40	8.05 ± 2.25	5.01 ± 0.56
Calcium	0.06 ± 0.01	0.07 ± 0.02	0.05 ± 0.02
Phosphorus	0.15 ± 0.01	0.14 ± 0.02	0.17 ± 0.01*

* $P \geq 0.95$.

When considering the biochemical parameters of the blood of rainbow trout, during the period of the study, we did not find significant and reliable changes in the studied blood parameters. All of them were within the physiological norms. This confirms the absence of a negative effect of crayfish meal on the work and functions of the internal organs of fish and the absence of pathological processes in the body. To determine the effect of feed additives on the formation of various organs and structures of rainbow trout, a control slaughter was carried out. The fish were dissected, and the head, skin, muscle tissue (Fig. 1), and internal organs were separated.

Edible parts include the muscles, the liver, the caviar, the milt. Inedible parts: the skin, the heart, the scales, the gills, the alimentary tract, the kidneys, the air bladder. Conditionally edible parts are the parts that become edible

after heat treatment. These include the head, the bones, the fins, and the cartilage. They are used for cooking fish soup and aspic. Under the influence of raw crayfish meal in the compound feed, the weight of all edible and conditionally edible parts of trout reached higher values than in the specimens with the diet that included boiled crayfish or the control feed. The weight of the head and fins, the weight of the skin, the weight of bones and muscle tissue in the fish in the experimental group significantly exceeded those parameters in the fish in the control group. It was found that in fish fed with raw crayfish meal, the output of edible parts was almost 2% higher than in the control group, and the output of inedible parts in the experimental group was less than in the control by 4%. The trout from the second experimental group had a 1.62% more output of edible parts than in the control group, and less edible parts by 4.14% than in the control group.

The composition of compound feeds influenced the concentration of amino acids, except for glycine and arginine, the content of which in the muscles of fish of all experimental groups was practically at the same level. In fish with the diet that included raw crayfish meal, the concentration of almost all amino acids had increased in comparison with the control group and the second variant of the experiment. At the same time, the data on the increase in ichthyomass indicate that the addition of boiled crayfish meal to the compound feed gives less effect than raw crayfish meal. Probably, this can be explained by the fact that the process of intermediate protein metabolism was disturbed in the trout in the second experimental group. The transamination reaction, as the main source of the formation of new amino acids, is crucial to the intermediate

metabolism of proteins. A disturbance in transamination can result from a deficiency of vitamin B6 in the body, as this vitamin is destroyed during heat treatment.

Determination of the amino acid score allows identifying the limiting amino acid and taking appropriate measures to eliminate its deficiency. It was found that in the muscular tissue of trout with the diet where crayfish meal from raw crayfish had been added, only 2 amino acids, lysine, and isoleucine, were limited, and in the group where crayfish meal from boiled crayfish had been added, the amino acid score corresponded to a complete protein only in terms of serine, histidine, and arginine. Thus, we can conclude that raw crayfish meal provides the compound feed used in rainbow trout feeding with almost all the essential amino acids. At the end of the experiment, we performed a chemical analysis of the muscle tissue of the rainbow trout of the studied groups. The analysis results are presented in Table 5.

Analyzing the data in Table 2, it can be noted that in terms of the protein content in muscle tissue in individuals of the 2nd experimental group, this indicator was higher than in other groups and amounted to 22.0%. The fat content in the 1st experimental group exceeded the values of the control group by 2.7%, and the values in the 2nd experimental group were lower by 0.34% than in the control group. Regarding the content of inorganic substances, such as calcium, no significant differences were found between the groups. The amount of phosphorus was significantly higher in the 2nd experimental group and amounted to 0.17%. Economic efficiency is the main criterion for introducing raw materials into production (Table 6).

