DIGESTIBILITY AND NUTRIENT UTILIZATION OF DIFFERENTLY PROCESSED TROPICAL ALMOND (*TERMINALIA CATAPPA*) KERNEL MEAL AND CAKE BASED DIETS BY *CLARIAS GARIEPINUS* JUVENILES

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Abstract
This study examined the nutrient digestibility and utilization indices of differently processed tropical almond (*Terminalia catappa*) kernel for *Clarias gariepinus* juveniles. A total of 420 *C. gariepinus* stocked at 20 fish /65 litres plastic tank were allocated to seven dietary treatments in triplicates of differently processed almond kernel meal of Raw (RWAM), Boiled (BOAM), Soaked (SOAM), Roasted (ROAM), Mechanically Extracted cake (MEAC), Solvent Extracted cake (SEAC) and control (REFR) diet. Fish were fed at 3% of their body weight twice daily, the excess feed siphoned out after 45 minutes while faecal collection was done 8 hours after every feeding. Apparent digestibility co-efficient of crude protein (ADCP), Gross energy (ADCGE) and dry matter (ADCDM) were calculated from the results of proximate analysis of treatment diets and faeces. Nutrient utilization indices were calculated from records of feeds administered and weights of fish. ROAM had the highest ADCP and ADCGE with 89.03% and 88.51%, respectively, while the lowest were recorded in SEAC (87.06%) and REFR (86.80%) respectively. There were significant differences ($p<0.05$) between SEAC's ADCP value and all the other treatments' values and between SOAM's ADCP value and BOAM, REFR, ROAM and MEAC's ADCP values. There were also significant differences ($p<0.05$) between RWAM's ADCP value and ADCP values of REFR, ROAM, and MEAC. All the treatments' ADCGE values significantly ($p<0.05$) differed from each other. ADCDM was highest in MEAC, 74.54% followed by ROAM, 74.43% and least in SEAC, 72.03%. All the treatments' ADCDM values significantly ($p<0.05$) differed from each other. The lowest Feed conversion ratio was observed in ROAM, 1.00 and highest in SEAC, 1.64. ROAM recorded the highest Protein intake (PI) 3.56/100g diet, Protein efficiency ratio (PER) 2.54, Net protein utilization (NPU) 30.74% and Nitrogen metabolism (NM) 210.09 and lowest in SOAM (3.03g/100g diet, 1.60, 27.81% and 176.67 respectively). There was no significant difference ($p>0.05$) in the PI and NPU values while there were significant differences ($p<0.05$) between ROAM and the other treatments for PER and NM. *Clarias gariepinus* can effectively digest and utilize raw and differently processed Almond kernel meal and cake with the

roasted meal and mechanically extracted cake having better nutrient digestibility and utilization indices.

Key words: Almond kernel, *Clarias gariepinus,* processing, growth, digestibility

1.0 Introduction

Feed is estimated to account for more than 60-70% of total cost of fish production (Falaye, 1992). Fish meal has been utilized as a main protein component in balanced diet for fish (Bekibele, 2005). It is the single most expensive fish feed ingredient and makes up over 50% of the total cost of feed (Ekeleme *et. al*., 2000). Fish meal is especially rich in the essential amino acids (EAAs) and is highly digestible for fish (Ayinla, 2005). However, it is mostly imported into Nigeria. Its price is exorbitant and so makes the cost of finished fish feed to be high. Tropical Almond (*Terminalia catappa)* is a widely growing plant in West Africa. It provides fruits that are consumed by man especially children and it is readily and locally available (Burkill, 1988). Global production is around 1.7 million tons annually (Molody, 2008). Nigeria produces about 0.1 million tons annually (Annongu *et al*., 2006). The fruit is a good source of nutrients. The kernel contains about 23.1% crude protein and 9.3% crude fibre (Burkill, 1988). This makes the kernel meal a potential protein concentrate in aqua feed. However, it is well known that plants generally contain anti- nutritional substances, most of which elicit very harmful biological responses, while some are widely applied in nutrition and as pharmacologically-active agents (Soetan, 2008). The presence of these substances in plants has put limitation in their use necessitating their being processed before use (Sotolu, 2008).

Digestibility determination is very important in the selection of feed ingredients for feed formulation and determination of nutrient digestibility (Sotolu, 2008; Falaye *et al*., 2014). According to Cho and Kaushik (1990) digestibility is one of the most important aspects in evaluating the efficiency of animal feedstuffs and a basic requirement for formulating fish diets. Results have shown that the determination of nutrient digestibility is the first step for evaluating the potential of any ingredient for use in the diet of reared species (Allan *et al*., 2000; Falaye *et al*., 2014). According to Lee (2002) feed ingredients' digestibility is not only a useful tool for diet formulation but it also gives the right estimation for fish growth. Information on the nutrient digestibility of tropical almond kernel meal by fish is scarce. This study is therefore aimed at evaluating the Apparent Digestibility Coefficient (ADC) for protein and nutrient utilization of differently processed almond kernel meal and cake based diets by *Clarias gariepinus* juveniles.

