



Study of Growth performance of African Catfish *Claria gariepinus* fed Supplemented diet of *Moringa olifera* and *Sargassum muticum* Leaves

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ABSTRACT

Growth performance of African catfish *Clarias gariepinus* fingerlings fed with *Moringa olifera* leaves and *Sargassum muticum* diets as protein supplements were evaluated for ninety (90) days. Five isonitrogenous diets that contained 0%, 25%, 50%, 75% and 100% inclusions levels were formulated and designated as M1, M2, M3, M4 and M5 for *M. olifera* leaf meal and S1, S2, S3, S4 and S5 for *S. muticum* meal. Coppens fed was used as controls. Final weight, which was highest in M1 (0%) differ significantly ($p < 0.05$) among the diets and the control feed. Specific growth rate, which is highest in diet M1 (0%) differ significantly ($p < 0.05$) with other diets and Coppens. Feed efficiency was highest in diet M4 (75%) differ significantly ($p < 0.05$) with other diets except M1 (0%). Protein efficiency ratio highest in Coppens differ significantly ($p < 0.05$) from other diets, highest in M2 (25%) and differ significantly ($p < 0.05$) among the diets. There were high survival rates among diets, Coppens being highest differ significantly ($p < 0.05$) from diets M1 - M5 and S1 - S5. This study revealed a significant ($p < 0.05$) difference between fish fed with the control diet of coppens feeds and all treatments of dietary supplements (*Moringa olifera* leaf and *Sargassum muticum*). Therefore, It may be concluded based on the results recorded in this study that supplementation in diets has positive effect on growth parameters of African catfish, *Clarias gariepinus* compared with Coppens standard feeds available in the market.

Keywords: *Moringa olifera* leaf, *Sargassum muticum*, *Clarias gariepinus*, Diet

INTRODUCTION

Fish is one of the major sources of quality protein in Nigeria, constituting about 40% of animal protein in the diet. Utilization of fish as a source of protein provides all the necessary nourishments needed for healthy growth and proper functioning of the body. Nigeria is blessed greatly with numerous natural water bodies, such as lakes, rivers, floodplains, swamps, reservoirs and wetland that have diverse fisheries resources. However, the country now is a well-known merchant of fish and also classified as a protein inadequate nation (Areola, 2008). Fish from these sources have been overstretched and cannot cope with the present demand for aquatic food. There is need for alternative and viable option of fish production that will take care of this demand adequately (FAO 2014).

Moringa oleifera leaf has been known to be a good potential alternative ingredient source in feed formulation because of its excellent protein, mineral, amino acids and vitamin contents (Gadzirayiet al., 2012). The tree is also commonly distributed in the tropics and has high

nutritional quality, which can be compared favourable with other source of protein (Abo-State et al., 2014). The seeds and their pods contain 20-30% protein, 35-45% fatty acids and 73% of oleic acid. Also the protein content is higher than that of grain legumes and soybean (Ferreira et al., 2008). *Sargassum muticum* has lot of essential nutrients especially trace elements and other bioactive substances. It is considered as food supplement for the 21st century because of the proteins, lipids, polysaccharides, mineral, vitamins and enzymes present. It has also been used in poultry to improve the animal immune status with decrease in microbial load contain in the digestive tract and for their beneficial effect on quality of poultry meat and eggs (Adubados et al., 2013; Wang et al. 2013).

Non-conventional plant materials have been used over the years as protein or energy sources

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in the feed of *C. gariepinus* as partial or total replacement of fishmeal. However, there is dearth of information on the use of *Sargassum muticum* as ingredient in the formulation of *C. gariepinus* feed. Also no feeding trials have been carried out to compare the responses of the fish to *M. oleifera* leaf and *S. muticum*. Commonly utilized plant protein by feed manufacturers include soybean meal, peanut meal and cottonseed meal (Naylor *et al.*, 2009). Therefore, finding other sustainable protein sources from plant is still a major drive in the aquaculture sector in order to reduce dependency on fish meal as the main protein component in aqua feeds (Naylor *et al.*, 2009). *Moringa oleifera* leaf and *Sargassum muticum* are good sources of protein, vitamins and minerals, which need to be given considerable attention as novel ingredients for use in fish feed production. Comparing the growth performances of fish with these ingredients is also very crucial. Therefore this study is aimed to evaluate the growth performance of *C. gariepinus* fingerlings fed *Moringa oleifera* leaves and *Sargassum muticum*.

