



Research Paper

Effects of dietary inclusion of *Saccharomyces cerevisiae* and Vitamin C on Growth Performance and Haematological Profile of *Clarias garipinus* Fingerlings

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Abstract

This study investigated the effects of dietary inclusion of *Saccharomyces cerevisiae* (probiotic) and Vitamin C (ascorbic acid) on the survival, growth performance and hematological profile of *Clarias gariepinus* fingerlings. A total of 240 fingerlings with mean initial weight (11.11–11.15 g) and length (7.13–7.37 cm) were randomly distributed into twelve tanks at 20 fish per tank, comprising four dietary treatments (T0, T1, T2, T3) in triplicate. The control diet (T0) contained no supplements, while T1, T2, and T3 were supplemented with graded levels of *S. cerevisiae* and Vitamin C at 1 g, 2 g, and 3 g per kg of diet, respectively. Fish were fed to satiation twice daily for 13 weeks. Survival rate, growth parameters and nutrient utilization indices were evaluated using standard methods. Survival rate increased progressively from 80% (T0) to 93.33% (T3). Results showed significant improvements ($P < 0.05$) in growth performance with increasing supplementation levels. The highest final weight (724.70 g), weight gain (713.56 g), specific growth rate (3.28%), and best feed conversion ratio (2.29) were recorded in T3. Hematological analysis revealed significantly higher ($P < 0.05$) values in supplemented groups compared to control. Red blood cell count was highest in T1 ($2.306 \times 10^3/\mu\text{L}$), white blood cell count peaked in T1 ($74.01 \times 10^3/\mu\text{L}$), while hemoglobin concentration showed a dose-dependent increase, with T3 recording the highest value (16.67 g/dL). Packed cell volume followed a similar trend with T1 (52.01%) being highest. The findings demonstrate that combined dietary inclusion of *Saccharomyces cerevisiae* and Vitamin C, particularly at 3 g/kg (T3), synergistically enhances growth performance, survival, and hematological health of *Clarias gariepinus* fingerlings. The study recommends dietary supplementation at 3 g/kg for optimal production outcomes in African catfish in aquaculture.

1. Introduction

Aquaculture has emerged as the world's fastest-growing food production sector, playing an increasingly vital role in global food security and nutrition (FAO, 2025). As the global population continues to expand, aquatic food supply chains must increase production by approximately 22% by 2050 to meet projected demand, with aquaculture expected to supply the majority of this increase (SIANI, 2024). The sector provides food, income, and livelihoods for millions of people worldwide, particularly in regions where hunger and poverty remain persistent challenges (ICSF, 2025).

The African catfish (*Clarias gariepinus*) is a highly valued species in global aquaculture due to its fast growth rate, hardiness, and tolerance to a wide range of environmental conditions (Fagbenro et al., 2020). However, intensive farming practices expose fish to various stressors, including poor water quality, high stocking densities, and suboptimal nutrition, which can

compromise their immune function, growth performance, and overall health (Adeoye et al., 2019). Consequently, there is a growing research and industry focus on functional feed additives that can enhance growth, boost disease resistance, and improve physiological well-being without relying on antibiotics.

Among the most promising categories of feed additives are probiotics and immunostimulants. The probiotic yeast *Saccharomyces cerevisiae* has been extensively studied for its beneficial effects in aquaculture. Its mode of action includes competitive exclusion of pathogens, improvement of gut morphology and microbiota balance, secretion of digestive enzymes, and enhancement of nutrient absorption (Lara-Flores et al., 2019). Studies on various fish species, including Nile tilapia and rainbow trout, have reported that dietary supplementation with *S. cerevisiae* can lead to significant improvements in growth parameters such as final weight, weight gain, and feed conversion ratio (FCR) (Tovar-Ramírez et al., 2020).

