

Research Article

Dietary effects of Zinc-L-Methionine supplementation on the growth, nutritional performance and haematology of African Catfish *Clarias gariepinus* (Burchell 1822)

Oluyemi Kazeem Gbadamosi

Department of Fisheries and Aquaculture Technology, School of Agriculture and Agricultural Technology, The Federal University of Technology Akure, Nigeria.

Corresponding author: Oluyemi Kazeem Gbadamosi; okgbadamosi@futa.edu.ng

Received 29 November 2025; Revised 14 December 2025; Accepted 20 December 2025

Abstract

Zinc-L-methionine represents an important advancement in aquaculture nutrition; the enhanced bioavailability of zinc-L-methionine compared to conventional inorganic zinc sources allows for superior absorption through amino acid transport mechanisms in the intestinal tract. However, the mechanisms of zinc-L-methionine in nutritional physiology of African catfish is still poorly understood. The present study assessed the dietary effects of zinc-L-methionine supplementation on growth performance, nutrient utilization and basic hematological profile of African catfish, *Clarias gariepinus* juveniles for 56 days. Six isonitrogenous diets were formulated to meet the 40% crude protein requirements of *C. gariepinus* juveniles. Fish were fed diets with different supplementation levels of zinc-L-methionine. The graded levels were 0.00g (control), 0.01g, 0.02g, 0.03g, 0.04g, 0.05g/100g for each diet denoted as T1, T2, T3, T4, T5 and T6 respectively. Key performance indicators, including weight gain, feed conversion ratio (FCR), protein efficiency ratio, (PER), specific growth rate (SGR) and basic hematology profile of African catfish juvenile were measured after the feeding trials. Results showed that fish fed diets with 0.03g/100g zinc-L-methionine supplementation demonstrated significant ($P<0.05$) improvements in weight gain, PER, FCR, SGR, an impressive growth rate and good hematological profile compared to the control and other groups. Additionally, the present study has proven that zinc-L-methionine at 0.03g/100g and 0.04g/100g inclusion levels have the potential of improving fish growth parameters and nutrient utilization for sustainable fish production without any detrimental effect on the basic health parameters.

Keywords: Micro-nutrients, Nutrition, Supplements, Aquafeed, Blood profile and African catfish

1. Introduction

Aquaculture is an important food production sector for meeting global food and nutrition security needs to curb the challenges of hunger and malnutrition. Fish farming and its contribution to global food production has continued to increase significantly reaching 122.6 million tons, of which 87.5 million tons were aquatic animals (FAO, 2022). The African catfish (*Clarias gariepinus*) is one the major aquaculture species accounting for 75% of the global aquaculture output (Naylor et al., 2021). It is a popular species of fish cultivated for its rapid growth, adaptability to various environmental conditions, and high nutritional value (De Silva and Davy, 2010; Gbadamosi et al., 2022). However, in African catfish farming, the formulation of quality and relatively cheap feed is one of the leading factors confronting sustainable production of the species in most developing countries (Mbokane et al., 2022). Over the years, many studies have attempted to investigate the nutritional requirement of the *C. gariepinus* to improve the species culture.

Micronutrients such as zinc play an essential role in various physiological processes of fish, including growth and immune function (Smith et al., 2005). Zinc-L-methionine is a chelated form of zinc that has been shown to have higher bioavailability and efficiency compared to inorganic forms of zinc (Pérez-Sánchez et al., 2015). Zinc-L-methionine represents an important advancement in aquaculture nutrition, particularly having potential for improving the nutritional physiology and health of *C. gariepinus* in intensive production systems. This organically chelated mineral compound has emerged as a superior alternative to traditional inorganic zinc sources (Kishawy et al., 2020), offering enhanced bioavailability and improved physiological benefits that directly impact fish health, growth performance, and production efficiency. The enhanced bioavailability of zinc-L-methionine compared to conventional inorganic zinc

sources such as zinc sulfate or zinc oxide stems from its unique molecular structure, with the chelated form allowing; superior absorption through amino acid transport mechanisms in the intestinal tract (Xu et al., 2023). Zinc-L-methionine promoted optimal growth and development in fish by supporting protein synthesis, enzyme activity, and cell division in Channel catfish (Paripatananont and Lovell, 1995; Apines et al., 2004). : Zinc-L-methionine improved bioavailability and ensured efficient utilization of nutrients in the diet, leading to better feed conversion ratios and overall nutrient retention in Rainbow trout, *Oncorhynchus mykiss* (Apines et al., 2004). As aquaculture continues to intensify to meet growing global protein demands, the use of highly bioavailable nutrients like zinc-L-methionine will become important for maintaining sustainable and profitable production systems (Naylor et al., 2021). The aim of this study is to assess the effects of the zinc-L-methionine supplementation on some physiological parameters in African catfish *Clarias gariepinus*.

2. Materials and Methods

2.1 Experimental Site

Two hundred (200) *C. gariepinus* juveniles with average weight ($29.05\text{g} \pm 1.50$) were sourced from reliable fish farm in Akure, Ondo state and were transported to the Teaching and Research Laboratory of the Department of Fisheries and Aquaculture Technology, Federal University of Technology Akure, Ondo, Nigeria. The experimental fish were acclimatized for one week and introduced into fifteen indoor plastic circular tanks of 60cm radius with three replicate per treatment. During this period, they were fed with a commercial diet of 40% Crude Protein (CP).

