

Dietary Supplementation of Pumpkin (*Cucurbita pepo*) Leaf Powder on Growth Performance and Nutrient Utilization of African Catfish (*Clarias gariepinus*) Fingerlings.

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ABSTRACT

This study evaluated the effects of dietary supplementation with *Cucurbita pepo* leaf powder on growth performance, nutrient utilization, haematological indices, biochemical profile, and carcass composition of *Clarias gariepinus* fingerlings. A total of 225 fingerlings with an average initial weight of 5.03 ± 0.05 g were randomly distributed into 15 tanks representing five dietary treatments with three replicates each over a 56-day feeding trial. Five isonitrogenous diets containing 40% crude protein were formulated with graded inclusion levels of *C. pepo* leaf powder at 0.0, 0.5, 1.0, 1.5, and 2.0 g/100 g diet. Fish fed diet CP4 (1.5 g/100 g) achieved the highest final weight, weight gain, specific growth rate, and feed intake, with the lowest feed conversion ratio, indicating improved feed efficiency. Polynomial regression estimated an optimum inclusion level of approximately 1.7 g/100 g diet. Haematological parameters including packed cell volume, haemoglobin, red blood cells, and white blood cells increased significantly ($P < 0.05$) with supplementation, reflecting improved physiological and immune status in supplemented groups. These results demonstrate that dietary *C. pepo* leaf powder enhances physiological status and immune response. Biochemical indices such as total protein, albumin, globulin, and cholesterol were also improved in supplemented groups. Therefore, *C. pepo* leaf powder can serve as a sustainable and cost-effective phytogenic feed additive in aquaculture diets.

Keywords: *Cucurbita pepo*, African catfish, fish growth; haematological parameters; serum biochemistry.

INTRODUCTION

Fish is an important component of human nutrition, providing high-quality protein, essential fatty acids, vitamins, and minerals that contribute significantly to global food security. Aquaculture has become one of the fastest-growing food production sectors and plays a crucial role in meeting the increasing global demand for aquatic animal protein. According to the Food and Agriculture Organization (FAO), global fisheries and aquaculture production reached about 223 million tonnes in 2022, with aquaculture contributing more than half of total aquatic animal production for the first time^[1]. In Africa, aquaculture is increasingly recognized as an important strategy for improving food security and rural livelihoods. Among the cultured species in the region, African catfish (*Clarias gariepinus*) is widely farmed due to its rapid growth rate, high feed conversion efficiency, disease resistance, tolerance to low dissolved oxygen, and ability to utilize diverse feed ingredients. However, the profitability of aquaculture is largely constrained by the high cost of feed, which often accounts for 60–70% of total production costs. Conventional protein sources such as fishmeal and soybean meal are expensive and subject to price fluctuations, thereby increasing the need for sustainable and affordable alternative feed resources^[2,3]. Plant-based feed ingredients have therefore attracted increasing attention as potential alternatives in aquafeed formulation. Many plant materials contain bioactive phytochemicals with growth-promoting, antioxidant, antimicrobial, and immunostimulatory properties that can enhance fish performance and health. Such phytogenic feed additives have been reported to improve growth performance, feed utilization, digestive enzyme activity, and immune responses in cultured fish species^[4,5]. One plant with promising potential is *Cucurbita pepo*, a member of the family Cucurbitaceae, widely cultivated for its nutritional and medicinal properties. While the fruits and seeds have been extensively studied, the leaves remain relatively underutilized

despite their high nutritional value. Pumpkin leaves contain proteins, essential minerals, vitamins, and phytochemicals such as flavonoids, tannins, alkaloids, and phenolic antioxidants, which are associated with improved metabolism, immune function, and antioxidant activity^[6,7,8]. Recent studies have shown that pumpkin-derived ingredients can enhance growth performance, feed efficiency, antioxidant status, and immune responses in several fish species, including common carp (*Cyprinus carpio*), rainbow trout (*Oncorhynchus mykiss*), and Nile tilapia (*Oreochromis niloticus*)^[9,10]. Given that pumpkin leaves are inexpensive, widely available, and often discarded as agricultural waste, their inclusion in aquafeeds could provide a sustainable and cost-effective feed resource. However, information on the use of *Cucurbita pepo* leaf powder in the diet of African catfish remains limited. Therefore, this study investigated the potential of *Cucurbita pepo* leaf powder as a dietary supplement to improve growth performance, feed utilization, and overall health of *Clarias gariepinus* fingerlings.

