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Growth performance and nutrient utilization of *Clarias gariepinus* fed with different dietary levels of processed cassava leaves

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The growth performance of *Clarias gariepinus* fed with different dietary levels of processed cassava leaves and their nutrient utilized were studied for a period of 24 weeks. One hundred and forty four experimental Catfish (*Clarias gariepinus*) with 0.75±0.20 g mean weight and 3.9±0.31 cm mean total length were collected from Aqua-fish Consult, Awka, Anambra State, Nigeria. Eighteen rectangular plastic tanks were used for this study. Green cassava leaves (*Manihot esculenta*) were collected from a farm in Uda, Igbo-Eze North of Enugu State. The leaves were soaked for 36 h and sun-dried for one week to reduce the presence of cyanogenic glycosides. The dried leaves were ground into fine powder and analyzed for proximate composition. The experimental design used was Complete Randomized Block Design (CRBD) consisting of 18 treatments. Triplicate culture tanks in treated (L_{25}-L_{100}), and control groups (L_0 and $A_{c)}$ were stocked with eight fingerlings per square meter, respectively. The cost benefit of *C. gariepinus* fingerlings was estimated using weight gain and specific growth rate against management and construction cost. Weight gain, specific growth rate (SGR), feed efficiency (FE) and total length (TL) of catfish in different treatments were plotted against water chemistry parameters. This trail was conducted to access the possibility of replacing maize (*Zea mays*) with varying levels of whole cassava leaf meal in the diet of *C. gariepinus* catfish. Five isocaloric and isonitrogenous diets were formulated to contain 0, 25, 50, 75 and 100% cassava leaves to replace equal weight of maize meal. Internationally made fish feed (coppens) was also used as a control feed. All the diets were fed to catfish (*C. gariepinus*) fingerlings in replicate for 24 weeks. The results revealed that optimum requirement of cassava leaves level in the formulation of practical diets for improved growth of *C. gariepinus* was 25%.

Key words: Growth performance, nutrient utilization, *Clarias gariepinu*, cassava leaves.

INTRODUCTION

The overall effect of food insecurity is not only inadequate food production but also imbalances in the nutritional status of the populace at large (Aderemi et al.,2012).The dearth of animal products in the diet of an average

Nigeria increases yearly, mainly due to poverty, high cost of animal feeds, political and economic instability coupled with decreased interest in animal production with greater efforts directed towards petroleum exploitation. Leaf meals of most tropical plants for example cassava leaf meal (Anyanwu, 2009) are available and cheap. Cassava is a multipurpose plant that thrives well in the tropics. It is a very good energy source widely grown in Nigeria. It has a wide range of adaptability, resistance to drought and tolerance to poor soils.

African Catfish (*C.garepinus*) are known to be omnivorous in their food habits (Anyarnwu et al., 2012). Besides, they are hardy and tolerant to a wide range of environmental conditions (Nwani et al., 2015). These attributes have indicated the fish as highly and veraciously disposed to accepting unconventional dietary feeds, such as leaf meals. The quest to intensify the culture of the fish so as to meet its ever increasing demand has made it vital to develop suitable diets either in supplementary forms in ponds or as whole feed in tanks (Olukunle, 2006).Feed is one of the major inputs in aquaculture production and fish feed technology has become one of the least development sectors of aquaculture particularly in Africa and other developing countries of the world (Gabriel et al., 2007). High cost of fish feed ingredients (maize and fish meal) is observed as one of the problems militating against aquaculture development in Nigeria (Gabriel et al., 2007). This leads to malnutrition of fish which subsequently results in decline in reproduction of individual fish. This eventually causes scarcity of fish species in the market which invariably results in high cost of fish. Leaf meals of most tropical plants, for example, cassava leaf meal (Anyanwu, 2009) are available and cheap.

Cassava roots and leaves are readily available and have also been found to support the growth of different fish species such as C. *gariepinus* (Catfish), *Oreochromis niloticus* (Tilapia), *Mystus cavasinus* (Catfish); but this can be limited by the presence of anti-nutrients such as linamarin. Linamarin is cyanogenic glycosides (2-B-D-glucopyranosy 1oxy-isobutryo nitrite) found in leaves and tuberous roots of cassava, which release high toxic cyanide (HCN) during hydrolysis at the time of digestion (Presston, 2004; Aderemi et al., 2012; Akapo et al., 2014). Previous researchers have attempted to increase non-conventional plant and animal materials to replace conventional feed ingredients like maize and fish meal in fish feed ration (Falaye, 1988; Fagbenro, 1992; Olatunde, 1996; Baruah et al., 2003; Eyo and Ezechie, 2004; Azaza et al., 2015). According to Olurin et al. (2006), maize is the major source of metabolizable energy in most compounded diets for *Hetorebranchus x clarias* hybrid species because it is readily available and digestible. However, the increasing prohibitive cost of this commodity has necessitated the need to search for an alternative source of energy.

