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Growth Performance of Clarias gariepinus Juveniles Fed Graded Levels of Roasted Tropical Almond (Terminalia catappa Linnaeus) Kernel Meal Based Diets

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Abstract
Feeding trial was conducted in experimental plastic tanks (50 x 35 x 33 cm) to assess the growth performance of *Clarias gariepinus* juveniles fed diets containing Roasted Tropical Almond Kernel Meal (ROAM) for 105 days. Five isonitrogenous diets composed of 0, 25, 50, 75 and 100% ROAM as a replacement for Soybean Meal (SBM) were fed to the fish twice daily at 3% body weight. Each dietary treatment was replicated with 20 fish per replicate (initial mean weight 12.03±0.01 g). Mean Weight Gain (MWG), Specific Growth Rate (SGR) and Feed Conversion Ratio (FCR) were calculated. Economic benefit of replacing SBM with ROAM in *C. gariepinus* diet was evaluated using Profit Index (PI) and Incidence of cost (IC). Data were subjected to Descriptive statistics and ANOVA at p=0.05. Fish fed 75% ROAM diet had the highest MWG (69.03 g), SGR (1.68 %), and the least FCR (1.57), while 100% ROAM had the least values for MWG (27.02 g), SGR (0.66 %) and the highest FCR (3.30). Incidence of cost (0.36) was least in 75% ROAM and highest (0.70) in 100% ROAM diet. 75% ROAM had the highest Profit Index (1.40) while 100% ROAM had the least value (0.76). Roasted Almond kernel meal can economically replace soybean meal up to 75% in *Clarias gariepinus* diet. Substitution beyond this level caused growth and economic depression.
Keywords: Catfish, feed conversion ratio, Indian almond, soybean meal, specific growth rate.

1. Introduction

Fish contributes over 40% of total dietary protein consumption of Nigerians and is a staple source of protein of the average Nigerian diet (Dada, 2003). It is relatively cheaper than most other types of animal protein (Eyo et al., 2003). It is also a rich source of Essential Amino Acids (EAAs) such as lysine, leucine, valine etcetera, suitable for complementing high carbohydrate diet (Falaye, 2013). Fish play a major role in both the diet and the economy of the rural poor in the developing countries (FAO, 1994). FAO (2010), states that 925 million people are undernourished and nearly all of the undernourished are in developing countries. To prevent malnutrition, there is need to increase protein supply particularly of animal origin in the diet of the Nigerian populace. However, aquaculture development in Nigeria is constrained by inadequate supply of fish feed stuff, particularly fish meal, which is scarce and expensive (Ayinla, 2005). This had led to fish nutritionist searching for alternative source of protein which is cheap and of good quality. Soya bean meal has been successfully used for sometime now to partly replace fish meal to produce cheaper fish feed in Nigeria. Recently, due to the increased alternative use of soya beans as food for man coupled with its competitive use by livestock feed industry and it's growing export potentials, it has become expensive (Bekibele, 2005). This has necessitated the search for other protein sources that can replace soya been meal to produce cheaper and good quality fish feed. Tropical almond kernel meal has great potentials of filling this gap.

Tropical almond (*Terminalia catappa* Linnaeus) also known as Indian almond is a widely growing plant in West Africa (Burkill, 1988). The same author noted that the tree is more of an ornamental plant used as sunshade and for land scaping than food. It is readily and locally available. Global production is around 1.7 million tons annually (Molody, 2008). Nigeria produces about 0.1 million tons annually (Annongu et al., 2006). Tropical almond has a kernel yield estimated at about 5kg per tree per year and 10 kg per tree per year for selected genetic stock grown on high quality sites (Traditional tree, 2006). The plant fruits twice in a year and it is estimated that only about 20% of the fruit is consumed, the remaining 80% being wasted (Burkill, 1988). However, the fruit is a good source of nutrients, the kernel contains about 24.50% crude protein, 28.00% crude fat and 6.00% ash (Olapade and Kargbo, 2015). This makes the kernel meal a potential alternative protein concentrate to soybean meal in aqua feed. However, there is little documentation on the use of roasted almond kernel meal as a low cost unconventional feedstuff in the diet of *Clarias gariepinus*. This study was conducted to assess the nutrient utilization indices of *Clarias gariepinus* juveniles fed roasted almond kernel meal based diets, the growth performance of *C. gariepinus* juveniles fed roasted almond kernel meal based diets and to estimate the economic benefit of replacing soya bean meal with roasted almond kernel meal in the diet of *Clarias gariepinus* juveniles.

