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Digestibility of Nutrients in Cassava Leaf Protein Concentrate by *Oreochromis niloticus* (Cichlidae) and *Clarias gariepinus* (Clariidae)

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Abstract

Two separate trials were conducted to determine the digestibility of nutrients in cassava leaf protein concentrate for Nile tilapia (*Oreochromis niloticus*) and African catfish. Fresh leaves of an improved cassava variety in Nigeria (cultivar TME 419), were harvested and processed into cassava leaf protein concentrate (CLPC); and was chemically analyzed for nutrient and antinutrient compositions using standard techniques. The apparent digestibility of dry diets TD1, TD2 (300g crude protein, 80g crude lipid, 17.5 MJ gross energy/Kg), CD3 and CD4 (400g crude protein, 120g crude lipid, 18 MJ gross energy/Kg), were determined *O. niloticus*) (6.3±0.5g) and *C. gariepinus*) (8.4±0.7g), respectively. The test diets (TD2, CD4) contained CLPC as total replacement for soybean meal (SBM) in control diets (TD1, CD3) (providing 80% of total dietary protein). Fingerlings were assigned in triplicate to treatments (60 fish/treatment) in a complete randomized design (60 fish/treatment) and fed to apparent satiation twice daily for 14 days. Water temperature (26.7-27.4˚C), dissolved oxygen (5.78-6.94 mg/L) and pH (6.12-7.18) were within recommended ranges for tilapia and catfish culture. There were significant differences ($P < 0.05$) in ether extracts and gross energy digestibility between diets TD1 and TD2 while crude fibre digestibility between diets CD3 and CD4 differed significantly ($P < 0.05$). Apparent digestibility of dry matter, crude protein, and ash were similar ($P > 0.05$) in tilapia and catfish. Nutrients in CLPC were as efficiently utilized as those in SBM by *O. niloticus* and *C. gariepinus*.

Keywords: Cassava leaf protein concentrate, Protein source, Nutrients digestibility, Fish feed.

Introduction

The use of soybean products (meal, protein concentrate) in aquafeeds is increasingly unjustified in economic terms; as it is increasingly being used in human foods and for feeds by poultry and livestock (Tacon *et al*., 1998). Therefore, there is need to exploit cheaper plant protein sources to substitute soybean meal for sustainable aquaculture production, thus stimulating the use of alternative plant protein feedstuff sources that are locally and commonly available. Cassava leaves are appropriate for this purpose as they are non-competitive feedstuff that can be developed as protein source in aquafeeds.

Discarded cassava leaves as wastes, after harvesting of the tubers, have been recognized as a cheap and abundant source of dietary protein for aquaculture species when processed into leaf meal or protein concentrate (Fagbenro, 2013). Cassava leaf protein concentrate (CLPC) contains 45-50 g/kg crude protein and low antinutrients (Müller, 1977; Ravindran, 1993; Aletor, 2010). In previous studies, CLPC produced from cultivar (TME 419) was similar to SBM in nutrient composition (Oresegun *et al*., 2016). CLPC was evaluated in poultry diets (Fasuyi and Aletor, 2005) b*ut limited studies are available on its use in fish diets (Bohnenberger et al.,* 2010).

Apparent digestibility of nutrients in diets by tropical aquaculture fish species have been determined for several feedstuff which include legume seed meals in Nile tilapia, *Oreochromis niloticus* (Fagbenro, 1998a), oilseed cakes/meals in African catfish, *Clarias gariepinus* (Fagbenro, 1998b), cereal grain by-products in common carp, *Cyprinus carpio* (Fagbenro, 1999), plant- and animal-based feedstuffs in dwarf African catfish, *C. isheriensis* (Fagbenro, 1996) and African bony tongue, *Heterotis niloticus* (Fagbenro, 2001). Therefore, this study investigates the apparent digestibility of nutrients in dry practical diets containing CLPC, as plant protein source, fed to *O. niloticus* and *C. gariepinus*.

