Journal of Fisheries and Aquatic Science

ISSN 1816-4927

Academic Journals Inc.

www.academicjournals.com

Journal of Fisheries and Aquatic Science 9 (2): 75-84, 2014
ISSN 1816-4927 / DOI: 10.3923/jfas.2014.75.84

Apparent Digestibility Coefficient of Differently Processed Lima Bean (*Phaseolus lunatus* L.) For *Clarias gariepinus* Juveniles

[1]A.E. Falaye, [2]A. Omoike and [1]O. Orisasona
[1]Department of Fisheries and Aquaculture, University of Ibadan, Ibadan, Nigeria
[2]Department of Biological Sciences, Bells University of technology, Ota, Nigeria

Corresponding Author: A. Omoike, Department of Biological Sciences, Bells University of technology, Ota, Nigeria

ABSTRACT

Apparent Digestibility Coefficient (ADC's) of crude protein, lipid and energy in differently processed lima bean (*Phaseoluslunatus*) were determined for *Clarias gariepinus* (13.57±0.07 g). Raw (RLM), boiled (BLM), soaked (SLM), autoclaved (ALM) and toasted (TLM) Lima bean were the test ingredients. Test diets contained 70% reference diets and 30% of test ingredients, with chromic oxide as the inert marker. All treatments were replicated. Fish were fed twice daily and excess feed siphoned out 30 min after each feeding, while faecal collection was done 8 h after every feeding. The digestibility coefficient of nutrients were calculated using proximate analysis of diets and faeces carried out for crude protein, energy, lipid and phosphorus. Apparent digestibility coefficients of energy was lowest in SLM and showed no significant difference among other treatments ($p<0.05$). ADC's of crude protein was highest in BLM (88.01%) and lowest in ALM. There were significant difference in all treatments ($p<0.05$). ADC's of phosphorus was highest in BLM closely followed by ALM and showing no significant difference ($p<0.05$).The least ADC phosphorus value was recorded in RLM. ADC's lipid was highest in BLM and showed significant difference with SLM and ALM ($p<0.05$). FCR for ALM varied significantly ($p<0.05$) from other treatment. *Clarias gariepinus* can effectively digest boiled and toasted Lima bean seed, with both treatments having better ADC's for protein, lipid, energy and phosphorus.

Key words: *Clarias gariepinus*, lima bean, processing, digestibility, growth

INTRODUCTION

Over the last decade, there has been a dramatic increase in the Inland aquaculture production in the world (Muir, 2003). This will continue to play increasingly important role in meeting the demand for fish (AIFP, 2004). The production of about 0.46 million tonnes of fish in Nigeria using artificial feed was reported (Fagbenro *et al.*, 2003). The fishmeal production has increased the total cost of fish production. FAO (2000) reported that the fish used as fishmeal raw materials in year 2000 accounted for about 30 out of 130 tonnes. Inadequate supply of feedstuff, fishmeal in particular which is scarce, expensive and not readily available has hampered aquaculture development (Nwanna, 2003; Gabriel *et al.*, 2007), necessitating the need for the development of fish feed from high quality inexpensive.

Lima bean (*Phaseolus lunatus*), a plant protein source and according to Aletor and Aladetimi (1989). It has been classified as one of the under-utilized legumes in Nigeria. Studies from Ologhobo (1980) and Aletor and Aladetimi (1989) showed a resemblance to a common bean in amino acid profile. This class of lesserlegume is largely due to a seemingly lack of awareness on its nutritional potentials. Lima bean is widely cultivated in the south-western, south-eastern and the middle belt regions of Nigeria. One major anti-nutritional constraint associated with the utilization of Lima bean in fish feed production is the presence of phytic acid (Phosphorus in a chemical form). It was found that the Chemically bound phosphorus in Lima beans in feed ingredient passes through fish gut unused which is eventually released into the pond. Moran *et al.* (1968) and Fagbemi *et al.* (2005) stated that traditional processing techniques could adequately reduce the anti-nutritional factors in legumes and oil seeds and that heat involved in the commercial processing improves their protein quality by destroying certain anti-nutritional factors. According to Tibbetts *et al.* (2004), plant protein sources can provide high quality protein in fish diets when properly incorporated into feed formulas, supplemented with crystalline amino acids and properly heated during feed processing. Alonso *et al.* (2000) also stated that a variety of processing techniques such as soaking, heat treatment (Boiling and soaking), roasting, fermentation and germination have been used to remove anti-nutritional compounds and hence improve bean nutritional value. Various processing methods including toasting, soaking in water, fermentation, autoclaving, sun-drying, boiling, have been employed for legumes. Digestibility study is very important in the selection of feed ingredients for feed formulation. According to Cho and Kaushik (1990a) digestibility is one of the most important aspects in evaluating the efficiency of animal feedstuffs and a basic requirement for formulating fish diets. Result has 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). According to Lee (2002) feed ingredients digestibility coefficients is not only a useful tool for diet formulation but it also give the right estimation for fish growth which reduces fish waste products.

