FUDMA Journal of Sciences (FJS)
ISSN online: 2616-1370
ISSN print: 2645 - 2944
Vol. 10 No. 23, December, 2026, pp 137 – 144
DOI: https://doi.org/10.33003/fjs-2026-1023-6502

Dietary Supplementation of Tumeric (*Curcuma longa*) Powder on Heamatological and Biochemical Indices of *Clarias gariepinus* Juveniles

***[1]Lawee, Aliyu Yusuf, [2]Ataya, Josiah Osu [2]Agbason, Nelson Anzaku, [3]Bala Babangida Manta, [4]Suswam Oraluter**

[1]Department of Aquaculture and Fisheries Management, Faculty of Agriculture Nasarawa State University, Keffi, Nigeria.
[2]Department of Fisheries Technology, College of Agriculture Science and Technology Lafia, Nasarawa State.
[3,4]Department of biology Faculty of life sciences Ahmadu Bello university Zaria.

*Corresponding authors' email: layusuf@nsuk.edu.ng

Received: 03 Sept. 2026
Accepted: 12 Nov. 2026
Published: 12 Nov. 2026

ABSTRACT
Dietary supplementation of fish feed with phytogenic feed additives in aquaculture has been shown to enhance aquaculture production by improving immune function and mitigating physiological dysfunctions associated with fish health. As a result, phytogenic additives contribute to better growth performance, increased disease resistance, and overall fish welfare, making them a promising natural alternative to synthetic feed additives. A three-month feeding trial was conducted to investigate the effects varied concentrations of turmeric (*Curcuma longa*) powder on the haematological and biochemical indices of *Clarias gariepinus* juveniles. A total of 150 juveniles of uniform weight were randomly assigned to five dietary treatments containing 0, 1, 2, 3, and 4% turmeric powder in two replicates. At the end of the experiment, blood samples were collected for haematological and serum biochemical analyses. Results obtained revealed that dietary turmeric supplementation significantly ($P<0.05$) increased white blood cell count, haemoglobin concentration, mean corpuscular volume, and mean corpuscular haemoglobin compared with the control. Red blood cell count and haematocrit were not significantly affected ($P>0.05$). There was significant reduction in cholesterol, serum glutamic pyruvic transaminase (GPT/ALT), and serum glutamic oxaloacetic transaminase (GOT/AST) activities in turmeric-fed fish. Total protein and alkaline phosphatase were not significantly influenced by the treatments. Conclusively, this result demonstrates that turmeric powder positively enhanced the physiological status and health of *C. gariepinus* juveniles with no adverse effects. Dietary inclusion of 1–2% turmeric powder is recommended as an effective natural feed additive for African catfish production.

Keywords: Immune Response, Turmeric Powder, Phytogenic Additive, Haematology, Serum Biochemistry

INTRODUCTION

Aquaculture has emerged as one of the fastest-growing food production sectors globally, playing a crucial role in meeting the increasing demand for animal protein. According to recent data from the Food and Agriculture Organization (FAO, 2023), global aquaculture production reached 114.5 million tonnes in 2022, with an estimated value of USD 264 billion. This significant growth highlights the importance of sustainable and efficient aquaculture practices to ensure food security for the growing global population. Among the various freshwater fish species cultured worldwide, *Clarias gariepinus* has gained prominence in many countries, particularly in Africa and parts of Asia. *Clarias gariepinus* is highly valued for its fast growth rate, disease resistance, ability to withstand poor water quality, high stocking density tolerance, and excellent flesh quality (Deepa *et al*., 2022). In Nigeria and many other African countries, *Clarias gariepinus* constitutes approximately 80% of the cultured fish species due to its adaptability to various farming systems and high consumer preference (Atter *et al.*, 2026). However, intensive farming practices often lead to stress, compromised immune function, reduced growth performance, and increased susceptibility to diseases in cultured fish (Wong *et al*., 2024). Traditionally, antibiotics and synthetic growth promoters have been used to address these challenges. Nevertheless, indiscriminate use of antibiotics has raised concerns regarding antibiotic resistance, environmental pollution, and potential risks to human health (Reverter *et al*., 2024). Consequently, there is a growing interest in developing sustainable alternatives to antibiotics and synthetic growth promoters, with natural plant-derived compounds emerging as promising candidates.

Turmeric (*Curcuma longa*), a rhizomatous herbaceous perennial plant belonging to the family Zingiberaceae, has been used for centuries in traditional medicine across various cultures. The bioactive compounds in turmeric, primarily curcuminoids (with *curcumin longa* being the most abundant), possess numerous pharmacological properties, including anti-inflammatory, antioxidant, antimicrobial, immunomodulatory, and growth-promoting effects (Hewlings and Kalman, 2023). These properties suggest turmeric a potential natural feed additive for aquaculture, potentially enhancing fish health, immunity, and growth performance. Recent studies have demonstrated the beneficial effects of turmeric supplementation in various fish species. For instance, Nwose *et al*. (2026) reported improved growth performance, feed utilization, immune response, and disease resistance in Nile tilapia (*Oreochromis niloticus*) fed diets supplemented with turmeric powder. Similarly, Joshi *et al*. (2024) observed enhanced immunological parameters and increased resistance against *Aeromonas hydrophila* infection in common carp (*Cyprinus carpio*) following dietary turmeric supplementation.

Despite the growing interest in phytogenic feed additives in fish nutrition, limited research has been conducted specifically on *Clarias gariepinus*, regarding the effects of turmeric on haematological and biochemical parameters. Haematological and biochemical analyses serve as valuable tools for evaluating fish health status, physiological responses to dietary interventions, stress levels, and immune function (Fawole *et al*., 2022). These parameters can provide insights into the underlying mechanisms through which turmeric influences fish health and performance. Therefore, this study aims to investigate the dietary supplementation of turmeric on the haematological and biochemical responses of *Clarias gariepinus* juveniles.

