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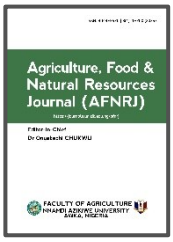

Original Article

Growth performance and nutrient utilization of *Clarias gariepinus* juvenile fed supplemented diet of Ginger and Garlic

OPEN ACCESS

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ABSTRACT

This study assessed the effects of dietary supplementation of the combination of Garlic (Allium sativum) and Ginger (Zingiber officinale) powders on growth performance, nutrient utilization, and survival of Clarias gariepinus juveniles. Thus, 180 juveniles were randomly divided in triplicate into four treatments. In treatment 1, juveniles were fed with the control diet, while in treatments 2 and 3, they were fed a diet containing equal quantities of ginger and garlic to give the final proportions of 1% each; for treatment 4, a mixture of ginger and garlic was fed at 1%. Feeding trials were carried out for 56 days during which juveniles were fed twice daily at the rate of 5% of their body weight. Fish sampling was done every 14 days, during which juveniles per treatment were counted and measurements taken on a representative sample. The results obtained indicate that statistically the treatments are all the same. Treatment 3 recorded the lowest mean weight gain value of 4.27±1.00g, although this was statistically similar to the remaining treatments 1, 2, and 4 ($p>0.05$). A peak mean weight gain value of 7.03±1.67g was recorded in treatment 2, which was non-significantly different from other treatments. Treatment 3 also recorded the lowest percentage weight gain of 215.99±35.54, which was statistically non-significant ($p>0.05$). The highest value of 257.46±38.04 was observed in treatment 1. The feed conversion ratio values in all the treatments were statistically similar ($p>0.05$); however, the lowest value of 0.74±0.15 was recorded in treatment 2, and the highest value of 1.30±0.34 was recorded in treatment 3. water parameters were registered at 2-week intervals; the result obtained are within the recommended range for aquaculture

KEYWORDS: *Additives, Feed conversion ratio, Fish, Juveniles,*

INTRODUCTION

Fish is an important and cheapest source of animal protein it accounts for about 37% of Nigeria's total protein requirement (Federal Department of Fisheries (FDF), 2002). *Clarias gariepinus* exhibits numerous advantageous characteristics for cultivation such as rapid growth, good survival in high density culture, tolerance to low oxygen levels as well as pH fluctuations, and resistance to diseases (Beingana *et al.,* 2016). It however requires high quality feeds with high protein content and some additives or dietary supplements to keep fish healthy and to enhanced growth (Adegbesan *et al.,* 2019; Sayed *et al.,* 2011). Phytogenic feed additives, also called phytobiotic products are natural biodegradable products of plant origin whose integration in the diets of several fish species improves performances through amelioration of feed properties, promotion of production performances and improving the quality of the product intended for the final (Olaniyi *et al.,* 2020).

Garlic (*Allium sativum L.*), used as spice and in traditional medicine since ages, garlic belong to family Liliaceae. It is the

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most dominant organ sulphur component present in garlic that actively kills parasites and pathogenic bacteria and has been found to regulate oxidative stress and immune responses by enhancing immuno- competence, improving gastrointestinal motility and modulating the secretion of various enzymes to improve digestion and nutrient absorption. It also improves digestion by promoting the performance of the intestinal flora, thereby enhancing the utilization of energy and improving growth (Ansal, 2020; Khalil *et al.,* 2001).

Ginger (*Zingiber officinale*), a flowering plant whose rhizome is frequently used as spice and flavouring agent, belongs to the family Zingiberaceae (Akram *et al.,* 2011). It contains compounds such as alkaloids, flavonoids, polyphenols, saponin, steroids, tannin, fiber, carbohydrate, vitamins, carotenoids and minerals (Abayomi *et al.,* 2018; Otunola *et al.,* 2010) and natural antioxidants as gingerols, shogaols and zingerone (Hori *et al.,* 2003). Ginger is reported antiplatelet, antibacterial, antifungal, antiviral, antiworm, anti-inflammatory, antihyperglycemic, antilipidemic, anti-oxidative activity and is also known to be effective as an immuno-modulatory agent in human and animals, including fish (Ghadikolaei *et al.,* 2016). Supplementing ginger in fish diets has been reported to enhance growth, survival and body composition (Ghadikolaei *et al.,* 2017; Iheanacho *et al.,* 2018).

