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The combined impact of high-protein diets and probiotics on meat quality in Indian and exotic carp

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Abstract
This study evaluates the synergistic effects of high-protein diets and probiotic supplementation on the meat composition of Indian major carps and exotic carps, contributing to sustainable aquaculture practices. The experiment, conducted over a year in three earthen ponds in Uttar Pradesh, India, involved three treatments: a control (Pond T_0), 30% protein supplementary feed (Pond T_1), and 30% protein supplementary feed with probiotics (Pond T_2). Parameters such as moisture, crude protein, fat, carbohydrates, and ash content were analyzed across six carp species. The results demonstrated significant improvements in meat quality for Pond T_2, with increased protein (up to 20.69%), fat (up to 2.91%), and carbohydrate contents (up to 1.83%), coupled with reduced moisture levels compared to the control. Probiotic supplementation enhanced nutrient retention, growth performance, and feed digestibility, attributed to improved digestive enzyme activity and immune response. These findings highlight the potential of combining high-protein diets with probiotics to optimize feed formulations, reduce environmental stress, and improve fish health and meat quality in aquaculture. The approach supports the transition towards innovative and efficient practices in India's rapidly growing inland fisheries sector.

Keywords: Aquaculture, probiotics, high-protein diets, meat composition, carps, sustainable fisheries

Introduction

Fisheries and aquaculture play a critical role in ensuring food security and strengthening India's economy. As one of the fastest-growing sectors, aquaculture has witnessed a transformative shift, particularly in inland fisheries, which now contribute nearly 70% to total fish production, up from 36% in the mid-1980s. This growth is largely driven by the transition from capture-based to culture-based fisheries, highlighting the sector's potential for innovation, sustainability, and efficient resource use in fostering a robust blue economy.

The probiotics in aquaculture, one must be concerned with their indirect effects on ecosystem cycles and food chains. Although the use of antibiotics and chemotherapy remains the method of choice as disease control strategy, the abuse of chemotherapeutics, especially antibiotics has resulted in development of multiple antibiotic resistant bacteria.

In aquaculture, probiotics have been used to control diseases, enhance specific and non-specific immunity, provide nutrients and enzymatic functions and improve water quality (Balcazar *et al.*, 2006) [9]. The immune system of aquatic organisms, such as fish, is continuously affected by periodic or unexpected changes of their environment. Adverse environmental situations may acutely or chronically stress the health of fish, altering some of their biochemical parameters and suppressing their innate and adaptive immune responses. The probiotics achieved improvement in water quality (Bioremediation). Concerning the immune stimulation point of view, many researches showed improvement in the immune response of fishes treated with probiotics (Krishna *et al.*, 2009) [10]. The use of probiotics or beneficial bacteria controls pathogens through a variety of mechanisms. The addition of probiotics will improve the diet and protein digestibility, which may in turn explain the better performance in aquatic species. The beneficial effects of probiotics in fish diets on feed nutrients digestion were reported attributable to the digestive enzyme activity of bacteria.

This study focuses on evaluating the synergistic effects of high-protein diets combined with probiotic supplementation on the meat composition of Indian major carps and exotic carps.

By examining key parameters such as moisture, crude protein, fat, carbohydrates, and ash content, this research aims to provide insights into optimizing feed formulations for sustainable and efficient aquaculture practices.

Materials and Methods

The experiment was carried out in three different earthen ponds of area 3 acar (50 m• 20 m) and depth of 2 m at Bareilly (Uttar Pradesh). The co-ordinates of the experimental location are 28° 22' 32.4984" N and 79° 26' 9.4524" E. The experiment was conducted for a period of 365 days from April to March in year 2020 and 2021. The pond has taken on lease by the individual.

Stocking density and feeding technique

Each pond was stocked with 27000 fingerlings of Indian Major Carp and Exotic carp (Average weight 50+5 gm and average length 13+2 cm) at the rate of 9000 fingerlings per hectare. At the time of stocking, morpho metric characteristics, such as body weight and total length were measured and recorded. All diets were fed to fingerlings in three different ponds everyday once in the morning between 7 a.m. to 8 a.m. at 5% of body weight the feeding is generally supplementary in nature. Feeding rates per pond were adjusted monthly after weighing minimum 20% of the fishes stocked.

Ingredients	Pond 1 T0	Pond2T1 (30% supplementary feed)	Pond3T2 (30% Supplementary Feed + Probiotics)
Organic manure	Cow dung (10,000 kg/ ha/crop)	Cowdung (6,000 kg/ha/crop)	Cowdung (5,000 kg/ha/crop)
Inorganic fertilizer	Diammonium Phosphate (500 kg/ ha/crop)	Diammonium Phosphate	Diammonium Phosphate -
Supplementary Feed (30% CP) (MOC, soya bean, fish meal, rice bran, wheat bran, corn, millets, him –c, live 52)	Less the 20% CP	Traditional Supplementary feed and Him –c, live 52	Traditional Supplementary feed and Him –c, live 52
Probiotics (Pond Shield, Pro boost – ws) + Supplementary Feed	-	-	Probiotics (Pond Shield, Pro boost – ws)
Grass, (berseem, maize, napier seasonal grass) For grasscarp	Grass, (Maize, seasonal grass) For grasscarp	Grass (berseem, maize, napier seasonal grass),	Grass (Berseem, maize, napier seasonal grass),

Pond 1 (T0 - Control Treatment)

This pond received no supplementary feed or probiotics. Organic manure was applied at 10,000 kg/ha/crop using cow dung, and 500 kg/ha/crop of inorganic fertilizer, specifically Diammonium Phosphate, was used. The supplementary feed provided had less than 20% crude protein (CP), and. Grass such as, maize, and seasonal grass was used for feeding grass carp.