2. Materials *and Methods*

2.1 Sample collection and preparation

Tropical almond fruits were manually picked from tropical almond trees within the premises of Nnamdi Azikiwe hall, University of Ibadan, Ibadan, Nigeria. They were sundried for four days and de-hulled manually to get the kernels. The kernels were sundried for three days to reduce their moisture content. One Kilogram of the kernel was put in a stainless steel pan, placed over a Stuart Scientific electric cooker (model SH 1) and roasted at 80^{o} C for 4 hours until the kernel coat became dark brown (Sotolu, 2008; Adesina, 2014) and emitted an aroma similar to that of roasted melon. The roasted kernels were milled using Thomas Wiley milling machine (Model K 925).

2.2 Formulation and preparation of Roasted Almond kernel Meal (ROAM) based diets

Five isonitrogenous diets containing 40% crude protein were formulated using ROAM at inclusion levels of 0%, 25%, 50%, 75% and 100% in replacement of soya bean meal respectively with 0% being the control diet (Table 1). Pearson square method was used in formulating the diets. Other ingredients used in compounding the diets were, fishmeal (72% crude protein), yellow maize, wheat offal, Vitamin/mineral premix, vegetable oil, dicalcium phosphate, table salt and cassava starch. All the ingredients were separately ground and measured according to the formulation. They were thoroughly mixed together to ensure homogeneity and pelletized using local manual pelleting machine of 2mm die. The pelleted feeds were sun- dried properly and packed in separate airtight polyethylene bags. They were stored safely at the experimental site.

Table 1: Gross ingredient composition of Roasted Almond kernel meal (ROAM) based diets at 0% to 100% inclusion levels for *C. gariepinus* juveniles.

Ingredient	Diet				
(g/100g DM)	1(0%)	2(25%)	3(50%)	4(75%)	5(100%)
Fish meal	30.95	30.95	30.95	30.95	30.95
Soya bean meal	30.95	26.59	20.72	12.47	-
Almond kernel meal	-	8.86	20.72	37.41	60.01
Yellow maize	15.18	12.93	9.93	5.71	0.65
Wheat offal	15.18	12.93	9.93	5.71	0.65
Palm oil	1.00	1.00	1.00	1.00	1.00
Cassava starch	2.50	2.50	2.50	2.50	2.50
Table salt	0.50	0.50	0.50	0.50	0.50
Dicalcium phosphate	1.75	1.75	1.75	1.75	1.75
Vit/mineral premix	2.00	2.00	2.00	2.00	2.00
Total	100	100	100	100	100

Legend: Diet 1 = Control diet (0% ROAM inclusion); Diet 2 = 25 % ROAM inclusion; Diet 3 = 50 % ROAM inclusion; Diet 4 = 75 % ROAM inclusion; Diet 5 = 100 % ROAM inclusion

2.3 Proximate analysis of the experimental diets.

Each of the five experimental diets was subjected to chemical analysis following the standard procedure of A.O.A.C. (2005). Parameters analyzed were crude protein, crude fat (ether extract), crude fibre, ash, moisture and nitrogen free extract. All the analyses were done in triplicates.

2.4 Experimental set-up for the replacement.

Twenty (20) *Clarias gariepinus* juveniles (average weight of 12.03±0.01 g) were stocked in each 63 litres plastic tank(50 x 35 x 33 cm) and replicated randomly thrice per treatment. The fish were acclimatized for seven days after which the feeding trial commenced. The fish were fed twice daily between 08:00- 09:30 hours and 16:00- 17:30 hours for 15 weeks at 3% of their body weight (Bello et al., 2012; Falaye et al., 2014). The culture water was changed every 3 days to maintain the water quality at optimum level. The fish were weighed forth-nightly using electronic weighing scale (Tesco Electronic scale, Model: EK 4150-STR). Fish mortality in each tank was recorded and used to calculate survival rate for each treatment. Water temperature, pH, dissolved oxygen, ammonia and nitrite were measured at the commencement of the experiment and forth nightly, throughout the period of the experiment using Horiba U-22 XD multi- parameter water quality checker and fresh water aquaculture test kit, model AQ-2, Code 3633-03, Lamotte, USA (for ammonia and nitrite).