Few works are available on the replacement of maize with cassava root and cassava leaf in fish diet. These include those on mirror carp, *Cyprinus Carpio* (Ufodike and Matty, 1983), Rainbow trout, Salmo trutta (Ufodike and Matty, 1984), Tilapia, *Oreochromis niloticus* (Faturoti and Akinbote, 1986), *Oreochromis mossambicus* (Wee and Ng, 1986); catfish, *C. gariepinus* fingerlings (Olurin et al., 2006); *C. gariepinus* advance fry (Olukunle, 2006), *C. gariepinus* (Anyanwu et al., 2009, 2012) and *Tinca tinca* (Garcia et al., 2015); hence the quest to determine the growth performance and nutrient utilization of *C. gariepinus* species fed with varying dietary levels of cassava leaf meal as substitute for maize.

MATERIALS AND METHODS

Procurement of *C.gariepinus*

One hundred and forty four experimental Catfish with 0.75±0.20 g mean weight and 3.9±0.31 cm mean total length were collected from Aqua-fish Consult, Awka, Anambra State, Nigeria. After collection, they were transported to the wet laboratory of Zoology Department, University of Nigeria, Nsukka and allowed to acclimatize for 2 weeks with rectangular plastic tanks.

Preparation of culture tanks

Eighteen rectangular plastic tanks were used for this study for a period of twenty four weeks. Each tank has a water-holding capacity of 95 L, but water was maintained at 60 L level within the period of the research (Eyo, 1994). However, they were covered with mosquito net to prevent escape of fish, as well as entry of predators, and leaves from falling in. All tanks were continuously aerated using air pump.

Collection and processing of cassava leaves

Green cassava leaves (*Manihot esculenta*) were collected from a farm in Uda, Igbo-Eze North of Enugu State. The leaves were soaked for 36 h and sun-dried for 1 week to reduce the presence of cyanogenic glycosides. The dried leaves were grounded into fine powder and analyzed for proximate composition according to the procedure of APHA (2006).The proximate composition of the nutrient contents is shown in Table 1.

Formulation of fish feed with cassava leaves

Proximate analysis of dietary ingredients was carried out. Then, five isocaloric and nitrogenous diets were prepared: they contain 0, 25, 50, 75 and 100% processed cassava leaves, which were labeled L_0, L_{25}, L_{50}, L_{75}, and L_{100} respectively, to replace equal weight of maize. Prior to formulation of the five inorganic diets, experimental feeds were ground to a fine powder by using hammer mill machine. One kilogram of the feed was weighed out using a triple beam

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Table 1. Proximate composition of nutrient content of cassava leaf.

Parameter	Percentage composition
Moisture	9.911
Ash	2.787
Fats	10.365
Fibre	4.386
Protein	21.628
Carbohydrate	50.923

Table 2. Percentage composition of experimental diets in different treatment (cassava leaves inclusion) .

Ingredients	Treatment				
	L_o (Control 0% cassava leaves inclusion)	L_{25} (25% cassava leaves inclusion)	L_{50} (50% cassava leaves inclusion)	L_{75} (75% cassava leaves inclusion)	L_{100} (100% cassava leaves inclusion)
Maize meal	40	30	20	10	0
Cassava leaves	0	10	20	30	40
Fish meal	15	15	15	15	15
Soya beans	31	31	31	31	31
Wheat middling	8	8	8	8	8
Vitamin premix	1	1	1	1	1
Mineral premix	1	1	1	1	1
Vegetable oil	2	2	2	2	2
Bone meal	1.5	1.5	1.5	1.5	1.5
Salts	0.5	0.5	0.5	0.5	0.5
Total	100	100	100	100	100

balance model 700. The diets were homogenously mixed with 200ml of water and placed in sealed heat resistant polythene bags. The polythene bags were steamed for an hour. This was done to facilitate the gelatinization of starch and binding of diets. The diets were run through meat mincer fitted with 3mm dye and the resulting nodule shaped strands were cut into pellets and oven dried at 50°C for 3 h. The proximate analysis of the diet was carried out (AOAC, 1975) and shown in Table 2.

Experimental design

The experimental design used was Complete Randomized Block Design (CRBD) involving 18 treatments. Triplicate culture tanks in treated (L_{25}-L_{100}), and control groups ($L_0$and $A_{c)}$ were stocked with eight (8) fingerlings M^{-2} respectively (Anibeze et al., 2003).

Control group A_c was fed with internationally made feed (coppens) while Control group L_0 was fed with 0% dietary level cassava leaves. Prior to feeding, the fish in each tank was left for 2 days during which no artificial diet was administered to them, but was starved to allow utter digestion of any food in their stomach. At the end of acclimatization, fish in each tank were weighed (with mettler top loading balance) to determine their initial mean weight. Also mean total length and mean standard length measurements were taken using fish measuring board. The fish were fed daily in two rations (at 9:00am and 4:00pm) at a rate equivalent to 5% of the total body weight of the fish in each tank. The quantity of the diet administered was adjusted fortnightly using weight gain data.

Acceptability of diet

The acceptability of diet was accessed using the "time to strike index" (Eyo, 1994). The fish in every treatment was starved overnight to induce hunger. Pellet of diets for each treatment was dropped into the aquarium; the time which elapsed from the time the pellet penetrates the water and the moment the last fish struck the pellet with its mouth was recorded in seconds. The acceptability index was calculated as the reciprocal of the "time to strike".

Production parameters

All the fingerlings in each treatment were harvested and weighed collectively using mettler electronic balance (PC 2000) to the nearest 0.01g.