Simultaneously, vitamin C (ascorbic acid) is a potent

antioxidant and essential micronutrient that fish cannot synthesize de novo. It plays a crucial role in collagen synthesis, iron absorption, and, most importantly, in modulating the immune system by scavenging free radicals produced during stress and metabolic processes (Lim & Webster, 2022). Vitamin C deficiency is linked to reduced growth, spinal deformities, and increased susceptibility to diseases. Supplementation has been shown to enhance both specific and non-specific immune responses, including lysozyme activity and phagocytosis, thereby improving hematological profiles and survival rates after challenge tests (Deng et al., 2021).

While the individual benefits of *S. cerevisiae* and vitamin C are well-documented in aquaculture, there is a paucity of information on their combined or synergistic effects, particularly in *Clarias gariepinus* fingerlings, a critical life stage where optimal growth and health set the foundation for successful production. Hematological parameters, such as red blood cell count, hemoglobin concentration, and differential white blood cell counts, serve as vital biomarkers for assessing the physiological and health status of fish (Fazio, 2019). The study aims to investigate the impact of varying inclusion levels of *Sacchromyces cerevisiae* and vitamin C on the survival, growth performance and hematological profile of *Clarias gariepinus* fingerlings.

2. Material and Methods

2.1 Study Area

The study was conducted at the Department of Animal health and Production Technology, School of Agricultural Technology, Federal polytechnic Daura, located in Katsina State, Nigeria. Federal polytechnic Daura is located in Daura, a city in Katsina state, Nigeria. The approximated latitude and longitude of Federal polytechnic Daura are 13.5°N and 8.3°E.

2.2 Sample collection and preparation

A total of 240 *Clarias gariepinus* fingerlings were obtained from Kaduna State Nigeria. The fish were transported in a twenty five liters (25) half-filled plastic Jeri can with water. The fish was acclimatized for two week in three nursery ponds at the rate of 80 fish per pond, after which they fed with 44% crude protein diets.

2.3 Source of feed ingredients

The feed ingredients such as Fish meal, Soybean meal, Maize, meal, guinea corn, Vitamin and Mineral premixes, probiotics (*Sacchromyces cerevisiae*) and vitamin c (ascorbic acid) were purchased from the railway station market, Kaduna State, Nigeria.

2.4 Diet formulation and production

Feed was formulated using Pearson's square method; four isonitrogenous contained 44% crude protein diets at 0g (T1), 1g (T2), 2g (T3), and 3g (T4) supplementation levels (Table 1). The diets formed were pelleted using a pelleting machine after weighing appropriately and thorough mixing of the ingredients.

2.5 Experimental design

A complete randomized block design was employed for the feeding trial. Two hundred and forty (240) *Clarias gariepinus* fingerlings of uniform size and weighed. Twenty *Clarias gariepinus* fingerlings were evenly distributed in each of the twelve plastic tanks. The daily feeding was done by hand at 5% of the cumulative body weight of the fish. Daily ration was divided into two feedings per day (09:00am and 05:00pm) and the fingerlings were weighed weekly so as to adjust the feed by virtue of weight gained, uneaten feeds together with fecal residues in the ponds were siphoned out every day before feeding. An electronic digital scale was used to measure weights of fish per week. The experiment was terminated for thirteen weeks (13 weeks). Water was changed every week during experimental period. Borehole was the water source for the experiment, and dissolved oxygen PH, temperature and other water quality parameters were maintained during experimental period.

2.6 Growth Performance

Survival Rate= (Number of Harvested Fishes)/(Number of Stocked Fishes)× 100 (%)

Mortality= (No× Ni)/No× 100 (%)

Therefore, NI and NO denote the number of the fishes at the beginning and the end of the experiment respectively.

Weight gain: Weight gain was determined the difference between the final weight and initial weight of the experimental fish (Ayool et al., 2012).

Weight gain = Final weight - Initial weight.

