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Growth Performance, Survival and Feed Utilization of the African Catfish *Heterobranchus longifilis* (Valenciennes, 1840) Fed Diets with Varying Inclusion Levels of *Moringa oleifera* Leaf Meal (MLM)

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Authors' contributions

This work was carried out in collaboration between both authors. Author EVO designed and set up the study, the performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors IEA managed the literature searches and analyses of the study. Both authors read and approved the final manuscript.

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ABSTRACT

Aims: To evaluate the effects of varying inclusion levels of *Moringa oleifera* leaf meal (MLM) on the growth, survival and food utilization of the African catfish *Heterobranchus longifilis*.
Place and Duration of Study: Institute of Oceanography, University of Calabar, Nigeria, between January 2017 and May 2017.
Methodology: Fifteen (15) tarpaulin unit measuring 100 by 80 by 100 cm was used to aid triplication of the five experimental groups. Five isonitrogenous feeds including Feed A (control), Feed B (5% MLM), Feed C (10% MLM), Feed D (15% MLM) and Feed E (20% MLM) were used for this study. A total of three hundred (300) fingerlings of *H. longifilis* with mean bulk body weight

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361.60 ± 0.3 g and total length 11.15 ± 0.04 cm were stocked in the 15 units (20 in each unit).
Results: *M. oleifera* leaf meal (MLM) had a crude protein level of 27.80 ± 0.02%, crude fibre (18.50 ± 0.01%), ash (6.45 ± 0.02%), moisture (8.36 ± 0.03%), crude fat (2.72 ± 0.02%) and nitrogen free extract (36.17 ± 0.02%). Best results for all the growth performance indices was obtained in fish fed Feed D (15% MLM) whereas least values were obtained in the control diets with no *M. oleifera* leaf meal. Weight gain (g), length gain (cm), growth rate (g/day), specific growth rate (%/day) and mean growth rate (mg/day) were significantly (*P*=0.05) highest in fish fed Feed D (15% MLM) and least in fish fed Feed A (control diet). Food conversion ratio (FCR) and food conversion efficiency of the experimental fishes did not vary significantly (P=0.05).
Conclusion: In conclusion, *M. oleifera* leaf meal (MLM) could be substituted with fish meal in *H. longifilis* diets up to 15 % level without any negation with regards to growth, food utilization and survival.

Keywords: Heterobranchus longifilis; Moringa oleifera leaf meal; growth performance; survival; food utilization; varying inclusion levels.

1. INTRODUCTION

In Nigeria, the present growth of aquaculture industry has impacted positively on the recessed economy since it has become a source of livelihood for over hundreds of thousands of the employed and unemployed populations. Nigeria is one of the highest fish consuming nation in Africa with an annual fish consumption record of 1.5 million tons [1]. The African Catfish *Heterobranchus longifilis* belonging to the family Clariidae is one of the most important aquaculture species in Nigeria because of its fast growth rate, appreciable size, disease resistance, high fecundity, ease of artificial breeding, tolerance of high stocking densities in captivity, tolerance of harsh of environmental conditions, acceptability of farm made feed, good market value, good taste and meat quality [2]. According to Ekanem et al. [3], catfish is valuable by fish consumers because of its excellent taste and meat quality especially when presented in smoked, fried or dried form. Apart from its acceptability and affordability, the African Catfish is rich in omega-3- fatty acid, thiamine, riboflavin, phosphorus, vitamins A, vitamin D, iron and calcium which is required for good health and tissue development [4,5,6]. Despite the growth of aquaculture industry in Nigeria, scarcity and expensive nature of high quality feed such as Coppens, Aller Aqua, Multi feed, Skrettings etc. especially in rural areas where some fish farms are located have slowed down the growth rate of this industry [7]. To Eyo et al. [8], this challenge has resulted in searching for cheaper and alternative feed ingredients that will boost fish growth without any negation. The use of leaf meals becomes not just an alternative feed ingredient but a cheaper and nutrient rich ingredient which is available all year round. *Moringa oleifera* belonging to the family Moringaceae is one of such plants that is rich in nutrients required by fish for optimal growth and health. According to Olson et al. [9], *M. oleifera* is commonly known as drumstick tree (because of its long, slender, triangular seed-pods), horseradish tree (it roots taste like horseradish) and ben oil or benzoil tree (because of the oil derived from the seeds). *M. oleifera* which is widely distributed in Africa and Asia is documented by Francis et al. [10] and Kakengi et al. [11] to contain 29.7% CP, 86% DM, 29.9% EE, 4.38% CF, 3056 kcal/kg energy, 0.26% calcium, with phosphorus and tannin (1.23 g/kg) in negligible amounts. Ochang et al. [12] opines that *M. oleifera* which has a good potential for forage also has a good coppicing ability and can be grown easily. *M. oleifera* is economical to produce in commercial quantities requiring inexpensive inputs to strive. The use of *M. oleifera* leaf meal as a non-conventional and cheap protein source in aquafeed for different fish species has yielded positive results in relation to growth performance, survival and economic evaluations. Chabi et al. [13] reported a positive effect of *M. oleifera* on the development of juvenile *Clarias gariepinus*. Richter et al. [14] recommended 30% substitution of *M. oleifera* leaf meal for fish meal in the diet of Nile tilapia (*Oreochromis niloticus*); Bundit et al. [15] reported a similar observation for Bocurtis catfish (*Pangasius bocourti*); Ochang et al. [12] recommended 20% *Moringa oleifera* leaf meal (MLM) for optimal growth of *C. gariepinus.* However, limited studies have been conducted on the effect of *Moringa oleifera* leaves meal on the African catfish *Heterobranchus longifilis* which is one of the popular aquaculture species in Nigeria. Therefore, the objective of this study is to evaluate the effects of varying inclusion

