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Effect of *Panicum maximum* Plant on Growth Criteria of *Cyprinus carpio* Fish

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ABSTRACT

Aquaculture is considered an important source of protein-rich food, particularly in light of global food shortages and the growing human population. Globally, *Cyprinus carpio* (common carp) is among the most widely cultivated species in freshwater aquaculture systems. For optimal growth within a short period, fish require a high-quality, nutritionally balanced diet. The aim of this study was to evaluate the replacement of conventional carbohydrate sources in fish feed—barley, yellow corn, and wheat bran—with Panicum maximum powder at substitution levels of 25%, 50%, and 75%. *Panicum maximum* is a perennial herbaceous plant commonly used in livestock feed. This study focused on its impact on the chemical composition of the formulated feeds and its effect on the growth performance of experimental fish. Statistical analysis of feed composition showed significant differences ($P \leq 0.05$) among treatments for protein, fat, and carbohydrate contents. Ash content also differed significantly among feed types ($P \leq 0.05$), although the control (C) and the 25% replacement group (T1) did not show a statistically significant difference. The study found slight variations in the chemical composition of the fish feeds due to the replacement of carbohydrate sources with *Panicum maximum*. In terms of growth performance, the highest total body weight was observed in the control group (C), which reached 20.589 ± 2.719 g, while the lowest was recorded in the 75% replacement group (T3) at 12.970 ± 1.069 g. The highest daily growth rate was also in the control group (0.294 ± 0.039 g/day), and the lowest was in T3 (0.185 ± 0.015 g/day). The highest relative weight gain was recorded in the control (70.335 ± 8.732), while T3 had the lowest (43.206 ± 4.085). For the specific growth rate, the control group again had the highest value (0.759 ± 0.072%/g), and T3 the lowest (0.512 ± 0.040%/g). In conclusion, the study suggests that while *Panicum maximum* can serve as a partial replacement for carbohydrate sources in fish feed, it is essential to determine the optimal substitution level that does not adversely affect fish growth performance.

INTRODUCTION

Aquatic animal proteins play a significant role in the global supply of animal-based protein, highlighting the increasing importance of aquaculture in comparison with capture fisheries for meeting global protein demands. Understanding their respective contributions is essential for evaluating and planning the future of aquatic food production to ensure sustainability and food security **(Boyd *et al.*, 2022; Al-Bayati *et al.*, 2024; Bashar *et al.*, 2025)**.

Aquaculture-derived protein is increasingly vital in the human diet, especially with rising global population numbers **(Ochokwu *et al.*, 2014; Aljoburi *et al.*, 2024)**. Meat remains a key component of human nutrition due to its high protein content compared to most plant-based foods **(Klurfeld, 2018; Tilami & Samples, 2018; Hussein & Jumma, 2024)**. According to the **FAO (2022)**, aquaculture and capture fisheries together contribute about 17% of total animal protein consumed by humans—a figure that becomes increasingly significant given the growing population and the concurrent decline in global food resources.

In recent years, fish farming has become the fastest-growing food production sector worldwide. It continues to develop, expand, and intensify across nearly all regions **(Khanum *et al.*, 2022)**. Supporting investment in local feed production—especially using less expensive and readily available raw materials—is critical to the continued growth of the aquaculture industry **(Ragasa *et al.*, 2022; Sankarapandian *et al.*, 2022; Jumma, 2024)**.

The common carp (*Cyprinus carpio* L.), a member of the Cyprinidae family—the largest freshwater fish family—is one of the most important species in aquaculture. It naturally inhabits ponds, rivers, and freshwater lakes and is highly adaptable to a range of ecological conditions. It is a fast-growing species and is highly favored in the market **(Barus, 2002; Al-Bachry & Al-Tawash, 2019; Yaqoob, 2021)**. Globally, common carp is among the most cultivated freshwater fish, accounting for 8.6% of total aquaculture production **(Biro, 1995; Zhou *et al.*, 2003; FAO, 2022)**.