Length gain = final length – initial length (cm)

Daily weight Increase (DWI)= (Weight Gain)/(Experimental Period)

Daily length increase (DLI)= (Length Gain)/(Experimental Period)

Percentage Weight Gain

% weight gain = (Final weight-Initial weight)/(Initial weight) ×100

Specific Growth Rate: It is the percentage rate of change in the logarithmic body weight

$$\text{Specific Growth Rate (\%/day)} = (\log(wt_2) - \log(wt_1)) / (t_2 - t_1)$$

Where Wt1= Initial weight gain, Wt2= Final weight gain
T2-T1= Duration (in days) considered between WT2 and WT1

Feed Conversion Ratio: This was calculate using the formula

$$\text{FCR} = (\text{Feed fed}) / (\text{Fish weight gain})$$

Protein Efficiency Ratio: It was calculated from the relationship between the increment in the weight of fish (i.e weight gain of fish) and protein consumed.

$$\text{PER} = (\text{Mean weight gain}) / (\text{Protein intake})$$

Protein Intake: PI = Feed intake × % of protein in diet

2.7 Hematology

Blood samples were from the experimental fishes at 90 day of the experiment. The blood samples were collected from the caudal peduncle with the aid of a 2 ml plastic syringe caudal vein using 5ml ethylene diamine tetra acetate (EDTA) as anticoagulant (Santiago et al., 2007). Blood, 2.0 ml, was decanted in heparinized bottles for determination of blood parameters. A compact Sysmex KX-21 was use to run the samples in whole blood mode and pre-dilute mode. The hematological parameters to be analyzed include:

Red Blood Cell (RBC) Count: This was measured using a hemocytometer or an automated blood cell counter (Herbert et al., 2010). The RBC count is an indicator of the fish's oxygen-carrying capacity.

White Blood Cell (WBC) Count: WBC counts are critical for assessing the immune response. This was done using the same methods as RBC counting (Wright et al., 2012). An increase in WBC count may indicate infection or inflammation.

Hemoglobin (Hb) Concentration: Hemoglobin levels are typically measured by a colorimetric method using spectrophotometers (Herbert et al., 2010). The concentration of hemoglobin reflects the oxygen-carrying capacity of the blood.

Hematocrit (Hct) or pack cell volume (PVC): Hematocrit levels indicate the proportion of blood volume occupied by RBCs. This was measured using a microhematocrit centrifuge or automated analyzers (Haro et al., 2013).

2.8 Statistical Analysis

The determinations were made in triplicate, parameters obtained were subjected to one way

analysis of variance (ANOVA) and, the treatment means was separated for significant differences following the procedure of Duncan Multiple Range Test (Steel and Torrie, 1980). All the analysis was carried out using the computer software Statistical Package for the Social Sciences (SPSS) version 20.0 windows (SPSS, 2013).

3. Results

3.1 Survival and growth performance indices of *Clarias gariepinus* fingerlings fed diets

Table 2, illustrates the survival, growth performance, and nutrient utilization and of *Clarias gariepinus* fingerlings fed diets with varying inclusions of *Saccharomyces cerevisiae* and Vitamin C over a specific experimental period. There were no significant differences ($P > 0.05$) in average initial weight and length among treatments. This indicates uniformity in stocking and confirms that subsequent variations in growth performance were due to dietary treatments rather than initial size differences. Survival and mortality rate, Survival rate improved progressively from 80.00% (T0) to 93.33% (T3), while mortality decreased from 20.00% (T0) to 6.67% (T3). This indicates enhanced disease resistance and stress tolerance in supplemented fish.

Average final weight and body weight gain increased significantly ($P < 0.05$) with increasing inclusion levels of *S. cerevisiae* probiotic and Vitamin C. The highest values were recorded in T3 (724.70 g final weight; 713.56 g weight gain), followed by T2 and T1 while the control (T0) had the lowest values. This shows a clear positive response of African catfish to dietary supplementation. A significant progressive increase ($P < 0.05$) in final length and length gain was observed from T0 to T3. Fish in T3 recorded the highest final length (46.17 cm) and length gain (39.04 cm), followed by T2, T1, and T0 indicating improved skeletal and muscular development. Daily weight increase and daily length increase were significantly higher ($P < 0.05$) in T2 and T3 compared to T0 and T1.