The purpose of this work was to determine the Apparent Digestibility Coefficient (ADC) for protein, energy and lipids in differently processed (Sun-dried raw, boiled, toasted, soaked and autoclaved) lima bean meal in the diets of juvenile *Clarias gariepinus*.

MATERIALS AND METHODS

Processing Lima bean: Raw lima beans were sun-dried for two days. A portion of it was milled and designated RLM. Another portion was added into boiling water (100°C), at atmospheric pressure at a proportion of 1:10 (kg: L) seed to water and allowed to boil for 1 h. The cooked bean was drained and oven dried at 50°C for 3 h (Adeparusi and Ajayi, 2004), milled and designated BLM. A third portion was soaked in water at room temperature for a period of 9 h at a bean: Water solution of 3:10 (kg: L). After soaking, beans were immediately removed from the water, drained and dried at 50°C in an oven for 3 h, milled and designated SLM. The fourth part was put in an autoclave at 121°C, 15 PSI for 30 min. The cooked beans were removed and the cooking broth discarded. The beans were dried in an oven at a temperature of 50°C for 3 h and designated ALM. The last portion was placed in a tray and put in an oven until the temperature reaches 204°C for 10 min (Adeparusi and Jimoh, 2002). The toasted beans were milled and designated TLM.

Raw and processed lima bean meals were analysed to determine the proximate, mineral, tannin, oxalate and phytate contents. Proximate analyses of samples were carried out according to the official methods of analysis described by the Association of Official Analytical Chemist (AOAC, 2005). All analysis was carried out in duplicate. Calcium, potassium and sodium were analysed using methods described by AOAC (2005) (975.11). Phytate content was determined as described by Maga (1982).

Table 1: Feed formulation for the experimental diets

Ingredient	Reference diet	Experimental diet
Fish meal	23.57	16.45
Soya bean meal	23.57	16.45
Groundnut cake	23.57	16.45
Yellow maize	22.79	15.95
Vitamin premix	20.00	10.40
Bone meal	10.00	00.70
Oyster shell	00.50	00.30
Palm oil	00.50	00.30
Salt	00.50	00.30
Starch	10.00	00.70
Chromic oxide	10.00	10.00
Lima bean meal	-	30.00
Total	100.00	100.00

Table 2: Ingredient composition for the experimental text diets fed *Clarias gariepinus* for digestibility study

Ingredient g-100 g-DM	Reference diet	RLM	BLM	SLM	ALM	TLM
Fish meal	23.57	16.45	16.45	16.45	16.45	16.45
Soya bean meal	23.57	16.45	16.45	16.45	16.45	16.45
Groundnut cake	23.57	16.45	16.45	16.45	16.45	16.45
Yellow maize	22.79	15.59	15.95	15.95	15.95	15.95
Vitamin premix	2.00	1.40	1.40	1.40	1.40	1.40
Bone meal	1.00	0.70	0.70	0.70	0.70	0.70
Oyster shell	0.50	0.30	0.30	0.30	0.30	0.30
Palm oil	0.50	0.30	0.30	0.30	0.30	0.30
Salt	0.50	0.30	0.30	0.30	0.30	0.30
Starch	1.00	0.70	0.70	0.70	0.70	0.70
Chromic oxide	1.00	1.00	1.00	1.00	1.00	1.00
Lima bean meal	-	30.00	30.00	30.00	30.00	30.00
Total	100.00	100.00	100.00	100.00	100.00	100.00
Crude protein (%)	40.00	40.00	40.00	40.00	40.00	40.00

RLM: Raw lima bean diet, BLM: Boiled lima bean diet, SLM: Soaked lima bean diet, ALM: Autoclaved lima bean diet, TLM: Toasted lima bean diet