The objectives of the study is to determine the effect of processing methods on the nutrient digestibility of tropical almond kernel meal and cake based diets by *Clarias gariepinus* juveniles and to assess the nutrient utilization indices of *C. gariepinus* juveniles fed differently processed tropical almond kernel meal and cake based diets.

2.0 Materials and Methods

2.1 Sample collection

Almond fruits were manually picked from Almond trees planted as shade tree at Nnamdi Azikiwe Hall, University of Ibadan, Ibadan, Nigeria. They were sun dried for three days and de-hulled manually.

2.2 Processing of Almond kernel Meals and Cakes

Raw Almond kernels were sun dried for 3 days. A portion of it was milled to 0.1mm particle size with Thomas Wiley milling machine (Model K 925) and designated as RWAM. Another portion was boiled in water (at atmospheric pressure) for 30 minutes at a proportion of 1:1.5 (kernel to water) w/v ratios. The boiled kernels were drained, sundried for three days, milled and designated as BOAM. Another portion was soaked in water at room temperature for 24 hours (with the water drained and changed at 12 hour interval) at a proportion of 1:2 (kernel to water) w/v ratio (Ijeh and Elezuo, 2008). After soaking, the kernels were drained, sun dried for 3 days, milled and designated SOAM. A fourth portion 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). The roasted kernels were milled and designated ROAM. Another portion was ground and de-oiled in a Soxhlet apparatus by soaking it inside 2.5 litres of petroleum ether (B.P. 60 - 80^{o}C) for 12 hours (Adesina, 2014). It was air-dried for 4 days for complete removal of residual solvent (Bello *et al*., 2012; Adesina, 2014) and designated SEAC. The last portion was ground and loaded into the receptacle of a mechanical screw press and pressed for 24 hours. The cake was manually broken into fine particles and designated MEAC.

2.3 Experimental Diet Preparation

Seven isonitrogenous and isocaloric diets at 40% crude protein level as recommended by Faturoti (2000) were formulated, six with each differently processed tropical almond kernel meal and cake and a reference diet (control) without tropical almond kernel, using Pearson square method. Chromium (III) oxide, Cr_2O_3 was used as an inert marker at a concentration of 0.5% in the experimental diets. The trial ingredients, BOAM (24.07% crude protein), SOAM (28.16% crude protein), ROAM (28.58% crude protein), MEAC (30.64% crude protein), SEAC (35.38% crude protein), RWAM (28.73% crude protein) (Table 1) were mixed homogenously with other ingredients, this included, fish meal, soybean meal, yellow maize, wheat offal, fish premix (vitamin and mineral premix), palm oil, dicalcium phosphate, table salt, cassava starch and Chromium (III) oxide marker (Table 2). Each ingredient was ground into a fine powder, carefully measured and mixed homogenously with other ingredients using hot water. The final mixture (dough) was made into pellets using a locally-made manual pelleting machine of 2 mm die. These were sufficiently sun-dried (for three days), packed in polyethylene bags, labeled appropriately and stored in a cool-dry place before usage. Each of the seven experimental diets was subjected to chemical analysis following the procedure of AOAC (2005).

2.4 Experimental Procedure

The experiment was set up in Aquaculture and Fisheries Management laboratory, University of Ibadan, Ibadan, Oyo State. The culture units consisted of 65-Litre rectangular plastic tanks filled with 48 litres of clean water. The experimental fish were acclimatized for 14 days prior to the commencement of the experiment. The duration of the experiment study was 28 days. A total of 420 *Clarias gariepinus* juveniles (mean weight 9.15±0.08g) were procured from a reputable commercial fish farm at Ibadan. Twenty *C. gariepinus* were randomly assigned to a treatment in each tank and fed each of the experimental diet in triplicates. The experimental fish were fed at 3% of their body weight twice daily (Bello *et al*., 2012; Falaye *et al*., 2014), between 08.00- 08.40 hours and 16.00-16.40 hours. Daily feed was recorded, while uneaten feeds were siphoned out of the tank 45 minutes after feeding to prevent their faeces being contaminated by the uneaten feed. Fish faeces were gently siphoned from the tanks 8 hours after feeding using 2 mm siphoning tube. Dead fish were counted and survival rate for each treatment was determined. On the last day of the experiment, faeces were also collected from the fish in each treatment eight hours after feeding by rectal dissection from the terminal 2.5cm of the intestine (Fagbenro, 1996; Sotolu, 2008). The faeces were pooled for each treatment, dried and stored for analysis. The tank water was changed with fresh water thrice weekly throughout the experimental period to prevent fouling of the culture water. Weight measurements of the fish were taken weekly for each treatment. These were used to determine the growth and nutrient utilization indices as described by Castel and Tiews (1980) and Sotolu (2008). Water quality parameters including temperature, dissolved oxygen and pH, were measured weekly throughout the period of the experiment using Horiba U-22 XD multi- parameter water quality checker.