MATERIALS AND METHODS

Experimental Site and Duration

The study was conducted over a 56-day period at the Research Laboratory of the Department of Fisheries and Aquaculture Technology, Federal University of Technology, Akure, Ondo State, Nigeria.

Plant Material

Fresh leaves of *C. pepo* were harvested from the Federal University of Technology, Akure fish farm. The leaves were thoroughly washed with distilled water to remove dirt and impurities and then air-dried at room temperature for 7 days to prevent nutrient degradation from direct sunlight. The dried leaves were milled into a fine powder using an electric blender (Model ES-242) and stored in airtight containers at room temperature until feed formulation.

Experimental Fish

Healthy *C. gariepinus* fingerlings, averaging 5.03 ± 0.05 g, were obtained from a reputable hatchery in Akure, Ondo State, Nigeria. The fish were acclimated for two weeks in fiberglass tanks under laboratory conditions before the commencement of the experiment. During acclimation, fish were fed a commercial diet containing 40% crude protein to apparent satiation twice daily between 08:00–09:00 GMT and 16:00–17:00 h GMT.

Experimental Diets

Five experimental diets (40% crude protein) were formulated incorporating varying levels of *C. pepo* leaf powder (0.0, 0.5, 1.0, 1.5, and 2.0 g/100 g). The diet containing 0.0 g/100 g *C. pepo* leaf meal served as the control. Other ingredients included fish meal, soybean meal, groundnut cake, yellow maize, methionine, lysine, vitamin-mineral premix, vegetable oil, and starch. The formulation was based on the proximate composition of feed ingredients (Table 1). Table 2 shows the gross composition of the experimental diets. The ingredients for each diet were thoroughly mixed and pelleted using a Hobart A-200T mixing and pelleting machine (Hobart Manufacturing Ltd., UK) with a 2-mm diameter die. The resulting strands were sun-dried for 4 days and then hand-crumbled into smaller sizes suitable for fingerlings. The diets were packed into separate airtight polyethylene bags, sealed, labeled according to treatments, and stored at 4 °C until feeding.

Table 1: Proximate composition of feed ingredients

Ingredients	Moisture (%)	Ash (%)	Protein (%)	Fibre (%)	Fat (%)
Fish meal	12.8	10.7	64.8	1.02	9.73
Soybean meal	9.34	5.93	42.0	6.26	8.15
Ground nut cake	9.48	6.62	44.6	5.83	10.9
Yellow maize	11.5	2.89	9.30	1.79	3.26

Table 2: Gross composition of the experimental diets (g/100g) for culturing *C. gariepinus* fingerlings

Ingredients	CP1 (0.0)	CP2 (0.5)	CP3 (1.0)	CP4 (1.5)	CP5 (2.0)
Fish meal (64.8%)	25.4	25.4	25.4	25.4	25.4
Soybean meal (42.0%)	28.2	28.2	28.2	28.2	28.2
Groundnut cake (44.6%)	23.5	23.5	23.5	23.5	23.5
Yellow maize (9.30%)	13.1	13.1	13.1	13.1	13.1
Vitamin-Mineral mix	2.30	2.30	2.30	2.30	2.30
Vegetable oil	5.00	5.00	5.00	5.00	5.00
Methionine	0.30	0.30	0.30	0.30	0.30
Lysine	0.20	0.20	0.20	0.20	0.20
Starch	2.00	2.00	2.00	2.00	2.00
(<i>C. pepo</i> g/100g)	0.00	0.5	1.0	1.5	2.0

Composition of vitamin-mineral mix (Aquamix) (quantity/kg), Vitamin A, 55,00,000 IU; Vitamin D3, 11,00,000 IU; Vitamin B2, 2,000 mg; Vitamin E, 750 mg; Vitamin K, 1,000 mg; Vitamin B6, 1,000 mg; Vitamin B12, 6 mcg; Calcium; Pantothenate, 2,500 mg; Nicotinamide, 10 g; Choline Chloride, 150 g; Mn, 27,000 mg; I, 1,000 mg; Fe, 7,500 mg; Zn, 5,000 mg; Cu, 2,000 mg; Co, 450. L- Lysine, 10 g; Selenium, 50 ppm.