The economic sustainability of aquaculture depends heavily on operational costs, with feed accounting for 50–80% of total expenses in semi-intensive and intensive fish farming systems. Therefore, reducing feed costs is critical to ensuring sustainability and maintaining a steady supply of fish to meet global demand **(Hasan & Soto, 2017; Al-Juhaishi *et al.*, 2025)**. Recently, growing attention has been given to the use of agri-food waste and by-products as alternative ingredients in fish feed, contributing to greater feed self-sufficiency **(Prabakusuma *et al.*, 2023; Alshumary *et al.*, 2024)**.

Panicum maximum, a perennial grass commonly used in livestock diets, is known for its high annual yield, dense foliage, and favorable nutritional profile. It is valued as a potential energy source, with a protein content ranging from 8 to 16% **(Morrone *et al.*, 2007; Jank *et al.*, 2013; Alrudainy & Jumaa, 2016; Eyoh *et al.*, 2019)**.

The present study aimed to investigate the effects of replacing traditional carbohydrate sources in common carp juvenile diets with *Panicum maximum* powder. The study evaluated growth performance, feed conversion efficiency, apparent total digestibility of the diet, and the chemical composition of the feed formulations.

MATERIALS AND METHODS

Experimental fish

The experiment involved 120 juvenile common carp (*Cyprinus carpio* L.) with an average weight of 29.10g. These fish were sourced from a private farm located in the Al-Siba district. Initially, 140 fish were brought to the experiment, but only 120 were ultimately used.

The *Panicum maximum* grass

In this study, *Panicum maximum* grass was harvested from a private farm in Al-Hartha. The harvested grass was air-dried, prepared into samples, and milled for use in the experimental diets (Fig. 1).

Fig. 1. Image of *Panicum maximum* grass

Plant material and experimental design

Feed ingredient collection and preparation

Locally made fish feed ingredients—wheat bran, barley flour, wheat flour, yellow corn, and soybean—were collected from various sources across Basrah. In addition, fish meal was prepared in the laboratory for inclusion in the diets.

Fish meal preparation

Fish meal was prepared from low-cost fish obtained from local markets in Basrah. The fish were thoroughly washed with water to eliminate dirt and suspended materials. They were then air-dried to remove moisture and subsequently ground into a fine powder. The resulting fish meal was stored in sealed plastic containers in a refrigerator until use.

Preparation of *Panicum maximum* powder

Panicum maximum grass was harvested from a private farm in Al-Hartha. The grass was air-dried for four weeks to remove moisture, then ground using an electric grinder. The powdered material was stored in plastic containers until used in feed formulation.

Feed formulation and experimental treatments

Four experimental diets were formulated. The control diet (C) contained traditional carbohydrate sources (barley, wheat bran, and maize) without replacement. In the three treatment diets (T1, T2, and T3), these carbohydrate sources were partially replaced with *Panicum maximum* powder at levels of 25%, 50%, and 75%, respectively.

Experimental aquaculture system

Juvenile common carp were transported from a fish farm in the Al-Siba district to the aquaculture laboratory using oxygenated plastic bags cooled with ice. Upon arrival, the fish were immersed in a saturated saline (sodium chloride) solution for 10 seconds to eliminate external parasites and bacteria.

An open-water system was used for the growth trial. The experimental setup consisted of glass tanks measuring 30 × 40 × 60 cm with a volume of 63 liters per tank. Twelve tanks were arranged in two rows and were sterilized with sodium chloride solution before use. The tanks were filled with tap water that had been left to stand for 24 hours to dissipate chlorine and were aerated using electric air pumps. Tanks were covered with plastic mesh to prevent fish from jumping.

The juvenile fish had an initial average weight of 29.10g. They were acclimatized for 14 days under laboratory conditions and fed experimental diets during this period. Fish were distributed into tanks at a density of 12 fish per tank, with three replicates per treatment. Feeding was carried out at 3% of body weight per day, divided into two meals—one at 9:00 AM and another at 2:00 PM. The feeding trial lasted for 70 days, from September 7, 2024, to November 16, 2024. Every 14 days, fish were weighed to adjust feed quantities. A daily 30% water exchange was performed using a siphon to remove waste and uneaten feed.