Weight gain

Weight gain was calculated using W_2-$W_{1,}$ where W_2 = final weight and W_1= initial weight over a period.

Specific growth rate (SGR)

Specific growth rate (SGR) was calculated using,

$$SGR = \frac{\log W_2 - \log W_1}{T_2 - T_1} \times \frac{100}{1}$$

Where W_2= weight at time T_2 (days); W_1=weight at time T_1 (days) (Brown, 1975).

Feed efficiency (FE)

Feed efficiency for catfish in different treatments was calculated using the formula;

$$\text{FE} = \frac{\text{Weight gain (b)}}{\text{Feed intake (a)}}$$

Where, feed intake (a) = feed eaten by the fish on a matter basis; weight gain (b) = a weight increase on wet matter basis (Boonyaratpalin, 1989).

Condition factor (K)

Condition factor of catfish in difference treatments was calculated using the formula:

$$K = \frac{100W}{L^3}$$

Where *W* = Weight of fish and L = total length of fish (Adikwu, 1992).

Total length (TL)

Total length of juvenile catfish in different treatments was recorded using fish measuring board to the nearest 0.01 cm.

Also, standard length of Juvenile catfish in different treatments was measured and recorded using fish measuring board to the nearest 0.01 cm.

Length-weight relationship (LWRs)

The length-weight relationship (LWRs) of the catfish in different treatments was plotted using the pooled data on length and weight of catfish in different treatments.

Water chemistry

Water quality parameters were measured during each sampling fortnightly. Temperature of the water was measured using mercury-in-glass thermometer, water pH was measured using Jenway P^H metre, dissolved oxygen was determined using dissolved oxygen metre, total hardness mg/L, total ammonia mg/L and nitrite were measured using spectrometer.

Growth parameters-water chemistry relationship

Weight gain, SGR, FE and TL of catfish in different treatments were plotted against water chemistry parameters. The TW was used to calculate the Normalized Biomass Index (NBI)(Beck, 1979):

$$NBI = (W_F \times N_F)(W_1 \times N_1) \times \frac{1}{100}$$

Where, W_F = Final weight of catfish in milligram, N_F = Final number of catfish, W_1 = Initial weight of catfish in milligram and N_1 = Initial number of catfish.

Cost benefit analysis

The cost benefit of *C. gariepinus* fingerlings was estimated using weight gain and specific growth rate against management and construction cost.

Feed cost

The cost of feeding the fish was computed using (Lipton and Harmel, 2004):

$C_{feed} = P \times W_A \times FCR/1-[0.5(1-S)]$

Where, C_{feed} = cost contribution of feed to produce a pound of fish, P=per pound price of fish, W_A = Weight added from purchase seed to harvest size (Harvest size - seed weight), FCR = Feed Conversion Ratio, and S=Percentage of fish surviving from seed to market size.

Seed cost

Cost of stocking at different densities was computed using:

$C_{seed} = P_{feed}/W \times S$ (Liption and Harmel, 2004).

Where, C_{seed} = Cost of contribution for producing a pound of fish, P_{feed}= Purchase price of seed (Cassava leaves), W= Average weight of harvestable fish, S = Percentage of fish surviving from seed to market size.

Management cost

Management Cost was computed using (Lipton and Harmel, 2004):

$C_{variable} = C_{seed} \times C_{feed}$

Where, C_{seed} = Cost of producing pound of fish; C_{feed} = Cost contribution of feed to produce a pound of fish.

All costs will be reduced to Naira (Nigeria National Currency) using Nsukka Urban Market Price.

Statistical analysis

Data resulting from the experiment were subjected to a two way analysis of variance using SPSS (Statistical package for social sciences) version 12. Turkey HSD, Dunkan, Fisher LSD and Tanhane were used to compare differences among individual means at P = 0.05.

RESULTS

Palatability of diets with different levels of cassava leaf meal inclusion fed to *Clarias gariepinus* juveniles

It was observed that it took the catfish 4.43 ± 0.08 s to strike diet A_c (coppens fish feed) as against 12.98 ± 0.12 s spent in striking diet L_{100} (100% cassava leaf meal substitution) (Figure 2). There was inconsistency in the

Table 3. Acceptibility index of *C. gariepinus* fed different dietary levels of CLM.

Diet	Week												
	0	**2**	**4**	**6**	**8**	**10**	**12**	**14**	**16**	**18**	**20**	**22**	**24**
L_o (0%CLM)	0.16	0.17	0.16	0.17	0.16	0.16	0.17	0.18	0.16	0.17	0.17	0.16	0.16
L_{25}(25%CLM)	0.19	0.17	0.17	0.19	0.18	0.18	0.18	0.20	0.17	0.20	0.20	0.19	0.19
L_{50}(50%CLM)	0.14	0.14	0.14	0.15	0.14	0.15	0.14	0.14	0.14	0.14	0.14	0.14	0.15
L_{75}(75%CLM)	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11
L_{100}(100%CLM)	0.08	0.07	0.08	0.07	0.08	0.07	0.08	0.08	0.08	0.08	0.08	0.08	0.08
A_c (IMCF)	0.24	0.24	0.25	0.24	0.20	0.23	0.21	0.24	0.23	0.22	0.22	0.20	0.24

*CLM = cassava leaf meal; *IMCF= Internationally made Coppens fish feed.