2.2 Preparation of Experimental Diet

The formulation of the diet was through Pearson's Square Method using 40% crude protein and 5% lipid (Table 1). The various ingredients were ground with hammer mill, weighed and mixed for homogeneity and pelleted using a pelleting machine (Hobart Ltd, London, UK). The pelleted feed was sun dried to a constant moisture level then packed in airtight polyethylene bags and stored. Diets were analyzed for their proximate composition using AOAC (2024). Zinc-L-Methionine powder procured from Chemiconsult™ International Limited, Ikeja, Lagos, Nigeria were supplemented as follows: T1 was the control with 0.00g zinc-L-methionine supplementation, T2 had 0.01 g, T3 with 0.20 g zinc-L-methionine supplementation, T4 had 0.30 g of zinc-L-methionine supplementation T5 has supplementation of 0.40 zinc-L-methionine supplementation, and T6 had 0.05 zinc-L-methionine supplementation. The different diet dough was individually run through a sieve with 2 mm dye and resulting stands were cut into pellets and sun-dried separately. The resulting diets were stored separately in labeled dry air-dried plastic containers.

2.3 Experimental Design

Completely randomized design (CRD) was used in allocating of *C. gariepinus* juveniles to the experimental tanks for the feeding trials. During the study, the fish were fed 5% body weight with the experimental diet twice daily between 8.00 hours- 9.00 and 16.00- 17.00 GMT). Feed was adjusted according to the new weight gain and the water in the plastic tanks changed at twice in a week to remove the waste and excreta of the fish.

2.4 Water Quality Parameters Determination

Temperature, pH and dissolved oxygen were measured weekly, HANNA™ (Poland) multi parameter water

checker instrument was used to measure the water quality parameters.

Growth Performance and nutrient utilisation of *Clarias gariepinus* fed with zinc-L-methionine

Calculation on growth performance and nutrient utilisation was carried out using the expressions below according to Gbadamosi (2022):

$$\text{Weight gain (g)} = \text{Final body weight} - \text{Initial body weight}$$

$$\text{Specific Growth Rate (\%/day)}$$

$$= \frac{\ln \text{ final body weight} - \ln \text{ initial body weight}}{\text{Duration of feeding}} \times 100$$

$$\text{Feed Intake (g)}$$

$$= \text{Total amount of feed given (g)} \times \text{number of days}$$

$$\text{Feed Conversion Ratio} = \frac{\text{Feed intake}}{\text{Weight gain}}$$

$$\text{Feed Efficiency Ratio} = \frac{\text{Weight gain}}{\text{Feed intake}}$$

$$\text{Protein Efficiency Ratio} = \frac{\text{Weight of fish}}{\text{Protein fed}}$$

2.5 Blood collection

At the end of the experimental (10 weeks) period, blood samples were collected by syringe from caudal vein of three catfish fingerlings per tank (nine fish per treatment) for the evaluation of haematological and serum biochemical parameters. EDTA (Ethylene di-amine tetra-acetic acid) at 1.0 mg/mL of blood was used as anticoagulant in samples meant for haematology, while no anticoagulant was added to samples meant for serum biochemical analysis.

2.6 Haematological analysis

Total erythrocyte and total leukocyte levels were determined using a haemocytometer following the methods described by Svobodova *et al.* (1991). Haematocrit was determined according to Gbadamosi and Oke (2024) using micro-haematocrit method and reported

Table 1: Gross composition of the experimental diet in g/100g containing graded levels of zinc -L-methionine for *C. gariepinus*

Ingredients	T1 (control)	T2	T3	T4	T5	T6
Fishmeal	20.00	20.00	20.00	20.00	20.00	20.00
Groundnut cake	25.00	25.00	25.00	25.00	25.00	25.00
Fishmeal	20.00	20.00	20.00	20.00	20.00	20.00
Groundnut cake	25.00	25.00	25.00	25.00	25.00	25.00
Yellow maize	19.80	19.80	19.80	19.80	19.80	19.80
Soyabean oil	5.00	5.00	5.00	5.00	5.00	5.00
Starch	2.00	2.00	2.00	2.00	2.00	2.00
Vitamin premix	2.00	2.00	2.00	2.00	2.00	2.00
Zinc L methionine	0.00	0.01	0.02	0.03	0.04	0.05

Premix manufactured by Chemiconsult International Limited, Ikeja, Lagos, Nigeria (2023). Vitamins supplied mg/100g diet: vitamin B1 (Thiamine) 1.2mg; vitamin B2 (Riboflavine) 2.4mg; vitamin B3 (Niacin) 10mg; vitamin B5 (Pantothenic acid) 4.0mg; vitamin B6 (Pyridoxine) 2.0mg; vitamin B7 (Biotin) 0.2mg; vitamin B9 (Folic acid) 0.4mg; vitamin K 2.0mg; vitamin B12 (Cyanocobalamin) 10.0mg; vitamin C (Ascorbic acid) 150mg, chlorine 160mg.

as percentage packed cell volume (% PCV). Sahli's method was used for the estimation of haemoglobin levels and derived blood parameters were estimated as follows: Mean corpuscular volume (MCV): This is average volume of red cells, and is expressed as;

$$\text{MCV (cu. } \mu\text{m}^3) = \frac{\text{Haematocrit (\%)} \times 10}{\text{RBC count in million}}$$

Mean corpuscular haemoglobin (MCH): This is the average haemoglobin content (by weight) of a red cell, and is expressed as;

$$\text{MCH (pg)} = \frac{\text{Haemoglobin} \times 10}{\text{RBC count in million}}$$

