

TIME BASED EFFECTS OF TOASTING ON THE NUTRITIVE VALUE OF *Canavalia ensiformis* IN THE DIETS OF *Clarias gariepinus* FINGERLINGS

TIAMIYU, L. O., * OYENIYI, M. E. & AONDOAKAA, F. D.

Department of Fisheries and Aquaculture, Federal University of Agriculture, Makurdi.

*Corresponding author: me.oyeniya@gmail.com, +2348051134255

ABSTRACT

Five isonitrogenous diets of 35% crude protein were formulated using raw and jack bean seeds toasted at 135°C for 10, 20, 30, and 40 minutes. Two hundred samples of *Clarias gariepinus* with average weight of 0.78g were allotted into net harpers in groups of 20 fish per treatment in a completely randomized experimental design. The data obtained were subjected to One Way Analysis of Variance at $P < 0.05$ and using SPSS 17.0. Fish fed diet containing jack bean seed meal, toasted for 40 minutes (DT₅), showed the best results in terms of mean weight gain (2.46 ± 0.01), specific growth rate (2.49 ± 0.03), protein efficiency ratio (0.067 ± 0.001) and survival rate (100.00 ± 0.50) while fish fed diet containing raw jack bean seed meal (DT₁) had the least values in terms of growth performance and survival rate. The least food conversion ratio was recorded for fish fed DT₅ (2.46 ± 0.34^a). There was significant differences in the growth parameters and carcass proximate composition between fish fed the control diet and the other experimental diets ($P < 0.05$). The study showed that toasting jack beans for about 40 minutes has the ability to reduce its anti-nutritional factors and improve its nutritive value for inclusion in the diets of *Clarias gariepinus* fingerlings.

Keywords: Anti-nutritional, Carcass, Juvenile, Parameters, Toasting.

INTRODUCTION

According to El-Saidy and Gaber (2002); Siddhuraju and Becker (2003); Wu *et al.* (2004), aquaculture has become the fastest-growing food production sector, with Nigeria becoming the second highest terms of aquaculture employment provision (135,000 jobs) after Egypt with 580,000 jobs (FAO, 2014) and in which fish meal is a primary protein source in fish diets. However, artificial feed plays an important role in semi intensive fish farming, where it is required to maintain a high density of fish than the natural carrying capacity of water (Jhingran, 1991).

Thus, increased production of fish from aquaculture places more pressure on capture fisheries through utilisation of whole fish and fish parts for the production of fishmeal, leading to about 35% of world fishmeal production being obtained from fish residues in 2012 (FAO, 2014). This therefore places extra cost on fish production through increased costs of fish feed and feed ingredients (Gabriel *et al.*, 2007). Thus, the high cost incurred in the use of fishmeal as raw material has necessitated researches into the use of plants protein in feed formulation. Legume grains represent viable protein and energy sources in fish nutrition.

Few varieties have been identified for use in fish feed as a result their rich protein composition, mineral content and widespread distribution, but only a few is being utilised (Adeparasi, 1994). Among the factors militating against the use of these plants is the occurrence of diverse range of natural compounds capable of precipitating deleterious effects in fish. These substances, arising principally from secondary metabolism in plants, are commonly referred to as anti-nutritional factors (ANF). They reduce food intake and nutrient utilization in animals.

They may also be hepatotoxic, neurotoxic and even lethal (D'Mello, 1991). However, thermal treatment presents significant nutritional advantages to the legumes, representing an essential component of a more complex detoxification procedure. A proportion of the anti-nutritional factors present in plant proteins can be destroyed and inactivated by heat treatment process (Tacon and Jackson, 1985).

However, among the plant protein sources readily available for use in animal nutrition, only soyabeans is in commercial use in fish nutrition. Hence, this research seeks to determine the possibility of commercial use of Jack beans in feeding *Clarias gariepinus* fingerlings.

Jack bean (*Canavalia ensiformis*) is an interesting Legume plant. The jack bean is native to tropical Africa and to South and Central America but is naturalized and cultivated worldwide (USDA, 2009; Chee *et al.*, 1992). While it thrives in humid lowland tropics, it can also be found at altitudes up to 1800 m. Optimal annual rainfall is between 800-2000 mm but its deep rooting system allows it to withstand dry periods.

It is reported to be tolerant to water logging and salinity (Ecoport, 2009). The mature seed has a crude protein content as high as 34% (Ogunji *et al.*, 2003) that recommends it for use as a substitute for fish meal in fish feed. It is cheap, readily available and hardly consumed by man. It however has some anti-nutritional factors some of which can be reduced by processing (Udedibie *et al.*, 1996).