Moreover, Ginger contains alkaloids, flavonoids, polyphenols, saponin, steroids, tannin, fiber, carbohydrate, vitamins, carotenoids and minerals (Otunola *et al.,* 2010).

MATERIALS AND METHOD

Study Location

The study was conducted at hatchery complex Fisheries and Aquaculture Department, Faculty of Agriculture, Federal University Dutse, Jigawa State, Nigeria. Located on latitudes 11° 70' North and longitude 9° 33' East and altitude of 431m above sea level (Elevation-map, 2019).

Experimental Fish

One hundred and eighty (180) juveniles of *Clarias gariepinus* was procured from A4 Global Fisheries Kano State, and transported to the hatchery complex of Fisheries and Aquaculture, Federal University Dutse in 50L Jerry cans and acclimatized for one week (7 days) in plastic tank 300 liters. After the acclimatization, the fish were fed ginger (*Zingiber officinale) and* garlic (*Allium sativum)* meal control from the experimental diet. Fish was starved for 24 hours before the commencement of the feeding trial.

Experimental Design

A Completely Randomized Design (CRD) was used for the experiment. Fifteen (15) juveniles of *Clarias gariepinus* were stocked randomly in duplicates per treatment and fed twice daily at (9:00am) and (6:00pm) by 5% body weight, for a period of eight weeks (two months). Four isonitrogenous diets of (40% crude protein) was formulated and coded as T1 (Control 0%), T2 (1% ginger), T3 (1% garlic) and T4 (1% mixture of ginger and garlic). The ground ingredients were measured using sensitive digital scale. The resulting mixture was pelletized. The wet pellets was shade in the departmental hatchery, followed by packaged into airtight containers, label accordingly and stored at room temperature to be crumbled before being used as a growth and finishing diet until it is ready for use (Falayi, 2003). The experimental fish at the beginning and the end of the feeding trial was subjected to proximate analysis. All analysis will pursue AOAC (2000) procedure.

Collection and Identification of Ginger and Garlic

Fresh ginger and fresh garlic bulbs were purchased from 'Yan-tipa, Dutse Local Government Jigawa State. Identification of the purchased sample was carried out at Fisheries and Aquaculture Department, Faculty of Agriculture, Federal University Dutse, Jigawa State, Nigeria.

Processing of the Feed Additives

After removing the dry skin of both fresh garlic and ginger, they were cut into small pieces and then oven dried. The dried ginger and garlic were then crushed finely using a household grinder and sieved using a household sieve and obtain 500g of each of the powders which were kept in dry containers for formulation and preparation of experimental diets (Farombi & Fakoya, 2005).

Experimental Procedure and Management

Fish weight and length was recorded using top loading sensitive digital scale and measuring board, respectively. The fish length and weight measurements for all the fish was carried out at two weeks interval.

Experimental Diets

Forty (40) percent crude protein diets were formulated using Pearson's square method as described by (NRC, 2011).

Water Quality Assessment

Water quality parameters checked during the study include; Temperature, pH and Dissolve oxygen using ATC pen type pH meter, and Hannah model dissolve oxygen meter respectively.

Growth Indices

Mean Weight Gain (MWG)

The total and mean weight gain was calculated for each replicate and treatment as follows; (Cheikyula & Ofojekwu, 2003; Odedeyi, 2007).

$$\text{Mean Weight Gain (g/week) (MWG)} = Wf - Wi \quad (1)$$

Where: Wf = final weigh of fish at the end of experiment, Wi = initial weight of fish at the beginning of the experiment, Average Daily Growth (ADG)

$$\text{(ADG) (g/day)} = \frac{W2 - W1}{t} \quad (2)$$

Where: W1= initial weight of fish at the beginning of experiment, W2= final weight of fish at the end of experiment, t = culture period (days).

Specific Growth Rate (SGR)

The specific growth rate within the experiment was calculated according to (Adewolu *et al.,* 2008).

$$(\text{SGR})(\%/\text{day}) = \frac{\log W_1 - \log W_o}{t} \times 100 \quad (3)$$

Survival Rate

The percentage of survival of *Clarias gariepinus* juveniles within the duration of the experiment was calculated according to the formula derived by; (Cheikyula & Ofojekwu, 2003; Odedeyi, 2007).

$$\text{SP}\ (\%) = \frac{S1}{S2} \times 100 \quad (4)$$

Where: S_1 = Number of fish at the end of experiment, S_2 = Number of fish at the beginning of experiment

Feed Conversion Ratio (FCR)

This is a numerical value that was used in measuring the utilization of feed for growth as stated by (Adikwu, 2003).