Mean corpuscular haemoglobin concentration (MCHC): This was obtained using the formula:

$$\text{MCHC (pg)} = \frac{\text{Haemoglobin}}{\text{PCV}} \times 100.$$

2.7 Statistical Analysis

Prior to statistical analysis, all data were tested for normality and heterogeneity of variance using Kolmogorov-Smirnov test. Analysis of variance (ANOVA) was used to assess the impact of dietary treatments on fish growth, nutritional performance and hematological response variables. All data was analyzed using Statistical Packages for Social Sciences (SPSS) version 23.0 (IBM Corporation, Armonk, USA). A 5th degree polynomial regression was employed to determine the optimum level of zinc-L-methionine supplementation level for African catfish.

3.0 Results

3.1 Proximate analysis of the experimental diets

The proximate analyses of the experimental diets are presented in Table 3. Results showed that the diets were iso-nitrogenous. There were significant differences ($p>0.05$) in all the other proximate components recorded.

The gross energy content of the six experimental diets supplemented with varying levels of zinc-L-methionine ranged from 1.89 to 1.96 MJ/kg (Table 3). T1 depicts an intermediate gross energy content of 1.93 ± 0.02 MJ/kg. Statistical analysis revealed no significant differences in gross energy content among treatments ($p<0.05$).

Table 3: Proximate composition of experimental diets (%DM)

Parameters	T1 (0.00g)	T2 (0.01g)	T3 (0.02g)	T4 (0.03g)	T5(0.04g)	T6(0.05g)
Moisture	4.64 ± 0.01^c	4.39 ± 0.01^b	5.14 ± 0.01^d	4.14 ± 0.01^a	5.74 ± 0.01^e	5.76 ± 0.01^e
Total Ash	11.99 ± 0.01^d	9.02 ± 0.03^a	9.49 ± 0.01^b	12.99 ± 0.01^e	9.90 ± 0.01^c	10.01 ± 0.01^c
Crude Fat	12.18 ± 0.02^e	11.66 ± 0.01^d	11.51 ± 0.02^c	11.67 ± 0.01^d	10.54 ± 0.01^b	10.34 ± 0.01^a
Crude Fibre	1.17 ± 0.00^d	0.87 ± 0.01^a	0.89 ± 0.01^a	0.99 ± 0.01^c	0.95 ± 0.01^b	1.37 ± 0.01^e
Crude Protein	40.37 ± 0.03^a	39.87 ± 0.01^a	40.29 ± 0.01^a	39.76 ± 0.00^b	39.76 ± 0.00^a	39.50 ± 0.01^a
NFE	29.68 ± 0.01^a	34.19 ± 0.01^f	32.89 ± 0.01^d	30.56 ± 0.01^b	32.12 ± 0.01^c	33.04 ± 0.01^e
Gross Energy	1.93 ± 0.02^a	1.96 ± 0.01^a	1.95 ± 0.02^a	1.89 ± 0.01^a	1.89 ± 0.01^a	1.90 ± 0.01^a

Values as mean $\pm$ SE. Values with different alphabet superscript along a column for each parameter were significantly different ($p<0.05$).

3.2 Water Quality Parameters

The water quality parameters measured during the experiment is presented in Table 2. There were no significance differences ($P>0.05$) in the temperature, pH, and Dissolved oxygen recorded among the treatments. The temperature varied from 26.65 ± 0.21 oC to 26.65 ± 0.39 oC, Dissolved Oxygen from 5.33 to 5.97 mg/l, pH from 6.9 ± 0.69 to 7.97 ± 0.53 .

3.3 Growth performance and nutrient utilisation of *Clarias gariepinus* fed with zinc-L-methionine supplemented diets

The growth performance and nutrient utilization of the experimental fish were presented in Table 4. There was no significant differences ($p>0.05$) recorded in the initial body weight among the treatments. There was no

significant differences ($p>0.05$) recorded in the feed intake (FI), the highest was recorded in T4, followed by T5, T1, T2, T6 and T3 which is the lowest with the values of $24.00\pm5.77g$, $23.70\pm5.19g$, $23.45\pm5.19g$, $21.82\pm13.42g$, $21.33\pm10.68g$, $21.27\pm3.61g$. The feed conversion ratio (FCR) of a fish-fed diet containing a T1 ($1.78\pm0.01g$) inclusion level had the highest FCR and the lowest was recorded in ($0.81\pm0.02g$) inclusion level. They are significantly different. The highest specific growth rate (SGR) of fish was observed in in the fish fed diet that has a T4 ($1.22\pm0.01g$) inclusion level, followed by T5 ($0.82\pm0.00g$), T3 ($0.80\pm0.09g$), T6 ($0.78\pm0.00g$), T2 ($0.65\pm0.00g$), and T1 ($0.65\pm0.01g$) inclusion had the lowest growth rate. They are significantly different. The weight gain of fish in group T4 was the highest

(29.08±1.69g), followed by T5 (17.48±1.29g), T3 (16.75±2.29g), T6 (16.35±0.29g), T2 (13.28±1.01g) and the lowest weight gain was recorded in T1 (13.15±0.87g). The percentage efficiency ratio of fish in group T4 was the highest (6.49±0.04g), followed by T5 (3.88±0.04g), T3 (3.69±0.05g), T6 (3.65±0.01g), T2 (2.95±0.03g) and the lowest weight gain was recorded in T1 (2.89±0.01g).