Materials and Methods

Juvenile *O. niloticus* and *C. gariepinus* were each acclimated for seven days in rectangular glass tanks (60cm x 45cm x 45cm) prior to the commencement of two separate digestibility trials. After acclimation, ten *O. niloticus* and ten *C. gariepinus* juveniles were stocked separately into four glass tanks each of 60cm x 45cm x 45cm (50 litres of water) for Nile tilapia and African catfish, using complete randomized design. Fish were fed for 14 days. at 5% body weight twice daily between 0830-0930h and 1630-1730h. Dry diets contained CLPC as replacement for solvent-extracted soybean meal (SBM) as protein source (Table 1).

Water temperature and dissolved oxygen (DO) concentration were measured daily using a combined digital YSI DO meter; pH was monitored weekly using a pH meter. Faecal matter of the fishes was collected daily, eight hours after feeding for *C. gariepinus* and six hours after feeding for *O. niloticus* for digestibility analyses, using a rubber hose as siphon. The faecal matter was oven-dried for 48 hours and frozen until used.

Apparent nutrient digestibility was determined using the Acid Insoluble Ash (AIA) method according to Atkinson *et al.* (1984) as:

$$100-100 \quad \frac{\text{(AIA in diet x nutrient in faeces)}}{\text{(AIA in faeces x nutrient in diet)}}$$

AIA in diets and faeces was obtained by adding 25 mL of 10% HCl to their weighed ash content and boiled gently over a low flame for five minutes after which it was filtered through ash-less filter paper and washed with hot distilled water. The residue from the filter was returned into the crucible and ignited until it was carbon-free and it was weighed.

Data were analyzed using students t-test and significant differences ($P < 0.05$) among means was determined using SPSS 16.0 Statistical Package.

Table 1. Ingredient and Nutrient Compositions (g/Kg) of experimental diets.

	TD1	TD2	CD3	CD4
Herring fish meal (78.2 cp)	150	150	210	210
Defatted soybean meal (48.5 cp)	480	0	540	0
Cassava leaf protein concentrate (49.1 cp)	0	480	0	540
Cassava starch	250	250	100	100
Corn oil : Fish oil (1:1)	80	80	100	100
Vitamin-Mineral premix[1]	20	20	30	30
Binder	20	20	20	20
Crude protein	325.0	326.3	423.6	424.9
Crude lipid	80.4	80.9	100.7	100.2
Crude fibre	23.8	33.4	24.8	34.4
Ash	41.9	34.5	48.3	40.9
Gross energy (kcal/Kg)	19.70	19.84	22.22	22.34

[1]Vitamin-Mineral mix (g/Kg): Manufactured by DSM Nutritional Products Limited, Basle, Switzerland - Vitamin A, 1600 IU; vitamin D, 2400 IU; vitamin E, 160 mg; vitamin K, 16 mg; thiamin, 36 mg; riboflavin, 48 mg; pyridoxine, 24 mg; niacin 288 mg; panthotenic acid, 96 mg; folic acid, 8 mg; biotin, 1.3 mg; cyanocobalamin, 48 mg; ascorbic acid, 720 mg; choline chloride, 320 mg; calcium 5.2 g; cobalt, 3.2 mg; iodine, 4.8 mg; copper, 8 mg; iron, 32 mg; manganese, 76 mg; zinc, 160 mg; Endox (antioxidant) 200 mg.

Results and Discussion

The water quality parameters measured during the study are presented in Table 2. Water temperature ranged from 26.7 to 27.4˚C, dissolved oxygen; 5.78-6.94 mg/L and the hydrogen ion concentration (pH); 6.12-7.18. The values were within the recommended ranges for tilapia and catfish culture (Haylor and Muir, 1998).