Diet preparation: A reference diet was formulated to contain 40% crude protein. Test ingredients for digestibility study were raw lima bean, boiled lima bean, soaked lima bean, toasted lima bean and autoclaved lima bean. Chromic oxide (Cr_2O_3) was used as an inert marker at a concentration of 1% in the reference and test diets. The five test ingredients (Table 1) contained 70% reference diet and 30% of each of the test ingredients on a dry weight basis (Dong *et al*., 2010; Luo *et al*., 2009; Koprucu and Ozdemir, 2005). The test ingredients were thoroughly mixed with other ingredients (Table 2) in a Hobart A-200T pelleting and mixing machine to obtain a homogeneous mass. Cassava starch and hot water were added to the mixtures to obtain a dough-like paste, which were then extruded through a 2 mm die mixer pelleting machine (Hobart A-200T) to form pellets. These were sundried and packed into air-tight polyethylene bags prior use.

Experimental procedure: *Clarias gariepinus* were acclimatized to laboratory condition for 7days. Total of 20 *Clarias gariepinus* juveniles (average weight 13.56±0.07) were distributed in triplicates randomly into plastic tanks each at 1 fish L^{-1} of water. For 21 days after acclimatization, fish were fed two times daily at 08.00-08.30 and 17.00-17.30 h. daily feed supplied were recorded, while uneaten feed were cleaned 30 min after feeding to prevent excess feed contaminating the faeces. Faeces were gently siphoned from the tanks using siphoning tube (2 mm diameter) every 8 h after feeding. The faeces were pooled for each treatment and dried. Initial and final proximate analysis of experimental fish was carried out. Fish mortalities were recorded and used to calculate survival rate for each treatment.

Initial and weekly weights of experimental fish were recorded for each treatment. These were used to determine the growth and nutrient utilization as described by Castell and Tiews (1980). Water quality parameters were determined before and after the experiment.

Analytical methods: Crude protein, dry matter and lipid were analysed for diets and faeces according to AOAC (2005) methods. Gross energy contents were determined by bomb calorimetry, while chromic oxide content in diets and faeces were determined by methods described by Farukawa and Tsukahara (1966). All chemical analysis from each treatment was done in triplicates.

Ash content was determined after combustion in a muffle furnace at 550°C for 12 h. Samples were analysed for dry matter at 65°C for 24 h in a vacuum oven. Crude protein (%N×6.25) was determined by the Kjeldahl method using an Auto Kjeldahl System.

Calcium and phosphorus were analysed using an atomic emission spectrometry. Energy contents were analysed using an Automatic Adiabatic Bomb Calorimeter.

The apparent digestibility coefficients (ADCs) of, protein, lipid and energy for test and reference diets were calculated as follows (Cho and Slinger, 1979):

Apparent digestibility coefficients in the test and reference diets were calculated as follows:

$$\text{ADC nutient} = 100 - 100\left\{\left(\frac{\text{CrO}_3\text{ in diet (\%)}}{\text{CrO}_3\text{ in feaces (\%)}}\right)\times\left(\frac{\text{Nutrient in feaces}}{\text{Nutrient in diet}}\right)\right\}$$

Since the test ingredients substituted 30% of the reference diet, the ADC of the ingredients were calculated according to the following equation (De Silva and Anderson, 1995):

$$\text{ADC n} = \frac{\{\text{ADCTD} - (\text{Y} \times \text{ADCRD})\}}{\text{Z}}$$

ADCn: Apparent digestibility coefficient of nutrient in test ingredient, ADC_{TD}: Apparent digestibility coefficient in test diet and ADC_{RD}: Apparent digestibility coefficient in reference diet, Y is the reference diet proportion and Z is the test diet proportion.

Statistical analysis: All data resulting from the experiment were subjected to a one way analysis of variance (ANOVA) and subjected to Duncan's multiple range test at a significant level of $p<0.05$. Analysis was carried out using the SPSS (Statistical Package Computer, Software 1988 version Chicago Illinois, USA).

RESULTS

The experimental diet used in this experiment is shown in Table 1. The composition of diets for digestibility study in this experiment showed that The ADC's of protein, lipid, energy and phosphorus for the differently processed lima bean are shown in Table 2.

Proximate and mineral composition of the experimental diets is reflected in Table 3.