$$\text{FCR} = \frac{\text{Weight of dry feed (g)}}{\text{Weight gain of the fish (g)}} \quad (5)$$

Feed Conversion Efficiency (%)

Feed conversion Efficiency of experimental fish was calculated using the formula as described by Adiaha and Obih (2007)

$$FCE = \frac{Weight gain of Fish}{Weight of food consumed by Fish} \times 100 \quad (6)$$

Table 1: Percentage Composition of the Ingredients used in the Experimental Diet

Ingredients	T1 (0%)	T2 (1%)	T3 (1%)	T4 (1%)
Methionine	0.75	0.75	0.75	0.75
Vitamin	0.5	0.5	0.5	0.5
Mineral	5.00	5.00	5.00	5.00
Lysine	0.75	0.75	0.75	0.75
Binder	0.30	0.30	0.30	0.30
Salt	0.25	0.25	0.25	0.25
Fish meal	19.75	19.75	19.75	19.75
Soya bean meal	0.30	19.75	19.75	19.75
Rice bran	26.3	26.3	26.3	26.3
Maize	26.3	26.3	26.3	26.3
Ginger	-	1	-	-
Garlic	-	-	1	-
G&G (combine)	-	-	-	1
Grand Total	100kg	100kg	100kg	100kg

Gross Feed Conversion Efficiency (%)

Feed conversion Efficiency of experimental fish was calculated using the formula as described by Adiaha & Obih (2007)

$$GFCE = \frac{1}{FCR} \times 100 \quad (7)$$

Length-weight Relationship and Condition Factor (K)

Estimation of Length-weight relationship was done using the formula W=aLb (Ricken 1978). Which is transformed into natural logarithmic form

$$\ln W = \ln a + b(\ln L) \quad (8)$$

And condition factor was computed using the formula given by Pauly (1983).

$$(\text{K}) = \frac{W}{L^3} \times 100 \quad (9)$$

Where: W = Final weight of fish (g), L = Final total length of fish (cm)

Data Analysis

The data obtained was analyzed using analysis of variance (ANOVA) to test the level of significance at $P<0.05$ probability level and means be separated using Duncan's Multiple Range Test (DMRT) using SPSS software Version 23.

RESULTS AND DISCUSSION

Growth Performance and Nutrient Utilization of Fish Fed Experimental Diet.

Treatment 3 recorded the lowest mean weight gain value of 4.27±1.00g although this was statistically similar to the remaining treatments 1, 2 and 4 ($p>0.05$). Peak mean weight gain value of 7.03±1.67g was recorded in treatment 2 and which was not statistically different from the other treatments. Treatment 3 also recorded lowest percentage weight gain of 215.99±35.54 while a statistically significant ($p>0.05$). Highest value of 257.46±38.04 was observed in treatment 1. The feed conversion ratio values in all the treatments were statistically similar ($p>0.05$) however, lowest value of 0.74±0.15 was recorded in treatment 2 and the highest value of 1.30±0.34 was recorded in treatment 3.

Assessment of Length-Weight Relationship

Table 3 Present the length-weight relationship of *C. gariepinus* fed diets supplemented with ginger (*Zingiber officinale*) and garlic (*Allium sativum*). Treatments 4 and 1 indicated an isometric growth with high value of 3.215 and 3.172 while treatments 3 and 2 indicated a negative allometric growth of 2.325 and 1.836 respectively.

Water Quality Parameters Monitored

The result of water quality parameters examined are within the recommended range for fish wellbeing, and thus the water is in good condition as shown in Table 3.

Table 2: Growth Performance, Nutrient utilization and Survival of *C. gariepinus* fed Diet Supplemented with Ginger and Garlic