Table 1: Crude protein content of differently processed almond kernel meal and cake

Meal/Cake Type	Crude protein content (%)
BOAM	24.07
SOAM	28.16
ROAM	28.58
MEAC	30.64
SEAC	35.38
RWAM	28.73

Legend: BOAM: Boiled Almond kernel meal; SOAM: Soaked Almond kernel meal; ROAM: Roasted Almond kernel meal; MEAC: Mechanically extracted Almond kernel cake; SEAC: Solvent Extracted Almond kernel cake; RWAM: Raw Almond kernel meal.
Source: Elezuo (2014)

Table 2: Gross Ingredient composition of the experimental diets for digestibility determination

Ingredient (g/100g DM)	REFR	BOAM	SOAM	ROAM	MEAC	SEAM	RWAM
Fish meal	26.72	26.72	26.72	26.72	26.72	26.72	26.72
Soya bean meal	39.16	26.72	26.72	26.72	26.72	26.72	26.72
Almond kernel meal	-	35.90	25.88	25.16	22.14	17.34	26.72
Yellow maize	13.06	1.33	6.34	6.70	8.21	10.61	5.92
Wheat bran	13.06	1.33	6.34	6.70	8.21	10.61	5.92
Palm oil	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Cassava starch	2.50	2.50	2.50	2.50	2.50	2.50	2.50
Dicalcium phosphate	1.75	1.75	1.75	1.75	1.75	1.75	1.75
Vitamin/mineral premix	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Table salt	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Chromic oxide	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Crude Protein (%)	40	40	40	40	40	40	40

REFR: Reference diet (control); BOAM: Boiled Almond kernel meal diet; SOAM: Soaked Almond kernel meal diet; ROAM: Roasted Almond kernel meal diet; MEAC: Mechanically extracted Almond kernel cake diet; SEAC: Solvent Extracted Almond kernel cake diet; RWAM: Raw Almond kernel meal diet (positive control); DM: Dry matter.

2.5 Analytical Methods

Proximate analysis (crude protein, crude fat, crude fibre, moisture, dry matter and Nitrogen –free extract) were analyzed for the experimental diets and fish faeces at the beginning and end of the experiment following the methods of AOAC (2005). Gross energy contents were determined by bomb calorimetry, while Chromium (III) oxide content in diets and faeces were determined by methods described by Furukawa and Tsukahara (1966). Apparent Digestibility Co-efficient (ADC) of crude protein, dry matter and gross energy in the experimental diets were calculated according to Nwanna (2003) as follows:

ADC nutrient = $10^2 - [10^2 \text{ X } (\text{Id X Nf})] / \text{If x Nd}$

Where, Id = % Chromium (III) oxide in the diet, If = % Chromium (III) oxide in fish faeces, Nf = Nutrient in fish faeces, Nd = Nutrient in the diet

2.6 Determination of Nutrient Utilization and Growth Performance Indices

The effects of various treatments (diets) on nutrient utilization and growth performance were evaluated as follows:

Mean Weight Gain (MWG):

$MWG = (W_2 - W_1)$ 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):

SGR (%) = $Log_e W_2 - Log_e W_1 \times 100/T$

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

Aveage Daily Growth (ADG):

ADG= Mean weight gain / Duration of experiment (in days)

Percentage Weight Gain (PWG):

PWG (%) = Mean weight Gain / Initial mean weight X 100

Condition factor (K):

$K = W/L^3 \text{ X } 100$

Where: W = weight of fish; L = Length of fish

Feed Conversion Ratio (FCR):

FCR = Feed intake (g) / Weight gain (g)

Gross Feed Conversion Efficieny (GFCE):

GFCE = 1/FCR X 100

Protein intake of feed (PrI):

PrI = feed intake x % protein in the diet (i e 40%)

Protein Efficiency Ratio (PER):

PER = Mean weight gain of fish (g) / Protein intake

Nitrogen Metabolism (Nm):

$Nm = 0.549 \times (W_1 + W_2)t /2$

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

Net Protein Utilization (NPU):

$NPU = N_2 - N_1 + Nm / Nd$

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

Survival Rate (SR):
S R (%) = Initial number of fish stocked – mortality x 100 / Initial number of fish stocked

2.7 Experimental Design

The digestibility study was set up using Completely Randomized Design (CRD). The seven isonitrogenous diets formulated with differently processed tropical almond kernel meals and cakes represented the seven treatments for this experiment.

2.8 Statistical Analysis

Data resulting 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 Duncan Multiple Range Test (Duncan, 1955).