Table 4. Total Length (cm) of C. *gariepinus* juveniles fed graded levels of cassava leaf meal (CLM) substitution for 24 weeks.

Diet	Week												
	0	**2**	**4**	**6**	**8**	**10**	**12**	**14**	**16**	**18**	**20**	**22**	**24**
L_o (0%CLM)	4.0	4.4	5.1	6.2	7.4	8.5	10.5	13.1	15.1	17.3	20.6	23.2	26.7
L_{25}(25%CLM)	4.2	4.6	5.2	6.1	7.3	8.3	9.8	12.3	14.7	17.0	20.2	22.9	25.8
L_{50}(50%CLM)	4.7	5.1	5.9	6.8	7.5	8.3	9.4	10.7	13.4	16.5	19.7	22.2	25.7
L_{75}(75%CLM)	4.8	5.3	6.0	7.1	7.7	8.4	9.5	11.9	13.7	15.1	19.0	21.7	26.0
L_{100}(100%CLM)	4.5	4.9	5.8	6.4	7.4	8.6	9.7	10.8	12.5	15.1	16.0	17.2	19.6
A_c (IMCF)	3.8	4.0	4.9	6.3	7.5	8.5	10.7	14.1	16.0	18.7	20.9	24.0	27.6

*CLM = cassava leaf meal; *IMCF = Internationally made Coppens fish feed.

time spent to strike pellets from diets L_{25}; 5.42 ± 0.09 , L_{50}; 7.00 ± 0.04 , L_{75}; 9.07 ± 0.04 and L_0; 6.04 ± 0.05 s respectively. Similarly, the acceptability indices indicated that diets L_{25}, L_{50}, L_0 andA_c (0.19 ± 0.00, 0.14 ± 0.00, 0.17 ± 0.00 and 0.23 ± 0.00 respectively) were easily accepted compared to L_{75} and L_{100} (0.11 ± 0.00 and 0.08 ± 0.00 respectively). All diets' acceptability indices were significantly different from control diet and from one another (P< 0.05) (Table 3).

Growth response

The total length of group Ac was the highest (12.85 ± 2.22a) while L100 had the lowest total length (10.65 ± 39[a]). The mean total length decreases in the following order: Ac > Lo > L_{25}> L_{75}> L_{50}> L_{100} (Table 4).

The mean weight of catfish fed diet L_{100} (14.98 ± 4.61) was very low compared to those fed other diets. Also, diet L_{25} had the highest mean weight (43.69 ± 17.51) among the varied levels of substitution of cassava leaf meal (Table 4 and Figure 1).

Furthermore, the mean condition factor (1.10± 0.01[a]) of fish in diet was the highest followed by diet Ac. L0 > (50 > L_{75} > L_{100} giving the trend L_{25}> A_c> L_0> (50 > L_{75}> L_{100} (Table 4)

Weight gain

The mean weight of catfish fed diet L_{100} (100% Cassava leaf meal) - 14.98 ± 4.61 was very low compared to the mean weight of catfish fed diets L_0,L_{25}, L_{50}, L_{75} and A_c (41.17 ± 16.03, 43.69 ± 17.51, 32.45 ± 13.03, 26.85 ± 10.35 and 49.98 ± 19.43 respectively). Apart from group A_c (Internationally made coppens fish feed) which mean weight is relatively high, that is, 49.98 ± 19.43, group L_{25} had the highest mean weight gain (43.69 ± 17.51) among the varied levels of substitution of cassava leaf meal (Table 5).

Mean values with alphabets were compared with time to strike. Mean values with different alphabets differ significantly (P<0.05). Mean values with figures were compared with acceptability index. The time to strike differed significant (P<0.05) when diet groups were compared, with mean time to strike decreasing in the following order: L_{100}<L_{75}<L_{50}<L_0<L_{25}<A_C.The acceptability index of A_C group was highest and it differed significantly (P<0.05) from those of the other groups. L_{25} had the next high acceptability index followed by that of L_0, L_{50}, L_{75} and L_{100}.

Water chemistry

The highest mean temperature occurred in diet L_{50} 27.5 ± 0.21) followed by diet L_{75} (75% - 27.4 ± 0.67), diet A_C- 27.4± 0.55), while the least mean temperature was observed in diet L_{25} (25% - 27.3± 0.88). Also, the D.O in diet A_c- 4.49 ± 1.23) was highest and this was followed by

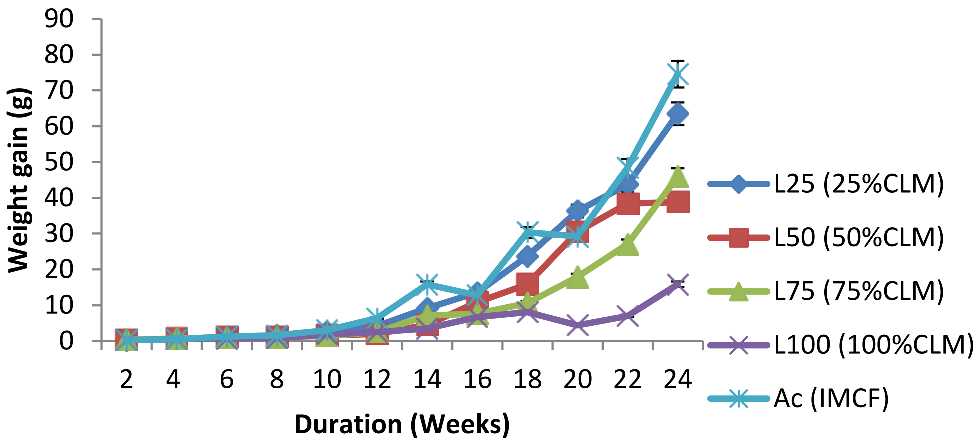

Figure 1. Weight gain of *Clarias gariepinus* juveniles fed different dietary levels of cassava leaf meal substitution for 24 weeks.