METHODOLOGY

Experimental Diet

Fresh *Moringa oleifera* leaves were collected from the main plant within Lapai town and sundried for 3 days while *Sargassum muticum* was bought from Minna Niger State. They were processed into powder form and used as meals according to the method of Erum *et al.*, (2017). Other ingredients used for the formulation of diets, which include fish meal, maize, soymeal and starch, were purchased from Lapai market. Diet formulation was carried out at the laboratory of the department of Biological Sciences, Ibrahim Badamasi Babangida University Lapai Niger State. The diets were formulated using Pearson's method of feed formulation. The diet ingredients were grounded separately into equal sizes with grinding machine and then weighed according to proportions needed for each diet. Starch was added to the feed to act as binder in holding the feed together after thorough and proper mixing of the ingredients. Hot water was added to bring about the binding ability to dough - like paste for smooth pelleting using pelleting machine. The resulting pellets were sun dried to remove moisture and then packaged in air tight polythene for storage in a dry place. The diets were formulated at 40% crude protein using

Pearson's square method in accordance to the standard methods of NRC (1993). Five diets each containing different levels of *Moringa oleifera* leaves and *Sargassum muticum* were formulated. The diets contain 0%, 25%, 50%, 75% and 100% inclusions to replace equal amount of these ingredients. The diets were designated as follows: *Moringa oleifera* leaf meal inclusion (M₁, M₂, M₃, M₄ and M₅) and *Sargassum muticum* meal inclusion (S₁, S₂, S₃, S₄ and S₅). Coppens, which is a standard feed and fishmeal, was used as positive and negative control respectively. Proximate analyses of the experimental diets (M₁ - M₅ and S₁ - S₅), Coppens and Fishmeal were carried out according to standard methods (AOAC, 2006).

Experimental Set Up and Feeding Trials of fishes

Three hundred (300) healthy fingerlings of *Clarias gariepinus* were purchased from commercial fish farms at Minna Niger State. The experimental fish were then transported to Biological Science Department, Ibrahim Badamasi Babangida University Lapai, Niger State where the Fish were acclimatized for fourteen days (2 weeks) before the commencement of the experiment. Fish were fed with commercial feed (1mm Coppens) during acclimatization period. Thirty (30) transparent plastic aquaria of dimension (60×30×30 cm) were set for the 5 treatments of the diets and made in triplicates of 10 fingerlings per aquarium. The fingerlings were randomly selected, length and weight taking and then transferred into each aquarium and fed twice daily at 5% body weight between 8am and 6pm everyday. Feeding trials were done for a period of 90 days.

Determination of Feed efficiency and growth parameters

Feed efficiency and growth parameters were calculated by applying the appropriate formulae as described by (Roberson *et al.*, 2000; Venkatet *et al.*, 2004; Nalawade and Bhilave, 2011).

Body Weight Gain (BWG) = Final weight (g) - Initial weight (g)

Feed efficiency (EF) = $\frac{\text{Weight gained (g)}}{\text{Feed fed (g)}} \times 100$

Specific growth rate (SGR) = $\frac{\ln \text{Final weight} - \ln \text{Initial weight}}{\text{Feeding period (day)}} \times 100$

$$\text{Protein Efficiency Ratio} = \frac{\text{Weight body gain}}{\text{Protein intake (g)}} \times 100$$

$$\frac{\text{Survival Rate (SR)}}{\frac{\text{Total No of fish harvested}}{\text{Total No of fish stocked}}} \times 100 =$$

Determination of Water Quality Analyses

Temperature (°C), Biochemical Oxygen Demand (mg/l), pH, Electrical Conductivity (µ/cm), nitrate (mg/l) and nitrite (mg/l) of each plastic aquarium were monitored and measured during the period of experiment. These parameters were measured according to standard methods of APHA (1995).