3.0 Results and Discussion

3.1 Proximate and Gross Energy composition of Experimental diets for Digestibility studies

Results of proximate composition of the experimental diets are presented in Table 3. The proximate composition of experimental diets used for the digestibility study showed that the crude protein content of all the experimental diets fell within the range 40.03 to 40.24%. There was no significant difference ($P > 0.05$) in the crude protein content of the experimental diets. Crude fibre content ranged between 2.45 and 3.34% (mean, 2.9%). RWAM diet had the highest value while BOAM diet had the least value. The crude fibre content of the experimental diets in this study was 2.45 to 3.34% which are similar to 2.87 to 3.06% reported by Adesina (2014) in meal diets from sunflower while 3.50 to 4.28% was realized from biscuit waste based diets fed to *Clarias gariepinus* (Agbebi *et al*., 2012). The crude fibre content of all the experimental diets fell within the maximum recommended level (3-4%) for omnivorous fish species' juvenile/grower (Tacon, 1987; Ajani *et al*., 2011). Crude fat content ranged between 4.71% for SEAC diet to 6.99% for RWAM diet. There was significant difference ($p > 0.05$) among the treatments.

Table 3: Proximate (%) and gross energy contents (kcal/kg) of processed Tropical Almond kernel meal diets fed to Clarias gariepinus juveniles

Diet	Crude protein	Crude fat	Crude fibre	Ash	Moisture	NFE	Gross energy
REFR	40.10±0.01[a]	5.95±0.02[d]	2.98±0.02[c]	13.20±0.04[d]	5.14±0.01[b]	32.63±0.02[b]	3,504.00±2.89[c]
BOAM	40.24±0.02[a]	5.06±0.02[c]	2.45±0.01[a]	12.85±0.02[a]	6.23±0.03[f]	33.17±0.02[bc]	3,478.67±1.45a
SOAM	40.08±0.01[a]	6.86±0.01[e]	2.95±0.01[c]	13.01±0.01[b]	5.85±0.02[e]	31.25±0.01[ab]	3,601.00±2.89[e]
ROAM	40.05±0.02[a]	6.92±0.01[f]	3.30±0.10[a]	12.87±0.01[a]	5.04±0.02[a]	31.82±0.02[ab]	3,665.00±2.89[f]
MEAC	40.23±0.10[a]	4.93±0.02[b]	2.56±0.02[a]	13.09±0.01[c]	5.47±0.02[c]	33.72±0.10[c]	3,487.00±2.31[b]
SEAC	40.03±0.09[a]	4.71±0.02[a]	2.81±0.01[b]	13.21±0.01[d]	5.66±0.02[d]	33.58±0.09[bc]	3,529.33±2.40[d]
RWAM	40.18±0.01[a]	6.99±0.02[g]	3.34±0.01[d]	13.04±0.01[bc]	5.64±0.02[d]	30.81±h0.01[a]	3,698.00±3.46[g]

Means ± SEM

Mean values in each column with similar superscripts are not significantly different ($p > 0.05$)

REFR diet: Reference diet (control); BOAM diet: Boiled Almond kernel meal diet; SOAM diet: Soaked Almond kernel meal diet; ROAM diet: Roasted Almond kernel meal diet; MEAC diet: Mechanically extracted Almond kernel cake diet; SEAC diet: Solvent Extracted Almond kernel cake diet; RWAM diet: Raw Almond kernel meal diet.

The crude fat content of the experimental diets obtained in this study (4.71 to 6.99%) compares well with that of Sotolu and Sule (2011) (4.21 to 7.14%) for water hyacinth meal based diets. Sotolu (2008) reported 2.03 to 3.47% for differently processed leucaena seed meal diets while Adesina (2014) reported 3.71 to 5.22% for processed sunflower seed meal diets fed to *Clarias gariepinus*. Ash content ranged between 12.85% and 13.20%. The ash content of the experimental diets recorded in this study was between 12.85 to 13.20%. This is in the same range with that of Sotolu (2008) who reported 10.36 to 11.41% and Adesina (2014) with 11.53 to 12.73% for processed leucaena seed meal diets and processed sunflower seed meal diets, respectively. Moisture content of the experimental diets had a narrow range between 5.18 to 6.34%. ROAM had the lowest moisture content while BOAM had the highest moisture content. Control of moisture content of fish feed is important because high moisture content of feed reduces its shelf life and increases its chances of being infested by fungi. The values of moisture content obtained in this study fell within the recommended level of <10% for catfish diet (Onuoha and Elezuo, 2013). The positive control diet (RWAM) had the lowest NFE value while MEAC had the highest NFE value. The range of NFE values obtained in this study, 30.81 to 33.58% is similar to the values 28.75 to 35.94% reported by Agbabiaka *et al*. (2013) for tiger nut based diets; 29.69 to 34.12 reported by Adesina (2014) for processed sunflower seed meal diets and 21.29 to 34.64% reported by Ovie *et al*. (2012), for baker's yeast based diets. It is however higher than the values 27.12 to 29.36 reported by Falaye and Oloruntuyi (1998) for plantain peel meal based diet, 19.58 to 22.94% reported by Bello *et al*. (2012) for walnut leaf and onion bulb residues based diets, 19.32 to 25.21 reported by Ochang *et al*. (2007) for palm oil based diets. The difference in the NFE values could be attributed to differences in the ingredient composition of the diets.