MATERIALS AND METHODS

Study Area

This study was conducted at the Fisheries Research Farm, Department of Aquaculture and Fisheries Management, Faculty of Agriculture, Nasarawa State University, Keffi, Lafia Campus. The facility is located at latitude 8°35'N and longitude 8°32'E, with an elevation of approximately 181.5 meters above sea level. The area experiences a tropical sub-humid climate with distinct wet (April-October) and dry (November-March) seasons, with annual rainfall averaging 1,300mm and temperatures ranging between 22°C and 36°C (Adamu *et al*., 2023).

Collection and Processing of Turmeric

Fresh turmeric (*Curcuma longa*) rhizomes were purchased from Lafia Modern Market, Nasarawa State. The rhizomes were thoroughly washed with clean water to remove soil and debris, sliced into small pieces, and sun-dried for 7-10 days until a consistent dry weight was obtained. The dried turmeric rhizomes were milled into fine powder using an electric grinder and sieved through a 250µm mesh. The powder was stored in an airtight container at room temperature until use, following the method described of Ibrahim *et al*. (2024).

Source of Experimental Fish

One hundred and fifty (150) healthy *Clarias gariepinus* juvenile (average weight 10.5 ± 0.4g) were obtained from a reputable fish farm in Lafia, Nasarawa State. The fish were transported during cool hours in well aerated plastic containers to the laboratory and acclimatized for 14 days in holding tanks at the research facility. During acclimatization, the fish were fed a commercial diet (40% crude protein) at 5% body weight twice daily. Only active, disease-free juvenile exhibiting normal swimming behaviour were selected for the experiment.

Experimental Diets

Five experimental diets as shown in table 1 below were formulated to contain approximately 40% crude protein using the Pearson's Square Method based on the proximate composition of the feed ingredients. The diets consisted of a basal feed supplemented with graded levels of turmeric (*Curcuma longa*) powder as follows: Treatment T0 contained 0.0% turmeric powder (control), Treatment T1 contained 1.0% turmeric powder, Treatment T2 contained 2.0% turmeric powder, Treatment T3 contained 3.0% turmeric powder, and Treatment T4 contained 4.0% turmeric powder.

Experimental diets were prepared following the method described by Adewole (2021) with slight modifications. Feed ingredients including fish meal, soybean meal, maize meal, fish oil, vitamin premix, and mineral premix were accurately weighed according to the formulated composition and thoroughly mixed to obtain a homogeneous blend. Turmeric powder was then incorporated into the respective diets at the designated inclusion levels and pelleted using a mechanical pelletizer fitted with a 2 mm die. The resulting pellets were sun-dried to a constant weight and stored separately in labelled airtight plastic containers until use.

Experimental Design

The experiment was conducted using a Completely Randomized Design (CRD) comprising five dietary treatments, each replicated twice. A total of 150 healthy juveniles were randomly assigned to 10 plastic tanks (25 L capacity) at a stocking density of 15 fish per tank. The fish were acclimatized prior to the commencement of the feeding trial and maintained under uniform environmental conditions throughout the experimental period.

The fish were randomly allocated into five treatment groups corresponding to the experimental diets formulated with varying levels of turmeric (*Curcuma longa*) powder. Treatment T0 received the basal diet without turmeric supplementation (0.0%), Treatment T1 received the basal diet supplemented with 1.0% turmeric powder, Treatment T2 received 2.0% turmeric powder, Treatment T3 received 3.0% turmeric powder, and Treatment T4 received 4.0% turmeric powder. Each treatment was replicated twice.

The feeding trial lasted for twelve (12) weeks, during which the experimental fish were fed their respective diets at 5% of their body weight per day, divided into two equal rations administered at 9:00 a.m. and 5:00 p.m. Feeding rates were adjusted fortnightly following the determination of fish body weight during routine sampling. Water quality was maintained by regular cleaning of the tanks and periodic replacement of water to ensure a healthy culture environment throughout the study.

Table 1: Inclusion Levels of Ingredients for *Clarias gariepinus* Using Pearson Square (Catacutan 2002)

Ingredients	T1	T2	T3	T4	T5
Fishmeal	15	15	15	15	15
Groundnut cake	30	30	30	30	30
Soyabean cake	30	30	30	30	30
Maize bran	10	10	10	10	10
Wheat bran	13	13	13	13	13
Bone meal	0.5	0.5	0.5	0.5	0.5
Lysine	0.5	0.5	0.5	0.5	0.5
Methionine	0.5	0.5	0.5	0.5	0.5
Fish Oil	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Tumeric powder	0%	1%	2%	3%	4%

Physicochemical Parameters

Water quality parameters were monitored throughout the experimental period. Temperature and pH were measured fortnightly using a digital thermometer and pH meter (HI98107, Hanna Instruments), respectively. Dissolved oxygen was measured using DO meter (YSI Model 55, YSI Inc.). Ammonia-nitrogen, nitrite, and nitrate were determined using standard methods as described by APHA (2021) all these parameters were maintained within the optimal range for *Clarias gariepinus* culture.

Blood Collection

Fish were randomly collected from each treatment tanks at the end of the feeding trial for blood collection. Blood samples were collected through the caudal peduncle using 2mL heparinized and non-heparinized syringes following the method described by Fawole *et al*. (2022). Heparinized blood samples were used for haematological analysis, while non-heparinized blood samples were allowed to clot at room temperature for 2 hours, centrifuged at 3000 rpm for 15 minutes, and the serum collected for biochemical analysis.

