



ROLE OF BANANA PEEL POWDER (*MUSA PARADISICA*) IN GROWTH, BLOOD PROFILE, AND ANTIOXIDANT STATUS OF (*OREOCHROMIS NILOTICUS*) NILE TILAPIA

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ABSTRACT

Background: Aquaculture is a leading food-producing sector, banana peel is an agricultural waste, but it contains useful nutrients and natural antioxidants. Using banana peel powder in fish feed may improve growth, blood health, and resistance to stress.

Objective: This study examined the effect of banana peel powder (BPP) supplementation on the growth, hematology, and antioxidant capacity of *Oreochromis niloticus*.

Methodology: Sixty fingerlings were divided into four different treatments and supplemented with varying levels of banana peel powder and commercial diet. T₀ fed with the 20g/kg of basal diet, [T₁] 5g/kg of BPP, [T₂] 10g/kg of BPP and [T₃] were treated with 15g/kg of BPP as compared to other treatments for 28 days. One way of analysis of variance (ANOVA) was used to analyze data.

Results: The highest mean values of weight gain, feed intake ratio, and specific growth rate were recorded in T₃ (34.50 ± 6.45), (19.375 ± 0.548), and (4.750 ± 0.500), respectively ($P < 0.05$). The feed conversion ratio (FCR) was highest in T₀ (2.673 ± 0.3432) and lowest in T₃. Hematological indices were also greatest in T₃: RBCs (3.2050 ± 0.01500), WBCs (2.243 ± 0.0252), Hb (14.00 ± 0.1000), MCHC (43.000 ± 1.000), and HCT (39.000 ± 1.000). Antioxidant enzymes showed maximum activity in T₃, with catalase (125.50 ± 2.50) and sodium peroxidase (166.000 ± 1.000).

Conclusion: These findings suggest that inclusion of 15 g/kg banana peel powder improves growth, feed utilization, hematological parameters, and antioxidant activity in Nile tilapia without adverse effects.

Keywords: Fish nutrition, Sustainable feed additive, Blood profile, Antioxidant defense, Nile tilapia.

INTRODUCTION

The fastest-growing food-producing sector is aquaculture. Given that 223.2 million metric tons of aquaculture were harvested globally in 2022, it is crucial to provide a steady supply of food for the expanding population (Nielsen *et al.*, 2025). Fish is an essential source of micronutrients, including carbohydrates, proteins, vitamins and minerals that contribute to the nutritional value of fish. It is used as a bioindicator for monitoring the risk of aquatic organisms exposed to different harmful chemicals coming from different industrial and urban areas. Fish is the richest source of important fatty acids (Badoni *et al.*, 2021). Fish meat parameters such as fats, proteins, carbohydrates, and minerals can be affected by water quality (Habiba *et al.*, 2025).

Plants extract in aquaculture are used not only for their medicinal properties but also as feed additives (Akhtar and Abdullah, 2021). The risk of food shortages can be reduced by promoting healthy fish, as they serve as a rich source of high-quality protein, essential minerals, and beneficial fatty acids for the animal industry (Nazeer *et al.*, 2020). Plant extract supplying a range of nutrients, promoting the growth, stimulating appetite and possessing stress-relieving properties (Van Hai, 2015) Several plants are highly required for their unique immune-boosting properties enhancing bile secretion, stimulating digestion and pancreatic enzyme activity encouraging fish to consume more feed than usual (Guo *et al.*, 2020).

Nile tilapia is a freshwater fish species that were native to Africa. It is cultivated in more than 135 countries (Meurer *et al.*, 2024). *Oreochromis niloticus* is the second most cultured fish species worldwide with a production of 5.3 million metric tons (El-Sayed *et al.*, 2024). These are cultivated widely due to their rapid growth rate, resistance to stress, the ability to reproduce in captivity and short generation time (Geletu and Zhao, 2023).

Banana peels are commonly discarded fruit waste and are abundantly available by products in markets. It provides high nutritional value as an energy source with an abundance of vitamins and minerals. Banana peel powder contains antioxidant properties that improve fish health and immunological properties of fish (Giri *et al.*, 2016). Banana is a source of lignocellulose fiber. The inclusion of bananas on the fish diet increases immunity and phagocytic activity. The reason for enhanced growth performance may be attributed to the nutritional and bioactive components including flavonoids, polyphenols and alkaloids present in banana peel powder, which stimulates the intestinal morphology, improved gut health and enzyme activity. Ripe banana peel promoted better nutrient absorption and growth compared to green banana peel, possibly due to the higher existence of nutrient inhibitors in unripe banana peel (Sanvriya *et al.*, 2022).