Phosphorus values increased in all experimental fish from the initial value of 7.88 to 9.95% (SLM), 10.13% (RLM), 10.35% (ALM) and 11.5% (BLM). All final values showed an increase from the initial crude protein content (57.25%) for experimental fish when compared with 60.78% (RLM), 61.04% (BLM), 63.15% (SLM) and 60.08% (ALM). Values for crude fibre showed slight reduction from the initial value of 1.57 to 1.43% (RLM), 1.32% (BLM), 1.23% (SLM) and 1.38% (ALM). Percentage ash content slightly increased in all experimental fish above the initial value of 1.53%, with the highest observed in BLM (2.06%).Table 4.

Raw lima beans have a crude protein content of 23.19%, which is closely followed by autoclaved bean with a value of 22.81%. Boiled lima beans gave the least value of 21.22%. The crude fibre value showed that RLM has 6.87%, followed by ALM 5.84%, TLM 5.77%, SLM 5.65% and the least occurring in BLM with a value of 4.77%. Values for ash content was least in ALM with 3.65% followed by TLM 3.74%, then SLM 4.04%, with the highest value in BLM 4.36%. Phosphorus values was reduced as TLM has a value of 0.36% next to raw with a value of 0.44%, with the least value occurring in SLM with a value of 0.28% as shown in Table 5. Calcium content for BLM was found to be 0.102%, followed by 0.098% for ALM, 0.097% for SLM, RLM was 0.096% while the least value was 0.082% recorded in TLM. Phytate content reduced from 1.040% in RLM to 0.95% for ALM to 0.93% for TLM, 0.87% for SLM, with the lowest phytate content recorded in BLM. Table 5 shows the result of proximate composition including the minerals and anti nutritional factor analysis on processed lima bean meal. The growth and nutrient utilization of *C. Gariepinus* fed differently processed lima bean based diets for 21 days is reflected in Table 6. Showing the It also reflects the growth, digestibility, *C. gariepinus* response, protein and energy parameters of the test diets studied.

Table 3: Proximate analysis of the experimental diets fed *Clarias gariepinus*

Parameters	RLM diet	BLM diet	SLM diet	ALM diet	TLM diet
Crude protein (%)	40.49	40.65	40.62	40.40	40.60
Crude Fibre (%)	0.09	0.12	0.14	0.12	0.12
Lipid (%)	16.69	18.96	17.25	11.85	16.57
Moisture (%)	8.33	8.27	9.00	7.22	9.74
Ash (%)	0.93	1.06	1.13	1.04	0.81
Nitrogen fee extract (%)	33.47	30.94	31.86	32.36	32.16
Gross energy kcal kg^{-1}	1144.40	1139.25	1012.90	1127.15	1147.66

Table 4: Proximate composition of experimental fish carcass

	Crude protein (%)	Crude fibre (%)	Lipid (%)	Ash (%)	Moisture (%)	Phosphorus	Sodium	Potassium	Calcium	Magnesium
Initial	57.25	1.57	8.67	1.53	10.25	7.88	4.37	74.35	13.34	4.22
RLM	60.78	1.43	6.10	1.70	9.55	10.13	4.70	94.25	13.78	5.61
BLM	61.04	1.32	6.45	2.06	9.50	11.50	4.67	88.67	14.38	6.47
SLM	63.15	1.23	7.20	1.56	9.35	9.59	3.45	90.67	12.78	5.80
ALM	60.08	1.38	6.85	1.54	7.95	10.35	4.25	83.76	13.65	4.81
TLM	62.80	0.15	7.30	1.24	9.25	7.57	3.37	76.27	14.17	5.20

Table 5: Result of proximate composition and anti nutritional factor analysis on processed lima bean meal

	RLM	BLM	SLM	ALM	TLM
Crude protein (%)	23.190	21.220	22.640	22.810	22.540
Crude fat (%)	3.450	2.920	3.160	3.300	3.320
Crude fibre (%)	6.870	4.770	5.650	5.840	5.770
Ash (%)	4.130	4.360	4.040	3.650	3.740
DM (%)	91.170	89.140	89.810	92.360	92.300
NDF (%)	25.660	21.610	22.600	23.890	24.180
ADF (%)	16.370	12.470	13.780	15.770	15.850
ADL (%)	4.110	2.060	3.050	3.780	3.860
P (%)	0.440	0.320	0.280	0.350	0.360
Ca (%)	0.096	0.102	0.097	0.098	0.082
Mg (%)	0.017	0.136	0.158	0.163	0.154
K (%)	1.060	1.140	1.110	1.390	1.400
Na (%)	7.600	0.020	0.010	6.100	6.050
Phytate (%)	1.040	0.730	0.870	0.950	0.930
Tannin (%)	0.090	0.044	0.065	0.077	0.084
Oxalate (%)	1.090	0.620	0.895	0.930	1.000