Haematological Analysis

Prior to collection of fish blood, feeding of the fish was suspended 24 hrs before sampling. Fish were given MS 222 anesthetizer to reduce stress. Heparinized plastic syringe rinsed with 10% ethylene diaminetetraacetic acid (EDTA solution) was used to collect blood from the fish (4 fish per tank, n = 12 per experimental group) through the caudal vein. The blood was stored in eppendroff tube rinsed with EDTA and later used to estimate red blood cell (RBC), white blood cell (WBC), packed cell volume (PCV) and haemoglobin (Hb). RBC and WBC expressed in cubic millimeter were analysed using Neubauer-type hemocytometer according to Rusia and Sood (1992). Hb level of blood was estimated following the cyanmethemoglobin method according to Blaxhall and Daisely (1973). A volume of 0.02 mL specimen of blood was stirred with 4 mL Drabkin's solution and left to stay for 10 min for appropriate development of colour due to absorbance which was read at 540 nm by Unican spectrophotometer against a blank. PCV was analyzed in heparinized glass capillaries after centrifugation in a microhematocrit centrifuge according to Nelson and Morris (1989). Eosinophils, neutrophils, monocytes, lymphocytes, and basophils in the blood were estimated according to Anderson (2003). Mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) were calculated using the formulae:

$$\text{MCV (Fl)} = \frac{Haematocrit\ (\%) X\ 100}{RBC}$$

$$\text{MCH (pg)} = \frac{\left(\frac{g}{dL}\right) X\ 10}{RBC}$$

$$\text{MCHC = (g/dL)} = \frac{Hb\left(\frac{g}{L}\right) X\ 100}{RBC Haematocrit}$$

Biochemical Analysis

Fresh fish blood was collected with syringe from other batches of 4 fish per tank (n = 12 per experimental group) and then poured into a dried Eppendorf tube to allow for the clotting of the blood. The samples were centrifuged at 3,000 rpm for 10 mins at 4°C to get the serum. Glucose level was determined using O-toluidine method (Cooper and MacDaniel, 1970). Total protein was estimated spectrophotometrically according to Bradford (1976). Serum glutamic pyruvic transaminase (SGPT/ALT) and serum glutamic oxaloacetic transaminase (SGOT/AST) were determined following Reitman and Frankel (1957). Alkaline phosphatase (ALP) was determined according to Essey *et al.* (1946). Creatinine was determined according to Henry *et al.* (1974). Urea was assessed according to Coulombe and Favreau (1963) while cholesterol was determined according to Allain *et al.* (1974).

Data Analysis

All data were subjected to one-way analysis of variance (ANOVA) using the Statistical Package for Social Sciences (SPSS) version 26.0. Differences between treatment means were determined using Duncan's Multiple Range Test (DMRT) at a 5% level of significance ($p<0.05$).

RESULTS AND DISCUSSION

Haematological Responses

Results of blood parameters of *Clarias gariepinus* fed diet with varying levels of dietary turmeric powder as presented in Table 2 revealed that red blood cell (RBC) count did not differ significantly among the treatment groups (P = 0.726). Values ranged from $5.13 \pm 0.35 \times 10^{12}$/L in the control group (T_0) to $5.30 \pm 0.15 \times 10^{12}$/L in T_1. The RBC counts for T_2, T_3, and T_4 were 5.17 ± 0.29, 5.27 ± 0.29, and $5.21 \pm 0.18 \times 10^{12}$/L, respectively. White blood cell (WBC) count differed significantly among the treatment groups (P = 0.024). The control group (T_0) recorded the lowest value ($14.03 \pm 0.02 \times 10^9$/L), while the highest value was observed in T_1 ($17.67 \pm 0.13 \times 10^9$/L). Haemoglobin concentration showed significant differences among the treatment groups (P = 0.001). The highest value was recorded in T_1 (11.10 ± 0.15 g/dl), while the control group (T_0) had the lowest value (7.83 ± 0.76 g/dl). Haematocrit (packed cell volume) did not differ significantly among the treatment groups (P = 0.835). The values ranged from $31.17 \pm 0.79\%$ in T_4 to $32.93 \pm 0.41\%$ in T_3, with T_0, T_1, and T_2 recording $32.07 \pm 0.99\%$, $32.00 \pm 0.58\%$, and $31.47 \pm 1.57\%$. Mean corpuscular volume (MCV) varied significantly among the treatment groups (P = 0.001). The highest value was observed in T_1 (54.85 ± 2.72 fL), followed by T_2 (43.88 ± 3.04 fL), T_0 (43.13 ± 1.67 fL), T_3 (40.73 ± 2.78 fL), while the lowest value was recorded in T_4 (35.78 ± 1.69 fL). Mean corpuscular haemoglobin (MCH) differed significantly among the treatment groups (P = 0.002). The highest value was obtained in T_1 (16.52 ± 0.96 pg), followed by T_0 (13.07 ± 0.65 pg), T_2 (12.91 ± 0.93 pg), T_3 (11.89 ± 0.96 pg), while the lowest value was recorded in T_4 (11.51 ± 0.60 pg). Mean corpuscular haemoglobin concentration (MCHC) also showed significant variation among the treatment groups (P = 0.003). The highest value was observed in T_1 (33.99 ± 0.16 g/dL), followed by T_0 (33.65 ± 0.57 g/dL), T_4 (33.26 ± 0.38 g/dL), T_2 (32.80 ± 0.06 g/dL), while the lowest value was recorded in T_3 (32.74 ± 0.24 g/dL).