Antioxidant parameters can gain insight into the oxidative stress defense system in fish. Fish may benefit greatly from the antioxidant properties of banana peel powder by experiencing less oxidative stress, which would strengthen their immunity and increase their resistance to illness (Habotta *et al.*, 2022). Catalase is often employed by cells to speedily catalyze the decomposition of peroxide into less reactive chemical elements and water molecules. Superoxide is one of the most reactive chemical species within the cells, serving as a key inhibitor. (Anwar *et al.*, 2024). SOD is very important inhibitor defense in nearly all living cells exposed to chemical elements. The bioactive compounds in banana peels contain various health benefits, as it has medicinal properties natural growth promoter and is useful as an immunostimulant and controls diseases (Sanvriya *et al.*, 2022). The potential of banana peel powder to influence hematological parameters such as hemoglobin, erythrocytes and leucocytes, leading to an increase in oxygen carrying capacity and overall physiological health in fish (Asha and Kumar, 2024). Banana peel increases the expression of genes related to the immune system and cytokines. They are crucial for stimulating neutrophils, lymphocytes, and macrophages at infection sites, helping to eradicate pathogens, and bolstering the body's immune system (Giri *et al.*, 2016).

MATERIAL AND METHODS

Table 1. *Experimental diet*

Sr.no	Treatments	Experimental diets
1	T ₀	Commercial feed +0g banana peel powder
2	T ₁	Commercial feed +5g banana peel powder
3	T ₂	Commercial feed +10g banana peel powder
4	T ₃	Commercial feed +15.g of banana peel powder

Diet preparation

The banana peels used for the investigation were bought from the Faisalabad local market. To get rid of any contaminants, the samples were first washed with tap water and then distilled water. The ingredients were cleaned, then chopped into small pieces with a knife and dried for 24 hours at 80 °C in an oven. The hue shifted from yellow to brownish black when the moisture was eliminated throughout the drying process. A laboratory electric blender was used to finely grind the dry material, which was then kept at 25 °C until needed. All of the experimental diets were prepared using commercial feed that was acquired in powder form from a private supplier. A commercial diet was combined with 0g, 5g, 10g, and 15g of banana peel powder to create an experimental diet.

Experimental design

Sixty *Oreochromis niloticus* the experimental animal sometimes known as Nile Tilapia, from Faisalabad Fish Seed Hatchery Satyana Road, Pakistan were acclimated at the lab environment in 70L glass aquarium for 7 days and feed with basal diet. Their initial weight and length were measured. To prevent fungal infection, the glass aquarium underwent a cleansing process with 1% KMnO₄ solution, followed by air drying. Constant aeration was supplied in the tanks filled with dechlorinated tap water. Fish. The room temperature fluctuated from 32-34 °C during the experimentation and the water used for the experiment had dissolved oxygen of 4.5-4.9 ml/salinity of water 0.83- 0.84 ppm and pH was 7.3-7.4. After acclimatization, fish were divided into four treatments. Daily water renewal activity was performed to eliminate feces and leftover feed. The fish were randomly divided into four groups. The 70L tanks contained 15 fish in each. Fish of all tanks were fed with respect to their body weight. T₀ was the controlled treatment and fed with normal diet. T₁, T₂ and T₃ were experimental treatments and fed with 5g, 10g and 15g concentrations of BPP respectively.

Growth parameter

Fish from each tank selected randomly and weight was measured weekly to estimate the growth performance of fish. Growth performance and survival rate of fish were calculated using the following formula: weight gain (WG; g/fish) = $W_f - W_i$ specific growth rate (SGR) = $[100 \times (W_f - W_i) / t]$, feed conversion ratio (FCR) = $100 \times \text{total dry feed intake(g)} / \text{weight gain(g)}$ (Rahman and Arifuzzaman, 2021).

Sample collection

after 28 days, Fish from each group will be anesthetized for taking blood samples at the end of experimental trials. Blood samples will be obtained by using a sterile 1 ml syringe from the caudal vein. These samples will promptly be transferred to an EDTA-coated vial, which acts as an anticoagulant and stored at 4°C. After collecting blood sample was centrifuged at 2000× g for 10 minutes at 4 °C. the obtained blood plasma and leucocytes were stored at 20°C. Hematological parameters such as MCV, MCH, Hb, WBCs and RBCs, measured by hemocytometric method.