Table 6: Growth and nutrient utilization of *C. gariepinus* fed differently processed lima bean based diets for 21 days

Parameters	Raw (RLM)	Boiled (BLM)	Soaked (SLM)	Autoclaved (ALM)	Toasted (TLM)	Mean	SEM
Initial M W (g)	13.66±0.2	13.57±0.5	13.43±0.1	13.60±0.3	13.60±0.3	13.570	0.070
Final M W (g)	17.24±0.3^{ab}	18.21±0.2^{bc}	18.79±0.8^{c}	16.81±1.0^{a}	18.25±0.6^{bc}	17.910	0.200
MWG (g)	3.57^{ab}	4.640^{bc}	5.36^{c}	3.21^{a}	4.65^{bc}	4.286	0.200
WG (%)	20.70	25.50	28.60	19.10	25.50	23.880	
Daily WG (g)	0.17^{ab}	0.22^{bc}	0.25^{c}	0.15^{a}	0.22^{bc}	0.200	0.009
Survival (%)	96.66	93.33	93.33	93.33	95.00		
Feed consumed g fish^{-1}	9.39^{a}	9.40^{a}	9.40^{a}	9.10^{a}	9.34^{a}	9.330	0.050
Feed consumed g/fish/day	0.448	0.448	0.448	0.434	0.445	0.445	
SGR	1.10^{a}	1.39^{b}	1.59^{b}	1.00^{a}	1.40^{b}	1.290	0.050
FCR	2.63^{b}	2.03^{ab}	1.77^{a}	2.96^{c}	2.01^{ab}	2.280	0.120
PER	0.94^{a}	1.21^{b}	1.40^{b}	0.86^{a}	1.21^{b}	1.120	0.050
ADC protein	57.87^{b}	88.01^{d}	53.46^{a}	52.10^{a}	79.38^{c}	66.140	3.950
ADC energy	50.73^{b}	73.10^{c}	23.31^{a}	87.11^{e}	79.48^{d}	62.740	6.180
ADC lipid	40.56^{b}	85.59^{e}	57.23^{c}	33.51^{a}	68.54^{d}	57.080	5.030

Means of values with similar superscript are not significantly different ($p>0.05$)

DISCUSSION

The four processing methods showed slight reduction in the crude protein value compared to the raw lima bean, this trend was also observed in the crude fibre values. The values obtained are comparable to the values of 22.41, 5.58 and 5.058 means for crude protein, crude fibre and total ash, respectively reported for lima bean varieties (Ologhobo, 1980). A reduction in the crude protein value for processed beans is in agreement with Emenalom and Udedibie (2005) who reported cooking and soaking prior to cooking of mucuna bean reduced the crude protein contents of raw Nigerian and Brazilian seeds by 5.3 and 6.5%, respectively. Earlier study on jackbean also gave same trend (Udedibie *et al*., 1994). This could possibly be as a result of damage on nitrogenous compounds during cooking. Soaking of mucuna beans at various temperatures, pH and particle size levels caused a reduction in total crude protein content (Mugendi *et al*., 2010). Adeparusi (2001) also noted that raw lima bean had a higher protein, lipid and ash contents when compared with soaked, autoclaved and toasted lima bean seeds.

In this study, protein digestibility coefficients was high for toasted lima bean (79.83%) with boiled lima bean having the highest value (88.01%), indicating that they can be used as partial protein ingredient in the diet of *C. gariepinus*. This is in agreement with the range of protein digestibility values of 75 to 95% reported for freshwater fish fed selected diets (Koprucu and Ozdemir, 2005) and 85% mean value reported by Fagbenro (1996) for *C. isheriensis* fed hydrolysed feather meal. Low values were recorded for raw, soaked and autoclaved lima bean. The result for raw bean could be attributed to the presence of anti-nutritional factors. Heat treatment has been shown to improve dietary utilization in legumes (Alonso *et al*., 2000; Arndt *et al*., 1999; Drew *et al*., 2007; Newkirk, 2002). The low value recorded for soaked bean may be attributed to the structural characteristics of legumes. Mugendi *et al*. (2010) noted that the major protein fraction of legume seeds, the globulin, is fairly resistant to enzymic hydrolysis making denaturation by cooking important in protein digestion. It is important to note that protein content can equally be affected by heat treatment. Udedibie *et al*. (1994) and Emenalom and Udedibie (2005) reported a reduction in crude protein content for jack bean and mucuna bean, as a result of cooking. Thus, the low protein digestibility observed for autoclaved lima bean may be as a result of damage on the nitrogenous compound during the process.

