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USE OF NON-TRADITIONAL RAW MATERIALS IN THE PRODUCTION OF FISH FEED

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Abstract: In this scientific work, the scientific and practical foundations of using non-traditional raw materials as an alternative to fish meal in the composition of compound feeds intended for various age groups of cyprinid fish are systematically investigated for the first time. Research results showed that the presence of protein hydrolysis products with a medium degree of hydrolysis in the diet of cyprinid larvae significantly increases the activity of digestive enzymes that break down protein and carbohydrate components of the feed. This allows for the effective use of new compound feed without adding live food. On this basis, optimal inclusion rates of corn gluten, pumpkin flour, and hydrolyzed fish protein in compound feeds for the initial and production periods were determined, and new formulations were developed. Furthermore, based on the use of new dry compound feed formulations including non-traditional raw materials and biologically active additives, an intensive technology for rearing fingerlings and marketable fish has been developed. This technology makes it possible to increase the efficiency of fish farming and reduce the cost of feed.

Keywords: new fish product waste, water temperature, hydrolysate, formulations, innovative approaches, compound feeds.

Introduction. Aquatic biological resources are one of the main food sources for humans. In recent years, as a result of rising demand, natural resource stocks have significantly decreased, making artificial fish rearing a strategically important direction for the agro-industrial complex of Uzbekistan. Currently, many companies offer various compound feeds for fish. However, due to small production volumes, limited assortment, and raw material quality, fish farms often rely on imported products. Consequently, there is a need to develop new feed formulations based on non-traditional types of raw materials and biologically active preparations, taking into account scientific and practical aspects to increase fish feeding efficiency. This approach serves to reduce feed costs and improve nutritional value [1].

The problem of providing raw materials for compound feed production has remained relevant in our country for many years. This situation is primarily related to the high cost of fish meal and, subsequently, its shortage. Additionally, the low quality of some traditional feed components has stimulated scientific research aimed at finding alternative raw material sources and enriching feed with biologically active additives. Most previous research in this direction maintains its scientific and practical significance

today. At the same time, due to the rapid development of feed raw material processing technologies, the range of components that can be used in fish feed is constantly expanding. While the replacement of fish meal with cheaper components was previously mainly due to economic factors, its shortage and deteriorating quality indicators have become priority aspects of the problem at the current stage. Therefore, there is a need for a scientifically grounded integrated approach in developing fish feed formulations, considering the updated raw material base of feed production [2].

Currently, the cultivation of herbivorous fish in the fish farms of the Syrdarya region is mainly conducted extensively, relying on the natural food base of pond farms. Such an approach can lead to the depletion of natural food resources and a decrease in fish rearing efficiency. Therefore, supplemental feeding of herbivorous fish with cheap granulated feed is considered an important condition for transitioning fish farming to intensive cultivation technologies. [3].

Analysis of literary sources shows that carbohydrates have limited value in fish nutrition, and their role in the diet directly depends on the fish species, age period, and water temperature. For most fish species, proteins and lipids are the main energy and structural (plastic) substances, mobilized during metabolism as an energy source, including through gluconeogenesis. Compared to terrestrial animals, the degree of digestion and assimilation of plant-based components in fish is lower due to the characteristics of their enzymatic systems. However, modern technologies based on deep and targeted processing of grain raw materials create the possibility of effectively using plant-based components in fish feed. The main advantage of these components is the ability to replace a certain portion of expensive fish meal with economically acceptable alternative raw materials while maintaining the balance of basic nutrients. [4].

Methods. In substantiating the relevance of this topic, some scientific studies proposed the implementation of underwater lighting systems to utilize the phototaxis property of hydrobionts. This approach allows for reduced feed consumption by increasing the concentration of natural food objects in ponds and open waters, improving fish product quality, and reducing the feed conversion ratio. Additionally, the possibility of partial or complete replacement of fish meal with a hydrolysate obtained from the processing of new fish product waste has been scientifically substantiated. The high content of free and short-chain amino acids in the hydrolysate ensures high absorption by the body. This demonstrates the importance of this product in fish feeding, especially under the implementation of innovative technologies aimed at improving feed quality and biological safety.[5].