RWAM had the highest gross energy content, followed by ROAM while BOAM had the lowest value. The gross energy content of the experimental diets observed in this study, 3478.67 to 3698.00 kcal/kg are comparable to that of Sotolu (2008) with 3001.58 to 3132.21% observed for differently processed Leucaena seed meal based diets but slightly higher than 3,478.67 to 3698 kcal/kg reported by Sotolu and Faturoti (2009) for soaked Leucaena seed meal based diets. The difference in the energy values could be as a result of differences in the gross composition of experimental diets.

3.2 Growth Performance of Clarias Gariepinus Fed Differently Processed Tropical Almond

3.2.1 Kernel Meal Diets

Results of growth performance indices including Mean weight gain (MWG), Specific growth rate (SGR), Percentage weight gain (PWG), Survival rate and condition factor (K) are presented in Table 4 while A detailed mean weight change of experimental fish was shown in Figure 1.
Growth performance of *C. gariepinus* juveniles fed differently processed tropical almond kernel meal diets exhibited weight gain that indicated that the experimental fish were able to digest the feed and converted the protein in the feed to extra flesh in agreement with Eyo and Olatunde (2001). There were variations in the values of the mean weight gain of fish fed differently processed tropical almond kernel meal diets as a result of the extent of digestibility of the diets. This observation is similar to the report of Nwanna (2003) and Sotolu (2008) who reported a significant mean weight gain in the experimental fish with higher digestibility values.

Specific growth rate (SGR) was between 1.48 to 2.40%/day values recorded for soaked and roasted tropical almond kernel meal diets respectively. There was no significant difference (P> 0.05) among treatments 1, 2, 3 and 5. These values are higher than 0.131% to 0.182% recorded for *C. gariepinus* fed differently processed Leucaena seed meal based diets (Sotolu, 2008) and 0.49 to 0.62% recorded for the same species fed differently processed sunflower seed meal diets (Adesina, 2014). The other growth parameters namely, average daily growth and percentage weight gain (relative growth rate) followed the same pattern with roasted and soaked almond kernel meal diets having the highest and lowest values respectively.

Condition factor (K) is used in Fisheries science to express the robustness and general well- being of fish (Bello *et al.*, 2012). The condition factor of the experimental fish obtained in this study had a narrow range of 0.61 to 0.66. There was no significant difference (P>0.05) among the treatments. This indicates that all the differently processed almond kernel meal diets had a positive effect on the fish well-being of the experimental fish comparable to the control diets. The result of this study supports the findings of Lagler (1956) who reported a range of values, 0.5 to 1.0, for healthy fish. This study showed high survival rate of the experimental fish with values ranging from 98.33 to 100%. This is similar to that reported by Adesina (2014) for *C. gariepinus* fed differently processed sunflower seed meal diets between 96.67-100%. However, it is higher than that reported by Sotolu (2008) with values of 92-96% for the same species fed differently processed Leucaena seed meal diets. However, there was no significant difference (P>0.05) among the treatments. The generally high survival rate of the experimental fish in all the treatments suggests that the differently processed almond kernel meal diets support fish growth and survival.

This study revealed that the growth performance indices of fish fed roasted almond kernel meal (ROAM) diets had the highest final mean weight, mean weight gain, total percentage weight gain and specific growth rate followed by those fed mechanically-extracted almond kernel cake (MEAC) diet and boiled almond kernel meal (BOAM) diet. These results indicated that ROAM diet produced the best growth performance of *C. gariepinus* juveniles followed by MEAC diet and BOAM diet in that order.
This is similar to that of Adesina (2014) who reported that fish fed heat treated (boiled) and mechanically extracted sunflower seed meal diets produced the best and second best growth performance respectively.

Table 4: Growth performance indices of the Clarias gariepinus juvenile fed with differently processed Tropical Almond kernel meal diets for 28 days for digestibility study