Table 2: Haematological Parameters of *Clarias gariepinus* Juveniles Fed Diets Incorporated with Turmeric Powder

Parameters	T_0 (0%)	T_1 (1%)	T_2 (2%)	T_3 (3%)	T_4 (4%)	SEM	PValue
RBC ($x10^{12}$/L)	5.13±0.35^a	5.30±0.15^a	5.17±0.29^a	5.27±0.29^a	5.21±0.18^a	0.214	0.726
WBC (10^9/L)	14.03±0.02^b	17.67b±0.13^a	17.63±0.75^a	17.27±1.48^a	17.70±0.55^a	0.542	0.024
Haemoglobin (g/dl)	7.83±0.76^c	11.10±0.15^a	9.73±0.48^b	9.23±0.19^b	9.60±0.23^b	0.733	0.001
Haematocrit (%)	32.07±0.99^a	32.00±0.58^a	31.47±1.57^a	32.93±0.41^a	31.17±0.79^a	0.323	0.835
MCV (FL)	43.13±1.67^b	54.85±2.72^a	43.88±3.04^b	40.73±2.78^{bc}	35.78±1.69^d	0.422	0.001
MCH (pg)	13.07±0.65^b	16.52±0.96^a	12.91±0.93^c	11.89±0.96^c	11.51±0.60^c	0.244	0.002
MCHC (g/dL)	33.65±0.57^a	33.99±0.16^a	32.80±0.06^a	32.7a±0.24^a	33.26±0.38^a	0.187	0.003

RBC= red blood cell, WBC= white blood cell, MCV=Mean Corpuscular Volume, MCH= mean Corpuscular haemoglobin, MCHC=mean corpuscular haemoglobin concentration mean values with different letter superscripts along the rows differ significantly (P<0.05).

Biochemical Parameters

Results of Serum biochemistry of *Clarias gariepinus* fed diet with varying levels of dietary turmeric powder as presented in Table 3 showed that blood sugar differed significantly among the treatment groups (P = 0.002). The highest value was recorded in T_1 (75.47 ± 1.41 mg/dl), followed by T_2 (74.97 ± 1.17 mg/dl), T_0 (74.73 ± 0.64 mg/dl), T_3 (69.40 ± 1.30 mg/dl), while the lowest value was observed in T_4 (64.40 ± 1.36 mg/dl). Serum cholesterol showed a significant difference across treatments (P = 0.001). The control group (T_0) had the highest cholesterol concentration (83.40 ± 0.62 mg/dl), whereas T_1 recorded the lowest value (74.10 ± 0.12 mg/dl). Serum SGPT (ALT) activity varied significantly among treatments (P = 0.001). The highest activity was observed in T_0 (55.30 ± 0.91 U/l), followed by T_4 (54.43 ± 3.32 U/l). Lower values were recorded in T_3 (47.50 ± 9.72 U/l), T_2 (46.53 ± 6.65 U/l), and T_1 (44.47 ± 6.86 U/l). Serum SGOT (AST) activity differed significantly among the treatment groups (P = 0.001). The highest activity was recorded in T_4 (63.30 ± 0.18 U/l), followed by T_0 (62.32 ± 0.62 U/l), T_3 (56.53 ± 3.11 U/l), T_1 (51.48 ± 5.16 U/l), while the lowest value occurred in T_2 (47.22 ± 6.65 U/l). Alkaline phosphatase (ALP) activity showed significant variation among treatments (P = 0.004). The highest value was recorded in T_4 (58.43 ± 3.32 U/l), while the lowest value was observed in T_1 (53.33 ± 6.86 U/l). Glucose concentration differed significantly among the treatment groups (P = 0.002). The highest concentration was observed in T_1 (27.87 ± 0.84 mg/dl), followed by T_2 (26.80 ± 0.87 mg/dl), T_3 (25.83 ± 0.58 mg/dl), T_4 (24.77 ± 0.18 mg/dl), while the lowest value was recorded in the control group, T_0 (22.77 ± 1.31 mg/dl). Total protein did not differ significantly among the treatment groups (P = 0.749). Values ranged from 8.27 ± 0.15 mg/dl in T_0 to 8.43 ± 0.09 mg/dl in T_4, with T_1, T_2, and T_3 recording 8.42 ± 0.05, 8.33 ± 0.22, and 8.36 ± 0.38 mg/dl, respectively.

Table 3: Serum Biochemistry of *C. Gariepinus* Juveniles Fed Diets Incorporated with Turmeric Powder

Parameters	T0 (0%)	T1 (1%)	T2 (2%)	T3 (3%)	T4 (4%)	SEM	Pvalue
Blood sugar (mg/dl)	74.73±0.64^a	75.47±1.41^a	74.97±1.17^a	69.40±1.30^b	64.40±1.36^c	0.574	0.002
Cholesterol	83.40±0.62^a	74.10±0.12^b	78.30±1.13^a	79.27±1.13^a	77.53±0.92^a	0.836	0.001
SGPT/ALT (U/I)	55.30±0.91^a	44.47±6.86^c	46.53±6.65^b	47.50±9.72^b	54.43±3.32^a	0.267	0.001
SGOT/AST (U/I)	62.32±0.62^a	51.48±5.16^c	47.22±6.65^d	56.53±3.11^b	63.3±0.18^a	0.534	0.001
ALP (U/I)	57.27±0.98^a	53.33±6.86^{ab}	57.53±6.65^a	57.0±9.72^a	58.43±3.32^a	0.253	0.004
Glucose (mg/dl)	22.77±1.31^b	27.87±0.84^a	26.80±0.87^a	25.83±0.58^a	24.77±0.18^b	0.251	0.002
Total Protein (mg/dl)	8.27±0.15^a	8.42±0.05^a	8.33±0.22^a	8.36^a±0.38^a	8.43±0.09^a	0.254	0.749

SGPT/ALT= Serum glutamic pyruvic transaminase, SGOT/AST= Serum glutamic oxaloacetic transaminase, ALP=Alkaline Phosphates. Mean values with different letter superscripts along the rows differ significantly (P<0.05).