Table 2. Water Quality Parameters

Parameters	Minimum	Maximum	Mean ± SD
Temperature (°C)	26.70	27.40	27.10 ± 1.48
DO_2 (mg/L)	5.78	6.94	6.47 ± 0.72
pH	6.12	7.18	6.55 ± 1.28

Nutrient Digestibility in diets by *O. niloticus.*

The apparent digestibility coefficients of the diets by *O. niloticus* are shown in Table 3. There were significant differences (P <0.05) in the ether extracts and gross energy digestibility coefficients between both treatments. Tilapia fed TD1 had higher apparent energy (AED) and protein digestibility (APD) values (P <0.05) than tilapias fed diet TD2. Apparent protein digestibility (APD) values were similarly high in fish fed TD1 and TD2 (P >0.05) and were not significant (P <0.05). Higher lipid digestibility (ALD) values were obtained in tilapia fed diet TD1 compared with those fed TD2 (P >0.05).

Table 3. Apparent nutrient digestibility of Nile tilapia fed the test diets

	TD1	TD2
Dry matter	89.32±0.01	87.06±0.05
Crude protein	88.93±0.10	89.83±0.04
Crude lipid	82.93±0.11[a]	72.17±0.23[b]
Crude fibre	56.65±0.49	54.46±0.05
Ash	84.26±0.01	85.03±0.34
Gross energy	86.25±0.08[a]	82.20±0.01[b]

Mean values (±SD) in a row with different superscripts are significantly different (P < 0.05).

According to Smith (1971), the most important characteristic of feedstuffs is the bio-availability of nutrients, particularly digestible protein and energy. Hence reliable data on digestibility of different ingredients for each species might well be considered a necessary prerequisite. In this study, protein and energy digestibility of SBM- and CLPC-based diets were high (>80%), similarly reported by Fagbenro and Davies (2001) who fed *O. niloticus* with oil seed meals as replacement for fishmeal.

Tilapia fed diet TD1 had higher APD which was similar (P <0.05) to APD of tilapia fed TD2. Similar findings were reported by Bohnenberger *et al*. (2008) fed with CLPC-based diets and Olvera-Nova *et al.* (1990) in the APD of *O.*

mossambicus fed alfalfa leaf protein concentrates as a protein source, and Dewi-Krisna *et al.* (2014) in the APD of *O. niloticus* fed fermented *Cladophora*-based diets. Sklan *et al*. (2004) reported ranges of APD values in various ingredients of plant origin as 81.21-92.04% in *O. niloticus* (Sklan *et al.,* 2004). Therefore, it can be inferred that CLPC could replace SBM in diets of Nile tilapia since it has highly digestible crude protein content.

This study indicated that APD was not affected by CLPC substitution in the diets; and compares well with 90% reported for grass carp fed algal meal as the sole protein source (Hepher *et al.,* 1978). Similar high APD values recorded in both treatments is an indication that *O. niloticus* properly utilized the protein in both diets. The fairly high apparent dry matter digestibility coefficient indicated good diet acceptance and utilization by *O. niloticus*.

Apparent lipid digestibility of both diets were similar to those reported for common carp fed lime seed meal (Hossain and Jauncey, 1989). Other workers reported different ranges of ALD for plant derived feedstuffs: 73.4-100% in red tilapia (Lovell, 1977) and 79.6-90.2% in Nile tilapia (Kamarudin *et al*., 1989). Apparent crude fibre digestibility values *O. niloticus* were similar for both diets (P >0.05), but were higher (P <0.05) than the apparent ash digestibility values. Fagbenro (2009a, b) reported that omnivorous *O. niloticus* digest fibrous seed meals poorly than herbivorous tilapias (*T. zillii, T. guineensis*), while Mgbenka and Lovell (1987) reported that omnivorous *O. aureus* digests highly fibrous feedstuff such as alfalfa meal better than American channel catfish, *Ictalurus punctatus*.