Pond 2 (T1 - 30% Supplementary Feed Treatment)

This pond received 30% protein supplementary feed, with cow dung applied at a lower rate of 6,000 kg/ha/crop. The same inorganic fertilizer (Diammonium Phosphate) was used as in Pond 1. The feed contained a mix of ingredients including mustard oil cake (MOC), soybean, fish meal, rice bran, wheat bran, corn, millets, along with health supplements like Him-C and Liv-52. Grass such as berseem, maize, and napier was also provided for the grass carp. No probiotics were introduced in this pond.

Pond 3 (T2 - 30% Supplementary Feed + Probiotics Treatment)

Pond 3 received both 30% protein supplementary feed and probiotics. The organic manure rate was further reduced to 5,000 kg/ha/crop, and no inorganic fertilizer (Diammonium Phosphate) was applied. The feed was the same as Pond 2, containing a blend of MOC, soybean, fish meal, rice bran, wheat bran, corn, millets and health supplements such as Him-C and Liv-52. Additionally, probiotics like PondShield and Pro Boost-WS were used to improve the overall health and water quality of the pond. Grass such as berseem, maize, and napier was provided for the grass carp, similar to the other ponds.

Results

Meat composition

Moisture

The moisture content in Rohu was recorded as 76.45%, 72.23%, and 71.11% in pond 1, pond 2, and pond 3, respectively, with the minimum and maximum values being 71.11% in pond 3 and 76.45% in pond 1.For Catla, the moisture content was 75.67% in pond 1, 72.64% in pond 2, and 71.67% in pond 3. The minimum moisture content of Catla was 71.67% in pond 3, while the maximum was 75.67% in pond 1.Mrigal had moisture content values of 76.89% in pond 1 and 72.08% in pond 3. The maximum and minimum values recorded were 76.89% in pond 1 and 72.08% in pond 3.Grass carp showed moisture contents of 77.11%, 74.08%, and 72.11% in pond 1, pond 2, and pond 3, respectively. The maximum value was 77.11% in pond 1, while the minimum was 72.11% in pond 3.Common carp had moisture percentages of 76.23% in pond 1, 73.68% in pond 2, and 72.45% in pond 3, with the minimum and maximum values being 72.45% in pond 3 and 76.23% in pond 1.Silver carp recorded moisture contents of 77.56% in pond 1, 73.77% in pond 2, and 72.65% in pond 3. The highest value was 77.56% in pond 1, while the lowest was 72.65% in pond 3.The highest moisture content for all species was generally recorded in pond 1, while pond 3 had the lowest values across the stocked species.

Crude protein

For Rohu, the protein content was recorded as 19.09%, 19.75%, and 20.69% in pond 1, pond 2, and pond 3, respectively. The minimum and maximum values were 19.09% in pond 1 and 20.69% in pond 3.In Catla, the protein content was 18.11% in pond 1, 19.45% in pond 2, and 19.54% in pond 3. The minimum value was recorded as 18.11% in pond 1, while the maximum was 19.54% in pond 3. Mrigal had protein contents of 18.35%, 18.94%, and 19.23% in pond 1, pond 2, and pond 3, respectively. The minimum and maximum values were 18.35% in pond 1 and 19.23% in pond 3.For Grass carp, the protein content was 18.02% in pond 1, 18.92% in pond 2, and 19.12% in pond 3, with the minimum and maximum values being 18.02% in pond 1 and 19.12% in pond 3.Common carp recorded protein contents of 17.87%, 18.12%, and 18.72% in pond 1, pond 2, and pond 3, respectively. The minimum value was 17.87% in pond 1, while the maximum was 18.72% in pond 3.Silver carp showed protein contents of 17.25% in pond 1, 19.75% in pond 2, and 19.02% in pond 3, with the minimum and maximum values being 17.25% in pond 1 and 19.75% in pond 2.Overall, the protein content generally increased from pond 1 to pond 3 for all species, with the highest values typically recorded in pond 3. There was a significant (p<0.05) difference in the percentage protein of six carps in experimental ponds