Growth parameters	**Experimental Diets**						
	REFR	**BOAM**	**SOAM**	**ROAM**	**MEAC**	**SEAC**	**RWAM**
Initial mean wt.(g)	9.08 ± 0.03 ^{a}	9.17± 0.39 ^{a}	9.07 ± 0.11 ^{a}	9.21 ± 0.15 ^{a}	9.20 ± 0.30 ^{a}	9.10 ± 0.33 ^{a}	9.22 ± 0.23 ^{a}
Final mean wt. (g)	14.80 ± 0.72 ^{a}	15.80 ± 1.05 ^{a}	13.92 ± 0.21^{a}	18.12 ± 1.30 ^{b}	15.86 ± 0.89 ^{a}	14.13 ± 0.86 ^{a}	15.04 ± 0.85 ^{a}
Mean wt. gain (g)	5.71 ± 0.72 ^{ab}	6.64±0.66 ^{abc}	4.85±0.10 ^{a}	8.90±1.30 ^{c}	6.66±0.60 ^{abc}	5.03±0.61 ^{a}	5.83±0.72 ^{ab}
SGR (%/fish/day)	1.60±0.19 ^{a}	1.88±0.22 ^{a}	1.48±0.06 ^{a}	2.40±0.27^{b}	1.89±0.12 ^{a}	1.50±0.17 ^{a}	1.67±0.16 ^{a}
Av. daily growth (g)	0.20±0.03 ^{a}	0.24±0.02 ^{a}	0.18±0.00 ^{a}	0.32±0.05 ^{b}	0.24±0.02 ^{a}	0.18±0.02 ^{a}	0.21±0.03 ^{a}
PWG (%)	62.90±8.00 ^{a}	72.06±4.21 ^{a}	53.52±0.61 ^{a}	96.65±14.17^{b}	72.17±4.00 ^{a}	55.06±5.63 ^{a}	63.12±7.11 ^{a}
Survival rate (%)	98.33±1.67 ^{a}	98.33±1.67 ^{a}	98.33±1.67 ^{a}	100.00±0.00^{a}	98.33±1.67 ^{a}	98.33±1.67 ^{a}	98.33±1.67 ^{a}
Condition factor (K)	0.64±0.01 ^{a}	0.66±0.06 ^{a}	0.62±0.02 ^{a}	0.65±0.04 ^{a}	0.66±0.09 ^{a}	0.61±0.06 ^{a}	0.65±0.05 ^{a}

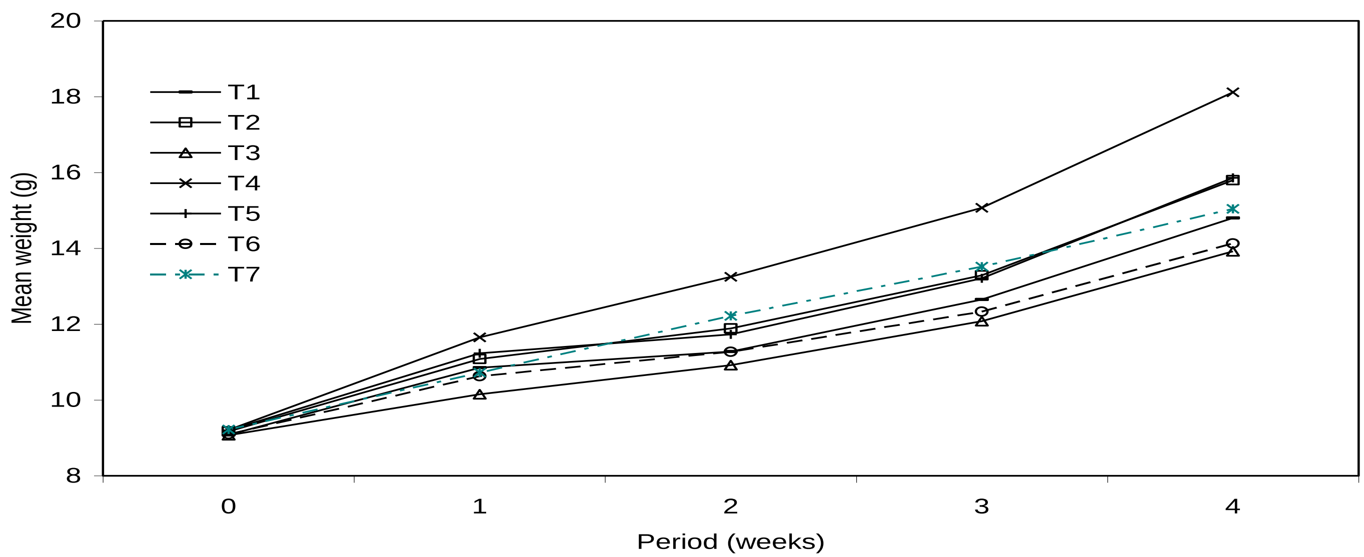
Means ± SEM

Mean values in each row with similar superscripts are not significantly different ($p>0.05$).

Legend: SGR= Specific growth rate; PWG= Percentage weight gain; wt. = weight; Av=Average

Figure 1: Mean weekly weight changes of *Clarias gariepinus* fed raw and differently processed tropical Almond kernel meal diets.

T1= REFR; T2= BOAM; T3= SOAM; T4= ROAM; T5= MEAC; T6= SEAC; T7= RWAM



3.3 Digestibility Indices of Clarias Gariepinus Fed Differently Processed Tropical Almond

3.3.1 Kernel Meal Diets

Results of Apparent digestibility indices and nutrient utilization indices are shown in Table 5 below. The nutrient utilization indices of *Clarias gariepiuus* juveniles fed differently processed tropical almond kernel meal diets have shown that fish fed ROAM diet had the highest total feed intake (TFI) (172.90g) while those fed SOAM diet had the least (148.61g).The high value of TFI for ROAM diet indicates that the feed was well accepted by the fish more than the control diets. Anti-nutritional factors have been reported to reduce the palatability of feed thereby reducing feed intake by fish (Sotolu, 2008; Olasunkanmi, 2011). However, Adesina *et al.* (2013) and Falaye *et al.* (2014) reported that processing such as heat treatment is very effective in reducing anti-nutitional factors in plant feedstuffs.