2.5 Determination of survival rate, nutrient utilization and growth performance indices

The experimental fish subjected to the five dietary treatments were weighed at the commencement of the experiment and fortnightly throughout the period of the 105-day feeding trial. The effects of various treatments (diets) on nutrient utilization and growth performance of *Clarias gariepinus* were evaluated as follows:

Mean Weight Gain (MWG) = $(W_2 - W_1)$ g

Where, W_1 = initial mean weight of fish at the beginning of the experiment

W_2 = final mean weight of fish at the end of the experiment
Specific Growth Rate (SGR) = $Log_e W_2 - Log_e W_1 / T \times 100$
Where: Log_e = natural logarithm; W_1 = Initial weight (g) of fish at the beginning of the experiment; W_2 = final weight (g) of fish at the end of the experiment; T = culture period/experimental period in days
Percentage Weight Gain (PWG) = Mean weight Gain / Initial mean weight X 100
Condition factor (K) = W/L^3 X 100
Where: W = weight of fish; L = Length of fish
Feed Conversion Ratio (FCR) = Feed intake (g) / Weight gain (g)
Gross Feed Conversion Efficiency (GFCE) = 1/FCR X 100 (Adesina *et al*., 2013)
Nitrogen Metabolism (Nm) = $0.549 \times (W_1 + W_2)t / 2$
Where W_1 = initial mean weight of fish; W_2 = final mean weight of fish; t = experimental period (in days); 0.549 = metabolism factor/constant (Nwanna, 2003)
Net Protein Utilization (NPU) = $N_2 - N_1 + Nm / Nd$
Where: N_1 = Nitrogen content of fish before experiment; N_2= nitrogen content of fish at the end of the experiment; Nm= nitrogen metabolism; Nd = nitrogen in experimental diet; Nitrogen content = Protein content / 6.25 (Bender and Miller, 1963) cited by Sotolu (2008).
Survival Rate (SR) = $\frac{\text{initial number of fish stocked} - \text{mortality}}{\text{Initial number of fish stocked}} \times 100$
Economic evaluation of the diets
Economic evaluation parameters for the diets were calculated following the method of New (1989) as follows:
Profit index (PI) = value of fish produced / Cost of feed used in production
Incidence of Cost (IC) = cost of feed used in production / fish weight gain
Economic analysis was based on the following:
1. A major assumption was that all other operating costs for fish production remained the same for all the dietary treatments. Thus, cost of feed was the only expenditure considered in this economic analysis.
2. Cost of feed was based on the prevailing market prices of the feed ingredients as at the time of purchase (that is time of commencement of the experiment)
3. Value of fish produced (cost of fish cropped) depended on the selling price of fish per kilogram (₦ 500/kg) in the markets around Ibadan as at the end of the experiment
4. Cost of producing almond kernel meals depended on the cost of gathering the fruits, de-hulling the fruits and processing the kernels.
5. Total weights of fish produced were obtained from the total weight of fish recovered at the end of the feeding trial.

2.6 Statistical analysis
Data obtained from the experiment were subjected to one- way analysis of variance (ANOVA) test using Statistical Package for the Social Sciences (SPSS) software. Determination of significant mean differences among individual means was done at P = 0.05 using Fisher's least significant difference (LSD). Descriptive statistics such as percentages and graphs etc were also used.

3. Results and Discussion
Proximate composition and gross energy content of ROAM based diets is shown in Table 2. The growth performance and nutrient utilization indices of *C. gariepinus* fed graded levels of ROAM based diets is presented in Table 3; Figure 1 and Table 4 respectively.