Amino acid analysis of *Panicum maximum*

The amino acid profile of *Panicum maximum* was analyzed based on the method described by **Dahl-Lassen *et al.* (2018)**. Three grams of powdered sample were weighed and hydrolyzed in 25 ml of hydrochloric acid at 55°C for three hours. The hydrolysate was then dried using a rotary evaporator, and the residue was dissolved in 5 ml sodium citrate buffer (pH 2.2). The solution was filtered using a 0.45 µm plastic filter and injected into the amino acid analyzer.

For derivatization, 1 ml of the sample extract was mixed with 200 µl of 5% OPA solution. After shaking for 2 minutes, 100 µl of the mixture was injected into the Amino Acid Analyzer. This process enables the formation of fluorescent derivatives, enhancing amino acid detection by HPLC. Data analysis was conducted using Clarity 2022 software.

Statistical analysis

A completely randomized design (CRD) was employed for this study. Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 21.0. Differences between treatments were evaluated at a significance level of $P \leq 0.05$.

RESULTS AND DISCUSSION

Chemical composition of the herb *Panicum maximum* and manufactured meals

The results of the chemical analysis of the manufactured feeds during the experimental period reflected the key nutritional components—namely protein, carbohydrates, fat, and ash. The development of balanced commercial diets has significantly enhanced fish nutrition, promoting optimal growth and health **(Craig & Helfrich, 2017)**.

Table (1) presents the proximate chemical composition of the *Panicum maximum* herb as well as the four types of experimental diets used in feeding common carp. The raw *Panicum maximum* herb was found to contain 16.56% protein, 3.62% fat, 62.29% carbohydrates, and 9.55% ash.

Among the experimental diets, the highest carbohydrate content was observed in the T3 meal (38.62%), where 75% of the traditional carbohydrate sources were replaced by *Panicum maximum*. The control meal, containing no *Panicum maximum,* exhibited the lowest carbohydrate content at 37.39%.

Statistical analysis revealed significant differences ($P \leq 0.05$) between treatments for protein, fat, and carbohydrate content. In terms of ash content, significant differences were also found across treatments ($P \leq 0.05$); however, no statistical difference was observed between the control and T1 meals.

The observed variation in the chemical composition of fish feeds can be attributed to the varying levels of *Panicum maximum* replacement, which slightly altered the nutritional profile of the diets (Table 1).

These results are consistent with those reported by **Alsunaydi *et al.* (2024)**, who noted a chemical composition of *Panicum maximum* in the range of 10–16% protein, 60–65% carbohydrates, 7–9% ash, and 23–37% fiber. However, the findings differ from those of **Ironkwe and Ukanwoko (2016)**, who reported higher protein (20.5%), slightly lower fat (2.5%), higher carbohydrate (69.5%), and lower ash (7.5%) content.

The present study aligns more closely with the findings of **Jameel and Al-Bayati (2021)**, who reported *Panicum maximum* containing approximately 16% protein, 10.35% ash, and 2.22% fat, although a discrepancy was noted in the carbohydrate content, which they reported as 51.21%.

Differences in reported values are likely due to environmental and agronomic variables, particularly nitrogen availability. As **Shilpakar (2024)** emphasized, nitrogen is a key determinant of protein concentration in plants, directly influencing the dry matter yield and overall nutritional value. Additionally, the fiber content in grasses tends to increase with plant age, further contributing to compositional differences.

Table 1. The chemical composition of manufactured meals and *Panicum maximum* herb

components	***Panicum maximum* herb**	C	T1	T2	T3
Protein	16.56 e	33.6 d	34.25 c	34.87 b	35.74 a
Fat	3.62 e	12.65 a	11.05 b	9.94 c	9.05 d
Carbohydrates	62.29 a	37.39 e	38.21 d	38.41 c	38.62 b
Ssh	9.55 a	7.25 d	7.48 d	7.89 c	8.11 b

Differently letters indicate significantly differences $P \leq 0.05$.

Amino acid determination of Panicum Mombasa

The rising costs of manufactured feeds in aquaculture systems necessitate the exploration of cost-effective, plant-based protein sources for fish diets. While many plant-derived feedstuffs contain appreciable amounts of protein, they are often limited by the presence of anti-nutritional factors that can impair fish growth, feed efficiency, and health **(Dogan & Bircan, 2009)**.