Parameters	T1 Control (0%)	T2 Ginger (1%)	T3 Garlic (1%)	T4 G &G (1%)
MINW (g)	4.24±0.79^{a}	4.09±0.41^{a}	4.00±0.32^{a}	4.03±0.63^{a}
MFW (g)	10.87±2.23^{a}	11.50±1.60^{a}	8.34±0.78^{b}	9.0±2.05^{ab}
INL (cm)	7.81±0.30^{a}	7.69±0.15^{a}	7.75±0.31^{a}	7.69±0.40^{a}
FL (cm)	10.95±0.58^{b}	11.12±0.76^{a}	10.20±0.38^{d}	10.22±0.72^{c}
MWG (g)	6.60±1.86^{b}	7.03±1.67^{a}	4.27±1.00^{d}	5.01±1.77^{c}
DWG (g)	0.70±0.18^{a}	0.13±0.03^{b}	0.09±0.15^{c}	0.09±0.03^{c}
PWG (%)	257.46±38.04^{b}	283.24±47.14^{a}	215.99±35.54^{d}	224.55±42.05^{c}
SGR (%/day)	138.28±54.45^{a}	105.79±7.56^{b}	90.91±4.24^{d}	93.72±10.34^{c}
FCR	0.84±0.21^{b}	0.74±0.15^{b}	1.30±0.34^{a}	1.15±0.40^{a}
FCE	90.86±27.32^{c}	129.41±45.46^{a}	80.44±19.11^{d}	94.53±38.21^{b}
GFCE	125.20±34.43^{b}	139.89±31.11^{a}	80.45±19.15^{d}	94.55±33.31^{c}
K	0.82±0.06^{a}	0.84±0.11^{a}	0.79±0.04^{a}	0.84±0.13^{a}
SR (%)	66.67±7.67^{b}	68.90±10.18^{b}	57.77±3.86^{c}	75.53±3.87^{a}

Values are mean ± standard deviation (SD). Mean values within the same row with similar superscript are not significantly different (P>0.05). KEYS: MINW= mean initial weight, MFW= mean final weight, MWG= mean weight gain, DWG= daily weight gain, INL= initial length, FL= final length, SGR= specific growth rate, FCR= feed conversion ratio, FCE= feed conversion efficiency, GFCE=gross feed conversion efficiency, K= condition factor, SR= survival rate, PWG= percentage weight gain.

Table 3: Length-weight Relationship of *C. gariepinus* fed diet supplemented with Ginger and Garlic

Parameters	A	B	Equation	G.P
T1	-2.312	3.172	Y=3.172*X-2.312	IS
T2	-0896	1.836	Y=1.836*X-0.896	NA
T3	-1.418	2.325	Y=2.325*X-1.418	NA
T4	-2.368	3.215	Y=3.215*X-2.368	IS

KEYS: a= intercept of regression line, b= slope of regression, GP= growth pattern, NA= negative allometric, IS= isometric growth, when b=3 represents isometric growth, b<3 signifies negative allometric and b>3 indicates positive allometric.

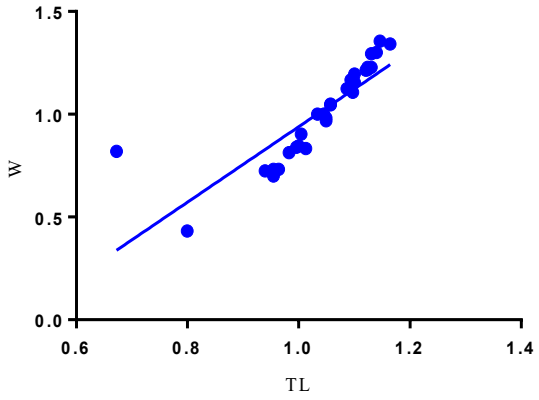

Figure 1: Length-Weight Relationship of Experimental Fish Fed T1 (Control)

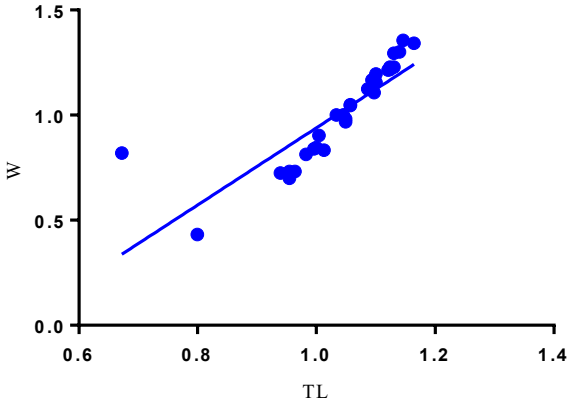

Figure 2: Length-Weight Relationship of Experimental Fish Fed T2 (Ginger)

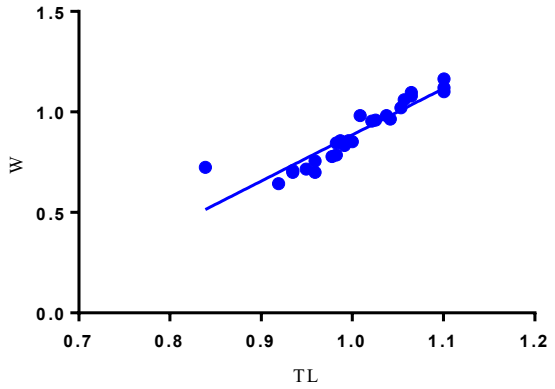

Figure 3: Length-Weight Relationship of Experimental Fish Fed T3 (Garlic)