Mean final weight and mean weight gain exhibited a similar trend at the end of the experiment. There were significant variations ($P < 0.05$) in the mean weight gain among the treatments. The control (0% ROAM) diet had a mean weight gain of 55.10 g, which progressively increased, with higher inclusion levels of ROAM up to 75% inclusion, which had the highest mean weight gain (69.03 g). At 100 % ROAM inclusion the mean weight gain fell to 27.02 g which was the least. Mean weight gain and specific growth rate are usually considered as the most important measurement of productivity of diets (Omitoyin and Faturoti, 2000). The highest MWG (69.03 g) obtained at 75% ROAM inclusion level was significantly higher ($P< 0.05$) than the MWG of fish fed the control diet (55.10 g). The decrease in MWG of fish at 100% inclusion level of ROAM could be attributed to low feed intake and low feed utilization. This trend is in agreement with the report of Bekibele (2005) who observed an increasing trend in MWG of *Clarias gariepinus* fed mucuna bean meal diet as the inclusion levels increased up to a certain limit. Jackson et al. (1982) reported good growth in tilapia (*Sarotherodon mossambicus*) fed 35.2% sunflower seed meal replacing 50% of the fish meal protein. Olukunle and Falaye (1998) also reported that 25% sesame seed cake incorporation supported weight gain in *Clarias gariepinus* similar to diets containing 100% fishmeal.

Specific Growth Rate (SGR) was highest in treatment 4 (75% ROAM diet) and least in treatment 5 (100%

ROAM diet). There were significant differences (P<0.05) among the treatments' SGR values. The values of SGR obtained in this study (1.12 to 1.82%) are higher than the values 1.00 to 1.59% reported by Falaye et al. (2014) for *C. gariepinus* fed differently processed lima bean based diets. This suggests that almond kernel meal supports faster growth of *C. gariepinus* than lima bean meal. A direct relationship was observed among mean weight gain, percentage weight gain (relative growth rate) and specific growth rate in the overall growth pattern of fish in this study. This observation is common in nutrition experiments (Faturoti 1989; Alegbeleye et al., 2001; Nwanna, 2003; Falaye et al., 2014) indicating that any of these parameters could be adequately used to describe the growth pattern of fish.

Condition factor (k) had a narrow range (0.56 to 0.68). Treatment 5 (100% inclusion level) had the least value while fish fed 25% ROAM diet had the highest value. There was no regular pattern in the variation of K values among the treatments. The K values obtained in this study indicate that the diets were utilized for growth and well being of the experimental fish since they fell within 0.5 and 1.0 (Lagler, 1956).

Table 2: Proximate composition and gross energy contents (Kcal /kg) of ROAM based diets at inclusion levels of 0% to 100%.

Parameters	Diet				
(Control)	1(0%)	2 (25%)	3 (50%)	4 (75%)	5(100%)
Crude protein (%)	40.08±0.02	39.96±0.06	40.10±0.06	40.06±0.02	40.02±0.03
Crude fat (%)	4.18±0.01	4.27±0.01	6.38±0.02	10.40±0.04	20.59±0.02
Crude fibre (%)	2.55±0.01	2.51±0.05	2.67±0.03	2.71±0.06	2.98±0.02
Ash (%)	13.25±0.01	13.31±0.01	13.21±0.01	13.19±0.01	11.68±0.03
Moisture (%)	4.84±0.01	4.79±0.01	4.90±0.00	4.88±0.02	5.20±0.01
Nitrogen-free extract (%)	35.11±0.03	35.38±0.05	34.74±0.04	28.76±0.11	19.53±0.07
Gross Energy (Kcal /kg)	3,802.00±8.00	3,803.00±10.50	3,809.00±10.00	3,899.00±2.50	3,995.00±4.00

Means ± SEM;Mean values in each row with similar superscript are not significantly different (p>0.05)

Table 3: Growth performance indices of *Clarias gariepinus* juvenile fed ROAM based diets at inclusion levels of 0% to 100% for 105 days.