Discussion

Haematological Parameters of *Clarias gariepinus* Juveniles Fed Diets Supplemented with Turmeric Powder

The haematological indices of fish fed diets containing graded levels of turmeric powder as additive showed that red blood cell (RBC) count and haematocrit (HCT) were not significantly affected (P > 0.05), whereas white blood cell (WBC) count, haemoglobin (Hb), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), and mean corpuscular haemoglobin concentration (MCHC) differed significantly (P < 0.05). These results indicate that dietary supplementation with the phytogenic additive (TP) influenced immune-related and erythrocyte quality parameters without adversely affecting erythrocyte numbers. The absence of significant differences in RBC count among the treatments suggests that the dietary turmeric powder did not impair erythropoiesis or induce haemolysis. Stable RBC values generally indicate that the dietary treatments maintained normal oxygen transport capacity and physiological status of the fish. Similarly, the non-significant variation in haematocrit further suggests that the diets did not compromise blood volume or red cell mass. These findings agree with those of Gabriel *et al*. (2015**)**, who reported that supplementation of *Moringa oleifera* leaf meal did not significantly alter RBC values in African catfish, indicating that the additive was physiologically safe. similarly, Abdel-Tawwab *et al*. (2018) observed stable RBC and haematocrit values in Nile tilapia fed diets supplemented with medicinal plant extracts.

Conversely, WBC counts increased significantly in the supplemented groups compared with the control. High leukocyte counts are widely recognized as indicators of enhanced innate immune competence and improved disease resistance in fish. Phytogenic feed additives contain bioactive compounds such as flavonoids, phenolics, alkaloids, tannins, and essential oils that stimulate immune cell proliferation and enhance host defence mechanisms. . Generally, white blood cells are known for self-defense against invading substances, pathogens and infections through production via distribution of antibodies and other immune-related factors (Ajima *et al.,* 2015). The increase in WBC count observed in this study therefore imply that turmeric powder possesses the ability to enhance immune response of *Clarias gariepinus* juveniles. Mooraki *et al.* (2019) observed increased WBC counts in Green Terror (*Andinoacara rivulatus*) fed diets containing turmeric powder. Similar findings have been reported in *Clarias gariepinus* juveniles fed ginger (*Zingiber officinale*) supplemented diets (Iheanacho *et al*., 2018) as well as in Wuchang bream (*Megalobrama amblycephala*) fed diets supplemented with curcumin (Xia *et al*., 2015). According to Reverter *et al*. (2014), medicinal plants can enhance leucocyte production and non-specific immunity in cultured fish. Similarly, Dawood *et al.* (2020) concluded that phytogenic feed additives improve immune responses through stimulation of leukocyte activity and antioxidant defence systems. The higher WBC counts observed in this study therefore suggest improved immunocompetence in the treated fish.

Haemoglobin concentration was significantly higher in fish fed 1% dietary turmeric powder than in the control, although values declined slightly at higher inclusion levels. Increased haemoglobin concentration is generally associated with improved oxygen-carrying capacity, enhanced metabolism, and better physiological performance. The improved haemoglobin concentration could be due to the optimal utilization of bioactive compounds that enhance iron metabolism and erythropoietic activity. These findings agree with Acar *et al*. (2015), who observed increased haemoglobin concentrations in fish fed herbal feed additives. However, the slight reduction at higher dietary inclusion levels may indicate that excessive supplementation does not provide additional haematological benefits, a trend also reported by Dawood *et al*. (2019) for certain phytogenic additives.

Significant reductions in MCV and MCH were observed with increasing dietary supplementation. Although these erythrocyte indices decreased, their values remained within the normal physiological ranges reported for healthy cultured fish. Variations in MCV and MCH may reflect alterations in erythrocyte morphology and haemoglobin content resulting from dietary modulation rather than pathological changes. Similarly, Hrubec *et al*. (2000) reported that erythrocyte indices are highly responsive to dietary composition and environmental factors in fish. Furthermore, phytogenic compounds may improve erythrocyte efficiency without necessarily increasing cell size or haemoglobin per cell.

MCHC also differed significantly among treatments but remained within a relatively narrow range, indicating that haemoglobin concentration within erythrocytes was maintained despite changes in MCV and MCH. This observation suggests that the phytogenic additive did not adversely affect erythrocyte integrity or oxygen transport efficiency. Similar observations were reported by Abdel-Latif *et al*. (2020**)**, who found that dietary phytogenic additives modified erythrocyte indices while maintaining normal physiological function in Nile tilapia.

Serum Biochemistry of *Clarias gariepinus* Juveniles Fed Diets Supplemented with Turmeric Powder

The serum biochemical responses of fish fed diets supplemented with different inclusion levels of the phytogenic additive (TP) demonstrated that dietary supplementation significantly ($P < 0.05$) influenced blood sugar, cholesterol, alanine aminotransferase (ALT/SGPT), aspartate aminotransferase (AST/SGOT), alkaline phosphatase (ALP), and glucose concentrations, whereas total protein was not significantly affected ($P > 0.05$). These findings suggest that the phytogenic additive exerted physiological and metabolic effects without adversely affecting protein metabolism.

Blood sugar concentration decreased significantly with increasing TP inclusion, with the lowest value recorded in fish fed 4% TP compared to the control. This reduction indicates that the phytogenic additive may possess hypoglycaemic properties capable of improving carbohydrate metabolism and glucose utilization. Several phytochemicals, including flavonoids, tannins, alkaloids, and phenolic compounds, have been reported to enhance insulin sensitivity and regulate glucose metabolism in fish. This finding agrees with the reports of Reverter *et al*. (2014) and Awad and Awaad (2017), who observed reduced blood glucose levels in fish fed herbal feed additives due to improved metabolic efficiency and reduced physiological stress. Similarly, Abdel-Latif *et al*. (2020) reported that phytogenic compounds improve carbohydrate metabolism through antioxidant and anti-inflammatory mechanisms.