levels of *Moringa oleifera* leaf meal (MLM) on the growth, survival and feed utilization of the African catfish *Heterobranchus longifilis*.

2. MATERIALS AND METHODS

2.1 Collection, Identification and Processing of *Moringa oleifera* leaves

The leaves of *M. oleifera* (Plate 1) were collected from the botanical garden of the University of Calabar and taken to Botany Department for authentication and identification. Thereafter, the leaves were washed to remove dirt and debris before sun-drying for one week. After sun-drying, the leaves were blended to fine powder to obtain moringa leaf meal (MLM).

Fig. 1. *Moringa oleifera* leaves used in this study

2.2 Composition and Formulation of Experimental Feeds

Five isonitrogenous feed (Table 1) including Feed A (control), Feed B (5% MLM), Feed C (10% MLM), Feed D (15% MLM) and Feed E (20% MLM) containing 43% crude protein was compounded using locally available raw materials following the Trial and Error method of feed formulation. Ingredients used in formulating the experimental feeds include Moringa leaf meal (MLM), fish meal (FM), groundnut meal (GNM), soybean meal (SBM), wheat offal, vitamin premix, calcium powder, lysine, methionine, sodium chloride (NaCl), wheat flour, and palm oil. The ingredients in powdery form were mixed based on the calculated percentages. Thereafter, the mixed feeds were pelletized with the aid of locally fabricated pelletizer before sun-drying.

2.3 Proximate Analysis of *M. oleifera* Leaf Meal and Experimental Diets

Proximate analysis of *M. oleifera* leaf meal and the five experimental feeds were performed based on methods of AOAC [16], in the Faculty of Agriculture Central Laboratory, University of Calabar, Nigeria. The moisture content, lipids content, crude protein, carbohydrate ash and contents was analyzed.

2.4 Experimental Design

The experiment was carried out for 150 days using 15 tarpaulin unit measuring 100 x 80 x 100 cm^3 to aid triplication. The triplicate groups of the 5 treatments were labeled A, B, C, D, and E. A total of five Feeds including Feed A (control), Feed B (5% MLM), Feed C (10% MLM), Feed D (15% MLM) and Feed E (20% MLM) was used for this study. A total of 300 healthy fingerlings of *H. longifilis* were stocked in the 15 tarpaulin units (20 in each unit). After stocking, the fingerlings were acclimated for two weeks (14 days) prior to the start of the experiment. During the acclimation period, the fish were fed to satiation with Coppens feed twice daily. After the fourteen days acclimation period, the fish were starved for 24 hours to eliminate variation in fish weight due to residue food in the gut, empty the gastrointestinal tract in preparation for the experimental feeds and to increase the appetite of the fish. After the 24 hours starvation period, the initial biometric measurements including body weight and total length of fish in each unit was measured following the methods of Eyo et al. [4] using Metlar MT-5000D electronic weighing balance for weight to the nearest gram and measuring board for length to the nearest 0.1 cm. Fish in units A_1, A_2 and A_3 were fed feed A (control), fish in units B_1, B_2 and B_3 were fed feed B (5% MLM), fish in units C_1, C_2 and C_3 were fed feed C (10% MLM), fish in units D_1, D_2 and D_3 were fed feed D (15% MLM) and fish in units E_1, E_2 and E_3 were fed feed E (20% MLM). Feeding was done twice daily by 8.00 am and 5.00 pm at 3% body weight. Biometric parameters of experimental fishes including total length (TL) and total weight (TW) were measured on bi-weekly basis.