3.2 Hematological Parameters

The hematological parameters of *Clarias gariepinus* fingerlings fed diets supplemented with varying levels of *Saccharomyces cerevisiae* and Vitamin C are presented in Table 3. The Red Blood Cell count, which reflects the oxygen-carrying capacity of the blood, was significantly influenced by the dietary treatments. The lowest RBC count ($1.373 \pm 0.696 \times 10^6/\mu\text{L}$) was recorded in the control group (T0), while all supplemented groups (T1, T2, and T3) showed significantly higher values. Interestingly, the highest RBC count was observed in T1 ($2.306 \pm 0.002 \times 10^6/\mu\text{L}$), followed by T2 ($1.998 \pm 0.008 \times 10^6/\mu\text{L}$) and then T3 ($1.726 \pm 0.107 \times 10^6/\mu\text{L}$).

White Blood Cells are a cornerstone of the immune system, and their count is a direct indicator of the immunostimulatory potential of a dietary component.

Table 1: Formulation and proximate composition of the diets

Ingredients	Diets (inclusion levels) %			
	T1	T2	T3	T4
Fish meal	26.39	26.39	26.39	26.39
Soya bean meal	26.39	26.39	26.39	26.39
Groundnut cake	26.39	26.39	26.39	26.39
Maize	9.66	9.66	9.66	9.66
Guinea corn	9.66	9.66	9.66	9.66
Salt	0.50	0.50	0.50	0.50
Vitamin premix	1.00	1.00	1.00	1.00
Total	100	100	100	100
<i>Sacchromyces cerevisiae</i> inclusion	0.0g	1g	2g	3g
Vitamin c inclusion	0.0mg	1.0g	2.0g	3.0g
Determined Analysis				
Crude protein	43.57	43.57	44.57	43.57
Crude lipid	5.63	5.63	5.63	5.63
Crude fiber	4.32	4.32	4.32	4.32
Ash	10.55	10.55	10.55	10.55
Moisture	7.20	7.20	7.20	7.20
Nitrogen Free Extract (NFE)	34.35	34.35	34.35	34.35

Table 2: Survival and growth performance indices of *Clarias gariepinus* fed diets

Parameters	Diets (inclusion levels) %			
	T0 (0%)	T1 (%)	T2 (%)	T3 (%)
Initial fish number	60	60	60	60
Mortality Rate (%)	0.00	14.00	10.00	6.67
Survival Rate (%)	80.00	86.00	90.00	93.33
Average Initial Weight (g)	11.11±0.68 ^a	11.15±0.15 ^a	11.13±0.43 ^a	11.14±0.30 ^a
Average Final Weight (g)	567.40±1.76 ^d	640.63±5.33 ^c	720.10±2.65 ^b	724.70±2.52 ^a
Average Initial Length (cm)	7.37±0.22	7.37±0.34	7.30±0.32	7.13±0.35
Average Final Length (cm)	30.87±0.24 ^d	35.33±1.25 ^c	40.83±1.33 ^b	46.17±1.07 ^a
Body Weight Gain (g)	556.29±1.18 ^d	629.50±5.24 ^c	708.97±2.52 ^b	713.56±2.42 ^a
Length Gain (cm)	23.50±0.02 ^d	27.96±0.91 ^c	33.50±1.01 ^b	39.04±0.72 ^a
Daily Weight Increase (g)	6.18±0.93 ^c	6.99±0.74 ^b	7.88±0.56 ^a	7.93±0.23 ^a
Daily Length Increase (cm)	0.26±0.19 ^b	0.31±0.08 ^b	0.37±0.04 ^a	0.433±0.01 ^a
Specific Growth Rate (%)	3.10±0.03 ^c	3.21±0.07 ^b	3.27±0.39 ^a	3.28±0.79 ^a
Feed Conversion Ratio (g)	2.46±0.01 ^b	2.48±0.03 ^a	2.30±0.91 ^c	2.29±0.99 ^c
Protein Efficiency Ratio	114.75±1.22 ^d	129.81±1.43 ^c	145.34±1.64 ^b	146.06±1.69 ^a

Table 3: Hematological parameters of *Clarias gariepinus* fingerlings fed with diets of different levels of *Sacchromyces cerevisiae* probiotics and Vitamin C.