Statistical Analyses

Data collected were subjected to one-way analysis of variance (ANOVA) using SPSS version 21.0. Differences between the mean were compared by Duncan's post hoc test at 5% (p<0.05) probability level. Data are presented as minimum, maximum, mean ± standard deviation.

RESULTS

The proximate composition (%) of *Moringa olifera* leaves meal diet used for the feeding trials is shown in Table 1. There were differences in nutrient compositions of the diets used during the study. The crude protein content was highest in M₅ (39.02%) within the diets and lowest in M₃ (34.12%). Moisture content was highest in M₃ (13.72%) and lowest in M₂ and Coppens feed (10.00%). Ash content was highest in fishmeal and lowest in Coppens (5.00). Fats were highest in Coppens (14.22%) and lowest (6.75) in M₅(100%). Crude fibre was highest (8.75%) in M₄(75%) and Coppens feed was lowest (6.88%).

The proximate composition (%) of *Sargassum muticum* meal diets used for the feeding trials is shown in Table 2. The crude protein content was highest in S₄ (42.85%) within the diets and lowest in S₂ (38.62%). Moisture content was highest in S₁ (10.20%) and lowest S₂ (9.46%). Ash content was highest in S₅ (22.00%) and lowest in Coppens(5.00%). Fat was highest in Copens (14.22%) and lowest in S₂ (7.32). Crude fibre was highest in S₅ (8.18%) and Coppens (6.88%).

Table 3 shows growth response of *Clarias gariepinus* fingerlings fed varying levels of *Moringa olifera* leaves meal with Coppens as

control. There were variations in initial weights, final weights and body weight gain of fish used during the period of study. Initial weight (g) was highest in M₂ (25%) with 10.70 and lowest in M₅ (100%) with 9.33 while final weight (g) was highest in M₁ (0%) (49.33) followed by Coppens with 49.00 and lowest in M₅ (100%) with 32.00. Also body weight gain (g) was highest and lowest in M₁ (0%) with 39.90, followed by Coppens with 38.33 and M₂ (25%) with 22.44 respectively. There was significant difference (p<0.05) in initial weights, final weight and body weight gain.

Table 4 shows growth response of *Clarias gariepinus* fingerlings fed varying levels of *Sargassum muticum* meal with Coppens as control. There were variations in initial length, total length, initial weights, final weights and body weight gain of fish used during the period of study. Initial weight (g) was highest in control (10.70) followed by S₁ (0%) with 10.33 and lowest in S₅ (9.60) while final weight (g) was highest in Coppens(49.00) followed by S₂ (25%) with 46.22 and lowest in S₅ (100%) with 33.00. Also body weight gain (g) was highest in Coppens with 38.33 followed by S₂ (25%) with 35.80 while the lowest was S₅ (23.44). There was significant difference (p<0.05) in initial weight, final weight and body weight gain during the period of study.

The utilization of *Moringa olifera* leaves meal by *Clarias gariepinus* with Coppens as control is shown on Table 5. Variations occurred in specific growth rate, feed efficiency, protein efficiency ratio and survival rates during the period of study. Specific growth rate was highest in M₁ (0%) with 1.41 and lowest in M₅ (100%) with 0.98. Likewise Protein efficiency ratio where highest was recorded in M₁ (0%) with 1.12 and lowest in M₅ (100%) with 0.60. Feed efficiency was highest in M₄ (75%) with 4.31 and lowest in Coppens with 2.74. The survival rate was highest in Coppens (100%) with M₄ (75%) and M₅ (100%) both with 71.70% while M₁ was lowest with 66.70%. There were significant differences (p<0.05) in specific growth rate, protein efficiency rate and survival rate between Coppens and other treatments. There was significant difference (p<0.05) in feed efficiency between Coppens and other treatments with the exception of M₃ (50%) and M₅ (100%).