Experimental Design and Management

The experiment was arranged in a Completely Randomized Design (CRD). After acclimatization, a total of 225 healthy *Clarias gariepinus* fingerlings with an average weight of 5.02 ± 0.01 g were batch-weighed using a digital electronic balance (Model PB3002 ± 0.01 g precision) and randomly distributed into 15 glass tanks (70 L capacity; $70 \times 45 \times 45$ cm). Each tank contained 15 fish, representing five dietary treatments with three replicates each. Fish were fed the experimental diets to apparent satiation twice daily between 08:00–09:00 GMT and 16:00–17:00 GMT for 56 days. Fish were batch-weighed at the beginning of the experiment and subsequently at two-week intervals throughout the feeding trial. Care was taken to minimize handling time and stress during weighing. Unconsumed feed and fecal materials were removed daily by siphoning before morning feeding, after which part of the culture water was replaced with fresh water. Complete water exchange in each tank was carried out twice weekly. Water quality parameters, including temperature, dissolved oxygen, and pH, were monitored twice weekly using standard methods. Growth performance and nutrient utilization indices were calculated according to procedures described by [11].

Proximate and Blood Analysis

Proximate composition of *C. pepo* leaf powder, formulated diets were determined following standard methods of the Association of Official Analytical Chemists [12] to evaluate moisture, crude protein, crude lipid, crude fibre, and ash contents. Nitrogen-free extract (NFE) was calculated by difference by subtracting the sum of moisture, crude protein, crude fibre, crude lipid, and ash from 100%. For hematological and serum biochemical analyses, four fish were randomly sampled from each replicate tank at the end of the experiment. Fish were anesthetized using clove oil (50 mg/L) prior to blood collection. Approximately 1 mL of blood was drawn from the caudal vein using sterile 2-mL syringes. For haematological analysis, blood samples were collected into tubes containing ethylene diamine tetraacetic acid (EDTA) as an anticoagulant and analyzed using standard laboratory techniques described by [13]. For serum biochemical analysis, additional blood samples were collected into clean, dry, non-heparinized tubes and allowed to clot at room temperature for 1–2 hours. The samples were then centrifuged at 3,000 rpm for 10–15 minutes to separate the serum. The resulting serum was carefully transferred into sterile containers and stored at -20 °C until analysis. Serum concentrations of total protein, albumin, globulin, cholesterol, and glucose were determined according to the methods described by [14].

Statistical Analysis

Experimental data were analyzed using one-way analysis of variance (ANOVA) to compare the means among treatment groups. Tukey’s post-hoc test was used to determine significant differences between treatment means. All statistical analyses were performed using SPSS version 23.0, with the level of significance set at $P < 0.05$.

RESULTS AND DISCUSSION

Proximate Composition of *C. pepo* Leaf Powder

The proximate analysis of *Cucurbita pepo* leaf powder revealed that carbohydrates constituted the largest proportion of the nutrient profile, representing 64.72% of the composition, whereas lipids were present in the lowest proportion at 3.75% (Table 3). The crude protein level was 6.82%, indicating that the leaf meal provides a moderate amount of protein for potential inclusion in fish diets. This value is lower than the 17.80% crude protein reported for dried *C. pepo* leaves by [15]. Variations in nutrient composition may arise from differences in plant variety, soil nutrient status, stage of plant maturity at harvest, as well as processing and drying techniques applied prior to analysis.