Clarias gariepinus, commonly called African mudfish is a native of African inland waters and the most farmed fish in Nigerian Aquaculture. Thus, the choice for this research work to determine the effects of period of toasting Jack beans on its nutritive values and utilization in feeding *Clarias gariepinus* fingerlings.

MATERIALS AND METHODS

The experiments were carried out at the Teaching and Research Farm and the general purpose laboratory of the Department of Fisheries and Aquaculture, University of Agriculture, Makurdi. The nutritional trials were carried out in an earth pond using 1m x 1m x 1m net happas.

Management of the Experimental Fish

Two hundred (200) fingerlings of *Clarias gariepinus* were purchased from Oracle Fish Farm in Makurdi, Nigeria and transferred to the research farm in an opened 50-litre capacity plastic container. The fish were acclimatized for 7 days in concrete tank while feeding them using commercial feed, Coppens.

Diet Formulation and Preparation

Jack beans, Soybeans and yellow maize grains were acquired from a commercial farm in Makurdi, Nigeria, well dried and without indication of pest infestation. The jack beans grains were toasted differently at 135°C (Newkirk, 2010) for 10, 20, 30 and 40 minutes respectively, using an aluminum pot on a non-smoking gas cooker. The temperature was monitored using mercury in glass thermometer while timing with a stop watch. The grains were ground into fine powder alongside with soybeans and yellow maize to form their respective meals.

Fishmeal, Vitamin and Mineral premix were bought from a reputable animal feed and drug store while dried cassava starch, vegetable oil and iodized salt were purchased from the Modern Market, Makurdi, Nigeria.

Five isonitrogenous, isolipidic and isoenergetic diets were formulated to obtain a 35% crude protein diet using Pearson Square method.

The feed ingredients (fishmeal, soybeans meal, jack beans meal, maize meal, vitamin and mineral premix, salt, vegetable oil and cassava starch) were kept constant in all the five diets DT₁, DT₂, DT₃, DT₄ and DT₅ containing raw jack beans, processed jack beans for 10, 20, 30, and 40 minutes respectively.

Warm water at 15°C was added to the properly mixed meals and continuously stirred until dough was formed. The dough was then passed through a 2mm diameter die in a pelleting machine. The pellets obtained were well dried under the sun and package in an air-tight plastic container for the nutritional trials.

Table 1 shows the ingredients composition of the various experimental diets in their individual percentages. It is indicated that the proportion of the ingredients remain constant across the experimental diets.

Experimental designs and Experimentation

Completely Randomized Design (CRD) was used for the experiment, replicating each treatment once. The experiment lasted for fifty six (56) days. The experimental fish were fed twice a day at 5% of their

body weight during 07:00 and 17:00 hours with the experimental diets.

Data on the weekly weight changes were taken using sensitive weighing balance while the water quality parameters were monitored using Hama HI 98122 multi parameter water checker. The water quality parameters determined include Dissolved Oxygen, Temperature, pH, Total Dissolved Solid (TDS) and Electrical Conductivity (EC). The growth performance and nutrient utilisation by the fish were determined in terms of the following parameters:

1. Mean Weight Gained =

$$\text{Mean Final Weight} - \text{Mean Initial Weight}$$
2. Specific Growth Rate =

$$\frac{\text{In mean Final Weight} - \text{In Mean Initial Weight} \times 100}{\text{Duration of Experiment (7 days)}}$$
3. Feed Conversion Ratio = $\frac{\text{Weight of Feed Fed}}{\text{Weight Gained}}$
4. Protein Efficiency Ratio = $\frac{\text{Weight Gained}}{\text{Protein Fed}}$

$$\text{Protein Fed} = \frac{\% \text{Crude Protein in Diet} \times \text{Weight of Feed Taken}}{100}$$
5. Feed Conversion Efficiency = $\frac{\text{Weight Gained}}{\text{Weight of Feed fed}}$
6. Apparent Net Protein Utilisation (ANPU) =

$$\frac{\text{Final Carcass Protein Content} \times 100}{\text{Protein Consumed in feed}}$$
7. Percentage Survival = $\frac{\text{Number of Surviving Fish} \times 100}{\text{Initial Number of Fish}}$

Statistical Analysis

Data collected were subjected to One Way Analysis of Variance to determine the mean differences among the various parameters between the treatments. The statistical package used was min tab 16.

