Efficiency of using vegetable proteins in trout feed

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Abstract. The article presents the results of quantitative indicators of the growth of rainbow trout when growing feed with a partial replacement of animal proteins with plant proteins. The results obtained show that the growth rate of fish and the feed coefficient when replacing protein by 10% with plant proteins do not change, provided that the animal, as well as the macro- and microelement balance of feed, are observed.

1. Introduction
Modern commercial fish farming, both in Russia and abroad, uses the use of artificial fish feed, the use of which allows to obtain a high-quality food product on time.

High fish-biological indicators in commercial fish farming are ensured through the use of artificial feeds balanced across the entire range of nutrients, taking into account a specific type of fish [1]. In addition, feed is the main cost item, and therefore, improving its properties has an economic effect on the fishing industry. So, for example, the cost of feed in the cost of marketable trout reared in the cage conditions of the Republic of Karelia is on average 50% of all costs [2]. In this regard, the selection of a suitable feed that satisfies fish producers in terms of price and quality, and the selection of the correct feed are becoming one of the main strategies in fish farming.

According to the Federal Agency for Fisheries in Russia, no more than 100 thousand tons of fish feed is produced for aquaculture, while the current needs of the industry exceed 250 thousand tons. The deficit of Russian feed is covered by imports [3]. In the Republic of Karelia, 90% (25 thousand tons per year) of trout feed is also purchased from foreign producers [4].

A limiting factor in the development of domestic production of feed for salmonids is the shortage and high cost of one of their main feed components used as a source of animal proteins - fish meal. Therefore, one of the possible ways to solve this problem is the partial replacement of animal proteins with plant proteins. Currently this issue is insufficiently studied and in some cases – controversial [5–7].

The aim of this study is to evaluate the effectiveness of trout rearing on a diet with an increased content of plant proteins.

Research objectives:
1. Justification of the composition of the feed used, balanced in terms of macro- and micronutrients.
2. Establishment of quantitative patterns of growth of trout when grown on a diet enriched with plant proteins.
2. Materials and methods
The studies were carried out in the spring of 2019 at the Research Center for Aquaculture of Petrozavodsk State University. The object of the study was juvenile rainbow trout (Parasalmo mykiss Val.) With an average initial weight of 231 ± 5 g. The experimental and control groups were seated in two aquarium installations with a volume of 180 liters each with a closed water supply cycle.

Trout was kept at a temperature (13.2 ± 0.5°C), concentration of dissolved O2 (8.8 ± 0.4 mg/l), pH (7.3 ± 0.5), NH3 total (0.010 ± 0.007 mg/l) and natural light. The duration of feeding was 14 days.

The diet of the control and experimental groups of trout was made on the basis of the "Massa +" feed of the "Karelsky Rybnye Zavody" LLC. The feed used was analyzed in terms of macro- and micronutrient composition, as well as compliance with the main microbiological and toxicological indicators. Also, during the experiment, the growth rate of fish and feed coefficients were estimated.

The experiments carried out were consistent with international ethical standards and requirements set forth in the Order of the USSR Ministry of Health dated 08.12.1977 No. 755 "On measures to further improve organizational forms of work using experimental animals" and other regulatory documents (conclusion of the Ethical Committee in the field of animal research in Petrozavodsk State University No. 274 of May 7, 2020).

3. The discussion of the results
The production and use of domestic feed is a priority task of import substitution, both in the Republic of Karelia and in Russia as a whole. The used feed fully complies with microbiological indicators (total bacterial contamination, salmonella, E. coli), indicators for the content of toxic elements (Hg, Cd, Pb, As), mycotoxins (aflatoxin B1, T-2 toxin) and pesticides.

One of the most important nutritional characteristics is the balance of the feed in terms of macro- and microelement composition. Macro- and microelements in the body of fish, to the same extent, as in the organisms of warm-blooded animals, perform many biological functions, without which the process of functioning of the body becomes impossible [8].

It is known that the main sources of macro- and microelements for fish are food and aquatic ecosystems. For reservoirs with low mineralization, the amount of essential elements coming from the aquatic environment is very limited, therefore, the main macro- and microelements are obtained from the fish feed [9]. Of particular relevance is the balance of fish feed in terms of macro- and microelement composition in conditions of industrial cultivation, where water undergoes thorough purification and additional filtration.

Macro- and microelement composition of the feed is presented in Table 1.

| №  | Biogenic element | Content, (mg / kg) |
|----|------------------|--------------------|
| 1  | Calcium          | 22200              |
| 2  | Phosphorus       | 15400              |
| 3  | Magnesium        | 1900               |
| 4  | Sodium           | 4000               |
| 5  | Iron             | 485                |
| 6  | Zinc             | 148                |
| 7  | Copper           | 24.8               |
| 8  | Manganese        | 34.2               |
| 9  | Iodine           | 0.5                |
| 10 | Selenium        | 0.21 mg / kg       |

Some of the essential macronutrients are calcium and phosphorus. These elements perform many biological functions, including participation in the formation of bone tissue. It is known that the
mineral base of bone tissue is mainly represented by calcium phosphate. For its formation, a balanced combination of phosphorus and calcium is required [10]. Calculated data show that the mass fractions of calcium and phosphorus in calcium phosphate are about 40% and 20%, respectively. Therefore, the ratio of elements calcium: phosphorus 2:1, apparently, is optimal; approximately the same ratio is observed in the used feed.