Table 3: Proximate composition of *C. pepo* leaf meal

Parameters (%)	Values
Ash	11.10
Fibre	4.44
Lipids	3.75
Moisture	9.17
Protein	6.82
Nitrogen Free Extract	64.72

Proximate Composition of Experimental Diets

The proximate composition of the formulated diets is presented in Table 4. Ash content ranged between 4.79% and 5.09%, with the lowest value recorded in CP1 and the highest in CP3. Crude fibre content increased gradually as the inclusion level of *C. pepo* leaf powder increased across the diets. Lipid levels varied slightly among treatments, ranging from 7.94% to 8.30%, with CP3 containing the highest concentration and CP1 the lowest. Moisture content showed minor variation among treatments, ranging from 7.73% to 8.04%. Similarly, crude protein levels remained relatively stable, varying between 39.55% and 39.99% across the experimental diets. The consistency in crude protein content indicates that the addition of *C. pepo* leaf powder did not significantly alter the overall protein balance of the diets. These protein levels fall within the recommended dietary protein range of 20–40% required for optimal growth of *Clarias gariepinus* fingerlings, as reported by [16,17].

Table 4: Proximate composition of experimental diets

Parameters (%)	CP1 (0.0)	CP2 (0.5)	CP3 (1.0)	CP4 (1.5)	CP5 (2.0)
Ash	4.79	4.96	5.09	5.01	5.05
Fiber	3.08	3.25	3.34	3.39	3.46
Lipids	7.94	8.21	8.30	8.27	8.23
Moisture	8.04	7.73	7.82	7.96	7.79
Protein	39.55	39.99	39.76	39.63	39.97
Nitrogen Free Extract	36.60	35.86	35.69	35.74	35.50

Water Quality Parameters

Water quality variables monitored throughout the 56-day feeding trial remained within acceptable limits for freshwater fish culture (Table 5). Dissolved oxygen concentrations ranged from 6.27 to 6.42 mg/L, while water temperature varied between 27.23°C and 27.40°C. The pH values recorded during the experiment ranged from 7.03 to 7.12. These relatively stable environmental conditions likely contributed to the satisfactory growth and survival of *C. gariepinus* fingerlings observed in this study. The recorded values were within the recommended ranges for the culture of most freshwater fish species, including African catfish. Similar water quality conditions have also been reported by [18] in studies involving *C. gariepinus* cultured under controlled aquaculture systems.

Table 5 Water quality parameters measured during the experimental period (56 days)

Parameters	CP1 (0.0)	CP2 (0.5)	CP3 (1.0)	CP4 (1.5)	CP5 (2.0)
DO (mg/L)	6.42±0.05 ^a	6.35±0.02 ^a	6.40±0.05 ^a	6.27±0.01 ^a	6.35±0.03 ^a
Temperature (°C)	27.26±0.02 ^a	27.40±0.11 ^a	27.23±0.01 ^a	27.32±0.04 ^a	27.28±0.08 ^a
pH	7.03±0.05 ^a	7.12±0.02 ^a	7.07±0.02 ^a	7.10±0.02 ^a	7.08±0.01 ^a

Means in the same row with different superscript letters are significantly different (P < 0.05).

Growth Performance of the Experimental Fish

The growth performance and nutrient utilization of *C. gariepinus* during the feeding trial are presented in Table 6. The highest growth performance was observed in fish fed the CP4 diet (1.5 g/100 g *C. pepo* leaf powder), while the lowest growth was recorded in fish fed the control diet (CP1). This result indicates that 1.5 g/100 g represents the optimal inclusion level among the tested diets. However, a slight reduction in growth was observed in the CP5 group (2.0 g/100 g), suggesting that excessive inclusion may reduce the beneficial effects. Polynomial regression analysis (Figure 1) further indicated an optimum inclusion level of approximately 1.7 g/100 g, confirming that inclusion levels between 1.5 and 1.7 g/100 g are most effective for promoting growth. Fish fed the CP4 diet also showed significantly higher feed intake (P < 0.05), whereas the lowest intake was observed in the control group. The best feed conversion ratio (FCR) was recorded in CP4 (1.78) compared with 1.92 in the control group. Feed efficiency ratio (FER) and survival rate were not significantly different among treatments, indicating that *C. pepo* leaf powder supplementation at the tested levels did not negatively affect fish health. These findings support the use of *C. pepo* leaf meal as a functional feed additive in aquaculture. Similar results have been reported in previous studies. For instance, ^[10] reported improved growth performance and nutrient utilization in *Oncorhynchus mykiss* fed diets containing 4% *C. pepo* extract. Likewise, ^[19] observed optimal growth and feed utilization in hybrid catfish (*Heterobranchus bidorsalis* × *Clarias gariepinus*) fed diets containing 20% pumpkin seed meal. ^[20] also reported comparable growth performance in Nile tilapia fed diets containing *Cucurbita maxima* seed meal. Beyond aquaculture, *C. pepo* has demonstrated beneficial nutritional effects in other livestock species. In poultry, *C. pepo* seed meal has been reported to improve growth performance, egg production, and antioxidant status in laying hens ^[21]. Studies in rabbits supplemented with pumpkin leaf meal have also shown improved weight gain, feed efficiency, and carcass quality ^[22]. In ruminants such as goats, pumpkin seed cake has been associated with improved nutrient digestibility and increased milk yield ^[23].