Table 6. Economic efficiency

Indicator	1st (control)	Group	
		2nd experimental	3rd experimental
The cost of 1 kg of compound feed, rub.	75	66	67
The amount of compound feed used, kg	39.69	39.478	39.37
Feed costs, rub.	2,976.60	2,605.55	2,637.79
Gross weight gain, kg	32.9	36.55	36.25
Feed costs per 1 kg of weight gain, rub.	90.47	71.29	72.77
Feed costs per 1 kg of weight gain, kg	1.21	1.08	1.09
Feed costs in the cost structure, %	40	40	40
Total cost per 1 kg of weight gain, rub.	226.19	178.22	181.92
The wholesale sale price of 1 kg of fish, rub.	350	350	350
The economic effect, rub.	123.81	171.78	168.08

The cost of compound feed in all groups had certain differences. The difference between the cost of compound feed in the control group and compound feed in the experimental groups is especially noticeable. Due to the higher cost of fish meal, the total cost of compound feed in the first group was 75 rubles/kg, and in the second group, it was 9 rubles less. Due to the cost of cooking crayfish, the price of compound feed in the third experimental group had increased by 1 ruble, compared with the second group, but

was still 8 rubles lower than in the control group. During the experiment, all three groups were fed a relatively equal amount of compound feed. Due to the price difference, the total cost of feed during this period was not the same. The difference between the control and experimental groups was 371.05 and 338.81 rubles, respectively. This made it possible to reduce feed costs by 1 kg of live weight gain in the first group by 19.18 rubles, and in the second group by 17.19 rubles.

Considering the existing structure of the cost of weight gain, the largest costs were recorded in group 1. To get 1 kg of weight gain, 226.19 rubles had to be spent. The lowest indicator was obtained in the second experimental group, where it was 178.22 rubles, or 47.97 rubles less than in the control group and 44.27 rubles less than in the 3rd group. The calculation of the economic effect from the use of crayfish meal in compound feed for rainbow trout shows that in the control group it was 123.81 rubles, in the second experimental group it was 171.78 rubles, and in the third experimental group it was 168.08 rubles. The group of economic indicators also includes the cost of feed to obtain 1 kg of live weight gain. Due to the higher rate of weight gain, this indicator in the control group was 1.21 kg, while in the second group it was 1.08 kg, and in the third one 1.09 kg.

Studies have been carried out by several scientists on the use of crab processing products in the diets of sturgeon fish (Bakhareva et al., 2019). It has been proved that the inclusion of 10% crab meal as a substitute for fish meal in the composition of starter and production feed for sturgeon fish allows increasing the weight gain of reared fish by 56% and survival rate up to 81% while reducing feed costs. The presence of shell-forming substances in the flour – chitin and chitosan, as well as the carotenoid – astaxanthin – promotes the synthesis of glycosaminoglycans and helps restore bone and cartilage tissue (Bakhareva et al., 2019; Moskalenko et al, 2020; Poddubnaya et al., 2020a).

The scientist Front (2002) assess the effectiveness of the use of chitosan in fish feed, a natural biopolymer obtained from the chitin of shells by means of a deacetylation reaction. It has been found that chitosan and its preparations, presented in dry form, exhibit high adhesive properties when added to granulated feed for salmon, sturgeon, and cyprinids. The use of freshwater crustacean meal in our studies, as a high-protein component, including chitin, chitosan, and the carotenoid pigment astaxanthin, in the feeding of rainbow trout is another step in finding an alternative to expensive fish meal. It is a cheaper feed component but no less nutritious in fish diets (Trukhin, 1992; Shiryaev, 1997; Shcherbina, & Gamygin, 2006; Moskalenko et al, 2020).

CONCLUSION

Thus, it follows from the results of the studies that the introduction of high-protein feed made from crustacean processing products in the form of crayfish meal into the composition of the rainbow trout compound feed has a positive effect on the increase in the live weight of fish, reduces feed costs, does not change the biochemical composition of blood, changes the chemical composition of muscle tissue, and improves the amino acid score in the 1st experimental group. Due to the relatively low cost compared to fish meal, the use of crayfish meal reduces the cost of compound feed and increases the economic effect of rainbow trout rearing.

Conflict of Interest: Authors declares no conflicts of interests to disclose.

Ethical Clearance Statement: The Current Research Work Was Ethically Approved by the Institutional Review Board (IRB) of University N.I. Vavilov, Saratov, Russian Federation Russia.