Nutrient Digestibility in diets by *C. gariepinus*

The apparent nutrient digestibility values of the experimental diets by *C. gariepinus* are presented in Table 4. There were significant differences (P <0.05) in only crude fibre digestibility values between treatments. Catfish fed CD3 had higher AED value (P <0.05) than catfish fed diet CD4. APD values were similarly high in fish fed CD3 and CD4 diets (P >0.05). Marginal variations (P >0.05) were observed in ALD and ADMD values of catfish.

Table 4. Apparent nutrient digestibility of African catfish fed the test diets

	CD3	CD4
Dry matter	85.51±0.05	85.10±0.01
Crude protein	92.15±0.14	89.94±0.19
Crude lipid	89.99±0.01	90.08±2.94
Crude fibre	70.10±0.58[a]	57.03±0.02[b]
Ash	87.60±0.02	86.49±0.06
Gross energy	82.75±0.37	86.44±0.11

Mean values (±SD) in a row with different superscripts are significantly different (P <0.05).

The apparent digestibility of dry matter, protein, lipid, energy, ash and organic matter in this study compared fairly with report of Fagbenro *et al.* (2013), Jimoh *et al*. (2014) and Falaye *et al.* (2016) who fed raw sesame seed meal, heat-treated sesame seed meal and *Terminalia catappa* kernel meal, respectively to *C. gariepinus*. APD values for *C. gariepinus* (Table 4) were similar to 64.18-80.18% reported by Sotolu (2008). Jimoh *et al.* (2014) reported APD values of 88.06-92.10% for heat-treated sesame seed meal fed to *C. gariepinus*. The high APD values observed in this study indicated that the catfish efficiently utilized protein in both CD3 and CD4. In this study, *C. gariepinus* digested CLPC-based diet (CD4) poorly than (P <0.05) SBM-based diet (Cd3).

Stickney *et al*. (1996) also reported very high APD values (79.5-90.6%) for rainbow trout fed sunflower protein concentrate. The APD and ALD values for CD3 and CD4 diets were also similar to values from Mukhopadhyay (2001) who fed *Labeo rohita* with fermented sesame seed meal; and compare well with values of (>85%) reported by Mukhopadhyay and Ray (1999) who fed *Labeo rohita* with copra meal. Other workers reported apparent protein digestibility values in plant feedstuff as 76.2-94.0% in Rohu (Hossain *et al*., 1997); 78.9-85.8% in common carp (Hossain & Jauncey, 1989); 52.5-94.1% in *Catla catla* (Jafri and Anwar, 1995) and 81.2-92.8% in grass carp (Singh, 1992). It was inferred that CLPC could therefore substitute SBM in *C. gariepinus* diets, being high in digestible protein content.

There was a marked reduction in ash digestibility compared to crude protein and ether extracts. The values compare fairly well with the ADMD obtained for *C. gariepinus* fed heat-treated sesame seed meal (Jimoh *et al*., 2014); Adesina (2014) also reported similar result for *C. gariepinus* fed mechanically-extracted sunflower seed meal-based diet. The ALD values were similar (Table 4) which shows that African catfish has the capacity to digest lipids in CLPC as effectively as SBM. Nandeesha *et al*. (1991) reported ALD for plant derived feedstuffs as 69.6-86.4% in *Catla catla*. ALD values for diets CD3 and CD4 obtained in this study are similar to those obtained by Unprasert (1994) and Sarker *et al.* (2016).

The ALD did not vary among the treatments (Table 4), which explains that *C. gariepinus* has the capacity to digest oil that are available in both feedstuffs effectively. Similar report by Jimoh *et al*. (2014) and Mohanta *et al*. (2006) for *Labeo rohita*. Falaye *et al.* (2016) noted that ADMD values provide better estimate of the digestible materials in feeds rather than the individual nutrients. The fairly high ADMD values (Table 4) indicate good diet acceptance and utilization by catfish. The AED values were marginally higher than 64.18-70.18% reported by Sotolu (2008) but compares favourably with 86.80-88.42% for *C. gariepinus* fed tropical Almond fruit-based diets (Falaye *et al*., 2016). Sutriana (2007) also reported similar values for *C. gariepinus* fry fed cassava leaf meal-based diets.