Table 6 Growth performance and nutrient utilization of experimental fish

Parameters	CP1 (0.0)	CP2 (0.5)	CP3 (1.0)	CP4 (1.5)	CP5 (2.0)
IW (g)	5.03±0.06 ^a	5.01±0.02 ^a	5.03±0.08 ^a	5.02±0.03 ^a	5.03±0.05 ^a
FW (g)	27.12±1.39 ^a	29.39±0.68 ^{ab}	32.71±0.38 ^b	41.77±1.23 ^d	34.83±1.81 ^c
WG (g)	22.09±1.39 ^a	24.38±0.68 ^{ab}	27.68±0.39 ^b	36.75±1.24 ^d	29.80±1.81 ^c
SGR (%/day)	3.01±0.09 ^a	3.16±0.04 ^{ab}	3.34±0.04 ^b	3.78±0.06 ^d	3.46±0.09 ^c
TFI (g/fish)	42.41±1.79 ^a	46.37±2.16 ^b	51.07±0.74 ^{bc}	65.52±2.47 ^d	53.89±0.52 ^c
FCR	1.92±0.05 ^a	1.90±0.06 ^a	1.85±0.05 ^a	1.78±0.01 ^a	1.81±0.12 ^a
FER	0.52±0.02 ^a	0.53±0.01 ^a	0.54±0.02 ^a	0.56±0.00 ^a	0.55±0.04 ^a
Survival (%)	93.33±3.84 ^a	95.57±4.43 ^a	97.78±2.23 ^a	93.33±3.84 ^a	97.78±2.23 ^a

Means in the same row with different superscript letters are significantly different (P < 0.05).

Key; IW = Initial weight, FW = Final weight, WG = Weight gain, SGR = Specific growth rate, TFI = Total feed intake, FCR = Feed conversion ratio, FER = Feed efficiency ratio.