2.5 Evaluation of Growth Performance Indices

Growth performance of experimental fish was assessed using weight gain (g), length gain (cm),

specific growth rate (%/day), mean growth rate (mg/day) and growth rate (g/day) according to De Silva and Anderson [17] as follows:

Weight gain (WG – g) = Final weight (W_2) - Initial bulk weight (W_1)

Length gain (LG – cm) = Final fish length (L_2) - Initial fish length (L_1)

Growth rate (GR – g/day) = Final weight (W_2) - Initial weight (W_1)/No. of days

Specific growth rate (SGR – %/day) = Ln final fish weight (w_2) – Ln initial fish weight (w_1)/(No. of days)* 100

Where Ln is the base of natural logarithm.

Mean growth rate (MGR – mg/day) = [(W_2 –W_1)/ 0.5 (W_2+ W_1) t] x 1000

Where W_2 is the final fish weight (g) at the end of the experiment, W_1 is the initial fish weight (g) at the beginning of the experiment and it is the number of days used for the feeding experiment.

Percentage survival (PS – %) = (number of fish survived/ number of fish stocked) *100

2.6 Evaluation of Food Utilization Indices

Food utilization indices of experimental fish was assessed using food consumption, food conversion ratio and food conversion efficiency following the methods of De Silva and Anderson [17] as follows:

Food consumption (g): 3 % *fish bulk body weight*No. of days

Food conversion ratio (FCR): feed consumed by fish (g)/ Weight gain (g)

Food conversion efficiency (FCE): [Weight gained by fish (g) / Feed consumed by fish (g)] *100

2.7 Measurement of Water Quality Parameters of Experimental Units

Water quality parameters of experimental units including pH, water temperature (°C) and dissolved oxygen (mg/l) were measured bi-weekly in each experimental unit throughout the study period. Dissolved oxygen was measured with the aid of Portable Hanna dissolved oxygen meter Model HI9142, pH was measured with the aid of Portable waterproof pH/EC/TDS Hanna meter (high range) - HI991301 and water temperature was measured with the aid of a mercury in glass thermometer.

2.8 Statistical Analysis

Data obtained for growth and food utilization indices were subjected to One Way Analysis of Variance (ANOVA) to test for significance in fish fed the five experimental diets using PASW windows software (predictive analytical software) program (version 19.0). Effects with a probability of P = 0.05 were considered significant.

Table 1. Composition of experimental diets (gram/kg) with varying inclusion levels of *Moringa oleifera* leaf meal (MLM)

Ingredients	Feed A (control)	Feed B (5 % MLM)	Feed C (10 % MLM)	Feed D (15 % MLM)	Feed E (20 % MLM)
Moringa leaf meal (MLM)	0	50	100	150	200
Fish meal (FM)	341	339	317	304	278
Groundnut meal (GNM)	210	202	200	194	187
Soybean meal (SBM)	213	205	203	202	190
Wheat offal (WO)	164	145	120	90	85
Vitamin premix	20	20	20	20	20
Calcium powder	5	5	5	5	5
Lysine	5	5	5	5	5
Methionine	5	5	5	5	5
Sodium chloride	5	5	5	5	5
Wheat flour	10	10	10	10	10
Palm oil	10	10	10	10	10
Total	**1000**	**1000**	**1000**	**1000**	**1000**

3. RESULTS

3.1 Proximate Composition of the Dry Matter of the Experimental Diets with Varying Inclusion Levels of *Moringa oleifera* Leaf Meal (MLM)