RESULTS

The results obtained from the experiments are as presented below. Table 2 shows the proximate composition of the experimental diets as obtained from the feed formulation. Slight differences exist in the proximate compositions of the experimental diets. Table 3 shows the nutrient utilisation of *Clarias gariepinus* fed diets containing differently toasted jack beans meal. Diet 5 gives the highest (100%, 2.46 and 40.69) survival rate, Mean Weight Gained and Feed Conversion Efficiency respectively while the control experiment (raw jack bean meal) gave the least (60%, 1.17 and 28.31) survival rate, Mean Weight Gained and Feed Conversion Efficiency respectively.

Table 4 presents the proximate composition of the carcass of the experimental fish showing the fish fed with diet 5 having the comparatively highest proximate parameters except for Nitrogen Free Extracts.

Figure 1 shows the growth of the experimental fish. It is observed that fish fed with diet 5 were able to utilise the nutrients more accurately for growth, followed by diets 4, 3, 2 while the least utilised diet for growth was diet 1. The experimental fish generally exhibited increase growth from week 1 to week

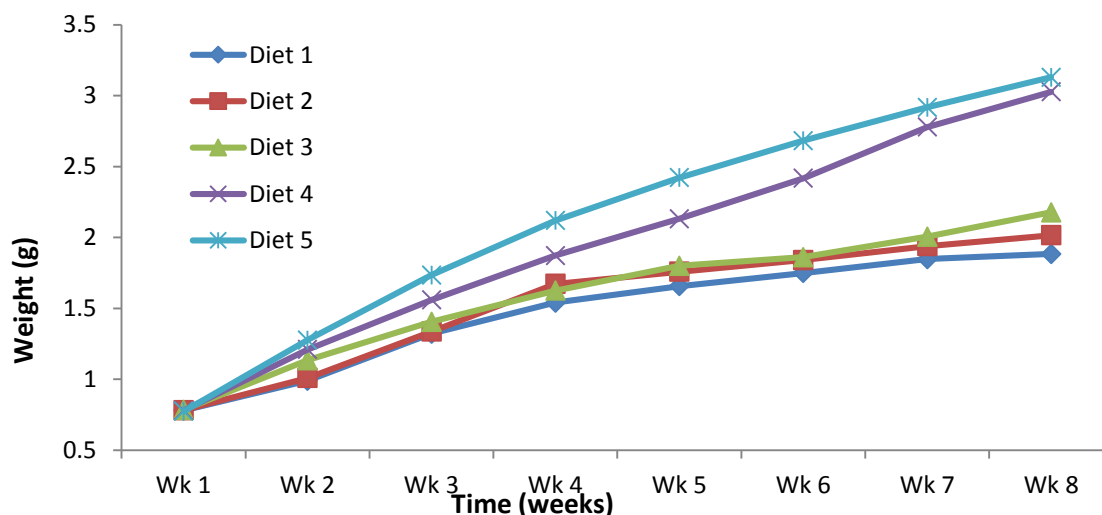


Figure 1: Weekly growth of *Clarias gariepinus* fed diets containing differently toasted jack beans seed meal

Table 5 shows some water quality parameters measured in the different weeks of the experiment. The result shows fairly constant water quality parameters throughout the experiment period.

Table 1: Gross Composition of Experimental Diets

Ingredients	DT1	DT2	DT3	DT4	DT5
Fish Meal	10.00	10.00	10.00	10.00	10.00
Soyabeans Meal	34.00	34.00	34.00	34.00	34.00
Jack beans Meal	20.00	20.00	20.00	20.00	20.00
Maize Meal	31.00	31.00	31.00	31.00	31.00
Mineral Premix	1.50	1.50	1.50	1.50	1.50
Vitamin Premix	1.50	1.50	1.50	1.50	1.50
Cassava Starch	1.00	1.00	1.00	1.00	1.00
Salt	0.50	0.50	0.50	0.50	0.50
Vegetable Oil	0.50	0.50	0.50	0.50	0.50
Total	100.00	100.00	100.00	100.00	100.00