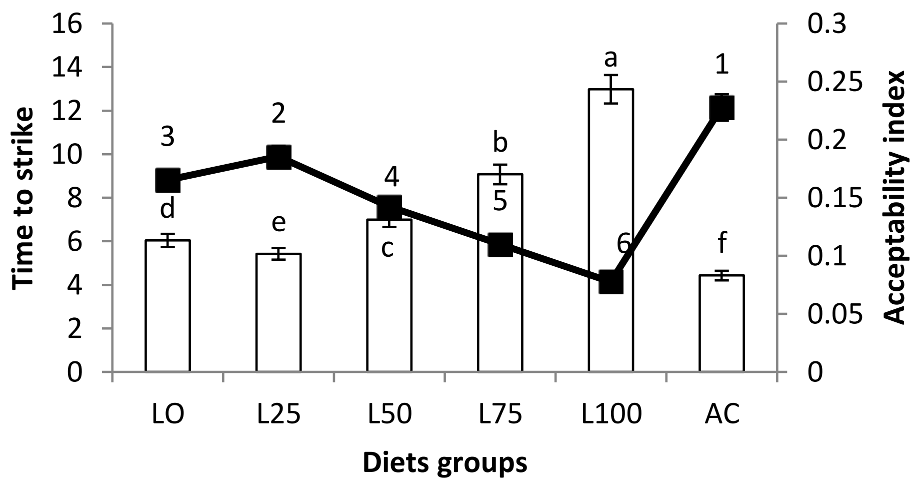

Figure 2. Time to strike and acceptability.

mean D.O. occurred in diet L_{100} (100% CLM substation - 4.22 ± 1.06) (Table 6). Similarly, the pH during the culture period ranged from 6.40 to 7.90 and the highest mean pH occurred in diet L_0 (0% CLM, first control diet - 7.10± 0.45), followed by diet L_{75} (75% CLM - 7.10± 0.2). The least mean P^H was observed in diet L_{50} (50% CLM substation - 6.9 ± 0.32). Also the highest mean NH_3-N occurred in diet L_{75} (75% CLM inclusion - 0.00029 ± 0.00001), followed by diet L_{100} (100% CLM - 0.00026 ± 0.00001). The least mean NH_3-N reading was observed in diet L_{25} (25% CLM - 0.000018± 0.00001) (Table 6).The highest mean nitrate was noticed in diet L_{25} (25% CLM - 0.00004 ± 0.00001) while the least mean nitrate was found in diet L_{100} (100% CLM inclusion - 0.00002 ± 0.00001) (Table 6).The highest mean nitrite occurred in diet L_{25} (25% CLM - 0.0003 ± 0.00004) while the least mean nitrite was observed in diet L_{50} (50% CLM - 0.00023 ± 0.00001) (Table 6).

DISCUSSION

The mean values for the water condition of the experimental aquaria (27.4± 0.55, 4.49± 1.23, and 7.1± 0.20) for temperature, pH and dissolved oxygen respectively fall within the optimal requirements for fish production (Ochang et al., 2007; Anyanwu et al., 2012). The highest mean feed efficiency was observed in diet Ac (coppens fish feed), followed by diet L_0 and then L_{25}; the lowest mean feed efficiency occurred in diet $L_{100.}$ The relatively low feed efficiency recorded in diet L100 (100% CLM - 9.82± 0.82) may be attributed to the presence of anti-nutrients in cassava leaf such as Linamarin (Presston, 2004; Azaza et al., 2015; Garcia et al., 2015).The chemical composition of cassava leaf meal showed very high level of crude fibre and low energy level, a future that is very common with leaf meals. The metabolizable energy value of the diets decreased with

Table 5. Growth performance and nutrient utilization of *Clarias gariepinus* fed different dietary levels of cassava leaf meal substitution for 24 weeks.