The utilization of *Sargassum muticum* meal by *Clarias gariepinus* with Coppens feeds as control is shown on Table 6. Variations were observed in specific growth rate, feed efficiency, protein efficiency ratio and survival rates during the period of study. Specific growth rate was highest in S₃ (50%) with 3.80 and lowest in control. Feed efficiency was highest in S₄ (75%) with 4.34 and lowest in Coppens with 2.74.

Protein efficiency ratio was highest in S₁ (0%) with 0.90 and lowest in S₃ (50%) with 0.64. The survival rate was highest in Coppens and S₅ (100%) as lowest with 66.70%. There was significant difference (p<0.05) in specific growth rate between Coppens and other treatments except S₂ (25%). There was significant difference (p<0.05) in survival rate between Coppens and other treatments.

Table 1: Proximate Composition (%) of *Moringa olifera* leaves meal diets

Diet	Moisture Content	Crude Protein	Ash Content	Fats	Crude Fibre
M ₁ (0%)	10.41±0.95	35.52±2.63	10.00±0.10	8.30±1.02	8.40±1.03
M ₂ (25%)	10.00±0.13	38.67±2.80	13.00±1.20	8.67±1.20	8.48±1.30
M ₃ (50%)	13.72±1.40	34.12±2.20	13.85±1.08	8.25±0.98	8.38±1.06
M ₄ (75%)	10.00±0.10	37.45±3.80	10.00±0.11	7.84±1.71	8.75±1.66
M ₅ (100%)	12.00±1.32	39.02±4.01	10.00±0.15	6.75±1.43	8.65±0.99
Coppens	10.00±0.11	44.40±2.23	5.00±0.04	14.22±1.09	6.88±0.22

Table 2: Proximate Composition (%) of *Sargassum muticum* meal diets

Diet	Moisture Content	Crude Protein	Ash Content	Fats	Crude Fibre
S ₁ (0%)	10.20±1.20	40.37±3.57	15.00±2.43	8.32±0.52	7.42±1.04
S ₂ (25%)	9.46±1.03	38.62±3.40	17.04±2.89	7.34±0.14	7.60±0.88
S ₃ (50%)	10.00±0.71	42.75±2.57	18.00±1.38	10.00±1.09	7.65±0.42
S ₄ (75%)	10.00±1.05	42.85±4.34	19.45±3.65	10.86±1.24	8.12±0.22
S ₅ (100%)	10.00±1.10	40.00±2.30	22.00±2.04	10.55±1.14	8.18±1.21
Coppens	10.00±0.98	44.40±5.60	5.00±0.01	14.22±1.90	6.88±0.91

Table 3: Growth response of *Clarias gariepinus* fingerlings fed varying levels of *Moringa olifera* leaves meal with coppens as control

Diet	Initial Weight (g/fish)	Final Weight (g/fish)	Body Weight Gain (g/fish)
Coppens	10.70±1.15 ^a	49.00±6.60 ^a	38.33±5.70 ^a
M ₁ (0%)	9.44 ±1.23 ^{ab}	49.33±2.45 ^a	39.90±2.71 ^a
M ₂ (25%)	10.70±0.90 ^a	43.00±4.44 ^b	32.25±4.05 ^b
M ₃ (50%)	9.70±1.03 ^{ab}	34.60±2.50 ^{cd}	24.90±2.42 ^{cd}
M ₄ (75%)	9.50±1.18 ^{ab}	37.11±3.80 ^c	28.00±3.65 ^c
M ₅ (100%)	9.33±0.71 ^b	32.00±2.19 ^d	22.44±2.01 ^d

Table 4: Growth response of *Clarias gariepinus* fingerlings fed varying levels of *Sargassum muticum* meal with coppens feed control

Diet	Initial Weight (g/fish)	Final Weight (g/fish)	Body Weight Gain (g/fish)
Coppens	10.70±1.15 ^a	49.00±6.60 ^a	38.33±5.70 ^a
S ₁ (0%)	10.33±0.71 ^{ab}	45.00±4.66 ^a	34.70±4.74 ^a
S ₂ (25%)	10.10±0.90 ^{ab}	46.22±4.35 ^a	35.80±4.64 ^a
S ₃ (50%)	9.60±0.72 ^b	38.44±3.64 ^b	28.90±3.41 ^b
S ₄ (75%)	9.60±0.88 ^b	33.80±1.90 ^c	24.22±2.22 ^c
S ₅ (100%)	9.60±0.53 ^b	33.00±2.35 ^c	23.44±2.40 ^c