Table 2: Proximate compositions of the experimental diets

PARAMETERS	DT ₁	DT ₂	DT ₃	DT ₄	DT ₅	P-Value
Moisture (%)	7.18±0.01 ^c	7.39±0.01 ^b	7.02±0.01 ^d	7.48±0.00 ^a	6.51±0.01 ^e	0.001
Ash (%)	8.31±0.01 ^d	8.51±0.01 ^b	8.38±0.01 ^c	8.17±0.01 ^e	9.31±0.01 ^a	0.001
Fat (%)	5.32±0.01 ^c	5.47±0.01 ^b	5.77±0.00 ^a	5.78±0.01 ^a	5.22±0.01 ^d	0.001
Crude Fibre (%)	4.67±0.01 ^d	4.72±0.01 ^c	4.92±0.01 ^b	5.09±0.01 ^a	4.12±0.00 ^e	0.001
Crude Protein (%)	35.80±0.01 ^c	36.11±0.01 ^a	36.10±0.01 ^a	36.12±0.01 ^a	35.89±0.01 ^b	0.001
NFE (%)	38.74±0.03 ^b	37.81±0.01 ^c	37.83±0.01 ^c	36.23±0.01 ^d	40.10±0.00 ^a	0.001

*means on the same row with different superscripts differ significantly (P<0.05)

**NFE: Nitrogen Free Extracts

Table 3: Growth performance and Nutrient Utilisation of *Clarias gariepinus* fingerlings fed experimental diets

PARAMETERS	DT ₁	DT ₂	DT ₃	DT ₄	DT ₅	P-Value
MWG	1.17±0.14 ^c	1.23±0.05 ^b	1.39±0.03 ^b	2.25±0.05 ^a	2.46±0.01 ^a	0.001
SGR	1.63±0.13 ^c	1.69±0.03 ^{bc}	1.82±0.03 ^b	2.42±0.02 ^a	2.49±0.03 ^a	0.001
FCR	3.56±0.34 ^a	3.51±0.03 ^a	3.22±0.09 ^a	2.54±0.03 ^a	2.46±0.34 ^a	0.01
FCE	28.31±2.67 ^b	28.51±0.27 ^b	31.11±0.87 ^b	39.44±0.12 ^a	40.69±0.68 ^a	0.002
PER	0.033±0.004 ^b	0.035±0.001 ^b	0.039±0.001 ^b	0.064±0.002 ^a	0.067±0.001 ^a	0.001
ANPU	9.30±0.04 ^a	6.19±0.07 ^d	6.81±0.13 ^c	7.56±0.01 ^b	2.44±0.04 ^e	0.001
Survival Rate (%)	60.00±5.00 ^d	87.50±2.50 ^{cd}	90.00±0.00 ^b	97.50±2.50 ^{ab}	100.00±0.50 ^a	0.018

*means on the same row with different superscripts differ significantly ($P < 0.05$)

**MWG: Mean Weight Gained

**SGR: Specific Growth Rate

**FCR: Feed Conversion Ratio

**FCE: Feed Conversion Efficiency

**PER: Protein Efficiency Ratio

**ANPU: Apparent Net Protein Utilisation

Table 4: Proximate composition of the experimental fish carcass

PARAMETERS	DT ₁	DT ₂	DT ₃	DT ₄	DT ₅	INITIAL	P-Value
Moisture (%)	56.69±0.01 ^c	56.86±0.01 ^b	56.87±0.00 ^b	56.90±0.00 ^a	56.91±0.00 ^a	55.21±0.01 ^d	0.001
Ash (%)	2.14±0.01 ^b	2.11±0.02 ^c	2.19±0.00 ^a	2.08±0.01 ^d	2.18±0.01 ^a	2.01±0.01 ^e	0.001
Fat (%)	2.56±0.01 ^d	2.68±0.01 ^c	2.68±0.00 ^c	2.96±0.00 ^b	2.98±0.01 ^a	2.12±0.00 ^e	0.001
Crude Fibre (%)	1.19±0.01 ^{bc}	1.19±0.00 ^{bc}	1.25±0.01 ^a	1.18±0.01 ^c	1.21±0.01 ^b	0.93±0.01 ^d	0.087
Crude Protein (%)	15.89±0.01 ^d	15.97±0.00 ^c	15.95±0.05 ^{cd}	16.15±0.01 ^b	16.23±0.00 ^a	14.85±0.00 ^e	0.001
NFE (%)	21.55±0.01 ^b	21.21±0.02 ^c	21.07±0.05 ^d	20.60±0.03 ^e	20.65±0.01 ^e	24.88±0.01 ^a	0.001

*means on the same row with different superscripts differ significantly ($P < 0.05$)

**NFE: Nitrogen Free Extracts

Table 5: Water Quality Parameters of the Bioassay Water of *Clarias gariepinus* fingerlings fed differently toasted jack beans seed meal