This may have contributed to the high total intake of ROAM diet by the experimental fish. The best (lowest) feed conversion ratio (FCR) was observed in fish fed ROAM diet (1.00) followed by those fed MEAC diet (1.27) while the highest was observed in fish fed SEAC diet. This indicates a superior level of utilization of the ROAM and MEAC diets by the experimental fish. El-block (1975) reported that FCR values for *Clarias gariepinus* ranged between 3.2 and 6.7 depending on the quality of the feed given. Adikwu (2003) documented that the lower the FCR the better the feed utilization. The FCR value 1.00 to 1.64 reported in this study are better than 5.72 to 5.81 reported by Ihimekpen (2003) for *Clarias gariepinus* fingerlings fed shrimp waste based diets, 5.72 to 5.81 values reported for *C. gariepinus* juveniles fed walnut leaf and onion bulb residues based diets (Bello *et al.,*2012); Bekibele (2005) recorded 2.46 to 2.66 for the same species fed mucuna beans based diets; the lower FCR for ROAM and MEAC diets indicates better feed utilization by fish fed these diets and is justified by better growth performance of fish feed these diets. Omitoyin and Faturoti (2000) reported that catfish fed parboiled chicken offal performed better than those fed raw chicken offals. They attributed this to improved nutritive value of the parboiled offal. Net protein utilization (NPU) was highest in fish fed ROAM diets (30.74%) followed by those fed MEAC diet (30.31%). Fish fed SOAM diet had the least NPU value of 27.81%. The NPU range (27.81 to 30.74%) obtained in this study is higher than the range 7.02 to 7.23% reported by Sotolu (2008) for the same species fed differently processed leucaena seed meal diets. NPU had been associated with superiority of feed and its protein quality (Steffens, 1989). ROAM and MEAC diets had the highest protein efficiency ratio (PER) of 2.54 and 2.03 respectively while fish fed SOAM and SEAC diets had the lowest value (1.60). The PER values obtained in this study (1.60-2.54) are higher than the values 0.90 to 1.30 reported by Adesina (2014).

Table 5: Nutrient utilization indices and digestibility co-efficient of fed processed tropical Almond kernel meal and cake based diet to Clarias gariepinus juvenile for 28 days

Parameters	Experimental Diets						
	REFR	BOAM	SOAM	ROAM	MEAC	SEAC	RWAM
Mean feed intake (g)	8.29±0.45[a]	8.53±0.13[a]	7.56±0.07[a]	8.64±0.46[a]	8.16±0.58[a]	7.84±0.55[a]	8.50±0.80[a]
Food conversion ratio	1.53±0.14[bc]	1.35±0.15[abc]	1.62±0.09[bc]	1.00±0.16[a]	1.27±0.07[ab]	1.64±0.14[c]	1.52±0.08[bc]
GFCE (%)	66.82±6.94[a]	76.04±9.15[a]	62.24±3.47[a]	101.97±8.08[b]	79.37±3.99[a]	61.75±5.45[a]	66.27±3.34[a]
Protein intake (g)	3.32±0.18[a]	3.43±0.05[a]	3.03±0.03[a]	3.56±0.18[a]	3.28±0.23[a]	3.13±0.22[a]	3.42±0.32[a]
Protein efficiency ratio	1.71±0.15[a]	1.94±0.21[a]	1.60±0.04[a]	2.54±0.26[b]	2.03±0.05[a]	1.60±0.11[a]	1.70±0.06[a]
NPU (%)	28.94±0.86[a]	30.15±1.72[a]	27.81±0.38[a]	30.74±1.57[a]	30.31±1.43[a]	28.22±1.38[a]	29.29±1.22[a]
Nitrogen metabolism	183.54±5.55[ab]	191.92±11.05[ab]	176.67±2.45[a]	210.09±10.06[b]	192.64±9.18[ab]	178.52±8.82[a]	186.46±7.86[ab]
ADCP (%)	88.95±0.06[d]	88.40±0.06[c]	87.59±0.06[b]	89.03±0.05[d]	88.92±0.18[d]	87.06±0.06[a]	87.70±0.06[b]
ADCGE (%)	86.80±0.02[a]	86.91±0.01[b]	87.42±0.01[c]	88.51±0.02[g]	88.19±0.01[f]	87.49±0.01[d]	88.08±0.03[e]
ADCDM (%)	72.27±0.00[c]	72.60±0.02[e]	72.49±0.00[d]	74.43±0.01[f]	74.54±0.00[g]	71.84±0.01[a]	72.03±0.01[b]

Means ± SEM.