Total fat

The total fat content percentages of different stocked species across three ponds were observed For Rohu, the fat content was recorded as 2.11%, 2.07%, and 2.91% in pond 1, pond 2, and pond 3, respectively. The minimum and maximum values were 2.07% in pond 2 and 2.91% in pond 3.In Catla, the fat content was 2.05% in pond 1, 2.12% in pond 2, and 2.84% in pond 3. The minimum and maximum values recorded were 2.05% in pond 1 and 2.84% in pond 3.Mrigal showed fat contents of 1.62%, 2.55%, and 2.65% in pond 1, pond 2, and pond 3, respectively. The minimum and maximum values were 1.62% in pond 1 and 2.65% in pond 3.For Grass carp, the fat content was 1.75% in pond 1, 2.18% in pond 2, and 2.25% in pond 3. The minimum value was 1.75% in pond 1, while the maximum was 2.25% in pond 3.Common carp recorded fat contents of 2.22%, 2.14%, and 2.34% in pond 1, pond 2, and pond 3, respectively. The minimum was 2.14% in pond 2, and the maximum was 2.34% in pond 3.Silver carp showed fat contents of 1.99% in pond 1, 2.67% in pond 2, and 2.64% in pond 3. The minimum and maximum values were 1.99% in pond 1 and 2.67% in pond 2.Overall, the highest fat contents were generally observed in pond 3, with the lowest values often recorded in pond 1 across the different species. There was a significant (p<0.05) difference in the percentage fat contents of six carps in experimental ponds.

Carbohydrates

The carbohydrate content percentages of different stocked species across three ponds were observed For Rohu, the carbohydrate content was 1.37%, 1.69%, and 1.72% in pond 1, pond 2, and pond 3, respectively. The minimum and maximum values were 1.37% in pond 1 and 1.72% in pond 3.In Catla, the carbohydrate content was 1.29% in pond 1, 1.59% in pond 2, and 1.61% in pond 3. The minimum and maximum values recorded were 1.29% in pond 1 and 1.61% in pond 3.Mrigal had carbohydrate contents of 1.27%, 1.49%, and 1.34% in pond 1, pond 2, and pond 3, respectively. The minimum and maximum values were 1.27% in pond 1 and 1.49% in pond 2.For Grass carp, the carbohydrate content was 1.05% in pond 1, 1.38% in pond 2, and 1.83% in pond 3. The minimum and maximum values were 1.05% in pond 1 and 1.83% in pond 3, showing a significant increase in pond 3.Common carp recorded carbohydrate contents of 1.16%, 1.48%, and 1.56% in pond 1, pond 2, and pond 3, respectively. The minimum value was 1.16% in pond 1, and the maximum was 1.56% in pond 3.Silver carp showed carbohydrate contents of 1.17% in pond 1, 1.57% in pond 2, and 1.68% in pond 3. The minimum and maximum values were 1.17% in pond 1 and 1.68% in pond 3.Overall, the carbohydrate content generally increased from pond 1 to pond 3 for most species. A significant increase was observed particularly for Grass carp, where the carbohydrate content rose markedly from 1.05% in pond 1 to 1.83% in pond 3. There was a significant (p<0.05) difference in the percentage fat contents of six carps in experimental ponds.

Total ash

The total ash content percentages of different stocked species across three ponds were observed for Rohu, the ash content was recorded as 2.02%, 2.69%, and 2.52% in pond 1, pond 2, and pond 3, respectively. The minimum and maximum values were 2.02% in pond 1 and 2.69% in pond 2.In Catla, the ash content was 2.19% in pond 1, 2.59% in pond 2, and 2.61% in pond 3. The minimum and maximum values recorded were 2.19% in pond 1 and 2.61% in pond 3.Mrigal showed ash contents of 2.17%, 2.49%, and 2.34% in pond 1, pond 2, and pond 3, respectively. The minimum and maximum values were 2.17% in pond 1 and 2.49% in pond 2.For Grass carp, the ash content was 2.05% in pond 1, 2.38% in pond 2, and 2.83% in pond 3. The minimum value was 2.05% in pond 1, while the maximum was 2.83% in pond 3, showing a significant increase in pond 3.Common carp recorded ash contents of 2.16%, 2.48%, and 2.26% in pond 1, pond 2, and pond 3, respectively. The minimum was 2.16% in pond 1, and the maximum was 2.48% in pond 2.Silver carp showed ash contents of 2.17% in pond 1, 2.57% in pond 2, and 2.28% in pond 3. The minimum and maximum values were 2.17% in pond 1 and 2.57% in pond 2.Overall, ash content varied across ponds for all species, with pond 2 generally showing higher values. A significant increase was observed in Grass carp, where the ash content rose to a maximum of 2.83% in pond 3. There was a significant (p<0.05) difference in the percentage fat contents of six carps in experimental ponds.

Conclusion

Enhancing the diet with food additives such as the probiotic and the Synergistic Effects of High-Protein Diets led to an increase in the retention and utilization of nutrients. This indicates an improvement in the nutritional value of the dirts through the availability of nutrients, the most important of which are the important amino acids in growth and tissue building. Increase was observed in fish growth, an improvement in the nutritional value of the ration, and the retention of nutrients, proteins and fats. The use of the probiotic and the Synergistic Effects of High-Protein Diets added to the fish ration led to stimulating and improving growth by improving the nutritional value of the ration, increasing digestive enzymes and depositing nutrients in the body of fish.

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