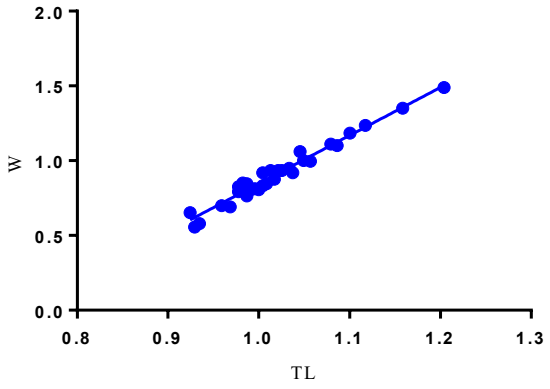

Figure 4: Length-Weight Relationship of Experimental Fish Fed T4 (Combination)

Table 4: Water quality parameters examined

Parameters	T1	T2	T3	T4
Temperature (ºC)	31.71±1.03[a]	29.18±0.91[d]	30.88±1.25[b]	30.38±0.17[c]
Dissolved oxygen (mg/l)	6.28±0.95[a]	5.25±0.96[c]	5.24±0.54[d]	5.48±0.42[b]
Ph	7.76±0.23[a]	6.42±0.36[c]	6.86±0.25[b]	6.26±0.82[d]

DISCUSSION

Fish growth depends not only on the quality of water and feed, but also to some extent on their physiological state which can be disturbed by pathogenic organisms or any other abiotic factor in the culture environment. Many findings have reported that addition of medicinal plant products or by-products to diet favor various activities like growth promotion, appetite and digestion stimulation, antistress, enhancement of tonicity and immune stimulation and antipathogen properties in fish and shrimp aquaculture (Reverter *et al.,* 2014) and (Hodar *et al.,* 2021). The finding of present study carried out evaluate the effects of dietary inclusion of *Z. officinale* and *A. sativum* powders on growth and survival of *C. gariepinus* in term of weight gain, length gain, specific growth rate, feed intake, feed conversion ratio as well as protein efficiency ratio compared to control diet and survival of *C. gariepinus* juveniles raised under intensive farming condition. The physico-chemical parameters of the breeding medium such as temperature and dissolved oxygen were observed to be within the range recommended for freshwater fish culture (Saraswathy *et al.,* 2014). The same trend was observed by Adewole (2014) who also reported significant increases in growth parameters (final weight, weight gain, specific rate and relative growth rate) in *C. gariepinus* fed roselle supplemented diets when compared with the control. Ginger roots also contain high levels of proteolytic enzymes and lipolytic which lead to improved digestion of dietary protein and lipid (Venkataramalingam *et al.,* 2007). Moreover, the results of the present study revealed that the specific growth rate, weight gain and daily weight gain is higher in T1 while percentage weight gain, feed conversion efficiency and gross feed conversion efficiency appear to be greater in T2 though there is no statistical difference among the treatments T1, T2, T3 and T4 as (P>0.05). Meanwhile (Iheanacho *et al.,* 2017) reported significant increases in weight gain, specific growth rate and final weight when *C. gariepinus* juvenile were exposed to varying concentrations (0.25, 0.50, 0.75 and 1.0 g/35 L) of ginger as compared to the control. These results are in contradiction with those reported by (Mahmoud *et al.* 2019) who found no significant difference between the growth performance and feed utilization of *O. niloticus* fingerlings fed on diet containing 1.5% ginger and garlic during 60 consecutive days. There were no significant different in the condition factor for all the treatments as (p>0.05), this indicate that the nutrient in the diets was well utilized. (Sahu *et al.,* 2007) also showed that feed conversion ratio and specific growth rate were not significantly influenced in *Labeorohita* fed on diet containing 0.5% and 1% garlic inclusion. The conflicting results of adding dietary garlic and ginger on growth performances and feed utilization of *C. gariepinus* fry may be attributed or depend on fish species differences, feeding program, period in which the supplemented diet was applied and the ambient culturing conditions. It may also be attributed to fish size, age, bioactive precursors present in feed additive and fish nutritional or physiological status.