Mean values in each row with similar superscripts are not significantly different (p>0.05); ADCP= Apparent digestibility Co-efficient of crude protein; ADCGE=Apparent digestibility co-efficient of Gross Energy; ADCDM= Apparent digestibility Co-efficient of Dry matter.

Nitrogen metabolism (Nm) ranged between (176.69 and 202.40%) with the highest value observed in fish fed ROAM diet while the least value was observed in fish fed SOAM diet. The Nm obtained in this study is lower than that reported by Adesina (2014) but higher than that reported by Sotolu (2008). Apparent digestibility co-efficient of crude protein (ADCP) recorded showed significant difference (P<0.05) among the dietary treatments. Fish fed ROAM diet had the highest (best) ADCP value of 89.03% followed by those fed MEAC diet

(88.95%) while fish fed SEAC diet had the least value (87.06%). The best ADCP observed in fish fed ROAM diet could be attributed to the effect of heat treatment in reducing the anti-nutritional factors in the roasted kernel thereby making the nutrients more available to the fish.

Anti-nutritional factors such as phytate, tannin, mimosine, glycoside, oxalate etcetera have been reported to make nutrients including protein, calcium, phosphorus, zinc, etcetera, unavailable to fish (Sotolu, 2008; Olasunkanmi, 2011; Adesina *et al.,* 2013). Adesina *et al.* (2013) and Falaye *et al.* (2014) reported that processing such as heat treatment is very effective in reducing anti-nutitional factors in plant feedstuffs. The ADCP obtained in this study is similar to that reported by Adesina (2014) with 80.69 to 85.69% but higher than that reported by Sotolu (2008) with 64.18 to 70.18% and Ihimekpen (2003) that reported 79.69 to 83.68%. The high ADCP values observed in all treatments indicated that the experimental fish properly utilized the protein in all the experimental diets.
There was significant difference ($P<0.05$) in the values of Apparent digestibility co-efficient of dry matter (ADCDM) obtained in this study. Fish fed SEAC diet had the least value (71.87%) while those fed MEAC diet had the highest value (74.54%).

This observation is in agreement with the report of Adesina (2014) which had fish fed mechanically-extracted sunflower seed meal diet having the highest ADCDM compared to other processing methods. Degani *et al*. (1997) maintained that apparent digestibility of dry matter provides a better estimate of the quantity of digestible materials in the feed rather than individual nutrients. The fairly high ADCDM values recorded in all treatments indicated good diets acceptance and utilization by *Clarias gariepinus*. Apparent digestibility co-efficient of gross energy ADCGE was generally high in all the treatments and varied significantly ($P<0.05$) among the treatments. ADCGE was highest in fish fed ROAM diet, followed by those fed MEAC diet while those fed the reference diet (control) had the least value. The ADCGE values recorded in this study are higher than that reported by Sotolu (2008) who reported 64.18 to 70.18% but lower than the values 98.97 to 98.98% reported by Adesina (2014). The fairly high ADCGE values recorded for all the diets suggest that the amount of energy ingested and digested were the required quantity by *Clarias gariepinus* for the best conversion of feed into flesh.

3.4 Water Quality Assessment of the Culturing experimental Tank

The results of water quality parameters of the experimental system monitored are presented in Table 6.
Physico chemical water quality parameters monitored in this study showed that the values were within the optimum range for *Clarias gariepinus* (Omitoyin, 2007; Ajani *et al.*, 2011). This indicates that the environmental conditions for the fish throughout the experimental period were adequate and conducive.

Table 6: Initial and final values of water quality parameters observed during the study

Treatments	Water quality parameters		
	pH	Dissolved O_2 (mg/L)	Temperature (^{o}C)
Initial values	6.95 ± 0.00^{c}	5.19 ± 0.01^{g}	27.95 ± 0.00^{c}
Final values			
Diet 1 (Control)	6.99 ± 0.01^{d}	4.78 ± 0.01^{f}	25.00 ± 0.03^{a}
Diet 2	6.85 ± 0.02^{a}	4.62 ± 0.01^{de}	25.00 ± 0.03^{a}
Diet 3	6.93 ± 0.01^{bc}	4.27 ± 0.01^{a}	25.05 ± 0.00^{ab}
Diet 4	6.85 ± 0.02^{a}	4.47 ± 0.01^{c}	25.05 ± 0.03^{ab}
Diet 5	6.95 ± 0.01^{c}	4.65 ± 0.02^{e}	25.00 ± 0.00^{a}
Diet 6	6.85 ± 0.01^{a}	4.42 ± 0.01^{b}	25.05 ± 0.03^{ab}
Diet 7	6.91 ± 0.01^{b}	4.60 ± 0.01^{d}	25.10 ± 0.03^{b}

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

4.0 Conclusion

This study has shown that *Clarias gariepinus* juveniles can effectively digest and utilize raw and processed almond kernel meal and cake based diets. Roasting and mechanical extraction methods produced diets with better nutrient digestibility, nutrient utilization and growth performance indices.

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