Table (2) summarizes the amino acid composition of *Panicum maximum* (also known as Panicum Mombasa) used in this study. The analysis revealed that the herb contains a wide range of essential amino acids (EAA), including lysine, phenylalanine, threonine, isoleucine, valine, methionine, histidine, and leucine. The total content of essential amino acids was recorded at 55.42µg/ 100g.

The ratio of essential amino acids to the total amino acids (TEAA/TAA) was calculated as 40.77%, while the ratio of essential to non-essential amino acids (TEAA/TNEAA) was 68.83%. The non-essential amino acids (NEAA) identified in *Panicum maximum* included proline, aspartic acid, serine, alanine, glycine, tyrosine, arginine, and glutamic acid.

These findings are consistent with those reported by **Wiedemair *et al.* (2020)**, who analyzed amino acid profiles of *Panicum miliaceum L.* (proso millet). Their results indicated that millet, particularly in its whole grain form, contains high levels of essential amino acids compared to other gluten-free grains such as rice, along with elevated levels of alanine and leucine.

The amino acid composition of *Panicum maximum* was also compared with that of commonly used feed components like maize and barley. **Li *et al.* (2022)** reported that maize contains 17 amino acids with favorable implications for nutritional and flavor profiles, showing broad alignment with the amino acid spectrum observed in this study.

In the case of barley, **Assveen (2009)** reported that the total essential amino acid content in different varieties ranged from 38.71 to 40.01g/ 100g, which is notably lower than that of *Panicum maximum* observed in the present research. Similarly, **Slavíková *et al.* (2024)** found that isolated wheat bran protein used in fortified yogurt formulations contained nearly the same essential amino acids as *Panicum maximum*, with the exception of threonine, which was present in *Panicum maximum* but not in wheat bran.

Conversely, tryptophan was detected in wheat bran but absent in *Panicum maximum*. The total essential amino acid content in wheat bran was reported to be 39.3g/ 100g—again lower than that found in *Panicum maximum*.

These results highlight the nutritional potential of *Panicum maximum* as a plant-based protein source, particularly due to its high essential amino acid content. This supports its inclusion in aquaculture feeds, particularly as a partial substitute for more costly carbohydrate and protein sources, without compromising dietary amino acid requirements.

Table 2. The compositions of non-essential and essential amino acids in the *Panicum maximum* herb

Essential amino acids (EAA)	µg/100 µg protein	Non-essential amino acids (NEAA)	µg/100 µg protein
Histidine	5.77	**Aspartic acid**	6.25
Isoleucine	6.25	**Alanine**	8.22
Leucine	10.36	**Arginine**	12.33
Lysine	9.45	**Glutamic acid**	12.65
Methionine	3.25	**cineGly**	4.11
aninePhenylal	3.14	**Leucine**	10.36
Threonine	13.8	**Proline**	10.12
Valine	4.12	**Serine**	10.22
		Tyrosine	6.25

Table (3) presents the growth performance of common carp (*Cyprinus carpio*) fingerlings across the different dietary treatment groups during the 70-day experimental period. The growth parameters assessed included initial and final body weights, total weight gain, daily growth rate, relative weight gain, and specific growth rate.

The highest final total weight was recorded in the control group (C) at 20.589 ± 2.719 g, while the lowest was observed in treatment group T3 (75% replacement with *Panicum maximum*) at 12.970 ± 1.069 g. Statistical analysis indicated that differences among groups C, T1 (25% replacement), and T2 (50% replacement) were not significant ($P \leq 0.05$), whereas T3 showed a significant reduction in total weight compared to both C and T1, but not T2.

Daily growth rate followed a similar trend. The control group exhibited the highest daily growth rate at 0.294 ± 0.039g/ day, whereas T3 recorded the lowest at 0.185 ± 0.015g/ day. Again, there were no significant differences between groups C, T1, and

T2, but T3 differed significantly from C and T1 ($P \leq 0.05$), with no significant difference when compared to T2.