Serum cholesterol was significantly lower in all TP-treated groups than in the control, with the greatest reduction occurring at 1%. The Lower cholesterol levels indicate improved lipid metabolism and suggest that the phytogenic additive possesses hypocholesterolemic activity. Plant secondary metabolites such as saponins and flavonoids are known to inhibit cholesterol synthesis and enhance lipid catabolism. This observation agrees with the findings of Sivaram *et al*. (2004) and Van Hai (2015**)**, who reported significant reductions in serum cholesterol in fish fed phytogenic feed additives. Similarly, Abdel-Tawwab *et al.* (2018) observed reduced serum cholesterol levels in *Clarias gariepinus* fed diets supplemented with *Ocimum gratissimum* leaf extract. The lower circulation of cholesterol reduces lipid accumulation in tissues and enhances cardiovascular and liver health, thereby improving fish welfare.

The activities of ALT (SGPT) and AST (SGOT) were significantly influenced by dietary TP supplementation. ALT activity declined markedly in fish fed 1–3% TP before slightly increasing at 4%, while AST showed the lowest value at 2% TP. Since ALT and AST are reliable biomarkers of hepatic integrity, their reduction suggests improved liver function and reduced hepatocellular damage. increased liver enzymes generally indicate leakage from damaged hepatocytes; therefore, their reduction suggests that TP may possess hepatoprotective properties attributable to its antioxidant constituents. These findings agree with Abdel-Tawwab *et al*. (2018), who reported lower serum transaminase activities in Nile tilapia fed medicinal plant extracts, indicating improved liver health. Similar reductions in GPT/ALT and GOT/AST have been reported in *Oreochromis niloticus* fed garlic-supplemented diets (Shalaby *et al.,* 2006) and in *Megalobrama amblycephala* fed curcumin-supplemented diets (Xia *et al*., 2015). Dewi *et al.* (2018) also reported that curcumin promotes liver cell regeneration and protects hepatic tissues against toxic compounds, which may explain the improved liver enzyme profile observed in the present study. According to Dawood

et al. (2020), phytogenic feed additives enhance hepatic antioxidant defense, thereby reducing liver enzyme leakage into circulation. However, the slight increase observed at 4% TP may suggest that excessive inclusion levels do not confer additional benefits and may slightly alter hepatic metabolism, emphasizing the importance of determining optimum dietary inclusion levels.

Alkaline phosphatase (ALP) activity differed significantly among treatments, although the numerical differences were relatively small. ALP is involved in membrane transport, bone metabolism, and hepatobiliary function. The relatively stable ALP values across treatments suggest that TP supplementation did not induce severe hepatic or biliary dysfunction. This observation agrees with the findings of Ahmadifar *et al*. (2019), who reported that medicinal herbs generally maintain normal ALP activity while improving antioxidant capacity in fish.

Glucose concentration also differed significantly among treatments. Fish fed 1% TP recorded the highest glucose value, whereas the 4% TP group showed values comparable to the control. Unlike blood sugar, serum glucose may fluctuate due to feeding status and stress responses. Nevertheless, the relatively narrow range observed suggests that TP supplementation did not induce metabolic stress. The antioxidant compounds present in phytogenic additives likely minimized cortisol-mediated hyperglycaemia, thereby stabilizing glucose homeostasis. This result agrees with Dawood *et al.* (2019), who reported improved energy metabolism and stress tolerance in fish fed phytogenic supplements. Similar increases in glucose concentration following dietary supplementation with phytogenic additives have been reported by Saeidi *et al*. (2017) and Inanan and Acar (2019).

In contrast, total protein remained statistically unchanged among treatments, indicating that dietary TP neither impaired nor markedly enhanced protein synthesis or protein metabolism. Stable serum total protein generally reflects normal hepatic protein synthesis and an uncompromised immune status. Similarly, Reverter *et al.* (2014) reported that many phytogenic feed additives improve physiological health without significantly altering serum protein concentrations, particularly under non-stressful rearing conditions. However, it disagrees with Abdel-Latif *et al*. (2020), who observed significant increases in serum total protein following phytogenic supplementation, attributing the improvement to enhanced immune protein synthesis. The discrepancy may be due to differences in fish species, plant source, inclusion level, feeding duration, environmental conditions, and phytochemical composition. However, Similar findings have been reported in rainbow trout fed *Urtica dioica* (Saeidi *et al.,* 2017) and in *Carassius auratus* fed *Ferula elaeochytris* root powder (Inanan *et al.,* 2021).

CONCLUSION

This study demonstrated that inclusion of turmeric powder in the diet of *C. gariepinus* improved haematological parameters by increasing the white blood cell count, reduced the activities of some liver function enzymes including GPT/ALT, GOT/AST and ALP but improved the immune response of fish via increased serum protein.

RECOMMENDATION

Turmeric powder can be used as a feed additive in the diet of *Clarias gariepinus* at 1% inclusion without any adverse effect on the physiological function of the fish.

REFERENCES

Abdel-Latif, H. M. R., Abdel-Tawwab, M., Khafaga, A. F., and Dawood, M. A. O. (2020). Dietary phytogenic feed additives in aquaculture: Recent advances in improving fish health and production. *Aquaculture Research, 51*(8), 3153–3167.

Abdel-Latif, H. M. R., Abdel-Tawwab, M., Khafaga, A. F., and Dawood, M. A. O. (2020). Dietary phytogenic feed additives in aquaculture: Current applications and prospects. *Aquaculture International, 28*, 187–210.

Abdel-Tawwab, M., Adeshina, I., Jenyo-Oni, A., Ajani, E. K., and Emikpe, B. O. (2018). Growth, physiological, antioxidant and immune responses of African catfish fed diets supplemented with herbal extracts. *Fish Physiology and Biochemistry, 44*, 1029–1040.