Group	Experimental											
	Total length (cm)	Standard Length (cm)	Weight (g)	Condition factor (k)	Time to strike (s)	Acceptability Index (cm^{-1})	5% biddy weight of feed (g)	Feed intake (g)	Weight gain (g)	Feed efficiency ratio	Specific growth rate	Feed conversion ratio
Lo	12.47 ±2.10^a	11.50±11.91^a	41.12±16.03^a	1.00±0.01^b	6.04± 0.05^d	0.17±0.00^c	2.06±0.80^a	1.92±0.77^a	15.64±5.75^a	14.66±1.16^a	1.48±0.10^b	0.12±0.01^a
L25	12.18±2.03^a	11.25±1.8^a	43.69±17.51^a	1.10±0.01^a	5.42±0.09^e	0.19±0.00^b	2.19±0.88^a	1.85±0.79^a	16.64±6.02^a	14.66±1.04^a	1.48±0.10^b	0.12 ± 0.01^a
L50	11.99±1.93^a	11.05±1.74^a	32.45±13.03^a	0.92±0.02^c	7.00±0.04^c	0.14±0.00^d	1.62±0.65^a	1.43±0.58^a	12.14±4.39^a	13.06±1.03^a	1.34 ± 0.01^{bb}	0.13 ± 0.01^a
L75	12.12±1.87^a	11.12±1.70^a	26.85±10.35^a	0.86±0.02^d	9.07±0.04^b	0.11±0.00^e	1.34±0.52^a	1.20±0.49^a	10.26±4.02^a	11.99±0.81^a	1.18 ± 0.05^b	0.13 ± 0.01^a
L100	10.65±1.39^a	9.78±1.24^a	14.98±4.61^a	0.81±0.02^e	12.98±0.12^a	0.08±0.00^f	0.75±0.23^a	0.67±0.21^a	4.33±1.31^a	9.82±0.82^a	1.08 ± 0.09^b	0.16 ± 0.02^a
Ac	12.85±2.22^a	11.87±2.05^a	49.98±19.43^a	1.07±0.01^a	4.43 ± 0.08^f	0.23 ± 0.00^a	2.50 ± 0.97^a	2.21 ± 0.89^a	18.67± 6.72^a	14.80± 1.31^a	1.56 ± 0.13^b	0.12 ± 0.02^a

Table 6. Water quality fluctuations during the 24 week feeding trial of *C. gariepinus* juveniles fed graded levels of CLM substitution.

Treatments	Water chemistry parameters											
	Temp(°C)	Mean±SD	DO(mg/l)	Mean±SD	PH	Mean±SD	NH_3–N (mg/l)	Mean± SD	NO_3- N	Mean±SD	NO_2- N	Mean±SD
L_o (0%CLM)	26.1-29.1	27.3±1.02	3.43-5.60	4.43± 0.60	6.78-7.80	7.1± 0.45	0.00018-0.00022	0.0002± 0.00001	0.00002-0.00004	0.00003±0.00001	0.00021-0.00034	0.00029±0.00001
L_{25} (25%CLM)	26.1-29.1	27.3±0.88	3.45-5.40	4.41± 1.20	6.52-7.69	6.9± 0.48	0.00014-0.00021	0.00018± 0.00001	0.00003-0.00004	0.00004±0.00001	0.00028-0.00032	0.00030±0.00001
L_{50} (50%CLM)	26.1-29.0	27.5±0.21	3.30-5.35	4.36± 0.70	6.44-7.60	6.9± 0.32	0.00017-0.00022	0.00021± 0.00001	0.00002-0.00003	0.00003±0.00001	0.00021-0.00024	0.00023±0.00001
L_{75} (75%CLM)	26.1-29.1	27.4±0.67	3.24-5.30	4.32± 1.33	6.40-7.90	7.1± 0.20	0.00026-0.00031	0.00029± 0.00001	0.00002-.0.00003	0.00003±0.00001	0.00025-0.00034	0.00029±0.00001
L_{100} (100%CLM)	26.1-29.0	27.3±1.28	3.11-5.20	4.22± 1.06	6.40-7.60	7.0± 0.50	0.00024-0.00029	0.00026± 0.00001	0.00001-0.00003	0.00002±0.00001	0.00024-0.00028	0.00026±0.00001
A_c (IMCF)	26.1-29.0	27.4±0.55	3.55-5.50	4.49± 1.23	6.66-7.88	7.0± 0.40	0.00021-0.00028	0.00025± 0.00002	0.00002-0.00004	0.00003±0.00001	0.00022-0.00030	0.00027±0.00001

increased levels of the leaf, indicating low energy status.

According to Lagler et al. (1977), the interaction of the factors affecting internal motivation or drive for feeding on specific diets range from intrinsic factor relating to physiology, genetics and morphology to extrinsic factors involving the living conditions especially food and feeding habits of the fish. Moreso, specific features such as size, age, sex, season and site of collection as well as species of fish, are of primary importance in determining the nutritional status and diet acceptability in catfish fed specific dietary types (Eyo, 1994). These factors however were taken care of since the catfishes were hatchery-raised, reared in the same pond and fed the same diet until they were collected for laboratory studies.

The incorporation of cassava leaf meal in the diet fed to *C.gariepinus* increased the palatability of the diets. The least mean time to strike (4.43± 0.08) was observed in diet Ac, followed by diet L_{25} (5.42± 0.09). There was observed inconsistency in the mean-time to strike the graded levels of substitution of cassava leaf meal. Statistically, each diet was significantly different ($p<0.05$) from another. Furthermore, despite the high acceptability observed in diet Ac. (Coppens fish feed), the acceptability index recorded in diet L_{25} was significantly higher than those of other test diets.