Table 5: Feed utilization *Clarias gariepinus* fingerlings fed varying levels of *Moringa olifera* leaves meal with copen feed as control

Diet	SGR	FE	PER	SR
Coppens	1.30±0.09 ^{ab}	2.74±0.41 ^c	0.86±0.13 ^b	100.00±0.00 ^a
M ₁ (0%)	1.41±0.16 ^a	4.00±0.27 ^a	1.12±0.08 ^a	66.70±15.10 ^c
M ₂ (25%)	1.13±0.11 ^{bc}	3.45±0.44 ^b	0.83±0.10 ^{bc}	83.30±10.30 ^b
M ₃ (50%)	1.02±0.11 ^c	2.86±0.30 ^c	0.73±0.07 ^d	75.00±5.50 ^{bc}
M ₄ (75%)	1.13±0.15 ^{bc}	4.31±0.56 ^a	0.75±0.10 ^{cd}	71.70±17.20 ^{bc}
M ₅ (100%)	0.98±0.11 ^c	2.95±0.27 ^c	0.60±0.05 ^e	71.70±17.20 ^{bc}

Values in the same column with different superscript are significantly different ($p < 0.05$) **SGR** = Specific Growth Rate **FE** = Feed Efficiency **PER** = Protein Efficiency Ratio **SR** = Survival Rate

Table 6: Feed utilization of *Clarias gariepinus* fingerlings fed varying levels of *Sargassum muticum* with copen feed as control

Diet	SGR	FE	PER	SR
Coppens	1.30±0.10 ^b	2.74±0.41 ^a	0.86±0.13 ^a	98.30±4.08 ^a
S ₁ (0%)	3.77±0.13 ^a	3.50±0.60 ^a	0.90±0.15 ^a	76.70±8.16 ^b
S ₂ (25%)	1.40±0.10 ^b	3.14±0.25 ^a	0.80±0.06 ^a	78.30±13.29 ^b
S ₃ (50%)	3.80±0.12 ^a	3.03±1.80 ^a	0.64±0.38 ^a	76.70±16.33 ^b
S ₄ (75%)	3.70±0.44 ^a	4.34±1.55 ^a	0.79±0.28 ^a	78.30±14.72 ^b
S ₅ (100%)	3.60±0.09 ^a	3.66±0.43 ^a	0.80±0.09 ^a	73.30±12.11 ^b

Values in the same column with different superscript are significantly different ($p < 0.05$) **SGR** = Specific Growth Rate **FE** = Feed Efficiency **PER** = Protein Efficiency Ratio **SR** = Survival Rate

Water Quality parameters

The water quality parameters used for culturing *C. gariepinus* fed *Moringaolifera* leaf diet during the study, are shown on Table 7. There were variations in temperature, pH, electrical conductivity, biochemical oxygen demand, nitrate and nitrite. Temperature of the water (°C) ranged between 21.00 and 32.00 of mean 30.32. The pH ranged between 6.00 and 7.50 with mean value of 6.55 indicate almost neutral. Electrical conductivity (μ /cm) ranged between 54.00 and 666.00 of mean 501.84. Others include BOD (mg/l) of range 4.80 and 52.00, nitrate (mg/l) of range 4.20 and 6.30 and nitrite (mg/l) of range 0.01 and 1.00 with mean values of 5.70, 5.36 and 0.09 respectively.