According to Kaur and Ansal (2020) and others, the beneficial effects of garlic on biochemical body content as well as their retention in *C. gariepinus* at the end of the study are attributed to biological activity of allicin that not only facilitate digestion process of feed, but also helps in a more efficient assimilation of dietary proteins and others macro-nutrients into the flesh, bones and some vital organs involved in feed metabolism.

Water quality is the most important limiting factor as its quality directly affects fish behavior, feeding and survival. Any changes in fish environment constitute a source of stress and the higher and faster the changes, the greater the stress. So, the maintenance of the physico-chemical parameters within the acceptable limits is very essential for getting good production Bhatnagar (2013). The average values of water quality parameters such as temperature, pH, dissolved oxygen recorded throughout the study were considered as suitable for good growth, the maintenance of stable physiological conditions as well as improving survival of *C. gariepinus* juveniles. These values are within the acceptable one (35-36ºC) and could partially justify the relatively low mortality observed throughout the study.

Assessment of Length-weight Relationship

The assessment of length-weight relationship of *C. gariepinus* juveniles fed with supplemented diet of ginger and garlic in this study shows that the simple linear regression slope (b) recorded fell within 1.836 and 3.215. The results presented in Table 3 revealed variations in the growth patterns of *Clarias gariepinus* fed diets supplemented with ginger and garlic. Fish in T1 exhibited a regression coefficient (b = 3.172), indicating an isometric growth pattern. Similarly, fish in T4 recorded a b-value of 3.215, also suggesting isometric growth. This implies that fish in these treatments increased in weight proportionately with their increase in length, reflecting balanced growth and efficient nutrient utilization. The near-isometric growth observed in these treatments may be attributed to the beneficial effects of ginger and garlic supplementation, which have been reported to improve feed utilization, digestive efficiency, and overall fish performance (Nya & Austin, 2009; Abdel-Tawwab *et al.,* 2018).

Conversely, fish in T2 and T3 recorded lower regression coefficients of 1.836 and 2.325, respectively, indicating negative allometric growth. This suggests that fish in these treatments increased in length at a faster rate than weight, resulting in a slenderer body form. Negative allometric growth may arise from suboptimal dietary inclusion levels, environmental factors, stocking density, or physiological stress that could limit weight gain relative to length increment (Froese, 2006). Similar observations have been reported in cultured African catfish where dietary treatments influenced nutrient partitioning and body composition.

The intercept values (a) ranged from -2.368 to -0.896, reflecting differences in the initial condition and body form of fish among treatments. Although the intercept has less biological significance than the slope coefficient, variations in "a" may indicate differences in environmental conditions, feeding efficiency, and fish physiological status during the experimental period.

The isometric growth observed in T1 and T4 suggests that these dietary treatments supported optimal growth performance and body development of *C. gariepinus*. The results agree with findings of several studies that reported improved growth and condition factors in fish fed phytogenic feed additives such as ginger (*Zingiber officinale*) and garlic (*Allium sativum*), owing to their antimicrobial, antioxidant, and growth-promoting properties (Adewumi *et al*., 2020; Abdel-Latif *et al*., 2020). The negative allometric growth recorded in T2 and T3, however, indicates that the dietary inclusion levels used in these treatments may not have been sufficient to promote proportional weight gain.

Overall, the study demonstrates that dietary supplementation with ginger and garlic can influence the length–weight relationship of Clarias gariepinus, with T1 and T4 producing more desirable growth patterns characterized by isometric growth.

CONCLUSION AND RECOMMENDATIONS

This study investigated the effect of incorporation of *Zingiber officinale, Allium sativum* and mixture of ginger and garlic together in the diet on the survival rate and growth characteristics of *Claris gariepinus* juveniles led to higher growth and better survival than the control. This could be attributed to the synergistic actions of the bioactive molecules of each of the phyto-additives as growth promoting agents by enhancing the appetite and the digestion mechanism as well as the state of health in the juveniles. It can be concluded that *Zingiber officinale* at 1% inclusion level resulted best protein growth and survival efficiency, followed by mixture of *Zingiber officinale* and *Alliyum sativum.* Further research should be conducted on *Zingiber officinale* and *Alliyum sativum* with different inclusion levels and on different processing methods for *A. sativum.*

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Authors' Contributions
HIM conceptualized the study, performed data analysis and interpretations. YC & IB designed the experiment, collected data and AI and RAA wrote the manuscript. All authors read and approved the final draft of the manuscript.

Ethical Statement

Not applicable

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