The aim of the work is to increase the efficiency of cyprinid fish cultivation through the use of biologically active preparations and the partial replacement of fish meal with non-traditional feed raw materials in the fish diet.

Various age groups and main species of cyprinid fish were chosen as the research object. Experiments on fish rearing using new types of feed raw materials and biologically active preparations were conducted in the laboratory conditions of Gulistan State University, as well as at industrial fish farming enterprises in Yangiyer, Syrdarya

region, during 2024–2025. The experimental design was developed based on an analysis of available literature on the problem. During the study, samples for biochemical, hematological, and histological indicators were collected and analyzed. All studies were performed based on generally accepted classical methods, and the results obtained were subjected to statistical processing.

Results and discussion. Corn is one of the main grain components widely used in compound feeds for farm animals. Although it has a high starch content, it is characterized by low protein levels and a deficiency of important essential amino acids such as lysine and tryptophan. The water solubility of corn proteins is less than 17%, which limits their biological value and digestibility. Due to the low digestibility of protein fractions, the use of corn in fish feed is somewhat limited. At the same time, due to its technological properties, corn is used as an important structural component in the production of extruded floating and slow-sinking feeds. Feeds with high corn content have low storage stability, and molding processes accelerate under high humidity.

The extrusion process, by ensuring starch gelatinization and structural changes in proteins under high temperature and pressure, significantly increases the nutritional and energy value of corn for fish. Specifically, through the breakdown of proteins and carbohydrates and the effective assimilation of the energy they contain, overall digestibility indicators improve in cyprinid fish. Furthermore, the extrusion process contributes to the inactivation of mycotoxins formed by microorganisms and increases the sanitary-hygienic safety of the feed. A byproduct of corn processing—corn gluten meal—is considered a promising source of plant-based proteins. However, studies conducted under mono-diet conditions based on gluten in cyprinid fish showed very low protein digestibility. At the same time, it was established that carbohydrate digestibility in gluten is higher compared to proteins.

According to the concept of adaptive-corrective activity of the fish digestive tract, increased excretion of endogenous substances into the intestinal lumen indicates biological imbalance in the diet. This situation is explained by the insufficiency and imbalance of lipid and mineral components in gluten. Consequently, metabolic losses increase during digestion, while biological efficiency and protein digestibility decrease. Thus, the low digestibility of gluten proteins is mainly related to the imbalance of its chemical composition.

Research was conducted in laboratory and production conditions. In laboratory conditions, fish larvae were kept in plastic trays (0.5 × 0.5 m) with a recirculating aquaculture system (RAS); in production conditions, they were reared in industrial fish ponds. For older age groups, square ponds (2 × 2 m) with circular water flow and cages (5 × 5 m) were used. Dissolved oxygen levels were maintained at an optimal level of about 6 mg/l throughout the experiment. Under flow-through water supply conditions, water consumption was determined by the biomass of the fish and varied between 0.6–3 l/hour for larvae. For older age groups in ponds, a full water exchange was carried out every 30–40 minutes. Main hydrochemical indicators (temperature, oxygen, pH, nitrogen compounds) were monitored daily using multi-parameter analyzers.

In laboratory conditions, feeding was done manually; in production conditions, automatic feeders were used. Pellet size was chosen according to the live weight and age group. Standard compound feed formulations KP-2 (starter) and KP-7 (production) for cyprinid fish were used as base feeds. These included traditional products like fish meal, soybean meal, wheat flour, skimmed milk powder, feed yeast, vitazar, fish oil, and premixes. It was established that their chemical composition meets the physiological needs of cyprinid fish.