Conclusion

Nutrients in cassava leaf protein concentrate were as highly digestible as those in solvent-extracted soybean meal by both Nile tilapia and African catfish, and represents an alternative/replacement dietary plant protein source for both species.

References

Adesina, S.A. (2014). Growth performance and nutrient utilization of *Clarias gariepinus* juveniles fed graded levels of differently processed sunflower (*Helianthuss annuus*) seed meal-based diets. Ph.D. Thesis, University of Ibadan, Ibadan. Nigeria. Pp.306.

Aletor, O. (2010). Comparative, nutritive and physico-chemical evaluation of cassava *(Manihot esculenta)* leaf protein concentrate and fish meal. *Journal of Food, Agriculture and Environment* 8 (2): 39-43.

Atkinson, L.J., J.W. Hilton, and Slinger, S.J. (1984). Evaluation of acid insoluble ash as an indicator of feed digestibility in rainbow trout (*Salmo gairdneri*). *Canadian Journal of Fisheries and Aquatic Science* 1: 1384-1386.

Bohnenberger, L., Gomes, S.D., Coelho, S.R.M. and Boscolo, W.R. (2008). Chemical composition and apparent digestibility of the cassava leaf protein concentrate (CLPC) for Nile tilapia (*Oreochromis niloticus*). Proceedings of the Brazilian Congress of Agricultural Engineering, International Livestock Environment Symposium - ILES VIII, Iguassu Falls City, Brazil.

Bohnenberger, L., Gomes, S.D., Coelho, S.R.M. and Boscolo, W.R. (2010). Concentrado proteico de folhas de mandioca na alimentação de tilápias-do-nilo na fase de reversão sexual (Cassava leaf protein concentrate in Nile tilapia diets during sex reversal phase). *Revista Brasileira de Zootecnia* 39 (6): 1169-1174.

Dewi-Krisna., A.P.W., Nursyam, H. and Hariati., A.M. (2014). Response of fermented *Cladophora* containing diet on growth performance and feed efficiency of Tilapia (*Oreochromis spp.*). *International Journal of Agronomy and Agricultural Research* 5 (6): 78-85.

Fagbenro, O.A. (1996). Apparent digestibility of crude protein and gross energy in some plant and animal-based feedstuffs by *Clarias isheriensis* (Siluriformes: Clariidae) (Sydenham 1980). *Journal of Applied Ichthyology* 12: 67-68.

Fagbenro, O.A. (1998a). Apparent digestibility of various legume seed meals in Nile tilapia diets. *Aquaculture International* 6: 83-87.

Fagbenro, O.A. (1998b). Apparent digestibility of various oilseed cakes/meals in African catfish diets. *Aquaculture International* 6: 317-322.

Fagbenro, O.A. (1999). Apparent digestibility of various cereal grain by-products in common carp diets. *Aquaculture International* 7: 277-281.

Fagbenro, O.A. (2001a). Apparent digestibility of crude protein and gross energy in some plant- and animal-based feedstuffs by *Heterotis niloticus* (Clupeiformes: Osteoglossidae) (Cuvier 1829). *Journal of Aquaculture in the Tropics* 16: 277-282.

Fagbenro, O.A. (2001b). Feedstuff digestibility in culturable freshwater fish species in Nigeria.

Proceedings of the First National Symposium on Fish Nutrition and Fish Feed Technology in Nigeria, pp. 26-37 (A.A. Eyo, editor). Fisheries Society of Nigeria and Nigerian Institute for Oceanography and Marine Research, Lagos, Nigeria.

Fagbenro, O.A. (2009a). Apparent digestibility of cucurbit seed meals in Nile tilapia diets. pp. 64. Book of Abstracts, 24th Annual Conference of Fisheries Society of Nigeria. Akure, Nigeria.