Results of the proximate composition of the dry matter (Table 2) of the experimental diets (g/100 g) showed that there was no significant difference ($P > 0.05$) in the crude protein content of the five experimental feed which was highest in Feed B (42.75 ± 0.01%) and least in Feed C (42.54 ± 0.02%). Similarly, crude fibre content did not show any significant difference ($P = 0.05$) in the five experimental feed with highest value of 7.95 ± 0.05% obtained in Feed C and least value in Feed A (7.51 ± 0.01%). Ash content was not significantly different ($P > 0.05$) in the five experimental feed with highest in Feed E (5.87 ± 0.02%) and least value in Feed A (5.55 ± 0.05%). Also, moisture content was not significantly different ($P > 0.05$) in the five experimental feed with highest in Feed A and Feed D (1.71 ± 0.01%) and least value in Feed B (1.61 ± 0.01%). Crude fat was not significantly different ($P > 0.05$) in the five experimental feed with highest in Feed D (2.62 ± 0.01%) and least value in Feed A (2.51 ± 0.01%). Nitrogen free extract was not significantly different ($P > 0.05$) in the five experimental feed with highest in Feed A (40.18 ± 0.03%) and least value in Feed E (39.31 ± 0.09%). For *M. oleifera* leaf meal (MLM), crude protein was 27.80 ± 139 0.02%, crude fibre (18.50 ± 0.01%), ash (6.45 ± 0.02%), moisture (8.36 ± 0.03 %), crude fat (2.72 ± 0.02%) and 140 nitrogen free extract (36.17 ± 0.02%).

3.2 Growth Performance Indices of *H. longifilis* Fed Diets with Varying Inclusion Levels of *M. oleifera* Leaf Meal (MLM)

Evaluation of growth performance indices of *H. longifilis* (Table 3) fed diets with varying inclusion levels of *M. oleifera* leaf meal (MLM) showed that weight gain (g) was significantly ($P < 0.05$) highest (16990.00 ± 59.50 g) in fish fed Feed D (15% MLM), and least (14540.00 ± 4.00 g) in fish fed Feed A (control diet). Length gain (cm) was also significantly ($P = 0.05$) highest (37.33 ± 0.37 cm) in fish fed Feed D (15% MLM) and least (35.19 ± 0.07 cm) in fish fed Feed A (control feed).

Similarly, growth rate (g/day) was significantly ($P = 0.05$) highest (113.27 ± 40 g/day) in fish fed Feed D (15% MLM) and least (96.94 ± 0.03 g/day) in fish fed Feed A (control diet). Specific growth rate (%/day) also followed the same trend with fish fed Feed D (15% MLM) having the highest value (2.79 ± 0.01%/day) which was significantly different ($P < 0.05$) from other treatments while least value (2.69 ± 0.01%/day) was obtain in fish fed Feed A (control feed). Also, mean growth rate (mg/day) was significantly ($P < 0.05$) highest (12.94 ± 0.01 mg/day) in fish fed Feed D (15% MLM), and least (12.87 ± 0.01 mg/day) in fish fed Feed A (control feed). There was no significantly difference ($P > 0.05$) in percentage survival (%) was highest (100.00 ± 0.0%) in fish fed Feed B (5% MLM) and least (97.50 ± 2.50%) in fish fed Feed A (control feed), Feed C (10% MLM), Feed D (15% MLM) and Feed E (20% MLM).

3.3 Feed Utilization Indices of *H. longifilis* Fed Diets with Varying Inclusion Levels of *Moringa oleifera* Leaf Meal (MLM)

Evaluation of food utilization indices of *H. longifilis* (Table 4) fed diets with varying inclusion levels of *M. oleifera* leaf meal (MLM) showed that food consumed (g) was significantly ($P < 0.05$) highest (33672.50 ± 316.50 g) in fish fed Feed D (15% MLM) and least (29075.00 ± 5.00 g) in fish fed Feed A (control diet). Highest values of food conversion ratio (2.00 ± 0.10 obtained for fish fed Feed A (control) and Feed C (10% MLM) was not significantly different ($P > 0.05$) from values obtained for other treatments with least value of 1.98 ± 0.10 recorded for fish fed Feed D (15% MLM). Similarly, food conversion efficiency (%) was not significantly different ($P > 0.05$) in fish fed the five diets with highest value (50.46 ± 0.30%) obtained in fish fed Feed D (15% MLM) and least value (50.01 ± 0.01%) obtained in fish fed Feed A (control feed).