REFERENCES

- Bakhareva, A.A. & Grozesku, Yu.N., Sergeeva, A. N. Nevalenny, N. A. (2019). Franov Complex supplement based on crustacean flour in compound feed for sturgeon fish. *Bulletin of the Astrakhan State Technical University. Series: Fisheries.* No. 3. 66–73.
- Brug, C. & Ridler, N. (2004). Global aquaculture outlook in the next decades: analysis of national aquaculture production forecasts to 2030. In: *FAO Fisheries Circular*, No. 1001. FAO, Rome, Italy. 47 p.
- Gamygin, E.A. & Sazonova, T.I. (1999). Experience in the production of compound feed with chitosan at the Dnepropetrovsk plant of fish granulated feed. In: *Materials of the 5th All-Russian conference: New perspectives in the study of chitin and chitosan.* VNIRO, Moscow, Russia. pp. 61-63.
- Guseva, Y.A.; Vasiliev, A.A.; Bannikova, A.V.; Kitaev, I.A.; Kokorev, V.A.; Baimishev, K.B. & Zaitsev, V.V. (2018a). The relationship between introducing pancreatic hydrolysate of soy protein into the diet and the amino acid content in the muscle tissue of rainbow trout. *Journal of Pharmaceutical Sciences and Research* 10(12): 3330-3332.
- Guseva, Y.A.; Vasiliev, A.A.; Poddubnaya, I.V.; Zabelina, M.V.; Fedorov, I.P.; Dikusarov, V.G. & Randelin, D.A. (2018b). Growth rate and commercial qualities of the muscle tissue of rainbow trout with hydrolysate of soya protein used for feeding. *Journal of Pharmaceutical Sciences and Research* 10(8): 1956-1958.
- Kiyashko, V.V.; Gurkina, O.A. & Vasilev, A.A. (2016a). Growing crayfish in an artificial reservoir. *Agrarnyi nauchnyi zhurnal* 2: 10-12.
- Kiyashko, V.V.; Gurkina, O.A.; Vasilev, A.A. & Dolgoplova, M.N. (2016b). Testing the cultivation of crayfish in industrial conditions. *Vestnik Michurinskogo gosudarstvennogo agrarnogo universiteta* 1: 47-50.
- Moskalenko SP, Vasiliev DS, Poddubnaya IV, Vilutis OE, (2020). Feasibility of using crustacean processing products in the composition of feed for rainbow trout. *Agrarian scientific journal.* No. 2. 55-60
- Perednya, A.A. (2002). Use of chitosan in fish feed. *Korma i kormlenie v akvakulture* 4: 3-10.
- Poddubnaya IV, O.E. Vilutis, D.S. Vasiliev, (2020a). Assessment of the physiological state of rainbow trout with the introduction of flour from raw crayfish into the diet. Status and development of aquaculture in the Russian Federation. *Materials of the V national scientific and practical conference.* Saratov Amirit , 192-197

Poddubnaya IV, Vasiliev DS, Kozhevnikova LV, Kabakova OI, (2020b). Efficiency of growing marketable rainbow trout on compound feed with crayfish processing products. Modern ways to improve the productive qualities of farm animals, birds and fish, Materials of the International Scientific and Practical Conference. Saratov: Publishing house Saratov GAU..190-195.

Shcherbina, M.A. & Gamygin, E.A. (2006). Fish feeding in freshwater aquaculture. Izdatelstvo VNIPRO, Moscow, Russia. 360 p.

Shiryayev, E.D. (1997). Waste-free technology in the fishery

of Far Eastern crabs (Experience of Fishing collective farm Vostok-1 CJSC for the production of chitosan). Rybnoe khozyaistvo 6: 58-59.

Trukhin, N.V. (1992). Manufacture of technical products from waste obtained from the processing of commercial crustaceans. Obrabotka ryby i moreproduktov. Sovershenstvovanie tekhnologii obrabotki rakoobraznykh 3(2): 25-37.

Voronova, Yu.G. (1989). The use of invertebrates for food and forage purposes. Obrabotka ryby i moreproduktov 2(1): 3-20.