Week	pH	Temperature (°C)	Dissolve oxygen (mg/l)
Week 1	6.65±0.15 ^b	22.69±0.50 ^a	4.40±0.52 ^a
Week 2	6.05±0.15 ^c	23.43±0.63 ^a	4.25±0.60 ^a
Week 3	7.40±0.10 ^a	22.71±0.62 ^a	5.11±0.01 ^a
Week 4	6.45±0.15 ^{bc}	22.84±0.51 ^a	3.50±0.60 ^a
Week 5	6.25±0.25 ^{bc}	22.95±0.50 ^a	5.05±0.25 ^a
Week 6	7.25±0.15 ^a	23.46±0.60 ^a	3.83±0.89 ^a
Week 7	6.60±0.20 ^{bc}	23.90±0.65 ^a	4.55±0.01 ^a
Week 8	7.40±0.20 ^a	22.73±0.67 ^a	5.00±0.50 ^a

DISCUSSION

The use of plant protein sources, which is developing fast because of its less cost and availability has some attendant challenges which has to be

addressed for optimal utility. Example of such challenges is the anti-nutritional factors that are inherent in the various crop plants. The advantages of obtaining adequate level of crude protein from Jack beans also comes with the problem of having to battle with some

significant level of L-Canavanine as pointed out by Alegbeleye *et al.*, (2001) that the anti-nutritional factor is inherent in Jack beans. The effects of this phytochemical was confirmed in this experiment when the experimental fish began to exhibit lethargic behaviour, poor growth and some mortality. These symptoms of the effects of the anti-nutritional factor was in the decreasing trend from the diet 1 to diet 5. This pattern of reaction was also reported by Alegbeleye *et al.* (2001) when *Clarias gariepinus* fingerlings were fed with jack beans meal treated by soaking and autoclaving as well as Anyawu *et al.* (2011) in jack bean meal from jack bean grains that were cracked, soaked for 24 hours and boiled for 1 hour and fed to *Clarias gariepinus* fingerlings at 20% inclusion level in their diets.

The proximate analysis shows the experimental diets with crude protein level of 35.80% to 36.12% as well as minimum crude fat and crude fibre content of 5.22 and 4.12 respectively. These are in agreement with the recommendations of Lovell (1997) and Robinson (2006).

Clarias gariepinus fingerlings used in this experiment showed significant differences in the growth and nutrient utilisation parameters between the various treatments. The Specific Growth Rate (SGR), Feed Conversion Efficiency (FCE) and the Protein Efficiency Ratio (PER) were in the increasing order from diet 1 through to diet 5. This shows increasing nutrient utilisation and growth performance as Jack beans were subjected to increased heat treatment. Thus, increased heat treatment reduces the level of anti-nutritional factor inherent in jack beans.

This is good news that has also been reported by Tacon and Jackson (1985) and Michelangeli *et al.*, (1997) who proved that the canavanine content of jack beans can be appreciably reduced by 90% when toasted. The toasted jack beans gave better performance in the experimental fish than the result obtained by Olaniyi *et al.* (2013) when the highest mean weight gain by *Clarias gariepinus* fingerlings fed diet containing 12.5% *Moringa oleifera* leaf meal was 14.35g and Anyawu *et al.*, (2011) who obtained the highest mean weight gain of 3.94g by feeding *Clarias gariepinus* fingerlings with diet containing 30% of processed jack bean seed meal.

CONCLUSION

From this research work, it is concluded that jack beans seed can be used in fish feeds as a protein source when adequately toasted at about 140°C for 30 to 40 minutes. This will provide an alternative protein source in the formulation and production of feed for *Clarias gariepinus*.

REFERENCES

Adeparusi, F. D. (1994). Evaluation of nutritive potential of cooked pigeon pea (*Cajanus cajan*) meal as a plant protein source for *Clarias*

gariepinus fingerlings; *Journal of Agricultural Technology*. 2(1):48 – 57.

Alegbeleye, W. O., Oresegun, A. and Ajitomi, O. O. (2001). An assessment of Jack bean (*Canavalia ensiformis*) meal as an ingredient in the diets for *Clarias gariepinus* (Buchell, 1822) Fingerlings. *Fish Nutrition and Feed Technology*, ed. Eyo, A.A., FISON, pp. 92 –97.

Anyanwu, D. C., Ukaegbu, E. P. and Ogueri, C. (2011). Nutrient utilization and growth responses of *Clarias gariepinus* fingerlings fed dietary levels of jack bean (*Canavalia ensiformis*) meal. *New York Science Journal*, 4(4). Retrieved on April, 16, 2015. from <http://www.sciencepub.net/newyork>.