The growth pattern revealed that C. *gariepinus* performed better in diet L_{25} than all other diets. It has been documented that 50% replacement of maize with cassava root meal in broiler diet showed no depression in growth or unfavourable feed conversion ratio (Essers et al., 1995) and that the best growth performance was recorded in layers fed 10% cassava root meal. Olurin et al. (2006) reported a replacement level of 50% cassava meal for maize without a depression growth in C. *gariepinus*. In this present study, the best growth performance and nutrient utilization were recorded in fish fed 25% level of whole cassava leaf meal. This implies that the inclusion of 25% level of whole cassava leaf meal in the diet of *C. gariepinus* catfish enhanced growth rate. This is in line with the work of Ernesto et al. (2000; Amisah et al., 2009), where broiler had the best growth performance at 25% cassava root meal inclusion level.

However, the poor growth performance recorded in diet L_{100} (100% CLM inclusion) may be attributed to the amount of anti-nutritional factors such as hydrogen cyanide (HCN) present in cassava leaf. This was indicated by the condition factor (k) of catfish in diet L_{100}. In the present study, it is shown that the inclusion of cassava leaf meal at 75% and above led to poor growth performance of the catfish. Feed stuffs which have anti-nutritional factors recorded poor growth performance in fish when supplemented at high levels (Ugwu and Mgbenka, 2006; Adewolu, 2008).Replacement of corn meal with cassava leaf meal recorded the highest mean weight gain and specific growth rate among catfishes fed diet L_{25} (25% CLM inclusion). This represents the highest level of CLM incorporation. On the contrary, the least mean weight gain and specific growth rate were recorded in diet L_{100} (100% CLM inclusion).

Furthermore, the ability of an organism to convert nutrients especially protein positively influences its growth performance. This was justified by the growth performance in 25% whole cassava leaf meal inclusion diet. Lower feed conversion ratio indicates better utilization of the feed by the fish. According to De Silva and Anderson (2001), feed conversion ratio is between 1.2 to 1.8 for fish fed carefully prepared diets, and the results from the present study fall within this range when multiplied by 10. The least mean feed conversion ratio was observed in diet L_{25}, indicating that fish in this diet had the best utilization of the feed. However, the mean feed conversion ratio was highest in diet L_{100} (100% CLM inclusion), indicating that fish in this diet had the worst utilization of the feed. Diet L_{100} was significantly different ($p<0.05$) from all other diets.

In addition, condition factor (k) of fish in diet Ac (internationally made coppens fish feed) and diet L_{25} (25% CLM inclusion) were not significantly different ($p>0.05$). Both had the best condition factor, implying that 25% CLM inclusion is the best rate of CLM substitution for maize in the growth of C*. gariepinus* catfish (Azaza et al., 2015). The optimum survival rates recorded in this study indicate that feeding C*. gariepinus* catfish with processed cassava leaf meal does not lead to mortality of the fish. This may probably be due to the substantial reduction in the cyanide content (by boiling and drying) of the whole cassava leaf meal (Garcia et al., 2015). Cardoso et al. (2005) observed that good processing of cassava enhanced survival and healthy state of fish at all stages of their lives.

Conclusion

Based on the results obtained in this study, it is recommended that under standard culture conditions, up to 25% cassava leaf meal can be used to substitute maize. Cassava leaf is abundant in Nigeria and extremely less expensive compared to maize. This will reduce over-dependence on imported fish feed and maize feed used in aquaculture.

Conflict of Interests

The authors have not declared any conflict of interests.

REFERENCES

Adewolu MA (2008).Potentials of potato leaf as dietary ingredient for *Tilapia zillii* fingerlings. Pak. J. Nutr. 7:444-449.

Adikwu P (1992). Dietary Carbohydrate utilization in Tilapia (*Oreochromis niloticus*). J. Agric. Sci. Technol. 1:33-37.

Akapo AO, Oso AO, Bamgbose AM, Sanwo KA, Jegede AV, Sobayo RA, Idowu OM, Fan J, Li L, Olorunsola RA (2014) .Effect of feeding cassava (Manihot esculenta Crantz) root meal on growth performance, hydrocyanide intake and haematological parameters of broiler chicks. Trop Anim Health Prod. 46(7):1167-1172.

Amisah S, Oteng MA, Ofori JK (2009).Growth performance of the Afirican cat fish Clarias gariepinus, fed varying inclusion levels of Leucaena leuccocephala leaf. J. Appl. Sci.Environ. Manage. 13:21-26.

Anibeze CIP, Amulu UC, Anibeze CI (2003). Evaluation of the Biomass and Profitability of *Heterobranchus Longifilis* under different Environmental Stocking Densities Enugu State Agricultural Development (ENADEP) Annual Report Zoo. 63 p.

Anyanwu DC, Udedibie ABI, Esonu BO, Osuigwe DI (2009).Growth and nutrient utilization of heteroclarias (Heterobranchui bidorsalis xClarias gariepinus fed dietary levels of Microdesmis puberurla leaf meal. Int. J. Agric. Rural Dev. 11:10-13.

Anyanwu DC, Umeh OI,Maduka BC,Mbchu MU (2012).Nutrient utilization and growth of catfish *(Clarias gariepinus* fed dietary levels of cassava leaf meal. Pak. J. Nutr.11(11):1037-1040.

AOAC (1975). Official Methods of Analysis. Kethed Association of Analytical Chemists, Washington, DC., USA.