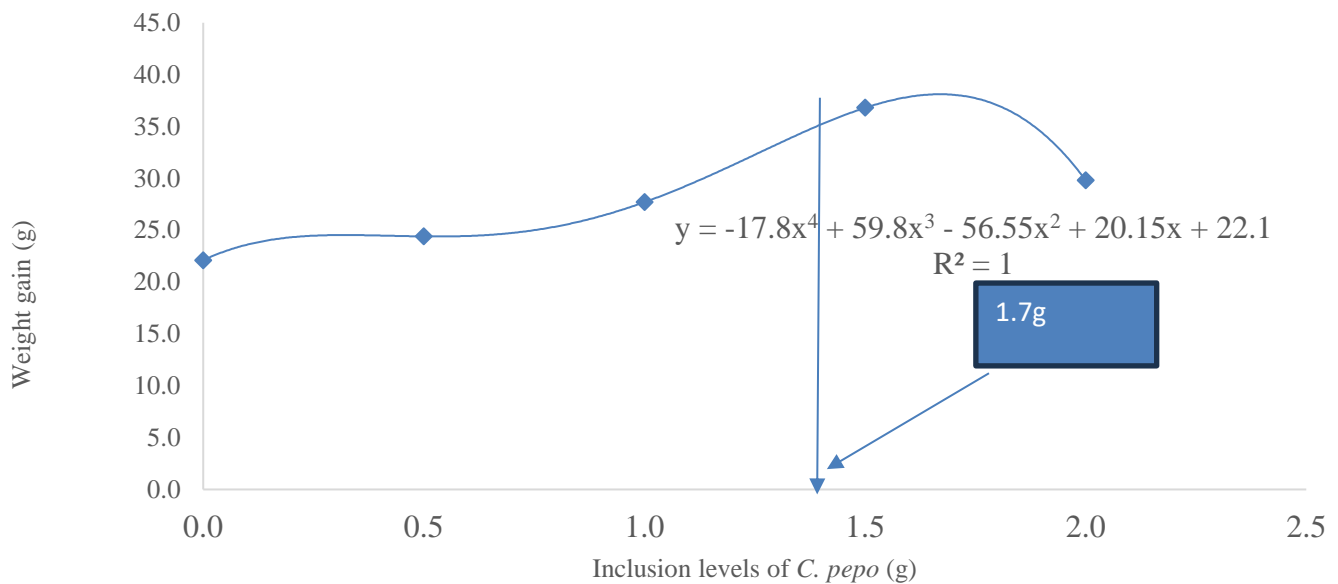


Figure 1. Polynomial regression showing the relationship between *C. pepo* inclusion level and weight gain of *C. gariepinus*.

Haematological Parameters

The haematological parameters of *C. gariepinus* fed diets containing varying levels of *C. pepo* leaf powder are presented in Table 7. Packed cell volume (PCV) increased from 19.8% in the control group to 28.1% in fish fed 1.5 g/100 g (CP4), with a slight reduction in CP5 but still higher than the control. Hemoglobin (Hb) levels followed a similar trend, increasing from 6.33 g/100 ml in the control group to 9.37 g/100 ml in CP4. White blood cell (WBC) counts increased progressively from $4.87 \times 10^3/\text{mm}^3$ in CP1 to $8.52 \times 10^3/\text{mm}^3$ in CP5, suggesting enhanced immune response with increasing supplementation. Red blood cell (RBC) counts also improved from $2.15 \times 10^3/\text{mm}^3$ in the control to $3.16 \times 10^3/\text{mm}^3$ in CP4, although a slight reduction was observed at the highest inclusion level. However, MCV, MCH, and MCHC did not differ significantly across treatments, indicating stable erythrocyte morphology and hemoglobin content. These results suggest that dietary supplementation with *C. pepo* may enhance erythropoiesis, oxygen transport, and immune competence in fish. Similar findings were reported by [24] in *Oreochromis niloticus* fed olive leaf extract and by [25] in *Oncorhynchus mykiss* fed *C. pepo* seed extract. The observed increase in WBC counts agrees with [11], who reported enhanced immune cell proliferation in *C. gariepinus* fed herbal supplements. Comparable improvements in RBC counts have also been reported in fish fed plant-based additives such as *Moringa oleifera* and *Garcinia kola* [26,27].

Table 7. Haematological parameters of experimental fish

Parameters	CP1 (0.0)	CP2 (0.5)	CP3 (1.0)	CP4 (1.5)	CP5 (2.0)
PCV (%)	19.8±0.88 ^a	24.2±0.57 ^b	23.6±1.20 ^b	28.1±1.15 ^d	26.4±1.07 ^c
Hb (g/100ml)	6.33±0.15 ^a	8.12±0.15 ^{bc}	7.70±0.12 ^b	9.37±0.18 ^c	8.79±0.11 ^{bc}
WBC ($\times 10^3/\text{mm}^3$)	4.87±0.02 ^a	6.58±0.01 ^b	6.75±0.02 ^b	8.46±0.01 ^c	8.52±0.02 ^c
RBC ($\times 10^3/\text{mm}^3$)	2.15±0.03 ^a	2.63±0.01 ^b	2.55±0.03 ^b	3.16±0.01 ^c	2.93±0.00 ^b
MCV (fl)	92.1±2.91 ^a	92.0±2.14 ^a	92.5±3.61 ^a	88.9±3.25 ^a	90.1±4.01 ^a
MCH (pg)	29.4±0.28 ^a	30.9±0.59 ^a	30.2±0.83 ^a	29.7±0.69 ^a	30.0±0.40 ^a
MCHC (%)	32.0±0.73 ^a	33.6±1.41 ^a	32.6±2.07 ^a	33.3±2.03 ^a	33.3±1.08 ^a

Means in the same row with different superscript letters are significantly different (P < 0.05).