The percentage survival rate for fish fed with different inclusion levels of zinc-L-methionine mean range between (90.00 - 95.00 %). They are not significantly different. The fish fed with diet T4 (0.03g inclusion level) recorded the highest growth response across the 8 weeks period followed by T5 (0.04g inclusion level), T3 (0.02g), T1 (control), T6 (0.05g) and the lowest was observed in *C. gariepinus* fed with 0.01g inclusion level (T2) of zinc-L-methionine.

Table 2: Water quality parameters

Parameters	T1	T2	T3	T4	T5	T6
Temp (°C)	26.65±0.39 ^a	26.65±0.23 ^a	26.65±0.21 ^a	26.65±0.25 ^a	26.65±0.29 ^a	26.65±0.27 ^a
DO (mg/l)	5.39±0.63 ^a	5.38±0.72 ^a	5.97±0.84 ^a	5.35±0.85 ^a	5.33±0.85 ^a	5.37±0.85 ^a
pH	6.9±0.69 ^a	7.6±0.41 ^a	6.19±0.66 ^a	7.97±0.53 ^a	7.12±0.48 ^a	7.51±0.14 ^a

Key= T—Temperature, DO —Dissolved oxygen, pH — Hydrogen on concentration

Values as mean ± SE. Values with different alphabet superscript along a column for each parameter were significantly different ($p < 0.05$).

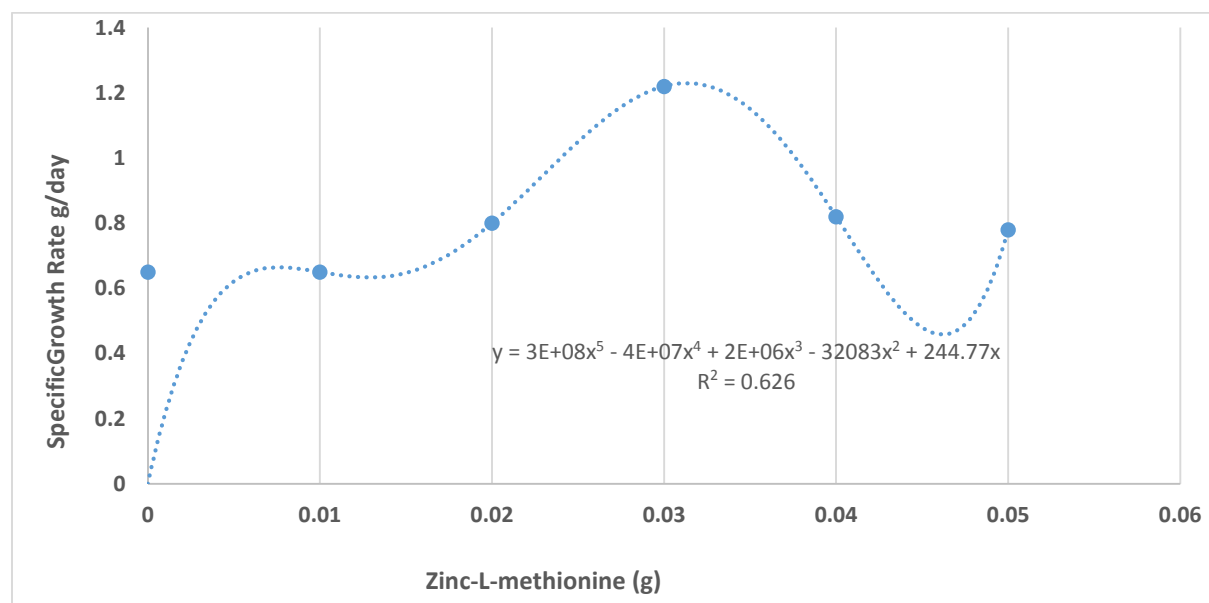


Figure 1: The optimum dietary zinc-L-methionine supplementation level for *Clarias gariepinus* juveniles

Table 4: Growth Performance and nutrient utilization of *Clarias gariepinus* juveniles fed with Zinc-L-Methionine Supplemented diets

Parameters	T1	T2	T3	T4	T5	T6
IW (g)	29.58±1.69 ^a	29.60±2.31 ^a	29.05±0.29 ^a	29.46±2.03 ^a	29.58±1.09 ^a	29.43±2.40 ^a
FW (g)	42.73±1.76 ^a	42.88±3.00 ^a	45.80±2.52 ^b	58.55±1.44 ^d	47.06±3.38 ^c	45.76±2.72 ^b
WG (g)	13.15±0.87 ^a	13.28±1.01 ^a	16.75±2.29 ^b	29.08±1.69 ^d	17.48±1.69 ^c	16.35±0.29 ^b
%WG	44.40±0.40 ^a	44.83±0.32 ^a	57.5±0.69 ^c	98.66±1.69 ^d	59.03±0.22 ^c	55.50±0.38 ^b
FI	23.45±3.18 ^a b	21.82±13.42 ^{ab}	21.27±3.61 ^a	24.00±5.77 ^b	23.70±5.19 ^{ab}	21.33±10.68 ^{ab}
FCR	1.78±0.01 ^c	1.64±0.11 ^c	1.26±0.01 ^b	0.81±0.02 ^a	1.35±0.03 ^b	1.53±0.18 ^{bc}
FER	0.80±0.25 ^a	0.61±0.40 ^a	0.78±0.01 ^a	1.20±0.03 ^b	0.73±0.02 ^a	0.74±0.05 ^a
SGR	0.65±0.01 ^a	0.65±0.00 ^a	0.80±0.09 ^c	1.22±0.01 ^d	0.82±0.00 ^c	0.78±0.00 ^b
PER	2.89±0.01 ^a	2.95±0.03 ^a	3.69±0.05 ^b	6.49±0.04 ^d	3.88±0.04 ^c	3.65±0.01 ^b
SUR (%)	94.00±8.81 ^a	95.00±14.50 ^a	97.00±5.87 ^a	95.00±8.78 ^a	96.00±4.33 ^a	96.00±6.56 ^a