Fagbenro, O.A. (2009b). Apparent digestibility of protein and energy in fibrous seed meals by herbivorous tilapias, *Tilapia guineensis* (Dumeril) and *T. zillii* (Gervais). pp. 34. Book of Abstracts, 24th Annual Conference of Fisheries Society of Nigeria. Akure, Nigeria.

Fagbenro, O.A. (2013). Overview on the use of cassava by-products in aquafeeds. *Applied Tropical Agriculture 18 (2): 58-65.*

Fagbenro, O.A. and Davies, S.J. (2001). Use of soybean flour (dehulled, solvent-extracted soybean) as a fish meal substitute in practical diets for African catfish, *Clarias gariepinus* (Burchell 1822): Growth, feed utilization and digestibility. *Journal of Applied Ichthyology* 17 (2): 64-69.Fagbenro, O.A., Adeparusi, E.O. and Jimoh, W.A. (2013). Apparent nutrient digestibility of sunflower and sesame seed meal in *Clarias gariepinus* (Burchell, 1822) fingerlings. *Journal of Fisheries and Aquatic Sciences* 8: 43-50.

Falaye, A.E., Elezuo, K.O., Ajani E.K. and Omoike, A. (2016). Digestibility and nutrient utilization of differently processed tropical almond (*Terminalia catappa*) kernel meal and cake based diets by *Clarias gariepinus* juveniles. *Journal of Agriculture, Science and Technology* 17 (1): 42-60.

Fasuyi, A.O. and Aletor, V.A. (2005). Protein replacement value of cassava (*Manihot esculenta*, Crantz) leaf protein concentrate (CLPC) in broiler starter: Effect on performance, muscle growth, haematology and serum metabolites. International Journal of Poultry Science, 4, 339-349.Haylor, G.S. and Muir, J. (1998) A fish hatchery manual for Africa. Pisces Press, Stirling, Scotland, UK. 207pp.

Hepher, E., Sandbank, E. and Shelef, G. (1978). Alternative protein sources for warm water fish diets. FAO, Rome (Italy).

Hossain, M.A. and Jauncey, K. (1989) Studies on the protein, energy and amino acid digestibility of fish meal, mustard oil cake, linseed and sesame meal for common carp (*Cyprinus carpio* L). *Aquaculture* 83: 59-72.

Hossain, M.A., Nahar, N. and Kamal, M., (1997). Nutrient digestibility coefficients of some plant and animal proteins for Rohu (*Labeo rohita*). *Aquaculture* 151: 37-45.

Jafri, A.K. and Anwar, M.F. (1995) Protein digestibility of some low-cost feedstuffs in fingerling Indian major carps. *Asian Fisheries Science* 8: 47-53.

Jimoh, W.A., Oladele-Bukola, M.O., Adebayo, M.D., Yusuff, A.A., Azeez, F.A. and Salami, O.O. (2014). Microbial flora of the gastro-intestinal tract of *Clarias gariepinus* caught from river Danduru, Nigeria. *Sokoto Journal of Veterinary Sciences* 12 (2): 19-24.

Kamarudin, M.S., Kalipan, K.M. and Siraj, S.S. (1989). The digestibility of several feedstuffs in Red Tilapia. Fish Nutrition Research in Asia. Proceedings of the 3rd Asian Fish Nutrition Network Meeting, Bangkok, 6-10 June 1988, pp.118-122.

Lovell, R.T. (1977). Digestibility of nutrients in feedstuffs of catfish. In: Stickney, R.R. and Lovell, R.T., editors, *Nutrition and feeding of Channel Catfish*, Auburn University, Auburn, pp. 33-37

Mgbenka, B.A. and Lovell, R.T. (1987). Digestibility of feedstuff and supplementary diets by grass carp. *Nigerian Journal of Applied Fisheries and Hydrobiology* 2: 65-71.