Acar, Ü., Kesbiç, O. S., Yılmaz, S., Gültepe, N., and Türker, A. (2015). Evaluation of the effects of dietary herbal extracts on haematological and immune parameters of fish. *Aquaculture International, 23*, 221–232.

Adamu, Y. K., Dauda, A. B. and Tiamiyu, L. O. (2023). Climate variability and fisheries production in Nasarawa State, Nigeria: A ten-year assessment. *Journal of Climate Change and Sustainability*, 8(2), 112-124.

Adewole, H. A. (2021). Growth performance and feed utilization of *Clarias gariepinus* juveniles fed diets containing varying levels of herbal additives. *African Journal of Aquatic Science*, 46(1), 97-105.

Ahmadifar, E., Sheikhzadeh, N., Roshanaei, K., Dargahi, N., & Faggio, C. (2019). Can dietary ginger (Zingiber officinale) alter biochemical and immunological parameters and gene expression related to growth, immunity and antioxidant system in zebrafish (Danio rerio)?. *Aquaculture, 507*, 341-348.

Ajima, M.N.O., Ogo, O.A., Audu, B. S. and Ugwoegbu, K.C. (2015). Chronic diclofenac (DCF) exposure alters both enzymatic and haematological profile of African catfish, *Clarias gariepinus*. *Drug and Chemical Toxicology*, 38(4), 383-390.

Ajima, M.N.O., Pandey, P.K., Kumar, K., Poojary, N. and Gora, A.H. (2019). Verapamil caused biochemical alteration, DNA damage and expression of hepatic stress-related gene biomarkers in Nile tilapia, *Oreochromis niloticus. Comparative Clinical Pathology*, 29 (1), 135-144.

Allain, C.C. Poon, L.S, Chan, C.S.G. Richmond, W. and Fu, P.C (1974), Enzymatic determination of total serum cholesterol. *Clinical Chemistry*, 20, 470-475.

APHA (American Public Health Association) (2021). Standard Methods for the Examination of Water and Wastewater (24th ed.). American Public Health Association, Washington, DC.

Atter, A., Taye, N. Osei Tutu, C., Asiedu, B.K., Acheampong, R. Ofori, H. et al. (2026). Nutritional Composition of African Cat fish (*Clarias gariepinus*) in Ghana: Effects of culture conditions, feed and processing. *Aquaculture, Fish and Fisheries*, 6(4): e70303.https:///doi.org/10.1002/aff2.70303.

Awad, E., and Awaad, A. (2017). Role of medicinal plants on growth performance and immune status in fish. *Fish & Shellfish Immunology, 67*, 40–54.

Blaxhall, P.C. and Dalsely, K.W. (1973). Routine hematological methods for use with fish blood. *Journal of Fish Biology*, 5,771-781.

Bradford, M.M. (1976). Rapid and sensitive method for quantitation of microgram quantities of protein utilizing principle of protein dye binding. *Annals of Biochemistry*, 72,248-254.

Catacutan, M.R. (2002). Formulation of aquafeeds in. O.M. Millamena, R.M. Coloso, and F.P. Pascual (Eds), *Nutrition in Tropical Aquaculture Essentials of Fish Nutrition, Feed and Feeding of Tropical Aquatic Species* (pp.99-123).

Cooper, G.R. and McDaniel, V. (1970). Estimation of biochemical parameters. In: McDonald RP, ed. Standard Methods of Clinical Chemistry. New York: Academic Press, 162.

Coulombe, J.J. and Favreau, L. (1963). A new simple semi micro method for colorimetric determination of urea. *Clinical Chemistry*, 9, 102-108.

Dawood, M. A. O., Koshio, S., Abdel-Daim, M. M., and Van Doan, H. (2019). Probiotic and phytogenic feed additives in aquaculture: Roles in fish health and performance. *Aquaculture, 500*, 72–86.

Dawood, M. A. O., Magouz, F. I., Mansour, M., Saleh, A. A., and Fadl, S. E. (2020). Dietary herbal supplementation improves liver function and antioxidant status in cultured fish. *Aquaculture Research, 51*, 2417–2430.

Deepa, G., Ayesha, S. and Nishitha, K. (2022). Comparative evaluation of different drying methods on curcuminoid retention and antioxidant activity of turmeric rhizomes. Journal of Food Processing and Preservation, 46(4), e16321.

Dewi, C.O., Manalu, W., Ekastuti, D.R. and Sudrajat A.O. (2018). The Role of Turmeric Powder Supplementation in improving Liver Performances to Support the Production of Siam Catfish (*Pangasianodon hypophthalmus*). Omni Akuatika, 14 (1), 44~53,

Essey, O.A., Lowky, O.H. and Brock, M.J. (1946). A method for the rapid determination of alkaline phosphatase with five cubic millimetres of serum. *Journal of Biology and Chemistry*, 164:321-329.

FAO (Food and Agriculture Organization). (2024). FAOSTAT Database on Turmeric Production. Rome, Italy: FAO.

Fawole, F. J., Adeoye, A. A. and Tiamiyu, L. O. (2022). Dietary turmeric supplementation improves growth, antioxidant status, and disease resistance in African catfish (*Clarias gariepinus*). *Aquaculture Reports*, 24, 101138.

Gabriel, U. U., Akinrotimi, O. A., Bekibele, D. O., Onunkwo, D. N., & Anyanwu, P. E. (2015). Haematological responses of African catfish (*Clarias gariepinus*) fed diets containing *Moringa oleifera* leaf meal. *Journal of Aquaculture Research & Development, 6*, 311.

Henry, J.B. (1974). Clinical Diagnosis and Management, 17* ed. W.B. Saunders, Philadelphia.

Hewlings, S.J. and Kalman, D.S. (2023). Curcumin: An updated review of its molecular mechanisms and therapeutic applications. *Foods*, 12(1), 122.