3.4 Mean Water Quality Parameters of Experimental Units

Results obtained for the mean water quality parameters of the experimental units showed that mean pH ranged from 7.05 ± 0.50 in tank D fed Feed D (15% MLM) to 7.10 ± 0.50 in tank fed the Feed A (control). Mean Water temperature (°C) ranged from 29.50 ± 0.20°C in tank fed the Feed C (10% MLM) to 29.60 ± 0.20°C in tank B fed Feed B (5% MLM). Mean dissolved oxygen (mg/l) ranged from 5.18 ± 0.42 mg/l in tank fed the Feed D (15% MLM) to 5.29 ± 0.28 mg/l in tank E fed Feed E (20% MLM).

Table 2. Proximate composition of the dry matter of *M. oleifera* leaf meal (MLM) and the experimental diets (g/100 g) with varying inclusion levels of *Moringa oleifera* leaf meal (MLM)

Proximate indices	Feed A (Control)	Feed B (5% MLM)	Feed C (10 % MLM)	Feed D (15 % MLM)	Feed E (20 % MLM)	MLM
Crude protein (%)	42.55 ± 0.05	42.75 ± 0.01	42.54 ± 0.02	42.66 ± 0.01	42.59 ± 0.01	27.80 ± 0.02
Crude fibre (%)	7.51 ± 0.01	7.75 ± 0.01	7.80 ± 0.01	7.85 ± 0.01	7.95 ± 0.05	18.50 ± 0.01
Ash (%)	5.55 ± 0.05	5.60 ± 0.01	5.75 ± 0.05	5.81 ± 0.01	5.87 ± 0.02	6.45 ± 0.02
Moisture (%)	1.71 ± 0.01	1.61 ± 0.01	1.69 ± 0.01	1.71 ± 0.01	1.69 ± 0.01	8.36 ± 0.03
Crude fat (%)	2.51 ± 0.01	2.61 ± 0.01	2.58 ± 0.01	2.62 ± 0.01	2.60 ± 0.01	2.72 ± 0.02
Nitrogen free extract (%)	40.18 ± 0.03	39.74 ± 0.12	39.65 ± 0.04	39.36 ± 0.04	39.31 ± 0.09	36.17 ± 0.02

**Values represents mean ± standard error for triplicate of each treatment. MLM = Moringa oleifera leaf meal*

Table 3. Growth performance indices of *H. longifilis* fed diets with varying inclusion levels of *Moringa oleifera* leaf meal (MLM)

Indices	Feed A (Control)	Feed B (5% MLM)	Feed C (10 % MLM)	Feed D (15 % MLM)	Feed E (20 % MLM)
Initial weight (g)	261.00 ± 1.00	261.50 ± 0.50	261.00 ± 1.50	261.50 ± 0.50	262.50 ± 0.50
Final weight (g)	14801.00 ± 3.00^{e}	15470.00 ± 52.50^{d}	16180.50 ± 4.50^{b}	17252.00 ± 60.00^{a}	16026.50 ± 25.50^{c}
Weight gain (g)	14540.00 ± 4.00^{e}	15209.00 ± 52.00^{d}	15919.00 ± 6.00^{b}	16990.00 ± 59.50^{a}	15764.00 ± 26.60^{c}
Initial length (cm)	11.10 ± 0.10	11.15 ± 0.15	11.05 ± 0.05	11.25 ± 0.05	11.20 ± 0.10
Final length (cm)	46.29 ± 0.17^{e}	46.98 ± 0.22^{c}	47.52 ± 0.16^{b}	48.58 ± 0.32^{a}	46.53 ± 0.13^{d}
Length gain (cm)	35.19 ± 0.07^{e}	35.83 ± 0.37^{c}	36.47 ± 0.11^{b}	37.33 ± 0.37^{a}	35.33 ± 0.03^{d}
Growth rate (g/day)	96.94 ± 0.03^{e}	101.40 ± 0.35^{d}	106.13 ± 0.04^{b}	113.27 ± 0.40^{a}	105.10 ± 0.18^{c}
SGR (%/day)	2.69 ± 0.01^{e}	2.72 ± 0.01^{d}	2.75 ± 0.01^{b}	2.79 ± 0.01^{a}	2.74 ± 0.01^{c}
MGR (mg/day)	12.87 ± 0.01^{d}	12.89 ± 0.01^{c}	12.91 ± 0.01^{b}	12.94 ± 0.01^{a}	12.91 ± 0.01^{b}
No. Stocked	20.00 ± 0.00	20.00 ± 0.00	20.00 ± 0.00	20.00 ± 0.00	20.00 ± 0.00
No. Survived	19.50 ± 0.50^{a}	20.00 ± 0.00^{a}	19.50 ± 0.50^{a}	19.50 ± 0.50^{a}	19.50 ± 0.50^{a}
Survival (%)	97.50 ± 0.50^{a}	100.00 ± 0.00^{a}	97.50 ± 0.50^{a}	97.50 ± 0.50^{a}	97.50 ± 0.50^{a}