APHA-American Public Health Association (2006). Standard methods for the examination of water and waste water. APHA Washington DC. 14th ed. P. 107.

Azaza MS, Khiari N,Dhraief MN,Alonui N Kratem MM,Elfeki A (2015). Growth performance oxidative stress indices and hepatic carbohydrate metabolic enzymes activities of juvenile Nile tilapia ,Oreochromis niloticus L.in response to dietary starch to mprotein ratios. Aquac. Res. 46:14-27.

Baruah K, Sahu NP, Denath D (2003). Dietary Phytase: An ideal approach for a cost effective and low polluting aquafeed. NAGA, WorldFish Center Quarterly 27(3-4):15-19.

Beck A (1979). Parel discussion of live feed versus artificial feed in feed fry. In: E & Styezriska – Junewises, T. Backnel, E. Jaspers and G. Personne (eds). Cultivation of fish fry and IBS line feed. European Mariculture Society, Special Publication No. 4. Bredere Belgum. pp. 515-527.

Boonyaratpalin M (1989). Methodologies for Vitamin requirements studies. In: De Silver S.S. (ed) Fish Nutrition Research in Asia. Proceedings of the third Asia fish Nutrition Network Meeting. Asia fish society, special publication Asian Fisheries Society, Maula, Philippines*.* pp. 58-67.

Brown ME (1975). Experimental Studies on Growth. The physiology of fishes. In: Brown M.E. (Ed) Academic Press, London, 1:401.

Cardoso AP, Mirione E, Ernesto M, Massazer F, CLIFF J, Haque RM , Bradbun HH (2005). Processing of Cassava Roots to remove cyanides. J. Food Compost. Anal. 18:451-460.

De Silva SS, Anderson TA (1995). Fish Nutrition in Aquaculture. London, UK: Chapman and Hall Aquaculture series 1.

Ernesto M, Cardoso AP, Nicala D, Mineone E, Massasa F, Cupp J, Haque RM, Brasubry JH (2000). Persistent Konzo and cyanogens toxicity from cassava in Northern Mozambique. Acta Trop. 82:357-360.

Eyo AA (1994). The requirement for formulating standard artificial fish feed. Paper presented at the 11th Annual Conference of The Fisheries Society of Nigeria (FISON) held at the Lagos State Auditorium Secretariat Alausa Ikeja, Lagos State, 22nd -24th February, 1994, P 15.

Eyo JE, Ezechie CV (2004). The effects of rubber (*Havea brasilienis*) seed meal based diets on diets acceptability and growth performance of *Heterbranchus bidorsalis* (male) x *clarias gariepinus* (female) hybrid. J. Sustain. Trop. Agric. Res. 10:20-25.

Fagbenro OA (1992) dried fermented fish silage in diets for *Oreochromia niloticus.* Isr. J. Aquac. 46(3):140-147.

Falaye AE (1988). Utilization of Agro-Industrial Wastes as Fish Feed stuffs in Nigeria. Proc. of the 10^{th} Annual Conf. FISON, Abeokuta, 16 – 20 November, pp. 47-56.

Faturoti EO, Akinbote RE (1986). Growth response and nutrient utilization in *Oreochronis niloticus* fed varing levels of dietary cassava peel. Niger. J. Appl. Fish. Hydrobiol. 1:47-50.

Gabriel UO, Akinrotimi OA, Ananwu PE, Bekibele DO , Onunkwo DN (2007). Locally produced fish feed potential for aquaculture development in sub-Saharan Africa. J. Agric. Res. 2:287-295.

Garcia V, Celada JD, González R, Carral JM, Sáez-Royuela M, González Á (2015). Response of juvenile tench (*Tinca tinca* L.) fed practical diets with different protein contents and substitution levels of fish meal by soybean meal. Aquat. Res. 46(1):28-38.

Lipton D, Hanel R (2004). Figuring Production Cost in Finfish aquaculture. Publication number: UM – SG – MAP – 90:02. 10 p. http://www.mdsg.umd.edu/ Assessed August 12, 2011.

Nwani CD, Ifo CT, Nwamba HO, Ejere VC, Onyishi G, Ikwuagwu EO, Odo GE (2015). Oxidative stress and biochemical responses in the tissues of African catfish *Clarias gariepinus* juvenile following exposure to primextra herbicide. Drug Chem. Toxicol. 38(3):278-285.

Ochang SN, Fagbenro OA, Adebayo OT (2007). Growth performance, body composition haematology and product quality of the African catfish (*Clarias gariepinus*) fed diets with palm oil. Pak. J. Nutr. 6:452-459.

Olatunde AA (1996). Effect of supplementary of soyabean diet with L. and D.L. methionine on the growth of mud fish *Claria anguillaris.* Niger. J. Biotechnol. 9(1):9-16.

Olukunle O (2006). Nutritive potential sweet potato peel meal and root replacement value for maize in diets of African catfish (*Clarias gariepinus*) advanced Fry. J. Food Technol. 4:289-293.

Olurin KBE, Olujo AA , Olukoya OA (2006). Growth of African Catfish *clarias gariepitus fingerlings,* fed different levels of cassava. World J. Zool. 1:54-56.

Presston TR (2004). Potential of cassava in integrated farming systems. Livest. Resour. Rural Dev. 10(8):20-28.