ADC's for lipid showed same trend in the present study. Boiled bean has the highest value of 85.59% indicating that *C. gariepinus* was capable of digesting lipid very efficiently in boiled lima bean. ADC's for energy was low for raw and soaked beans. Some studies have shown low energy digestibility in plant protein sources with high carbohydrate and fibre contents (Luo *et al*., 2009). Lupatsch *et al*. (1997) reported low energy digestibility in plant ingredients with high carbohydrate content for carnivorous fish. Heat treated Lima bean had values ranging from 73.1% for boiled, 79.48 for toasted and 87.11% for autoclaved bean. These values are comparable to values of 78.7-80.5% recorded for *C. gariepinus* fed shrimp head waste meal (Nwanna, 2003). The removal of a large percentage of carbohydrate during heat cooking and the increase in the digestibility of the remaining carbohydrate may be responsible for the high digestibility of energy. Phosphorus is a very important factor in aquaculture. Its utilization in fed diets is critical in aquaculture effluent as it affects eutrophication. Phosphorus availability varies with fish species and diet composition (Schwarz, 1995; Nwanna *et al*., 2008). Percentage phosphorus was reduced with different processing methods.

There is a slight increase in the calcium content of some processed beans compared to raw beans. This trend is also observed in the magnesium content for processed beans. The phytate content recorded in the present study is less than 2.52% as also reported by Shi *et al*. (2004) that a reduction in the phytate content is as a result of processing. Domestic cooking and industrial processing generally reduce the phytate content of edible beans moderately. During processing, the degradation of phytate (IP6) to lower (IP3-IP5) is as a result of the endogenous phytase enzyme activity (Fredrikson *et al*., 2001). Similar result was obtained with boiled breadfruit (Ugwu and Oranye, 2006).

While all final values showed an increase from the initial value of crude protein content (57.25%) for experimental fish the ash percentage showed an increase.

There is no significant difference ($p>0.05$) in feed consumed by all experimental fish. Fish fed ALM had the least values for MWG and SGR, having 3.21 and 1.0, respectively and varied significantly from the MWG and SGR of fish fed BLM, SLM and TLM, but did not vary with fish fed ALM.

FCR for ALM varied significantly ($p>0.05$) from all other treatments, while there was no significant difference in RLM, BLM and TLM.

It has shown in this study that *C. Gariepinus* can effectively digest boiled and toasted lima bean meal, with both treatments having better ADC's for protein, lipid, energy and phosphorus.

REFERENCES

AIFP., 2004. Farming Nigerian water newsletter of the Aquaculture and Inland Fisheries Project of the National Special Programme for Food Security in Nigeria. FAO. Office Abuja, Nigeria, Vol. 3(4), pp: 2-4.

AOAC, 2005. Association of Official Analytical Chemists of Official Methods of Analysis. 18th Edn., AOAC, Maryland, Washington, DC., USA.

Adeparusi, E.O. and A.D. Ajayi, 2004. Hematological characteristics of Nile Tilapia (*Oreochromis niloticus*) fed differently processed lima bean (*Phaseolus lunatus* L.) diets. J. Res. Sci. Manage., 2: 73-80.

Adeparusi, E.O., 2001. Effect of processing on the nutrients and anti-nutrients of lima bean (*Phaseolus linatus* L.) flour. Nuhrung/Food, 45: 94-96.

Adeparusi, E.O. and W.A. Jimoh, 2002. Digestibility coefficients of raw and processed lima bean diet for nile Tilapia, *Oreochromis niloticus*. J. Applied Aquac., 12: 89-98.

Aletor, V.A. and O.O. Aladetimi, 1989. Compositional evaluation of some cowpea varieties and some underutilized edible legumes in Nigeria. Food/Nahrung, 33: 999-1007.