KEY= IW —Initial weight, FW —Final weight, WG — Weight gain, %WG — Percentage weight gain, FI — Feed intake, FCR — Feed conversion ratio, FER — Feed efficiency, SGR — Specific growth rate, PER — Percentage efficiency ratio, SUR (%) — Survival percentage.

Values as mean ± SE. Values with different alphabet superscript along a column for each parameter were significantly different ($p < 0.05$)

3.4 Optimal inclusion dosage of dietary zinc-L-methionine in African catfish diet

The polynomial regression graph shows that *Clarias gariepinus* exhibits an impressive dose response relationship between dietary zinc-L-methionine inclusion

(in g/100g protein) and specific growth rate (SGR). At very low levels (< 0.01 g/100 g), SGR is depressed, indicating deficiency; SGR increases with increasing zinc-L-methionine, increased from 0.03 to 0.033 g/100 g, and then declines with increasing dosage from 0.04 to

0.05 g/100 g), reflecting potential negative effects of overdosing or diminishing returns.

4. Discussion

4.1 The water quality parameters

The water quality parameters during the current study remained relatively stable across the groups (Table 3), consistent with optimal ranges for *C. gariepinus* growth as reported by Gbadamosi and Alao (2025), ensuring that the fish were not negatively affected by inconsistent physico-chemical parameters.

4.2 Proximate analysis of the experiments diets

The proximate analysis of experimental diets revealed that all experimental diets provided optimum protein for *Clarias gariepinus* and were iso-nitrogenous (44.69–45.37% crude protein). Contemporary studies place the practical protein requirement for intensively reared African catfish juveniles broadly within 35–40% CP, balancing growth with cost; thus, the current diets sit within the upper, performance-oriented end and are appropriate for growth trials (Ali, 2024; Naeem et al., 2024). Dietary crude fat ranged from 10.34% (T6) to 12.18% (T1), which falls within modern recommendations for juvenile *C. gariepinus* (5–15% lipid), supporting energetic sufficiency without predisposing to excessive carcass lipid (Langi et al., 2024; Enyidi and Duru, 2017). Gross energy values indicated that the diets were iso-caloric (1.89–1.96 MJ kg⁻¹ as reported in Table 3). The lack of significant differences across treatments shows that zinc-L-methionine inclusion did not alter energy density, which is consistent with recent work where varying zinc sources did not affect whole-body proximate composition (hence diet energy supply) at practical inclusion levels. Maintaining comparable energy supply among treatments is essential for interpreting zinc bioavailability and metabolic

outcomes because energy intake regulates nutrient utilization efficiency; recent feed formulation reviews reinforce that appropriate energy nutrient balance underpins valid comparisons of additive efficacy (Glencross, 2024).

Growth performance and nutrient utilisation of *Clarias gariepinus* fed with zinc-L-methionine supplemented diets

The weight of fish in groups fed diets supplemented with 0.03 and 0.04 g of zinc-L-methionine were significantly higher and better compared to the control and other groups. This indicated that inclusion at these levels were very effective on fish growth. The finding of this study agreed with the report of Bethke et al., (2001) on weight gain, efficiency and feed conversion ratio of Atlantic cod which was attributed to the inclusion of zinc and other micronutrients. The good nutritional performance of zinc-L-methionine, a chelated form of zinc was attributed to higher bioavailability and efficiency compared to inorganic forms of zinc (Pérez-Sánchez et al., 2015). The result of the present study showed that the various levels of zinc-L-methionine supplementation in diets played a major role in fish growth and utilization of feed by the experimental African catfish. The physiological mechanisms underlying the benefits of zinc-L-methionine supplementation involve complex metabolic pathways, with methionine regulating fish growth and health mainly through the TOR and GCN2 pathways, and dietary methionine requirements ranging from 0.49% to 2.5% of the diet depending on species, age, methionine forms, and cystine and taurine levels (Xu et al., 2023). The optimum dietary zinc-L-methionine level of *C. gariepinus* juveniles is presented in Figure 2. The 5th order polynomial regression model depicted that a significant and moderately strong relationship existed between the specific growth rate and zinc-L-methionine concentration

Table 5: Haematological profile of fish fed graded level of zinc-L-methionine supplementation