**Values represent mean ± standard error for the triplicate data of each treatment. Mean values having the same superscript are not significantly different (P > 0.05)*

Table 4. Feed utilization indices of H. longifilis fed diets with varying inclusion levels of *Moringa oleifera* leaf meal (MLM)

Indices	Feed A (Control)	Feed B (5% MLM)	Feed C (10 % MLM)	Feed D (15 % MLM)	Feed E (20 % MLM)
Weight gain (g)	14540.00 ± 4.00^{e}	15209.00 ± 52.00^{d}	15919.00 ± 6.00^{b}	16990.00 ± 59.50^{a}	15764.00 ± 26.60^{c}
Food Consumed (g)	29075.00 ± 5.00^{e}	30273.00 ± 42.00^{d}	31821.50 ± 10.50^{b}	33672.50 ± 316.50^{a}	31438.50 ± 61.50^{c}
FCR	2.00 ± 0.10^{a}	1.99 ± 0.10^{a}	2.00 ± 0.10^{a}	1.98 ± 0.01^{a}	1.99 ± 0.10^{a}
FCE (%)	50.01 ± 0.01^{a}	50.24 ± 0.10^{a}	50.03 ± 0.01^{a}	50.46 ± 0.30^{a}	50.15 ± 0.02^{a}

**Values represent mean ± standard error for the triplicate data of each treatment. Mean values having the same superscript are not significantly different (P > 0.05)*

Table 5. Mean Water quality parameters of experimental units

Indices	Tank A (Control)	Tank B (5% MLM)	Tank C (10 % MLM)	Tank D (15 % MLM)	Tank E (20 % MLM)
pH	7.10 ± 0.50	7.06 ± 0.60	7.08 ± 0.50	7.05 ± 0.50	7.80 ± 0.60
Water temperature (°C)	29.50 ± 0.30	29.60 ± 0.20	29.50 ± 0.20	29.50 ± 0.25	29.55 ± 0.20
Dissolved Oxygen (mg/l)	5.20 ± 0.50	5.24 ± 0.45	5.28 ± 0.50	5.18 ± 0.42	5.29 ± 0.28

**Values represent mean ± standard error for the triplicate data of each treatment. Mean values having the same superscript are not significantly different (P > 0.05)*