Haematological parameters

The hematology parameters were evaluated by the automated hematological analyzer.

Antioxidant parameters

Sodium oxidase dismutase was determined by the enzymatic assay method with reagent kit. Catalase catalyzes the decomposition of hydrogen peroxide (H_2O_2) into water and oxygen. The decrease in absorbance of H_2O_2 is measured at 240 nm (He *et al.*, 2021).

Statistical analysis

One way of analysis of variance (ANOVA) was used to analyze data. The Tuckey pairwise test used between different treatments for the comparison of different values. Results were expressed as MEAN $\pm$ SD. The level of significance was set at $p < 0.05$.

RESULTS Growth performance

The effect of banana peel powder on the growth performance of Nile tilapia is shown in Table 2. After the feeding trial of 28 days, the highest mean $\pm$ SD of weight gain (34.50 ± 6.45), SGR (4.750 ± 0.500) and feed intake ratio (19.375 ± 0.548) were recorded as ($P < 0.05$) in T_3 treatment fed with 15g of banana peel powder as compared to the control group. FCR was significantly lower in T_3 (1.797 ± 0.523) than in the control group.

Table 2. Effect of banana peel powder on the growth performance of *Oreochromis niloticus*

Parameters	Treatments			
	T0	T1	T2	T3
WG	20.75 ± 2.50^c	24.75 ± 2.22^c	25.25 ± 4.79^c	34.50 ± 6.45^c
Feed intake ratio	19.200 ± 0.275^{ab}	18.800 ± 0.572^b	19.175 ± 0.538^b	19.375 ± 0.548^{ab}
FCR	2.673 ± 0.3432^a	2.413 ± 0.221^{ab}	1.987 ± 0.420^{ab}	1.797 ± 0.523^b
SGR	2.00 ± 0.816^b	2.00 ± 0.816^b	3.500 ± 0.577^a	4.750 ± 0.500^a
Survival rate%	46.7 ± 46.2	46.7 ± 46.2	46.7 ± 46.2	46.7 ± 46.2

Note: WG = weight gain; FCR= feed conversion ratio; SGR= specific growth rate Values in the same columns with different subscript letters are significantly different ($p < 0.05$), showing significant results. Values are presented as mean $\pm$ SD. (n=15 fish in each group).

Haematological parameter

The effect of dietary administration of BPP on Haematological parameters is shown in Table 3. The number of RBCs (3.2050 ± 0.01500), WBCs (2.243 ± 0.0252), Hb (14.00 ± 0.1000), hematocrit (43.000 ± 1.000) and mean corpuscular concentration of haemoglobin (39.000 ± 1.000) were observed as ($P < 0.05$) in T_3 .

Table 3. Effect of banana peel powder on haematology of *Oreochromis niloticus*

Parameters	Treatments			
	T ₀	T ₁	T ₂	T ₃
RBCs $\times (10^6/\mu L)$	2.5500 ± 0.0500^c	2.800 ± 0.0200^b	3.1250 ± 0.0750^a	3.2050 ± 0.01500^a
WBC $\times (10^3/\mu L)$	1.433 ± 0.0152^d	1.643 ± 0.0152^c	2.133 ± 0.0306^b	2.243 ± 0.022^a
Hemoglobin(g/)	10.90 ± 0.100^d	12.35 ± 0.1500^c	11.35 ± 0.050^b	14.00 ± 0.1000^a
(MCHC) (g/dL)	37.667 ± 1.528^c	42.000 ± 1.000^{bc}	39.000 ± 1.000^{ab}	43.000 ± 1.000^a
HCT%	31.667 ± 1.528^b	32.67 ± 2.08^b	34.00 ± 2.00^b	39.000 ± 1.000^a

Note: RBCs= red blood cells; WBCs= White blood cells; MCHC= Mean corpuscular hemoglobin concentration; HCT= Hematocrit.

Antioxidant parameters

Table 4. Effect of banana peel powder on antioxidant parameter of *Oreochromis niloticus*

Parameters	Treatments			
	T ₀	T ₁	T ₂	T ₃
Sodium peroxidase (U/ml)	102.500±0.500 ^d	106.000±1.000 ^c	129.000±1.000 ^b	166.000±1.000 ^a
Catalase (U/ml)	66.500±0.500 ^c	69.500 ±0.500 ^c	96.000 ±1.000 ^b	125.50 ± 2.50 ^a

In the above table antioxidant parameters including SOD and catalase were significantly ($P < 0.05$) recorded high in in T₃ than control group fed with basal diet.