Table 1. Main nutrient content in base compound feed formulations for cyprinid fish

Indicator	Compound feed recipe	
	KP-2	KP-7
Protein, %	50,0 - 52,0	45,0 - 50,0
Fat, %	8,0 – 12,0	11,0- 12,0
Carbohydrates, %	14,0 - 18,0	26,0 – 28,0
Total energy, thousand mJ/kg	18,0-19,0	17,5 – 18,0

To determine optimal inclusion norms, various doses of non-traditional raw materials and additives were added during the mixing stage.

Table 2. Inclusion norms of non-traditional raw materials and biologically active substances

Component	Dose per 1 kg of feed (variants, g)	
	Initial	Productive
Fish protein	25,50,75,100	-
Corn gluten	50,75,100	50,100, 150, 250
Pumpkin flour	0,5, 1,0, 1,5, 2,0	4,0, 6,0, 8,0,10,0
Lactobacterin	-	0,2, 0,4, 0,6, 0,8,10

Experiments involved two biological replicates, with data processed statistically using Student's t-test ($P \leq 0.05; 0.01; 0.001$). To determine the optimal inclusion of protein hydrolysate in starter feed, amounts (2.5%, 5.0%, 7.5%, and 10% dry matter) replaced corresponding fish meal. Inclusion over 10% was deemed economically impractical. No statistically significant differences in basic nutritional indicators were found between groups ($P > 0.05$). However, the 10% hydrolysate variant showed slightly higher fat content than recommended, limiting higher doses. Fatty acid analysis of starter feed with hydrolysate showed a predominance of polyunsaturated fatty acids. A 10% inclusion led to a statistically significant increase in this indicator ($P \leq 0.05$). Balancing $\omega-6$ and $\omega-3$ fatty acids is vital; $\omega-3$ is high in hydrobionts, while $\omega-6$ is high in plant components. Excessive $\omega-6$ can impair growth and lipid metabolism. Optimal ratios were achieved with 10% inclusion.

Conclusion. Currently, due to the high cost of fish meal produced abroad, the reduction in supply volumes, and the instability of its quality indicators, the search for cheap and effective alternative feed raw materials suitable for use in compound feeds for cyprinid fish has become an urgent task. Proteins in the natural food of cyprinids are represented mainly by fractions with a relatively low molecular weight, which ensures their high digestibility and efficient assimilation. Therefore, the use of protein products as close as possible in composition and fractional structure to natural food is a scientifically and practically promising direction. Within the framework of the study, the presence of a small amount of free amino acids, oligopeptides, and polypeptides, as well as low-molecular-weight soluble and high-molecular-weight protein fractions, was established in the studied protein component, which justifies the possibility of its use in compound feed.

Partial replacement of the traditional protein source - fish meal - with a new protein component (protein hydrolysate) did not have a negative impact on the overall nutritional properties of the compound feed. The new protein component possesses high attractive properties and increased the feeding activity of larvae, which facilitated their adaptation process under intensive rearing conditions. Inclusion of the new component in the feed in an amount of 10% led to a reduction in feed consumption by approximately 20% and an increase in the activity of digestive enzymes. Free amino acids and oligopeptides contained in the hydrolysate in small quantities are rapidly absorbed through the intestinal wall without the action of proteases during the first days of exogenous feeding of cyprinid larvae, providing intensification of growth and development processes. These results confirm the biological and economic efficiency of using the new protein component in the starter feed.

Research results showed that young fish raised on compound feed with the addition of fish protein hydrolysate (dispersed protein) undergo the process of adaptation to production compound feed faster and more stably. Compared to the mortality observed at the stage of transitioning from "live food" under traditional technology, these negative phenomena are significantly reduced when using feed containing hydrolysate. The chemical composition of the body and blood of larvae raised on hydrolysate-based compound feed is close to physiological norm indicators, which confirms the stability of their metabolism and general functional state. The results of the economic evaluation showed the feasibility of using dry compound feed containing dispersed protein: the conditional income increased by approximately 2% due to the reduction in the need for "live food". Overall, it has been established that the use of fish protein hydrolysate in starter feed is a biologically, technologically, and economically effective solution.

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