It is noteworthy that in addition to the macronutrients magnesium and sodium, the composition of the used feed also includes a set of essential trace elements - zinc, copper, manganese, as well as iodine and selenium.

The presence of iodine is all the more necessary, since the overwhelming majority of fresh waters contain a very small concentration of this bioelement, which excludes its entry into the fish organism from the aquatic environment. At the same time, iodine is a necessary bioelement for fish, since, as in the body of warm-blooded animals, takes part in the synthesis of thyroid hormones. Three hormones are currently isolated from the thyroid formations of fish: diiodothyronine (T2), triiodothyronine (T3) and tetraiodothyronine (T4) [11, 12].

It is noteworthy that the main hormone found in the blood of fish is tetraiodothyronine. Note that the same hormones are produced by the human thyroid gland, however, the T3-thyroxine hormone, which plays the main physiological role, is most active in the human blood. The synthesis of thyroxine (T3) is carried out from T4. This process is selenium-dependent and the lack of this trace element aggravates the imbalance of human thyroid hormones.

Taking into account the fact that the main physiological role in the fish organism is played by the T4 hormone, the role of selenium in this metabolism in fish is apparently not relevant. However, it should be borne in mind that selenium is the most important bioelement necessary for the normal functioning of the fish organism. The requirement for this element in fish ranges from 0.15 to 0.5 mg per 1 kg of feed. The optimal amount of selenium in the diet of salmonids does not exceed 0.38 mg/kg of feed. In freshwater fish, the highest concentration of selenium is found in the liver, as well as in the gill lobe and gonads. Selenium is part of glutathione peroxidase and thus exhibits a protective function of the body against free radical oxidation of lipids.

Taking into account the presence of easily oxidizing lipids in the body of fish, the normal functioning of the antioxidant system is especially important. At the same time, it is necessary to take into account the interaction of selenium with such a natural antioxidant as vitamin E. Selenium is necessary for the intake of this vitamin into the body and its retention in the blood plasma.

Thus, the use of domestic feed is justified not only economically, but also from the point of view of physiological processes in the fish organism.

Taking into account the higher cost of fodder with animal proteins, it is advisable to partially replace them with vegetable proteins. At the same time, even with a minimal difference in the price of these components, a significant economic effect is achieved due to large volumes of fish farming. For this reason, it is of scientific interest to study the quantitative patterns of trout growth when using feed enriched with vegetable protein.

To establish quantitative patterns of trout growth, we analyzed the data obtained in control and experiment. Under control conditions, the fish were fed using a standard feed for salmon species, which was analyzed above. Under the experimental conditions, about 10% of proteins of animal origin were replaced by plant proteins. At the same time, the nutritional value of the feed in the control and experiment remained the same. This was achieved by selecting a different ratio of feed components. The balance of amino acids in the control and experiment was also kept the same. In the experiment, the amino acid balance was adjusted with components of plant origin. The content of the main nutritional elements of the feed in the control and experiment is shown in Table 2.
### Table 2. The main nutrients of the feed for control and experiment.

| №   | Indicator                      | Content                |
|-----|-------------------------------|------------------------|
| 1   | Crude protein                 | Not less than 45%      |
| 2   | Crude fat                     | No more than 20%       |
| 3   | Raw fiber                     | No more than 2%        |
| 4   | Ash                           | Not more than 6.5%     |
| 5   | Carbohydrates (BEV)           | 15–18 %                |
| 6   | Phosphorus                    | 0.9 %                  |
| 7   | Metabolic energy of feed, MJ  | 19.7                   |

The results are presented as kinetic curves in mass-time coordinates (Figure 1).

![Trout Kinetic Growth Curve: A – control; B – experiment](image)

**Figure 1.** Trout Kinetic Growth Curve: A – control; B – experiment.

The presented dependences were processed taking into account various functions, including polynomial, logarithmic, exponential and power, but the most expedient was the analysis of the linear dependence. This is due to the fact that this dependence is characterized by correlation coefficients comparable with some other; moreover, it is the most simple to process. The tangents of the angles of inclination of straight lines in the coordinates mass - time characterize the growth rate in units of g / day, while the growth rates in the control variant and in the experiment are practically the same and amount to 4.8 and 4.4 g / day, respectively.

In addition to the growth rate, we estimated the feed coefficients, which in the control and experiment are practically the same and amount to 1.02.

### 4. Conclusion

The obtained quantitative characteristics show that partial replacement of proteins of animal origin with vegetable proteins is acceptable, provided that the amino acid balance is observed and the feed is corrected for macro and microelement composition. The positive effect is confirmed by the results of feed experiments carried out in production conditions on a cage farm, which makes it possible to create alternative feeds containing plant proteins.

Taking into account the analysis of the effectiveness of the use of plant proteins in trout feed, the result obtained is a research base for further study of the effect of partial or complete replacement of fish meal with plant proteins in the diets of rainbow trout.

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