DISCUSSION

The goal of current study was to determine the effects of banana peel powder on the growth performance, hematology and antioxidant capacity of *Oreochromis niloticus*. It has been found that growth, haematology and antioxidants increased in T₃ fed with 15g of banana peel powder. The results of the present study showed that the maximum weight gain, absolute weight gain, and specific growth rate were recorded in T₃ as (34.50 ± 6.45), (28.00 ± 12.29) and (4.750 ± 0.500) respectively, treatment fed with 15g banana peel supplementary diet as compared to other treatments. The nutritional inclusions of banana peel enhanced the growth in Nile tilapia due the presence of the nutrients that increased the effectiveness of feed and supplementary diet to promote feed absorption (Aisyah *et al.*, 2021);(Fatmawati *et al.*, 2018)The reason of enhanced growth performance may be attributed to the nutritional and bioactive components including flavonoids, polyphenols and alkaloids present in banana peel powder, which stimulates the intestinal morphology, improved gut health and enzyme activity.

The Feed conversion ratio was shown maximum in T₀ treatment fed with basal diet as (2.673 ± 0.3432). The minimum feed conversion ratio was observed in T₃ as (1.797 ± 0.523) treated with 15g of banana peel powder. The reason for minimum Feed conversion ratio is the presence of fiber and bioactive compounds from banana peel may support healthier gut microbiota and improving feed utilization lower the FCR ratio. In case of T₀ lack of the bioactive compounds leading to slower digestion and lower nutrient absorption, which means more feed is needed for the same weight gain, increasing FCR ratio (Mayrhofer *et al.*, 2017; Sanvriya *et al.*, 2022).

The effects of essential oil produced from banana on the growth performance, biochemical and haematology parameters of *Oreochromis niloticus* (Mansour *et al.*, 2024);(Olaseni *et al.*, 2020).The results of present study showed that the highest mean concentration of red blood cells, WBCs, hemoglobin, hematocrit and mean corpuscular hemoglobin concentration were recorded as (3.2050 ± 0.01500), (2.243 ± 0.0252), (14.00 ± 0.1000), (39.000 ± 1.000), (43.000 ± 1.000) in T₃ treatment fed with 15g banana peel supplementary diet. This may be attributed to flavonoids and tannis which stimulate the bone marrow to produce more red blood cells, improve the oxygen carrying capacity and strengthen the white blood cells to fight against disease Banana peel provides iron, vitamin B6, copper and folate all are essential for hemoglobin synthesis and red blood cells formation. In terms of antioxidant activity, the T₃ group again showed the highest capacity, evidenced by increased activity of key antioxidant enzymes such as catalase and sodium peroxidase in T₃ as (125.50 ± 2.50) and (166.000 ± 1.000) respectively. The antioxidant level and immunological responses on Nile tilapia by exposure of banana peel extract which thereby promoting better health and resilience against environmental stressors mitigate oxidative damage by neutralizing free radicals (Habotta *et al.*, 2022).

The overall results of the study showed that 15g banana peel diet significantly enhanced weight gain, specific growth rate and feed intake ratio compared to a basal diet. Key growth metrics such as weight gain (34.50 ± 6.45) and specific growth rate (4.750 ± 0.500) were highest in the group receiving 15g of banana peel. Hematological parameters also improved with the 15g banana peel diet showing

higher concentrations of red blood cells, hemoglobin and hematocrit. To support sustainable aquaculture practices, particularly as a sustainable substitute for traditional feed additives, future perspectives included optimizing the inclusion level for commercial diets, assessing its cost effectiveness, and investigating its synergistic effect with agro-industrial byproducts.

CONCLUSION

It is concluded from the present study that 15g banana peel diet significantly enhanced weight gain, specific growth rate and feed intake in *Oreochromis niloticus*. Hematological parameters also improved with the 15g banana peel diet showing higher concentrations of red blood cells, hemoglobin and hematocrit. The survival rate remained 100% across all groups indicating no negative effects on fish health. In general, adding banana peeling to fish meals at the right amounts can improve development, antioxidant activity, and health without having a negative impact.

Author's contribution

Conceptualization: IM, AK. Methodology: UH, MR, AF. Formal analysis: MUH, MAS. Writing review and editing: FJ, JK

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