Growth parameters	Diet				
	1(0%)	2 (25%)	3 (50%)	4 (75%)	5 (100%)
Initial mean weight (g)	12.03±0.06[a]	12.03±0.07[a]	12.02±0.08[a]	12.02±0.08[a]	12.03±0.07[a]
Final mean weight (g)	67.13±2.28[b]	73.21±2.92[bc]	77.53±2.37[cd]	81.05±2.82[d]	39.06±0.99[a]
Mean weight gain (g)	55.10±2.24[b]	61.17±2.89[bc]	65.51±2.37[cd]	69.03±2.90[d]	27.02±0.92[a]
Specific growth rate (%)	1.64±0.05[b]	1.72±0.04[ab]	1.76±0.03[a]	1.82±0.06[a]	1.12±0.07[c]
Percentage weight gain (%)	457.78±17.29[b]	508.29±22.91[bc]	545.24±20.37[cd]	574.87±28.52[d]	224.50±6.41[a]
Survival rate (%)	88.33±1.67[b]	90.00±0.00[b]	86.67±1.67[b]	86.67±1.67[b]	61.67±3.33[a]
Condition factor	0.65±0.03[b]	0.68±0.02[b]	0.65±0.01[b]	0.63±0.01[b]	0.56±0.01[a]

Means ± SEM; Mean values in each row with similar superscripts are not significantly different (p>0.05).

Table 4: Nutrient utilization indices of *Clarias gariepinus* juvenile fed ROAM based diets at inclusion levels of 0% to 100% for 105 days. Means ± SEM

Parameters	Diet				
	1(0%)	2 (25%)	3 (50%)	4 (75%)	5 (100%)
Total feed intake (g)	1504.06±24.97[b]	1736.71±33.16[c]	1758.49±31.29[c]	1838.21±54.00[c]	714.97±54.16[a]
Mean feed intake (g)	85.25±3.06[b]	96.49±1.84[c]	101.49±1.96[cd]	106.02±1.49[d]	57.91±2.40[a]
Feed conversion ratio	1.55±0.05[a]	1.58±0.05[a]	1.55±0.03[a]	1.54±0.05[a]	2.14±0.06[b]
GFCE (%)	64.52±3.61[b]	63.29±2.08[b]	64.52±1.31[b]	65.36±2.28[b]	46.73±2.12[a]
Nitrogen metabolism	2281.69±66.80[b]	2456.83±84.99[bc]	2580.86±68.13[cd]	2682.33±78.65[d]	1472.50±30.53[a]
N P U (%)	356.37±10.42[b]	384.86±13.30[bc]	402.37±10.61[cd]	418.88±12.27[d]	230.26±4.77[a]

Mean values in each row with similar superscripts are not significantly different (P < 0.05);
GFCE: Gross feed conversion efficiency
NPU: Net protein utilization