Key: PCV = Packed Cell Volume, Hb = Haemoglobin Content, WBC = White Blood Cell, RBC = Red Blood Cell, MCH = Mean Corpuscular Haemoglobin, MCHC = Mean Corpuscular Haemoglobin Concentration, MCV = Mean Corpuscular Volume.

Biochemical Profile of Experimental Fish

The biochemical parameters of *C. gariepinus* fed diets containing varying levels of *C. pepo* leaf powder are presented in Table 8. Glucose levels decreased initially at 0.5 g/100 g inclusion, but increased significantly at higher supplementation levels (1.5 and 2.0 g/100 g). This pattern may reflect changes in energy metabolism or mild physiological stress associated with higher inclusion levels. Total protein, albumin, and globulin concentrations increased progressively with increasing *C. pepo* supplementation, reaching their highest values at 1.5–2.0 g/100 g, suggesting improved nutritional status and enhanced immune function. Cholesterol levels also increased with increasing dietary inclusion, indicating possible effects on lipid metabolism and cell membrane structure. These results are consistent with previous studies. [28] reported increased serum protein levels in *Oreochromis niloticus* fed diets containing pumpkin seed cake. Pumpkin seed oil has also been shown to possess anti-inflammatory and antioxidant properties, which may contribute to improved metabolic and immune responses [29]. The increase in cholesterol levels observed in this study is consistent with findings by [30], who reported lipid modulation in animals supplemented with pumpkin seed protein. Similar effects have been reported in fish fed plant-based feed additives [31]. These results suggest that *C. pepo* functions as a functional feed additive capable of enhancing metabolic efficiency and immune competence in fish.

Table 8. Biochemical profile of experimental fish

Parameters	CP1 (0.0)	CP2 (0.5)	CP3 (1.0)	CP4 (1.5)	CP5 (2.0)
Glucose (mg/dl)	28.4±1.76 ^b	20.1±1.45 ^a	24.5±1.76 ^{ab}	38.3±1.33 ^c	40.7±1.20 ^d
Protein (g/dl)	3.93±0.03 ^a	4.54±0.06 ^b	4.61±0.01 ^b	6.02±0.02 ^c	5.95±0.01 ^c
Albumin (g/dl)	1.72±0.02 ^a	2.10±0.03 ^b	2.05±0.03 ^b	2.48±0.01 ^c	2.52±0.05 ^c
Globulin (g/dl)	2.26±0.02 ^a	2.64±0.19 ^b	2.82±0.02 ^b	3.64±0.03 ^c	3.21±0.02 ^{bc}
Cholesterol (mg/dl)	34.7±1.20 ^a	39.2±0.88 ^b	40.5±0.88 ^b	44.0±1.15 ^c	46.3±1.15 ^d

Means in the same row with different superscript letters are significantly different (P < 0.05).

CONCLUSION

This study demonstrates that dietary supplementation with *Cucurbita pepo* leaf powder positively influences the growth performance, nutrient utilization, haematological parameters, and biochemical profile of *Clarias gariepinus* fingerlings. Fish fed diets containing *C. pepo* exhibited improved weight gain, specific growth rate, and feed intake compared with the control group, with the best performance recorded at 1.5 g/100 g diet. Polynomial regression analysis indicated an optimum inclusion level of approximately 1.7 g/100 g, suggesting that moderate supplementation within the range of 1.5–1.7 g/100 g yields the most beneficial effects. Therefore, *C. pepo* leaf powder can be considered a safe, economical, and sustainable feed additive for improving growth performance, health status, and nutrient efficiency in *C. gariepinus* fingerlings.

Institutional Review Board (Ethics Approval)

The experiment was conducted in accordance with institutional guidelines for the care and use of laboratory animals in research

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Conflict Of Interest

All authors declare that they have no conflict of interest.

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