Table 7: Water Quality Parameters used in culturing *Clariasgariepinus* fed *Moringa olifera* leaves diets

Parameter	Minimum- Maximum	Mean \pm Standard Deviation
Temperature (°C)	21.00 - 32.00	30.32 \pm 0.70
pH	6.00-7.50	6.55±0.41
EC(μ /cm)	54.00-666.00	501.84±53.80
BOD (mg/l)	4.80-52.00	5.70±2.50
Nitrate (mg/l)	4.20-6.30	5.36±0.31
Nitrite (mg/l)	0.01-1.00	0.09±0.07

The water quality parameters used for culturing *C. gariepinus* fed *Sargassum muticum* diet during the study, are shown on Table 4.12. There were variations in temperature, pH, electrical conductivity, biochemical oxygen demand, nitrate and nitrite. Temperature of the water (°C) ranged between 25.00 and 32.00 of mean 30.08. The pH ranged between 6.00 and 7.50 with mean value of 6.53 indicate almost neutral. Electrical conductivity (μ /cm) ranged between 223.00 and 663.00 of mean 494.24. Others include BOD (mg/l) of range 4.79 and 6.50, nitrate (mg/l) of range 4.62 and 8.21 and nitrite (mg/l) of range 0.009 and 0.098 with mean values of 5.47, 5.47 and 0.09 respectively.

Table 4.12: Water Quality Parameters of plastic transparent aquaria used in culturing *Clarias gariepinus* fed *Sargassum muticum* diets

Parameter	Minimum-Maximum	Mean \pm Standard Deviation
Temperature (°C)	25.00-32.00	30.08 \pm 0.73
pH	6.00-7.50	6.53 \pm 0.40
EC(μ /cm)	223.00-663.00	494.24 \pm 46.80
BOD (mg/l)	4.79-6.50	5.60 \pm 0.38
Nitrate (mg/l)	4.62-8.21	5.47 \pm 0.38
Nitrite (mg/l)	0.009-0.098	0.09 \pm 0.009

DISCUSSION

The quality of feed used in aquaculture on the basis of its nutritional value is assessed from the growth and well-being of fish being produced. The proximate compositions of these feeds revealed variations in constituents and proportions, which plays a significant role in growth rate as well as acceptability by the fish. Moisture content of *Moringa olifera* leaves diet, which was highest (13.72) in M₃ (50%), can be compared to Coppens and other *M. olifera* diets. This was higher than 6.23 reported by Eteng (2019). The lowest moisture content in coppens feed could be due to adequate dryness. Crude protein is of great importance to fish growth and being highest in Coppens (44.40), can be compared with other diets of *M. olifera* leaves. The differences observed in the diets could be due to processing method and percentage composition of ingredients. Nevertheless, this fall within 25-50% range of crude protein contents required in fish feed according to

Hammed *et al.* (2013). Ash content with highest in M₃ (13.85) can be compared with *M. olifera* leaves diets, which is higher than Coppens. This could be due to the differences in mineral contents or resulted from the added minerals (premix) during diet formulation. Ash content of 9.48 was reported by Eteng (2019), which was lower than *M. olifera* leaves diets. Fats is important in fish diet but once in excess could cause less feed intake by fish and also leading to feed spoilage. The high fat content in Coppens diet could be due to the nature of feed ingredients. This is supported by the fact that there was decrease in fats of diets as inclusion level of *M. olifera* leaves increased (M₂<M₃<M₄<M₅). Crude fibre with high values recorded in both *M. olifera* leaves diets compared to Coppens could be due to the presence of high proportion of plant materials in them. This is because plant materials have been known to contain high percentage of cellulose.

The content of moisture of *Sargassum muticum* meal diet, which was highest in diet S₁ (0%) can be compared to Coppens and other diets. The lowest moisture content in S₂ could be due to processing level and ingredients composition. Crude protein in *S. muticum* meal diets can be compared with that of Coppens (44.40) being highest and better than that of other diets. Hardouin *et al.* (2013) reported crude protein of 22.1%, which is less than range of 37.63-42.85 recorded in this study. The ash content highest (22.00) in S₅ (100%) and lowest in Coppens (5.00) could be due to differences in mineral contents or feed ingredients because 100% of the constituents is *S. muticum*. Holdt and Keran (2011) reported ash contents range of *S. muticum* of 14.00-44.00, which is within the findings of this study. Fat that is highest in Coppens (14.22%) and lowest (7.34) in S₂ (25%) can be compared to S₄ (75%). Crude fat of 0.5-3.9% was reported by Holdt and Kraan (2011), which is less than the findings of this study. This could be due to the nature of feed ingredients. The crude fibre highest in S₅ (100%) *S. muticum* diets compared to Coppens and fishmeal could be due to the presence of high proportion of plant materials in them. This is because plant materials have been known to contain high percentage of cellulose. This is also evident in other *S. muticum* diets compared with the control feed.