Allan, G.L., S. Parkinson, M.A. Booth, D.A.J. Stone, S.J. Rowland, J. Frances and R. Warner-Smith, 2000. Replacement of fish meal in diets for Australian silver perch, *Bidyanus bidyanus*: I. Digestibility of alternative ingredients. Aquaculture, 186: 293-310.

Alonso, R., A. Aguirre and F. Marzo, 2000. Effects of extrusion and traditional processing methods on antinutrients and *in vitro* digestibility of protein and starch in faba and kidney beans-effect of extrusion cooking on digestibility. Food Chem., 68: 159-165.

Arndt, R.E., R.W. Hardy, S.H. Sugiura and F.M. Dong, 1999. Effects of heat treatment and substitution level on palatability and nutritional value of soy defatted flour in feeds for Coho Salmon, *Oncorhynchus kisutch*. Aquaculture, 180: 129-145.

Castell, J.D. and K. Tiews, 1980. Report of the EIFAC, IUNS and ICES Working Group on Standardization of Methodology in Fish Nutrition Research: (Hamburg, Federal Republic of Germany, 21-23 March 1979). Food and Agriculture Organization of the United Nations, New York, ISBN: 9789251009185, Pages: 24.

Cho, C.Y. and S.J. Kaushik, 1990. Nutritional energetics in fish: energy and protein utilization in rainbow trout (*Salmo gairdneri*). World Rev. Nutr. Diet, 61: 132-172.

Cho, C.Y. and S.J. Slinger, 1979. Apparent Digestibility Measurement in Feedstuffs for Rainbow Trout. In: Finfish Nutrition and Fish feed Technology, Halver, J.E. and K. Tiews (Eds.). Vol. 2. Heenemann GmbH, Berlin, Germany, pp: 239-247.

De Silva, S.S. and T.A. Anderson, 1995. Fish Nutrition in Aquaculture. Chapman and Hall, London, UK., ISBN-13: 9780412550300, Pages: 319.

Dong, X.H., Y.X. Guo, J.D. Ye, W.D. Song, X.H. Huang and H. Wang, 2010. Apparent digestibility of selected feed ingredients in diets for juvenile hybrid tilapia, *Oreochromis niloticus* x *Oreochromis aureus*. Aquac. Res., 14: 1356-1364.

Drew, M.D., T.L. Borgeson and D.L. Thiessen, 2007. A review of processing of feed ingredients to enhance diet digestibility in finfish. Anim. Feed Science Technol., 138: 118-136.

Emenalom, O.O. and A.B.I. Udedibie, 2005. Evaluation of different heat processing methods on the nutritive value of *Mucuna pruriens* (Velvet Bean) seed meals for broilers. Int. J. Poult. Sci., 4: 543-548.

FAO, 2000. The State of World Fisheries and Aquaculture, 2000. Food and Agricultural Organization, Rome, ISBN: 9789251044926, Pages: 142.

Fagbemi, T.N., A.A. Oshodi and K.O. Ipinmoroti, 2005. Processing effects on some antinutritional factors and *in vitro* multienzyme Protein Digestibility (IVPD) of three tropical seeds: Breadnut (*Artocarpus altilis*), cashewnut (*Anacardium occidentale*) and fluted pumpkin (*Telfairia occidentalis*). Pak. J. Nutr., 4: 250-256.

Fagbenro, O.A., 1996. Preparation, properties and preservation of lactic acid fermented shrimp heads. Food Res. Int., 29: 595-599.

Fagbenro, O.A., E.O. Adeparusi and O.O. Fapohunda, 2003. Feedstuff and dietary substitution for farmed fish in Nigeria. Proceedings of the Fisheries Society of Nigeria/National Institute For Freshwater Fisheries Research/FAO-National Special Programme For Food Security National Workshop on Fish Feed Development and Feeding Practices in Aquaculture, September 15-19, 2003, National Institute for Freshwater Fisheries Research, New-Bussa, pp: 60-72.

Farukawa, A. and H. Tsukahara, 1966. On the acid digestion method for the determination of chromic oxide as an index substance in the study of digestibility of fish feed. Bull. Jap. Soc. Sci. Fish., 32: 502-506.