BP	T1	T2	T3	T4	T5	T6
WBC ($\times 10^3/\mu\text{L}$)	17.7 $\pm$ 0.14 ^b	11.8 $\pm$ 0.09 ^a	17.2 $\pm$ 0.20 ^b	16.3 $\pm$ 0.45 ^b	18.1 $\pm$ 1.06 ^b	21.2 $\pm$ 0.61 ^c
RBC ($\times 10^6/\mu\text{L}$)	2.43 $\pm$ 0.15 ^{ab}	1.86 $\pm$ 0.09 ^a	2.60 $\pm$ 0.10 ^{ab}	3.10 $\pm$ 0.10 ^{ab}	3.76 $\pm$ 0.18 ^b	6.03 $\pm$ 0.92 ^c
HGB (g/dL)	6.30 $\pm$ 0.10 ^{ab}	7.83 $\pm$ 0.12 ^c	6.65 $\pm$ 0.15 ^{abc}	5.83 $\pm$ 0.58 ^a	6.06 $\pm$ 0.28 ^{ab}	7.50 $\pm$ 0.75 ^{bc}
PCV (%)	18.2 $\pm$ 0.12 ^a	22.1 $\pm$ 0.15 ^{bc}	19.2 $\pm$ 0.20 ^{ab}	17.1 $\pm$ 1.03 ^a	18.2 $\pm$ 0.92 ^a	23.1 $\pm$ 2.03 ^c
MCV (fL)	176.8 $\pm$ 0.12 ^c	199.3 $\pm$ 0.12 ^d	171.8 $\pm$ 0.15 ^c	156.3 $\pm$ 7.73 ^{ab}	151.4 $\pm$ 1.22 ^a	167.4 $\pm$ 7.23 ^{bc}
MCHC (g/dL)	35.4 $\pm$ 0.27 ^d	34.6 $\pm$ 0.88 ^c	32.6 $\pm$ 0.10 ^a	33.3 $\pm$ 0.27 ^b	33.5 $\pm$ 0.21 ^b	32.5 $\pm$ 0.24 ^a
MCH (pg)	25.6 $\pm$ 0.09 ^c	43.2 $\pm$ 0.88 ^d	23.9 $\pm$ 0.05 ^{bc}	18.7 $\pm$ 2.50 ^{ab}	17.2 $\pm$ 0.44 ^a	22.3 $\pm$ 2.65 ^{abc}
LYM (%)	47.2 $\pm$ 0.12 ^a	52.7 $\pm$ 0.64 ^c	54.3 $\pm$ 0.10 ^d	50.2 $\pm$ 0.12 ^b	49.2 $\pm$ 0.12 ^b	49.8 $\pm$ 0.33 ^b
MON (%)	0.33 $\pm$ 1.10 ^a	0.00 $\pm$ 0.00 ^a	0.00 $\pm$ 0.00 ^a	0.33 $\pm$ 0.33 ^a	0.00 $\pm$ 0.00 ^a	0.66 $\pm$ 0.33 ^a
NEU (%)	52.2 $\pm$ 0.12 ^c	48.2 $\pm$ 0.12 ^{ab}	48.1 $\pm$ 0.15 ^{ab}	48.9 $\pm$ 0.26 ^{ab}	49.2 $\pm$ 0.11 ^b	47.1 $\pm$ 1.11 ^a
EOS (%)	0.00 $\pm$ 0.00 ^a	0.00 $\pm$ 0.00 ^a	0.00 $\pm$ 0.00 ^a	0.66 $\pm$ 0.33 ^b	0.00 $\pm$ 0.00 ^a	0.00 $\pm$ 0.00 ^a
BAS (%)	0.00 $\pm$ 0.00 ^a	0.00 $\pm$ 0.00 ^a	0.00 $\pm$ 0.00 ^a	0.66 $\pm$ 0.33 ^b	0.00 $\pm$ 0.00 ^a	0.00 $\pm$ 0.00 ^a

KEY=BP — Blood Parameter, WBC — White blood cell, RBC — Red blood cell, HGB — Haemoglobin estimation, PCV — Packed cell volume, MCV — Mean corpuscular volume, MCHC — Mean corpuscular haemoglobin estimation, LYM — Lymphocytes, MON — Monocytes, NEU — Neutrophils, EOS — Eosinophils, BAS — Basophils
 Values as mean $\pm$ SE.

Values with different alphabet superscript along a column for each parameter were significantly different ($p < 0.05$).

(g/100g protein) in the fish diets ($R = 0.626$) and the equation of $y = 3E+08x^5 - 4E+07x^4 + 2E+06x^3 - 32083x^2 + 244.77x$. The optimum dietary level zinc-L-methionine requirement of *C. gariepinus* juveniles is 0.033 g/100g protein at the specific growth rate of 1.24%/day-1.

4.3 Optimal inclusion dosage of dietary zinc-L-methionine in African catfish diet

This optimum (0.033 g/100 g) indicated the point where incremental benefit is maximal. Thus, it implies that about 0.033 g/100g of zinc-L-methionine is appropriate for maxima growth in *C. gariepinus* juvenile. The organic chelation of zinc with methionine (zinc-L-methionine) increases zinc bioavailability compared to inorganic salts, thereby improving growth, antioxidant status, and immune responses while reducing antagonistic interactions with other minerals (Khan et al., 2024; Xu et al., 2023).

4.4 Haematological profile of fish fed graded levels of Zinc-L-methionine supplementation

Blood composition is often altered during disease, stress, or nutritional imbalances in fish (Ranzani-Paiva et al., 2015). Red blood cell count, and packed cell volume (PCV) are particularly sensitive to dietary treatments and nutritional quality (Abdel-Tawwab et al., 2017). Under normal physiological conditions, haematological indices remain relatively stable within species-specific ranges. With deviations often reflecting dietary composition and health status (Fazio, 2019). In the current study, the lowest PCV and RBC values were observed in fish fed the control diet without zinc-L-methionine supplementation, which may be attributed to reduced iron absorption and impaired haemoglobin synthesis. The highest PCV ($23.1 \pm 2.03\%$) was recorded in fish fed 0.05 g/100 g zinc-L-methionine, aligning with the established normal range for catfish (20–35%) (Olaniyi et al., 2020). This suggests

that dietary zinc plays a role in erythropoiesis and maintenance of blood oxygen-carrying capacity.