Growth is determined by the extent of size (length and weight) an organism can reach or

attain at a particular point in time. The initial mean weights of fish in different diets with the exception of M₂ (25%) differ significantly ($p < 0.05$) with Coppens. This could be due to the fact that some grows faster than others even if fish belong to the same age group. The final weight, which was highest in Coppens differ significantly ($p < 0.05$) from other diets except M₁ (0%) without inclusion of *M. olifera* leaves meal. This could be due to the nutritional composition or acceptability of these diets by the fish. The body weight gain was highest in M₁ (0%), which differ significantly ($p < 0.05$) with other diets except Coppens. This implies that the diets were utilized differently by fish. The decreased in body weight gain as the level of *M. olifera* leaves meal increased could be due to difference in nutrients composition or non-acceptability of the diet by the fish. Ogaga *et al.* (2017) reported that increased substitution of defatted *M. olifera* seed meal caused decreased in growth rate. This could be the reason for such observation. The initial weight of fish, which was highest in M₂ (25%) did not differ significantly ($p > 0.05$) from other diets. This shows that fish used for this study are from the same age group. However, diet M₁ (0%) being highest shows significant difference ($p < 0.05$) with other diets. Eteng (2019) reported mean weight gain of 7.51g for fish fed *M. olifera* diet which is lower than the findings of this study.

The initial weight of fish fed Coppens, which is highest differ significantly ($p < 0.05$) with other *Sargassum muticum* meal diets, although diets S₁ (0%) and S₂ (25%); S₃ (50%), S₄ (75%) and S₅ (100%) can be compared favorably because they did not differ significantly. Coppens, which recorded the highest final weight gain can be compared with diets S₁ (0%) and S₂ (25%), which follow the same trend with body weight gain. This implies that these diets could provide the necessary nutrients needed for good growth. However, Coppens differ significantly ($p < 0.05$) with diets S₃, S₄ and S₅ in final weight and body weight gain. This could be due to difference in the nutritional values of the diets. The decreased in body weight gain with exception of S₂ (25%) showed the acceptability of this diet by fish. The final weight that was highest in S₂ (25%) differ significantly ($p < 0.05$) with other diets except S₁ (0%). This followed the same trend with body weight gain and there was also decrease in such gain as the inclusion level of *S. muticum* meal increases. This could also be due to the anti-

nutritional attributes of the weed. Abdul-Qadir *et al.* (2020) reported mean weight gain of 13.25g for *S. muticum* diet, which was lower than the findings of this study.

Determination of extent or level of feed being consumed by fish and its safety is very important in any culture practice. The specific growth rate, which relates fish growth with the diet consumed was highest (1.41) in diet M₁ (0%) and significantly different ($p < 0.05$) with Coppens and other diets, although M₃ (50%) and M₅ (100%) did not differ significantly. This parameter decreased as inclusion level of *M. olifera* leaves meal increased. This implies that low inclusion level promote better growth. SGR that is also highest in M₁ (0%) significantly differ ($p < 0.05$) from other *M. olifera* diets. The insignificant difference observed in other diets implies that fish growth rate can be compared. SGR of 0.28 and 0.21 for *M. olifera* diet and diet with fishmeal reported by Eteng (2019) were lower than the findings of this study. Specific growth rate of *S. muticum* meal diet that is highest in S₃ (50%) differ significantly ($p < 0.05$) with Coppens and S₂ (25%) but compared with other diets. Abdul-Qadir *et al.* (2020) reported 0.16 as mean SGR, which is lower than the findings of this study. This could be due to the difference in level of utilization by the fish.