Fredrikson, M., M.L. Alminger, N.G. Carlsson and A.S. Sandberg, 2001. Phytate content and phytate degradation by endogenous phytase in pea (*Pisum sativum*). J. Sci. Food Agric., 81: 1139-1144.

Gabriel, U.U., O.A. Akinrotimi, P.E. Anyanwu, D.O. Bekibele and.N. Onunkwo, 2007. The role of Dietary Phytase in formulation of least cost and less polluting fish feed for sustainable aquaculture development in Nigeria. Afr. J. Agric. Res. 2: 279-286.

Koprucu, K. and Y. Ozdemir, 2005. Apparent digestibility of selected feed ingredients for Nile Tilapia (*Oreochromis niloticus*). Aquaculture, 250: 308-316.

Lee, S.M., 2002. Apparent digestibility coefficients of various feed ingredients for juvenile and grower rockfish (*Sebastes schlegeli*). Aquaculture, 207: 79-95.

Luo, Z., X.D. Li, S.Y. Gong and W.Q. Xi, 2009. Apparent digestibility coefficients of four feed ingredients for *Synechogobius hasta*. Aquac. Res., 40: 558-565.

Lupatsch, I., G.W. Kissil, D. Sklan and E. Pfeffer, 1997. Apparent digestibility coefficients of feed ingredients and their predictability in compound diets for gilthead seabream, *Sparus aurata* L. Aquacult. Nutr., 3: 81-89.

Maga, J.A., 1982. Phytate: Its chemistry, occurrence, food interactions, nutritional significance and methods of analysis. J. Agric. Food Chem., 30: 1-9.

Moran, Jr. E.T., J.D. Summers and E.J. Bass, 1968. Heat-processing of wheat germ meal and its effect on utilization and protein quality for the growing chick: Toasting and autoclaving. Heat Process. Wheat Germ Meal, 45: 304-318.

Mugendi, J.B., E.N.M. Njagi, E.N. Kuria, M.A. Mwasaru, J.G. Mureithi and Z. Apostolides, 2010. Effects of processing methods on the protein quality of mucuna bean (*Mucuna pruriens* L.). Afr. J. Food Agric. Nut. Dev., 10: 2394-2412.

Muir, J.F., 2003. The future for fisheries: Economic performance. Fisheries Sector Review and Future Development Study, Commissioned with the Association of the World Bank, DANIDA, USAID, FAO, DFID with the Cooperation of the Bangladesh Ministry of Fisheries and Livestock and the Department of Fisheries, Dhaka, pp: 25-2.

Newkirk, R.W., 2002. The effects of processing on the nutritional value of canola meal for broiler chickens. Ph.D. Thesis, University of Saskatchewan, Ssakatoon, SK, Canada.

Nwanna, L.C., 2003. Nutritional value and digestibility of fermented shrimp head waste meal by African catfish *Clarias gariepinus*. Pak. J. Nutr., 2: 339-345.

Nwanna, L.C., I.A. Adebayo and B. Omitoyin, 2008. Effect of different levels of phosphorus on growth and mineralization in African giant catfish *Heterobranchus bidorsalis* (Geoffrey Saint Hillarie, 1809). J. Applied Sci. Environ. Manage., 12: 25-32.

Ologhobo, A.D., 1980. Biochemical and nutritional studies of cowpea and lima bean with particular reference to some inherent antinutritional components. Ph.D. Thesis, University of Ibadan, Ibadan, Nigeria.

Schwarz, F.J., 1995. Determination of mineral requirements of fish. J. Appl. Ichthyol., 11: 164-174.

Shi, J., K. Arunasalam, D. Yeung, Y. Kakuda and G. Mittal, 2004. Phytate from edible beans: Chemistry, processing and health benefits. Food Agric. Environ., 2: 49-58.

Tibbetts, S.M., S.P. Lall and J.E. Milley, 2004. Apparent digestibility of common fed ingredients by juvenile haddock, (*Melanogrammus aeglefinus* L.). Aquauc. Res., 35: 643-651.

Udedibie, A.B., B.O. Esonu, C.N. Obasi and C.S. Durunna, 1994. Dry urea treatment as a method of improving the nutritive value of black bean (*C. ensiformis*) for broilers. Anim. Food Sci. Technol., 48: 335-345.

Ugwu, F.M. and N.A. Oranye, 2006. Effects of some processing methods on the toxic components of African breadfruit (*Treculia africana*). Afr. J. Biotechnol., 5: 2329-2333.