Chee, Y. K., Hacker, J. B., Ramirez, L. and Chen, C. P. (1992). *Canavalia ensiformis* (L.) DC. Record from Proseabase. Mannetje, L.'t and Jones, R.M. (Editors). PROSEA (Plant Resources of South-East Asia) Foundation, Bogor, Indonesia

D'Mello, J. P. F. (1991). Anti-nutritional substances in legume seeds; in: Toxic substances in crop plants, edited by D'Mello, J. P. F., Duffus, C. M. and Duffus, J. H.; pages 135 –172; The Royal Society of Chemistry, Cambridge. Ecoport, (2009). Ecoport database. Ecoport. <http://www.ecoport.org>

El-Saidy, D. and Gaber, M. (2002). Complete replacement of fish meal by soybean meal with dietary L-lysine supplementation for Nile tilapia *Oreochromis niloticus* (L.) fingerlings. *The Journal of World Aquaculture Society*. 33(3): 297-306.

FAO. (2014). *The State of World Fisheries and Aquaculture 2014*. Rome. 223 pp.

Gabriel U. U., Akinrotimi, O.A, Bekibele, D. O., Onunkwo, D. N. and Anyanwu, P. E. (2007). locally produced fish feed, potentials for aquaculture development in sub-Saharan African. *Journal of Agricultural Research*. Vol. 297, pp. 287-295.

Jhingran, V. G. (1991). *Fish and Fisheries of India*. 3rd Ed., Hindustan Publishing Co. Delhi, India.

Lovell R. T. (1977). Digestibility of nutrients in feedstuff of Catfish. In nutrition and feeding of channel catfish by R.R. Stickney, R.T. Lovell (eds) southern cooperative ser. Bull. 218. Auburn, Ala, Auburn University.

Michelangeli, C., Perez G. and Vargas R. E. (1997). Ileal and fecal digestibility of various dietary component in raw or toasted jack beans seed (*Canavalia ensiformis*). *Centro de Bioquimica Nutricional*. Venezuela. 2-5pp.

Newkirk, R. (2010). *Soybean: Feed Industry Guide*. 1st Edition. Canadian International Grains Institute. Canada. 9-10pp.

Ogunji J. O., Wirth M. and Osuigwe D. I. (2003). Nutrient Composition of some Tropical Legumes Capable of Substituting Fish Meal in Fish Diets. *Journal of Agriculture and*

- Rural Development in the Tropics and Subtropics*. 104 (2): 143–148.
- Olaniyi C. O., Ajani, N. O. and Adetomi, M.N. (2013). Growth Performance and Nutrient Utilization of *Clarias gariepinus* Fed *Moringa Oleifera* Leaf Meal. *Journal of Natural Sciences Research*. 3 (8): 21-29.
- Robinson, E. D. (2006). Delta Research and Extension Center; Menghe H. Li Delta Research and Extension Center, and Charles D. Hogue, Extension Associate III, Northeast District Extension Office.
- Siddhuraju P. and Becker K. (2003). Antioxidant properties of various solvent extracts of total phenolic constituents from three different agroclimatic origins of drumstick tree (*Moringa oleifera* Lam.) leaves. *Journal of Agricultural and Food Chemistry* 51: 2144-2155.
- Tacon, A. G. and Jackson, A. J. (1985). Utilisation of conventional and unconventional protein sources in practical fish feeds; in: Nutrition and Feeding in Fish, edited by Cowey, C. B., Mackie, A. M. and Bell, J. G. Academic Press, London. Pp 119–145.
- Udedibie, A. B. I., Esonu, B. O., Iwuoha, M. C. and Unachukwu, C. N. (1996). Two-staged cooking as a method for improving the nutritive value of jack bean (*Canivalia enciformis*) for broiler chicks. *Nig. Journ. Anim. Prod.* 24 (3): 56-71.
- USDA (2009). GRIN - Germplasm Resources Information Network. National Germplasm Resources Laboratory, Beltsville, Maryland. Available at: <http://www.ars-grin.gov>
- Wu G. S., Chung Y. M., Lin W. Y. and Chen H. H. (2004). Effect of substituting dehulled or fermented soy bean meal for fish meal in diets on growth of hybrid tilapia, *Oreochromis niloticus* x *O. aureus*. *Journal of Fish Society Taiwan*. Vol 30, pp 291-297.