Parameters	T ₀	T ₁	T ₂	T ₃
RBC (10 ⁶ μ/L)	1.373 ± 0.696 ^a	2.306 ± 0.002 ^d	1.998 ± 0.008 ^c	1.726 ± 0.107 ^b
WBC (10 ³ μ/L)	42.02 ± 0.009 ^a	74.01 ± 0.003 ^d	69.22 ± 0.063 ^c	59.52 ± 0.058 ^b
PCV (%)	35.60 ± 0.153 ^a	52.01 ± 0.003 ^d	46.01 ± 0.000 ^c	40.90 ± 0.058 ^b
HGB (g/dL)	12.13 ± 0.067 ^a	13.72 ± 0.003 ^b	15.61 ± 0.006 ^c	16.67 ± 0.032 ^d

The WBC count followed a similar trend to RBCs, with all treated groups exhibiting significantly higher ($p < 0.05$) counts than the control ($42.02 \pm 0.009 \times 10^3/\mu\text{L}$). The highest WBC count was also found in T1 ($74.01 \pm 0.003 \times 10^3/\mu\text{L}$), followed closely by T2 ($69.22 \pm 0.063 \times 10^3/\mu\text{L}$) and T3 ($59.52 \pm 0.058 \times 10^3/\mu\text{L}$).

PCV measures the proportion of blood volume occupied by red blood cells, and it is closely related to the RBC count. The PCV values were significantly higher in all treatment groups compared to the control ($35.60 \pm 0.153\%$). The highest PCV was recorded in T1 ($52.01 \pm 0.003\%$), decreasing progressively in T2 ($46.01 \pm 0.000\%$) and T3 ($40.90 \pm 0.058\%$). Hemoglobin concentration, however, showed a distinct and crucial pattern. Unlike RBC and PCV, the HGB concentration increased consistently and significantly ($p < 0.05$) with increasing levels of dietary supplementation. The highest HGB value ($16.67 \pm 0.032 \text{ g/dL}$) was observed in T3, followed by T2 ($15.61 \pm 0.006 \text{ g/dL}$), T1 ($13.72 \pm 0.003 \text{ g/dL}$), and the lowest in T0 ($12.13 \pm 0.067 \text{ g/dL}$).

3.3 Water quality Parameters

Table 4, showed the mean values of key physico-chemical parameters of the water recorded during the feeding trial. The stability of water quality is crucial in aquaculture experiments, as fluctuations can induce stress in fish, potentially confounding the effects of the dietary treatments. The parameters measured include Dissolved Oxygen (D.O), pH, Ammonia (NH_3), Temperature, and Alkalinity. All values within each row share the same superscript letter (a), indicating that there were no statistically significant differences ($p > 0.05$) among the treatment groups (T0, T1, T2, and T3) for any of the measured parameters.

The mean dissolved oxygen levels across all treatments were relatively stable, ranging from $4.867 \pm 0.667 \text{ mg/l}$ to $5.533 \pm 0.667 \text{ mg/l}$. The statistical analysis confirms that there was no significant difference in D.O between any of the treatment groups. The mean pH values were highly consistent, ranging from 6.567 ± 0.067 to 6.700 ± 0.058 , with no significant differences between treatments.

The mean ammonia levels were uniform across all groups, with T0, T2, and T3 recording $8.230 \pm 0.590 \text{ mg/l}$ and T1 recording $7.640 \pm 0.590 \text{ mg/l}$. Statistically, all treatments were similar. Water temperature was maintained very consistently, with mean values between $25.67 \pm 1.202^\circ\text{C}$ and $26.33 \pm 0.333^\circ\text{C}$. No significant differences were observed among treatments. Total alkalinity was remarkably stable, with all treatments exhibiting a mean value of $23.33 \pm 3.333 \text{ mg/l}$ and no significant differences.