Mohanta, K.N., Mohanty, S.N., Jena, J.K. and Sahu, N.P. (2006). Apparent protein, lipid and energy digestibility coefficients of some commonly used feed ingredients in formulated pelleted diets for silver barb (*Puntius gonionotus*). *Aquaculture Nutrition* 12: 211-218.

Mukhopadhyay, N. (2001). Effect of fermentation in apparent and total nutrient digestibility of sesame (*Sesamum indicum*) seed meal in Rohu, *Labeo rohita* (Hamilton) fingerlings. *Acta Ichthyologia Piscatura* 31: 19-28.

Mukhopadhyay, N. and Ray, A.K. (1999). Utilization of copra meal in the formulation of compound diets for Rohu, *Labeo rohita*, Fingerlings. *Journal of Applied Ichthyology* 15: 127-131.

Müller, Z. (1977). Improving the quality of cassava root and leaf product technology. Pages 120-126 in Cassava as animal feed. Proceedings, Cassava as Animal Feed Workshop, (B. Nestel and M. Graham, editors). University of Guelph, Canada. IDRC-095e: Ottawa.

Olvera-Novoa, M.A., Silvia, C.G., Mirna, S.G. and

Palacios, C.A. (1990). The use of alfalfa leaf protein concentrates as a protein source in diets for tilapia (*Oreochromis mossambicus*). *Aquaculture* 9: 291-302.

Oresegun, A., Fagbenro, O.A., Ilona, P. and Edah B. (2016). Nutritional and anti-nutritional composition of cassava leaf protein concentrates from six cassava varieties for use in aqua feed. Cogent Food and Agriculture 2: 1147323. http://dx.doi.org/10.1080/23311932.2016 1147323.

Ravindran, V. (1993). Cassava leaves as animal feed; potential and limitations. *Journal of Food Science and Agriculture* 61: 141-150.

Sarker, P.K., Gamble., M.M., Kelson, S. and Kapusinski., A.R (2016). Nile tilapia (*Oreochromis niloticus*) show high digestibility of lipid and fatty acids from marine *Schizochytrium spp.* and of protein and essential amino acids from fresh water *Spirulina spp.* feed ingredients. *Aquaculture Nutrition* 22: 109-119.

Singh, B.N. (1992). Digestibility of protein and energy from feedstuffs and pelleted diets in Mrigal*, Cirrhinus mrigala* (Ham.) and Grass carp, *Ctenopharyngodon idella* (Val.). In: Wang, J.K. and Dehadrai, P.V., editors, *Aquaculture Research Needs for 2000 AD*, Oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, 135-142.

Sklan, D., Prag, T., Lupatsch, I. (2004). Apparent digestibility coefficients of feed ingredients and their prediction in diets for tilapia *Oreochromis niloticus x Oreochromis aureus* (Teleostei, Cichlidae). *Aquaculture Research* 35 (4): 358-364.

Smith, R.R. (1971). A method for measuring digestibility and metabolizable energy of fish feeds. *The Progressive Fish Culturist* 33 (3): 132-134.

Sotolu, A.O. and Faturoti, E.O. (2008). Digestibility and nutritional values of differently processed Leucaena leucocephala (Lam. De wit) seed meals in diets of African catfish *(Clarias gariepinus). Middle-East Journal of Scientific Research* 3 (4): 190-199.

Stickney, R.R. (1986). Tilapia tolerance of saline waters: a review, 48 (3): 161-167.

Sutriana., A. (2007). The use of cassava leaves as a dietary component for African catfish fry. *Journal Ked. Hewan* 1(2): 59-65.

Tacon, A.G.J., Dominy, W.G. and Pruder, G.J. (1998). Global trends and challenges in aquafeeds for marine shrimp. *Aquafeed International* 4: 25-35.

Unprasert, N.G. (1994). An evaluation of the use of "Ideal" Protein Concept to estimate essential amino acid requirements of the *Clarias* hybrid (*Clarias macrocephalus x Clarias gariepinus*). Ph.D. Dissertation, Mississippi State University, Starkville.