White blood cell (WBC) counts, particularly lymphocytes and monocytes, were enhanced in fish fed diets supplemented with 0.04–0.05 g zinc-L-methionine, indicating improved immune competence. The highest WBC was recorded in the blood of catfish fed with 0.04g and 0.05g of zinc-L-methionine supplemented diets. This indicate that the highest WBC is widely recognized as a marker of enhanced resistance to pathogens and better disease tolerance in fish (Martínez-Álvarez et al., 2021; Yarahmadi et al., 2016). The low percentage of neutrophil could be that the fish fed with that concentration of diet induces stress on the fish or that the fish may be suffering from infection which may have led to the low survival rate in fish, as neutrophils are often elevated during acute immune responses (Hoseinifar et al., 2020).

5. Conclusion

The result of the present study showed that the supplementation of zinc-L-methionine supplementation in diets played an undeniable role in fish growth and utilization of feed by the experimental fish. Fish fed with 0.033 g/100g of zinc-L-methionine supplemented diet had the highest growth performance, nutrient utilisation and good haematological profile in the present study. Therefore, the fish fed with 0.033 g/100g of zinc-L-methionine supplemented diet had the highest feed intake, highest feed efficiency ratio, highest growth rate, a good FCR and highest percentage ratio, an impressive growth rate and good haematological profile may also be chosen by fish farmers involved in fish farming for efficient growth and sustainable fish production. As aquaculture continues to intensify to meet growing global protein demands, the use of highly bioavailable nutrients like zinc-L-methionine will become important for maintaining sustainable and profitable production systems.

6. Statements and Declarations

Author Contributions: The author GOK designed the study and performed the experiments. GOK performed the statistical analysis of the data, writing of the draft and final versions of the manuscript.

Data Availability: All datasets, on which the conclusions of the manuscript rely, are present in the results section in the manuscript.

Conflict of Interest Declaration: The authors declare that they have no conflict of interest.

Declarations: Ethics Approval the experimental procedures were approved by the Institutional Animal Care and Use Committee of the Federal University of technology Akure, Nigeria; approval number FUTA/ETH/24/167.

7. References

- Abdel-Tawwab, M., Monier, M. N., Hoseinifar, S. H., and Faggio, C. (2017). Fish response to hypoxia stress: Growth, physiological, and immunological biomarkers. *Fish Physiology and Biochemistry*, 43(1), 1–12. <https://doi.org/10.1007/s10695-016-0257-6>.
- Ali, M. R. (2024). Determination of optimum dietary crude protein requirement for maximum growth of African catfish *Clarias gariepinus*. *Pakistan Journal of Zoology*.
- AOAC (Association of Official Analytical Chemists). (2024). *Official Methods of Analysis of AOAC International* (18th ed.). AOAC International.
- Apines, M. J. S., Satoh, S., Kiron, V., Watanabe, T., and Fujita, S. (2001). Availability of supplemental amino acid-chelated trace elements in diets containing tricalcium phosphate and phytate to rainbow trout, *Oncorhynchus mykiss*. *Aquaculture*, 225(1-4), 431-444.
- Bethke, E., Bernreuther, M. and Tallman, R. (2013). Feed efficiency versus feed conversion ratio demonstrated on feeding experiments with juvenile cod (*Gadus morhua*). SSRN product and services. <http://www.zbw.eu/econisarchiv/bitstream/111159/196738/1/EBPO849756870.pdf> Accessed July 27, 2023.
- De Silva, S. S., and Davy, F. B. (2010). Success stories in Asian aquaculture: Case studies from Bangladesh, China, India, Indonesia, Malaysia, Philippines, Thailand, and Vietnam. *Aquaculture*, 302(1), 1-18.
- FAO (Food and Agriculture Organization). (2022). *The State of World Fisheries and Aquaculture 2022: Towards Blue Transformation*. FAO.
- Fazio, F. (2019). Fish hematology analysis as an important tool of aquaculture: A review. *Aquaculture*, 500, 237–242. <https://doi.org/10.1016/j.aquaculture.2018.10.030>.
- Gbadamosi, O.K., Oke, O.P. and Olayeni, T.S. (2022). Effect of African basil (*Ocimum gratissimum*) on orexigenic factors and zootechnical parameters of African catfish (*Clarias gariepinus*). *International Journal of Recent Research in Life Sciences (IJRRLS)*. 9(3): 1-8.
- Gbadamosi O.K., and Alao, F.O. (2025). Dietary African Yam Bean Meal (*Sphenostylis sternocarpa*) as a Complementary Substitute for Soybean Meal in African Catfish (*Clarias gariepinus*) Fingerlings: Effect on Intestinal Histology and Zootechnical Performance. *Asian Journal of Fisheries and Aquatic Research* 27(2):29-39. DOI:10.9734/ajfar/2025/v27i2878