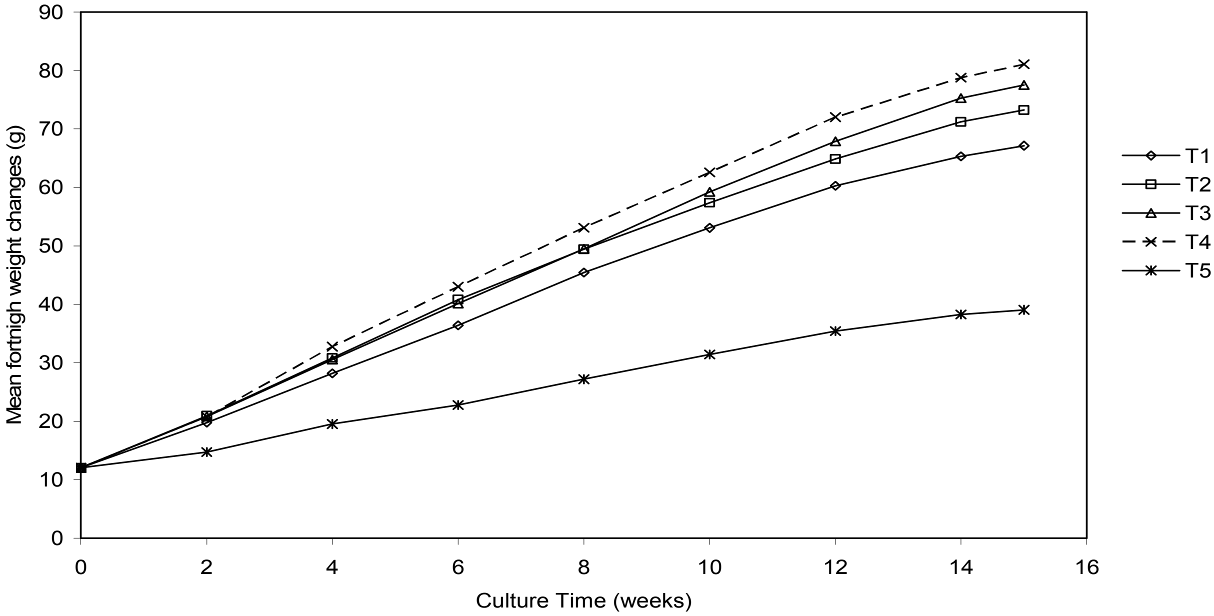

Figure 1: Mean fortnight weight changes of *Clarias gariepinus* juveniles fed varying inclusion levels of ROAM diets for 105 days
Legend: T1= Diet 1 (control); T2= Diet 2 (25%); T3= Diet 3 (50%);T4= Diet 4 (75%); T5= Diet 5 (100%)

Apart from treatment 5 (100% ROAM diet) which had the least survival rate (61.67 %), other treatments had a fair survival rate which ranged from 86.67 % to 90.00 %. There was no significant difference (P>0.05) in the survival rate of treatments 1 (control) to 4 (75% inclusion). However, survival rate of treatments 1 to 4 significantly differed (P<0.05) from that of treatment 5. The significantly lower survival rate of fish fed 100% ROAM diet could be attributed to starvation due to low feed intake as it was observed that fish fed this diet had significantly low total feed intake (714.97 g) compared to others (range, 1504.06 g to 1751.69 g).

Total feed intake (TFI) was highest (1751.69 g) in treatment 4 (75% inclusion level) and least (714.97 g) in treatment 5. The highest TFI value observed in fish fed 75% ROAM diet suggests that this diet was most palatable and acceptable to the fish. The progressive increase of total feed intake from 0% to 75% inclusion shows that the experimental fish accepted ROAM diets even more than the control diet. Mean feed intake (MFI) followed a similar trend like TFI with the highest value (106.02 g) observed in treatment 4 (75% ROAM diet) and least value (57.91g) observed in treatment 5(100% inclusion). The very low TFI and MFI observed in fish fed 100% ROAM diet could be linked to the high crude fat content of the diet (20.59%, Table 4) which probably resulted into poor palatability and acceptability of the diet. Feed palatability and acceptability on the other hand are affected by a number of factors including the appearance of the feed, taste of the feed and acceptability of the individual feedstuffs that make up the feed (NRC 1973; Tacon 1987).

Feed conversion ratio (FCR) was best (least value) in treatment 4 (75% ROAM diet) and poorest (highest value) in treatment 5(100 ROAM diet). There were no significant differences (P>0.05) in the FCR values of treatment 1 (control) to treatment 4 whereas there was a significant difference (p<0.05) between FCR value of treatment 5 (100% ROAM) and the other treatments' FCR values. The least FCR value recorded for fish fed 75% ROAM diet indicates a superior level of utilization of ROAM diet than the control diet. The FCR values obtained in this study (1.57 to 3.30) are lower than the values (2.81 to 6.05) reported by Olasunkanmi and Omitoyin (2011); (4.91 to 9.25) reported by Keremah and Green (2005) and (1.95 to 6.94) reported by Nweke and Ugwumba (2005). FAO (1993) documented that the lower the FCR the better the feed utilization by the fish. In this study, the lowest FCR value observed in treatment 4 indicates better feed utilization by the fish at 75% ROAM inclusion and this accounted for better growth performance of fish fed 75% ROAM diet among the other diets. FCR significantly (P<0.05) dropped to the poorest level (highest value) in fish fed 100% ROAM diet indicating that inclusion of roasted almond kernel meal beyond 75% caused significantly poor feed utilization and conversion to fish flesh.

Nitrogen metabolism (Nm) had treatment 4 and 5 having the highest and least values respectively. There were significant differences (P<0.05) among the treatments. There was progressive increase in the value of Nm from treatment 1(control) to treatment 4(75% inclusion) after which Nm fell significantly to the lowest value in treatment 5 (100 ROAM diet). The Nm values recorded in this study (range, 1472.54 to 2682.32) are similar to that reported by Adesina et al. (2013) (range, 1550.94 to 2742.75).