4. DISCUSSION

In fish culture, high quality fish feed is expected to supply all the nutrients required by fish for optimal growth performance and good health. In this study, the proximate composition of *M. oleifera* leaf meal (MLM), showed that crude protein level was 27.80 ± 0.02%, crude fibre (18.50 ± 0.01%), ash (6.45 ± 0.02%), moisture (8.36 ± 0.03%), crude fat (2.72 ± 0.02%) and nitrogen free extract (36.17 ± 0.02%). These results did not deviate too much from values obtained by Bello and Nzeh [18] for *M. oleifera* leaf meal (MLM) and this could be attributed to similarities in environmental factors such as season and geographical location. Results of this study showed clearly that *H. longifilis* responded positively to the five experimental diets as was noted in their growth performance and survival. Although, all the experimental fishes responded positively to the experimental diets, some treatments gave better growth indices than some. Best results for all the growth performance indices of *H. longifilis* fed was obtained in fish fed Feed D (15% MLM) whereas least values were obtained in the control diets with no *M. oleifera* leaf meal. Weight gain (g), growth rate (g/day), specific growth rate (%/day) and mean growth rate (mg/day) were significantly ($P<0.05$) highest in fish fed Feed D (15% MLM) and least in fish fed Feed A (control diet). Length gain (cm) did not follow the same trend although highest value was recorded for fish fed Feed D (15% MLM) and least in fish fed Feed A (control feed). Findings of this study disagrees with results obtained by [12] who reported a corresponding decrease in growth and nutrient utilization in the African catfish (*Clarias gariepinus*) with increase in *M. oleifera leaf meal* (MLM). Findings of our study also disagrees with findings of [18] who reported a steady decrease in growth indices of *C. gariepinus* with increase in the inclusion levels of *M. oleifera* leaf meal (MLM). Findings of this study showed that growth increased with increasing level of *M. oleifera* leaf meal up to 15 % inclusion where further increase (20%) resulted in reduced growth indices. This finding agrees with findings of [14] that higher levels of *M. oleifera* leaf meal (MLM) in fish feed resulted in a negative effect on growth performance. This could be attributed to the presence of antinutrients such as tannins, phytates, phenol and saponins [19-21]. [3] reported that antinutrients in could result in reduced growth performance in fish. According to [20, 22 and 23], antinutrients could be reduced through processing techniques which will lead to increased palatability, acceptability and growth in fish. In the present study, *M. oleifera* leaf meal (MLM) was processed based on standard methods, although it is not possible to reduce the anti-nutrients to 0% level. According to [4], a good feed should provide nutrients that are easily digested and absorbed in a form that the nutrients becomes available for providing energy and substrate for growth (bioavailability). The positive growth results obtained in this study indicates that the five experimental feeds provided nutrients that were easily digested, absorbed and utilized for growth. Percentage survival (%) of fish fed the five experimental diets did not vary significantly ($P>0.05$) indicating that variation in the inclusion levels of *M. oleifera* leaf meal (MLM) did influence fish survival. Few mortalities recorded in this study may be due to the cannibalistic nature of *H. longifilis* since only the skull of dead fish were removed from tanks during the process of water replacement. According to [18], the proximate chemical composition such as crude protein, crude fat, crude fibre, ash, moisture content and nitrogen free extract could be used to evaluate the potential of leaf meals as feedstuffs in fish diets. In aquaculture, feed conversion ratio (FCR) and feed conversion efficiency (FCE) are important food utilization indices evaluate the efficiency and quality of a given feed with regards to growth [2,8,21,24]. To [20], growth and food utilization indices such as FCR and FCE of fish gives valuable information on the acceptability of an artificial feed. In this study, food conversion ratio (FCR) and food conversion efficiency of fish fed

all the experimental diets did not vary significantly (P>0.05) indicating that all the experimental diets were high in quality and nutrients required by the experimental fish. was the highest in fish fed to diet C (3.39 ± 1.02), followed by fish fed to diet B (2.46 ± 0.73) and the least in fish fed to diet A (2.25 ± 0.31) implying that fish fed to control diet had the best FCR. This finding could be attributed to the presence of plant materials in diets B and C. According to [20] high fiber content is a major problem when leaf meals are used in fish diets as this can impair fish growth through poor food utilization. The results obtained in this present study support the findings of [2,25] that utilization of good quality feeds plays a major role in the growth performance of *C. gariepinus.* However, results obtained for FCR and FCE in this study for fish fed the five experimental feed were within the range recommended several authors for African catfish [25 and 26]. In fish culture set-up, environmental factors including pH, temperature and dissolved oxygen are reported to affect fish growth, survival and health [27]. Results obtained in this study for physicochemical parameters such as pH, water temperature and dissolved oxygen were within the acceptable and recommended range according to [28,29] for optimal growth and health of fish. This implies that growth, survival, food utilization of *H. longifilis* used in this study were not affected by physicochemical parameters of the fish culture tanks.

5. CONCLUSION

Findings of this study indicates that incorporation of *M. oleifera* leaf meal (MLM) as a plant-based protein source in *H. longifilis* diet at varying inclusion levels resulted in positive growth performance. In conclusion, *M. oleifera* leaf meal (MLM) could be included in *H. longifilis* diets up to 15% level without any negation with regards to growth, food utilization and survival.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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