- Gbadamosi, O.K. and Oke, P (2024) Effects of Composite Algal Supplementation (*Spirulina platensis* and *Phaeodactylum tricornutum*) on the Zoo-Technical Performance and Health Parameters of African Catfish (*Clarias gariepinus*). Journal of Association of Nigerian Fisheries Scientists Vol. 5 No. 1.
- Glencross, B. (2024). SWOT analysis of marine, grain, terrestrial-animal and novel protein ingredients in aquaculture feeds. Aquaculture Economics and Management.
- Hoseinifar, S. H., Sun, Y. Z., Wang, A., and Zhou, Z. (2020). Probiotics as means of diseases control in aquaculture, a review of current knowledge and future perspectives. Frontiers in Microbiology, 11, 1363. <https://doi.org/10.3389/fmicb.2020.01363>.
- Kishawy, A. T., Sewid, A. H., Nada, H. S., Kamel, M. A., El-Mandrawy, S. A., Abdelwahab, A. M., and El-Murr, A. E. (2020). Comparing the effect of diet supplementation with different zinc sources and levels on growth performance, immune response and antioxidant activity of tilapia, *Oreochromis niloticus*. Aquaculture Nutrition, 26(6), 1981-1994.
- Kong, D.-H., Zhang, C., Wang, X., Zhang, Y., and Liu, B. (2024). Effects of hydroxy-methionine zinc on growth performance, antioxidant capacity, and immune responses in fish. Aquaculture Reports, 34, 101017. <https://doi.org/10.1016/j.aqrep.2023.101017>.
- Liang, J. J., Yang, H. J., Liu, Y. J., Tian, L. X., and Liang, G. Y. (2012). Comparison of chelated zinc and zinc sulfate as zinc sources for growth and immune response of shrimp (*Litopenaeus vannamei*). Aquaculture, 406, 79-84.
- Luo, L., & Xue, M. (2023). Methionine in fish health and nutrition: Potential mechanisms, affecting factors, and future perspectives. Aquaculture, 565, 739111.
- Martínez-Álvarez et al., Y., Li, X., Liu, G., Bin, P., Yan, W., Más, D., and Yin, Y. (2021). The role of methionine on metabolism, oxidative stress, and diseases. Amino Acids, 49(12), 2091-2098.
- Mbokane, E. M., Van Wyk, J. H., and Gerber, R. (2022). A review of factors affecting feed intake, growth performance and feed conversion efficiency in African catfish (*Clarias gariepinus*). Aquaculture Research, 53(4), 1398-1420.
- Naylor, R. L., Hardy, R. W., Buschmann, A. H., Bush, S. R., Cao, L., Klinger, D. H., and Troell, M. (2021). A 20-year retrospective review of global aquaculture. Nature, 591(7851), 551-563.
- Olaniyi, C. O., Akegbejo-Samsons, Y., and Komolafe, O. O. (2020). Hematological responses of African catfish (*Clarias gariepinus*) to dietary supplementation with Moringa seed meal. Egyptian Journal of Aquatic Biology and Fisheries, 24(5), 55-67. <https://doi.org/10.21608/ejabf.2020.107366>.
- Paripatananont, T., & Lovell, R. T. (1995). Chelated zinc reduces cataracts in channel catfish. Journal of Aquatic Animal Health, 7(3), 248-254.
- Pérez-Sánchez, J., Benedito-Palos, L., Estensoro, I., Petropoulos, Y., Calduch-Giner, J. A., Browdy, C. L., & Sitjà-Bobadilla, A. (2015). Effects of dietary NEXT ENHANCE®150 on growth performance and expression of immune and intestinal integrity related genes in gilthead sea bream (*Sparus aurata* L.). Fish & Shellfish Immunology, 44(1), 117-128.
- Ranzani-Paiva, M. J. T., Ishikawa, C. M., and Eiras, J. C. (2015). Hematological parameters as indicators of fish health. Brazilian Journal of Veterinary Research and

- Animal Science, 52(2), 140–147. <https://doi.org/10.11606/issn.2318-3659.v52i2p140-147>.
- Smith, M. K., Brauner, C. J., Tollefsen, K. E., Kroglund, F., Lierhagen, S., Olsvik, P. A., & Teien, H. C. (2010). Effects of dietary zinc deficiency on the immune system and disease resistance in rainbow trout (*Oncorhynchus mykiss*). *Fish & Shellfish Immunology*, 29(6), 1013-1021.
- Svobodova, Z., Pravda, D., and Palackova, J. (1991). Unified Methods of Haematological Examination of Fish. Research Institute of Fish Culture and Hydrobiology. 31 pp.
- Watanabe, T. (2002). Strategies for further development of aquatic feeds. *Fisheries Science*, 68(2), 242-252.
- Xu, Y.-C., Li, S., Zhang, Y., & Chen, L. (2023). Effects of different dietary zinc sources on growth performance, antioxidant status and nutritional physiology in fish: A review. *Aquaculture Research*, 54(12), 7123–7136. <https://doi.org/10.1111/are.16528>.
- Yarahmadi, P., Farahmand, H., and Katouli, M. (2016). Dietary supplementation of immunostimulants enhances hematological and immune responses in rainbow trout. *Fish and Shellfish Immunology*, 56, 436–444. <https://doi.org/10.1016/j.fsi.2016.07.027>.

How to Cite: Gbadamosi, O.K. 2026. Dietary effects of Zinc-L-Methionine supplementation on the growth, nutritional performance and haematology of African Catfish *Clarias gariepinus* (Burchell 1822). *Journal of Fisheries and Zoological Sciences*, 1(1), 1-13.