Houston, A.H. (1997) Review: Are the classical haematological variables acceptable indicators of fish? *Transaction of American Fisheries Society*, 126,879-894.

Hrubec, T. C., Cardinale, J. L., & Smith, S. A. (2000). Hematology and plasma chemistry reference intervals for cultured tilapia (*Oreochromis hybrid*). *Veterinary Clinical Pathology, 29*(1), 7–12.

Ibrahim, M. A., Abdel-Hamid, N. M. and Mahmoud, O. M. (2024). Phytogenic feed additives in aquafeeds: A review on the potentials of turmeric (Curcuma longa) for sustainable aquaculture. *Reviews in Aquaculture*, 16(1), 267-285.

Iheanacho, S.C., Ogbu, M., Ude, E., Ayotunde, E., and Ogueji, E. (2018). Growth, haematology and immuno-modulatory potential of ginger (*Zingiber officinale*) supplemented diets in *Clarias gariepinus* Juvenile (Burchell, 1822). *Aquaculture Studie*s, 18(5), 41-49.

Inanan B.E. Acar U. and Inanan, T. (2021). Effects of dietary *Ferula elaeochytris* root powder concentrations on haematology, serum biochemical parameters, spermatozoa parameters, and oxidative status in tissues of males' goldfish (*Carassius auratus*). *Aquaculture*, 544, 737087,

Inanan, B.E. and Acar, U. (2019). Evaluation of sugar beet leave extracts in goldfish (Carassius auratus) diets: *Effects on blood and semen parameters Acta Aquatica Turcica*, 15(4), 458-468.

Joshi, R., Kaur, S., and Kansal, R. (2024). Genetic diversity assessment of elite turmeric (*Curcuma longa* L.) germplasm using phenotypic and SSR markers. Industrial

Mooraki, N., Batmany, Y., Zoriehzahram S.J. and Kakoolaki, S.H. (2019). Evaluating the effect of using turmeric (Curcuma longa) on growth performance and hematological parameters of the ornamental fish, Green Terror (*Andinocara rivulatus*). *Journal of Survey in Fisheries Sciences*, 5(2), 37-47.

Nelson, D.A. and Morris, M.W. (1989). Basic methodology, hematology and coagulation, Part IV. In: Nelson DA, Henry JB, eds. Clinical diagnosis and management by laboratory methods, 17th ed. Philadelphia (PA): W.B. Saunders, 578-625.

Nwose, F.O, Wachi, F.O and Ekelemu, J.K. (2026). Dietary turmeric enhancing physiological resilience of African Cat Fish (*Clarias gariepinus*) following Aeromonas hydrophila challenge: An integrated physiological assessment *FUDMA Journal of Sciences* 10(19), 185-197. https://doi.org/0.33003/fjs-2026-1019-5857

Olaniyi, C., Atoyebi, M.O., Obafunmiso, H.T., & Salaam, K.A. (2020). Effect of ginger (Zingiber officinale) in the nutrition of African catfishA cholesterol reducer and fertility enhancer. *International Journal of Aquatic Fish Science*, 6(2), 24-28.

Reitman, S. and Frankel, S. (1957). Acolorimetric method for the determination of serum glutamic oxalo acetic and glutamic pyruvic transaminase. *American Journal of Clinical Pathology*, 766,28-56,

Reverter, M., Bontemps, N., Lecchini, D., Banaigs, B., and Sasal, P. (2014). Use of plant extracts in fish aquaculture as an alternative to chemotherapy: Current status and future perspectives. *Aquaculture, 433*, 50–61.

Reverter, M., Tapissier-Bontemps, N., Lecchini, D., Banaigs, B. and Sasal, P. (2021). Biological and ecological roles of external fish mucus: *A review. Fishes*, 6(4), 66.

Rusia, V. and Sood, K. (1992). Routine hematological tests. tn: Mukeriee KL, ed Medical laboratory technology. New Detti Tata McGrawhill, 252-258

Saeidi, A.M.R., Adel, M, Caipang, C.M.A., and Oawood, M.A.O. (2017). Immunological responses and disease resistance of rainbow trout (Oncorhynchus mykiss) juveniles following dietary administration of stinging nettle (*Lirtice dronca*), *Fish Shellfish Immunology*, 71230-238.

Shalaby, A.M., Khattab, Y.A. and Abdel -Rahman, A.M. (2006). Effects of garlic (A/lium sativum) and chloramphenicol on growth performance, physiological parameters and survival of Nile tilapia. *Journal of Venomous Animal Toxins including Tropical Diseases*, 12(2), 172-201.

Sivaram, V., Babu, M. M., Immanuel, G., Murugadass, S., Citarasu, T., & Marian, M. P. (2004). Growth and immune response of fish fed herbal diets. *Aquaculture, 238*, 285–295.

Van Hai, N. (2015). The use of medicinal plants as immunostimulants in aquaculture: A review. *Aquaculture, 446*, 88–96.

Wong, K. E., Ngai, S.C., and Chan, K.G. (2024). Advanced nanoformulations of curcumin: Enhancing bioavailability and therapeutic efficacy. *International Journal of Nanomedicine*, 19, 563-585.

Xia, S.L. Ge, X.P., Liu, B., Xie, J., Miao, L.H., Ren M.C, Zhou Q.L. Zhang W.X., Jiang X.J. Chen R.L. and Pan l.K. (2015). Effects of Supplemented Dietary Curcumin on Growth and Non-Specific immune Responses in Juvenile Wuchang Bream (*Megalobrama amblycephala*). *The Israeli Journal of Aquaculture*, 67, 1174

©2026 This is an Open Access article distributed under the terms of the Creative Commons Attribution 4.0 International license viewed via https://creativecommons.org/licenses/by/4.0/ which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is cited appropriately.