4. Discussions

Blood indices are critical indicators of the physiological and health status of fish, providing valuable

information on their response to dietary manipulations and environmental conditions (Fagbenro et al., 2013). The results obtained in this study showed significant differences ($p < 0.05$) across all treatment groups for the parameters assessed, indicating a marked influence of the dietary supplements on the hematology of the fish. The increase in RBC count in the supplemented groups, particularly T1, suggests that the combination of *S. cerevisiae* and Vitamin C stimulated erythropoiesis (the production of red blood cells). This could be attributed to the role of Vitamin C in enhancing iron absorption and metabolism, which is essential for hemoglobin synthesis and red blood cell formation (Kori-Siakpere & Ubogu, 2008). Furthermore, the β -glucans in *S. cerevisiae* may have contributed to an improved overall health status, indirectly supporting hematopoietic activity. The subsequent decrease in RBC count from T1 to T3, while still being higher than the control, might indicate a dose-dependent regulatory mechanism, where excessively high levels of supplements could modulate the response to maintain physiological balance.

This marked increase in leukocytes in fish fed supplemented diets provides strong evidence of the immunostimulatory properties of both *S. cerevisiae* and Vitamin C. *S. cerevisiae* is rich in β -glucans and other immunogenic compounds that can activate macrophages and increase the proliferation of leukocytes (Sakai, 1999). Similarly, Vitamin C is a well-known immunomodulator that supports various immune cell functions, including the activity of phagocytes and lymphocytes (Verlhac et al., 1996). The elevated WBC levels in T1, T2, and T3 suggest that these fish had a heightened state of immune readiness, which likely contributed to the reduced mortality rates observed in Table 3. The slight reduction in WBC count at higher inclusion levels (T2 and T3) compared to T1 might suggest an optimal level for maximum leukocyte proliferation, beyond which the response stabilizes or is regulated. This pattern directly mirrors the RBC count, confirming that the increase in red cell mass was responsible for the higher PCV in the supplemented groups. The elevated PCV in treated fish indicates a better oxygen-carrying capacity, which can enhance aerobic metabolism and support the higher growth rates observed in these groups (Table 3). This is a particularly important finding. It suggests that while the number of red blood cells was highest in T1, the hemoglobin content per cell (and thus the oxygen-carrying capacity per cell) was highest in T3. This indicates that the highest inclusion level of *S. cerevisiae* and Vitamin C (T3) was most effective at enhancing the quality of the red blood cells. Vitamin C is a direct cofactor in hemoglobin synthesis and also protects red blood cells from oxidative damage, ensuring they function optimally (Faggio et al., 2014). The significantly higher HGB in T3 provides a physiological basis for the superior growth performance (final weight, SGR) also recorded in this group, as efficient oxygen transport is fundamental for metabolic processes driving growth.

Table 4: Mean value of physico-chemical of water during experiment

Parameters	T ₀	T ₁	T ₂	T ₃
D.O (mg/l)	5.533 ± 0.667 ^a	4.867 ± 0.667 ^a	5.533 ± 0.667 ^a	4.867 ± 0.667 ^a
PH (mg/l)	6.567 ± 0.067 ^a	6.567 ± 0.120 ^a	6.700 ± 0.058 ^a	6.567 ± 0.120 ^a
NH ₃ (mg/l)	8.230 ± 0.590 ^a	7.640 ± 0.590 ^a	8.230 ± 0.590 ^a	8.230 ± 0.590 ^a
Temp (°C)	26.00 ± 0.577 ^a	25.67 ± 1.202 ^a	26.00 ± 0.577 ^a	26.33 ± 0.333 ^a
Alkalinity (mg/l)	23.33 ± 3.333 ^a	23.33 ± 3.333 ^a	23.33 ± 3.333 ^a	23.33 ± 3.333 ^a

Values within each row not sharing a common superscript letter are significantly different. Data are means ± Standard Error (SE) of triplicate tanks

This uniformity is a critical finding, as it confirms that the observed differences in performance indices and haematological profile of the *Clarias gariepinus* fingerlings can be attributed primarily to the varying dietary inclusions of *Saccharomyces cerevisiae* and Vitamin C, rather than to variations in their environment.