Net protein utilization (NPU) varied significantly (P<0.05) among the treatments. The highest NPU value (418.88%) was recorded in treatment 4 (75% inclusion level) while the least (230.26%) was recorded in treatment 5 (100% ROAM diet). NPU is a factor of the quality, digestibility and utilization of the protein fed to the fish (Falaye et al., 1999). Inclusion of roasted almond kernel meal at 75% level resulted into a better NPU compared to the control and the other treatments. This observation is in consonant with the report of Bekibele (2005) who recorded highest NPU values at 30% -50% inclusion level of Mucuna bean meal in *C. gariepinus* diet. Results of water quality parameters monitored during the feeding trial are presented in Table 5. Initial and final values of pH ranged between 6.65 and 7.25. Initial value of dissolved oxygen was 5.87mg/l. This fell in final treatment values with the least value 4.5mg/l observed in treatment 5. Initial temperature value was 28.45°C, which reduced in all the final treatment values to the least 25.4°C observed in treatment 5. Initial and final values of the water quality parameters monitored in this study including ammonia and nitrite levels all fell within the recommended ranges for catfish culture (Boyd, 1979; Viveen *et al*., 1985). This revealed that ROAM did not have any deleterious effect on the quality of the culture water. Results of economic evaluation indices of replacing soya bean meal with 0% to 100% inclusions of ROAM in the diet of *C. gariepinus* are shown in Table 6. The replacement of soya bean meal with roasted tropical almond kernel meal in the present study reduced the cost of feed production, which indicates a cheaper and more cost effective non-conventional feed ingredient relative to soya bean meal. Thus, the farmer will benefit economically through the utilization of the cheaper roasted tropical almond kernel meal. The total cost of producing control diet was N236.60/kg, which reduced progressively to the least cost in diet 5. Highest values of total feed intake, total weight of fish produced and total weight gain were observed in fish fed 75% ROAM diet. This was earlier attributed to the fact that roasted almond kernel meal was better utilized at 75% inclusion level than at any other level. Value of fish produced (in naira) followed a similar trend as total feed intake, total weight of fish produced and total weight gain. In this study, the highest fish weight gain at 75% inclusion level produced the highest value of fish.

Table 5: Initial and final values of water quality parameters obtained during feeding trial with graded levels of ROAM based diets. Means ± SEM

Treatment	Water quality parameter				
	pH	Dissolved Oxygen (mg/L)	Temperature (°C)	Ammonia (mg/L)	Nitrite (mg/L)
Initial values	6.96±0.01	5.87±0.01	28.45±0.01	0.00±0.00	0.00±0.00
Diet 1 (0%, Control)	6.90±0.01	4.65±0.01	25.83±0.17	0.02±0.00	0.01±0.00
Diet 2 (25%)	6.65±0.01	5.25±0.03	25.77±0.15	0.02±0.00	0.01±0.00
Diet 3 (50%)	7.25±0.00	5.00±0.13	25.60±0.10	0.03±0.00	0.02±0.00
Diet 4 (75%)	6.75±0.01	4.70±0.06	25.80±0.15	0.03±0.01	0.02±0.00
Diet 5 (100%)	7.15±0.01	4.50±0.08	25.40±0.06	0.04±0.01	0.03±0.01

Table 6: Cost analysis of 0% to 100% ROAM based diets fed to *Clarias gariepinus* juveniles for 105 days.