Feed efficiency (FE) is the extent by which feed is used by fish in converting it into flesh. M₄ (75%), which is highest differ significantly ($p < 0.05$) with Coppens and other *M. olifera* leaves diets except M₁ (0%). This could be due to the palatability or acceptability of the diet by fish. This indicates difference in rate of converting these diets into flesh. Diet of *S. muticum* with 50% inclusion level (S₃), which was highest did not differ significantly ($p > 0.05$) with other diets and even Coppens. This implies that these diets can be compared in their conversion to flesh.

Protein efficiency ratio (PER) deals with fish weight gain resulting from protein intake. Diet M₁ (0%) being highest differ significantly ($p < 0.05$) with other diets of *M. olifera* leaves meal even with Coppens. This implies that protein was not used at the same rate by the fish for growth or weight gain. The lower the PER, the better the weight gain, which implies that M₁ (0%) was least utilized by the fish. There was decrease in PER with increased *M. olifera* leaves meal inclusion.. Umar (2018) did report

decreased PER with increased level of *M. olifera* leaves meal, which is similar with the findings of this study. Diet of *S.muticum* was also highest in S₁ (0%) but did not differ significantly ($p>0.05$) from other diets and Coppens, which implies that the weight gain resulting from protein intake was similar. S₄ (75%), which was highest also did not differ significantly ($p>0.05$) with fishmeal and other diets of *S. muticum*, implying similar rate of protein intake.

Survival rate is very important in feeding experiment and it helps to determine how safe diet is to fish on the basis of ingredients inclusion rate. Survival rate, which was highest in Coppens differ significantly ($p<0.05$) with diets of *M. olifera* leaves meal while diets M₃, M₄ and M₅ did not show any significant difference in survival rate. This could be due to the anti-nutritional factors as reported by Umar (2018). The survival rates of the fish were greater than 50% for the control feed, which implies that these meals is safe and those not have negative effect to the fish. Such survival rate of fish which was highest in Coppens differ significantly ($p>0.05$) from *S. muticum* diets although such differences was not observed among the diets. The survival rate was above 50% implying also the safety of the diet for fish.

Water quality is very important in determining the suitability of an environment to support fish growth and survival. Those monitored in this study for *M. olifera* leaf and *S. muticum* were temperature, pH and dissolved oxygen, which are also crucial in fish production. However, wide variations in these parameters due to pollution results in fish death. For *M. olifera* leaf and *S. muticum* diets mean temperatures ranged between 30.32 and 30.08 °C in this study is slightly above the acceptable range of 20.00-30.00°C according to Bhatnagar and Devi (2013) for fish survival and production. Changes of water pH affect the growth as well as health of fish especially if it is below or above acceptable range. The pH value of 6.55 and 6.53 reported in this study for *M. olifera* leaf and *S. muticum*, which is almost neutral fall within desirable range of 6.50 - 9.0 for fish survival. Electric conductivity relates to the total ion present in water, which could affect fish negatively especially at intolerable concentration. The mean value of 501.84 µ/cm and 494. 24 µ/cm *M. olifera* leaf and *S. muticum* falls within 30-5,000, which are acceptable ranges for the culture of fish. Mean biochemical

oxygen demands for *M. olifera* leaf and *S. muticum* that are 5.70 mg/l and 5.47mg/l also falls within acceptable range (3.00-6.00 mg/l) for fish culture. Nitrate determined in this study for *M. olifera* leaf and *S. muticum* being 5.36 mg/l and 5.47 mg/l fall within the acceptable range (0.00-100mg/l) for fish production. Nitrite reported for *M. olifera* leaf and *S. muticum* in this study (0.09mg/l and 0.09 mg/l) are within the acceptable range (0.02-2.00) as reported by Bhatnagar and Devi (2013).

It may be concluded based on the results obtained in this study that inclusion of *Moringaolifera* leaves and *Sargassum muticum* in diets for *C. gariepinus* positively affect feed efficiency and growth parameters of the fishes. *Moringa olifera* leaves and *Sargassum muticum* can be used as protein source replacement in the diet of fingerlings of *C. gariepinus* at the proper proportions.

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