Dissolved oxygen is a critical limiting factor in aquatic systems, essential for respiration and overall metabolism. The recorded D.O values in all treatments are within the acceptable range for tropical fish culture and specifically for *Clarias gariepinus*, which is known for its air-breathing ability but still requires adequate dissolved oxygen for optimal growth (Boyd & Tucker, 2012). Levels consistently above 3 mg/l are generally considered suitable for warm-water fish. The stability of D.O across treatments suggests that the fish biomass and feeding rates did not differentially impact the oxygen demand in the tanks. This finding aligns with studies where dietary supplements like probiotics and vitamins do not directly alter environmental D.O, provided that stocking density and water management are consistent (Emerenciano et al., 2013). pH is a measure of the water's acidity or alkalinity and significantly influences biological processes and the toxicity of other compounds like ammonia. The recorded pH range of 6.5 to 6.7 is considered near-neutral and falls within the optimal range (6.5 – 9.0) recommended for freshwater fish production (Boyd, 2015). This stability indicates that the metabolic waste products (like CO₂) from the fish and any residual feed did not lead to differential acidification of the water among the treatment groups. Similar stability in pH has been reported in studies evaluating the impact of dietary additives on water quality, reinforcing that the treatments themselves did not alter this parameter (Abdel-Tawwab et al., 2008).

Ammonia is the primary nitrogenous waste product of fish and is highly toxic, even at low concentrations. Elevated levels can damage gills, impair osmoregulation, and reduce growth. The values recorded appear relatively high. However, it is crucial to note that the table likely reports total ammonia nitrogen (TAN), of which the toxic fraction (un-ionized

ammonia, NH₃) is dependent on pH and temperature. Given the pH (6.6) and temperature (26°C) in this study, the toxic fraction would be minimal (Emerson et al., 1975). The lack of significant differences in ammonia levels is important; it suggests that the different diets did not result in significantly different rates of nitrogen excretion. This could imply that the protein utilization efficiency was similar across treatments, or that the system's biofiltration capacity was sufficient to process any differential output, maintaining equilibrium (Lazzari & Baldisserotto, 2008). Temperature is a master factor in aquaculture, governing metabolic rate, feed intake, and growth. *Clarias gariepinus* is a tropical species that thrives in warm water, with an optimal temperature range of 26-30°C (FAO, 2023).

Alkalinity refers to the buffering capacity of the water, primarily imparted by bicarbonates and carbonates. It resists drastic changes in pH, making the aquatic environment more stable. The recorded value of 23 mg/l (CaCO₃) is considered low to moderate but is generally acceptable for warm-water fish culture, as long as pH remains stable (Wurts & Durborow, 1992). The high uniformity across all treatments confirms that the buffering capacity of the water was the same for all experimental units. This finding is expected, as alkalinity is a function of the source water and its interaction with the system, rather than the dietary treatments (Boyd, 2015).

5. Conclusion

Based on the findings of this study, it can be concluded that dietary inclusion of *Saccharomyces cerevisiae* probiotic and Vitamin C significantly enhances the growth performance, feed efficiency, survival rate, and hematological status of *Clarias gariepinus* fingerlings. The improved growth indices (final weight, SGR, PER) and reduced FCR indicate enhanced nutrient digestibility and metabolic efficiency. Therefore, dietary supplementation of *Saccharomyces cerevisiae* and Vitamin C can serve as an effective, eco-friendly nutritional strategy to improve productivity and fish health in African catfish culture. Hematological parameters (RBC, WBC, PCV, and HGB) were

significantly influenced by dietary treatments. RBC, WBC, and PCV peaked at moderate supplementation (T1), while Hemoglobin concentration increased progressively and was highest in T3.

6. Statement of Declarations

Conflict of Interest: The authors in this article declare that they have no known competing financial interests or personal relationship that could have appeared to influence the work reported in this article.

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