Feed Ingredients	Cost of ingredient (N/Kg)	Dietary Treatment				
		1 (0%, Control.)	2 (25%)	3 (50%)	4 (75%)	5 (100%)
Fish meal	500.00	(30.95) 15.48	(30.95) 15.48	(30.95) 15.48	(30.95) 15.48	(30.95) 15.48
Soya bean meal	120.00	(30.95) 3.71	(26.59) 3.19	(20.72) 2.49	(12.47) 1.50	--
Almond kernel meal	69.98	--	(8.86) 0.62	(20.72) 1.45	(37.41) 2.62	(60.01) 4.20
Yellow maize	110.00	(15.18) 1.67	(12.93) 1.42	(9.93) 1.09	(5.71) 0.63	(0.65) 0.07
Wheat offal	36.00	(15.18) 0.55	(12.93) 0.47	(9.93) 0.36	(5.71) 0.21	(0.65) 0.02
Palm oil	250.00	(1.00) 0.25	(1.00) 0.25	(1.00) 0.25	(1.00) 0.25	(1.00) 0.25
Cassava starch	140.00	(2.50) 0.35	(2.50) 0.35	(2.50) 0.35	(2.50) 0.35	(2.50) 0.35
Table salt	50.00	(0.50) 0.03	(0.50) 0.03	(0.50) 0.03	(0.50) 0.03	(0.50) 0.03
Dicalcium phosphate	240.00	(1.75) 0.42	(1.75) 0.42	(1.75) 0.42	(1.75) 0.42	(1.75) 0.42
Fish Premix	600.00	(2.00) 1.20	(2.00) 1.20	(2.00) 1.20	(2.00) 1.20	(2.00) 1.20
Cost of feed (₦/100g feed)		23.66	23.43	23.12	22.69	22.02
Cost of feed per kg (₦)		236.60	234.30	231.20	226.90	220.20

Values of ingredient composition are indicated in parentheses. Costs of feed ingredients are prices of ingredient per kilogram as at the beginning of the experiment (March, 2013). Exchange rate: N 157.00: 1USD

This is consistent with the report of Nwanna et al. (2014) which reported that the dietary treatment with the highest weight gain also produced fish with the highest value for *Clarias gariepinus* fed plantain peel based diets. Treatment 5(100% ROAM) had the highest incidence of cost while treatment 4 (75% ROAM diet) had the least (best) incidence of cost. There was no significant difference (P>0.05) among treatments 1 to 4 incidence of cost values but treatment 5 had an incidence of cost value which was significantly higher (P<0.05) than the rest. Profit index was highest (best) at 75% ROAM inclusion level while it was lowest at 100% ROAM inclusion level. The highest profit index at 75% inclusion level indicates that profit was generated from fish fed 75% ROAM diet more than any other diet including the control diet. In the present study, though 100% ROAM diet was the cheapest diet, it produced fish of lower value compared to the other diets. 75% ROAM diet was therefore the most cost–effective feed in this study. This finding further buttresses the fact that 75% ROAM diet was better utilized (Table7) .

This study showed that roasted almond kernel meal can replace up to 75% of soya bean meal in *Clarias gariepinus* diet when growth and economic benefits are considered. Fish fed diet above 75% replacement level showed growth depression and economic loss.

Table 7: Economic evaluation indices of replacing soya bean meal with 0% to 100% inclusions of ROAM in the diet of *Clarias gariepinus* juveniles. Means ± SEM

Parameter	Diet				
	1 (0%)	2 (25%)	3 (50%)	4 (75%)	5 (100%)
Total feed intake (g)	1504.06±24.97	1736.71±33.16	1758.49±31.29	1838.21±54.00	714.97±54.16
Total weight of fish (g)	1187.33±7.00	1317.67±9.20	1334.33±9.50	1406.67±8.00	483.00±7.20
Total weight gain (g)	946.67±6.24	1077.00±8.30	1103.00±8.86	1166.33±7.20	242.33±6.45
Cost of feed per kg (₦)	236.60±0.00	234.30±0.00	231.20±0.00	226.90.±0.00	220.20±0.00
Total Cost of feed used in production (N)	355.86±5.91[b]	406.91±7.77[c]	406.56± 7.23[c]	417.09±12.25[c]	157.44±11.93[a]
Total value of fish produced (N)	593.67±3.12[b]	658.84.50±2.99[bc]	667.17±2.20[bc]	703.34±3.84[c]	241.50±1.09[a]
Incidence of cost	0.376±0.03 [a]	0.378±0.01 [a]	0.369±0.01 [a]	0.358±0.01 [a]	0.650±0.01[b]
Profit index	1.67±0.05 [b]	1.62±0.04 [b]	1.64±0.03 [b]	1.69±0.05 [b]	1.53±0.08 [a]

Mean values in each row with similar superscripts are not significantly different (P < 0.05).

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