In terms of relative weight gain, the highest value was also observed in the control group (70.335 ± 8.732%), while T3 recorded the lowest (43.206 ± 4.085%). T3 significantly differed from the other three groups ($P \leq 0.05$), which showed no significant differences among themselves.

Specific growth rate (SGR) mirrored the trends of other growth indicators. The highest SGR was recorded in group C (0.759 ± 0.072%/day), and the lowest in T3 (0.512 ± 0.040%/day). Groups C, T1, and T2 showed no statistically significant differences ($P \leq 0.05$), while T3 was significantly lower than all others.

These results suggest that replacing carbohydrate sources in the feed with *Panicum maximum* at 25% and 50% inclusion levels (T1 and T2) did not negatively impact the growth performance of common carp fingerlings, demonstrating their suitability as partial carbohydrate substitutes. This finding is supported by the nutritional profile of *Panicum maximum*, which contains approximately 16% protein and a rich profile of essential amino acids, including lysine and methionine **(Alsunaydi *et al*., 2024; Oday *et al.*, 2024)**.

However, the 75% replacement level (T3) was associated with a marked decline in growth parameters. This reduction can be attributed to the high fiber content in *Panicum maximum*, which has been reported to reach up to 30.66% **(Kelyni *et al.*, 2021)**. High dietary fiber increases digesta retention time, reducing nutrient absorption efficiency **(Mombach *et al.*, 2020; Sabah *et al.*, 2024)**. Furthermore, excessive inclusion of fibrous materials can compromise feed stability, leading to disintegration in water before consumption and nutrient leaching, which negatively affects growth performance **(Samuelsen *et al.*, 2021)**. Hence, feed quality—especially its water stability—is a critical determinant of both growth rates and feed conversion efficiency.

The findings of this study align with **Hadjeb et al. (2024)**, who investigated the replacement of fish meal with *Panicum maximum* in the Nile tilapia diets and found that substitution up to 50% did not negatively impact growth performance or feed efficiency. Similarly, **Suresh (2025)** demonstrated that mixing fish feed with seaweed and fish meal at a 1:1 ratio resulted in increased protein and carbohydrate contents, contributing to enhanced nutritional balance and growth outcomes. Additionally, **Yuangsoi and Masumoto (2012)** successfully incorporated Moringa leaves at a 30% replacement level in the diets of the Nile tilapia and common carp—after removing anti-nutritional compounds—without adverse effects on growth parameters.

In conclusion, moderate inclusion of *Panicum maximum* as a carbohydrate substitute—up to 50%—can be nutritionally and economically viable in aquaculture feed formulations. However, higher inclusion levels may compromise growth due to increased fiber content and reduced feed quality.

Table 3. The initial and final fish weight rate, specific growth rate, relative growth rate, daily growth rate, and total weight gain of common carp in different feeding with standard deviation

Growth parameter	C	T1	T2	T3
Initial weight (g)	29.2633±0.925	28.932±1.283	28.139±0.199	0.676±30.045
Final weight (g)	49.852±3.154 a	49.071±5.059 a	44.462±0.100 ab	43.016±0.997 b
Total weight gain (g)	20.589±2.719 a	20.138±3.842 a	16.322±0.119 ac	12.970±1.067 bc
Daily growth rate (g/day)	0.294±0.039 a	0.287±0.054 a	0.233±0.002 ac	0.185±0.015 bc
Relative growth rate (%)	70.335±8.732 a	69.329±10.669 a	58.008±0.816 a	43.206±4.085 b
Specific growth rate (%/day)	0.759±0.072 a	0.750±0.091 a	0.653±0.007 a	0.512±0.040 b

Differently letters in the columns indicated significantly differences ($P \leq 0.05$).

CONCLUSION

Investing in plant-based crops like *Panicum maximum* powder as a carbohydrate source in fish feed is advantageous due to its high digestibility. However, some plant crops may contain elevated levels of antinutritional factors such as phytates or tannins, making it essential to apply appropriate processing methods to minimize their impact. In this study, the inclusion of *Panicum maximum* (Mombasa grass) powder at suitable replacement levels did not negatively affect growth performance, digestibility, or the physical characteristics of the feed.

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