Turkish Journal of Fisheries and Aquatic Sciences 8: 159-164 (2008)

Nutritional Values of Some Non-Conventional Animal Protein Feedstuffs Used as Fishmeal Supplement in Aquaculture Practices in Nigeria

A.O. Sogbesan[1,]*, A.A.A. Ugwumba[2]

[1] Federal University of Technology, Department of Fisheries, Yola, Adamawa state, Nigeria.

[2] University of Ibadan, Department of Zoology, Ibadan, Nigeria.

* Corresponding Author: Tel.:+234.805 0957768

E-mail: sokay_2003@yahoo.com

Received 12 September 2007

Accepted 17 March 2008

Abstract

Four animal protein sources were cultured, processed and analysed for their basic nutrient values in comparison with the conventional clupeids fishmeal.

The result of study showed that the clupeid fishmeal had the highest crude protein, 71.64% and unskinned-dried tadpole meal, 43.50% had the lowest value. There was a significant difference ($P<0.05$) between the crude protein composition of these animal protein sources. Termite had the highest crude lipid, 30.50% and garden snail the lowest value, 7.85%. Termite meal recorded the highest gross energy, 2,457.61 kJ/100 g while the lowest 1,639.63 kJ/100 g was from unskinned-dried tadpole meal. The highest sodium and potassium, 2.32 g/100 g and 2.23 g/100 g respectively were from garden snail meal while termite meal had the lowest sodium, 0.20 g/100 g and unskinned-dried and skinned tadpole meal had the lowest potassium, 0.21 g/100 g. There were significant differences ($P<0.05$) between the highest and lowest minerals for the animals studied. The highest total essential amino acids, 51.33 g/16 N g were from fishmeal and the lowest 19.84 g/16 N g from termite meal.

Based on the results from this study, any of the understudied animal proteins have the tendency to supplement fishmeal in fish feed since they all have competitive nutrient values.

Key words: non-conventional animal, proteins, essential amino acids indices, proximate, fishmeal.

Introduction

Essential or indispensable amino acids (EAAs) cannot be synthesised by fish and often remain inadequate but are needed for growth and tissue development (Fagbenro *et al*., 2000; Wilson, 1989). Fishmeal is known to contain complete EAA profile that is needed to meet the protein requirement of most fish species. Since fishmeal is expensive as a feed ingredient, the use of non-conventional feedstuffs has been reported with good growth and better cost-benefit values.

The utilization of non-conventional feedstuffs of plant origin had been limited as a result of the presence of alkaloids, glycosides, oxalic acids, phytates, protease inhibitors, haematoglutinin, saponegin, momosine, cyanoglycosides, linamarin to mention a few despite their nutrient values and low cost implications (New, 1987; Sogbesan *et al*., 2006). These anti-nutritional factors negate growth and other physiological activities at higher inclusion levels (Oresegun and Alegbeleye, 2001).

Non-conventional feed resources (NCFRs) are feeds that are not usually common in the markets and are not the traditional ingredients used for commercial fish feed production (Devendra, 1988; Madu *et al.*, 2003). NCFRs are credited for being non competitive in terms of human consumption, very cheap to purchase, by-products or waste products from agriculture, farm made feeds and processing industries and are able to serve as a form of waste management in enhancing good sanitation.

These include all types of feedstuffs from animal (silkworm, maggot, termite, grub, earthworm, snail, tadpoles etc.), plant wastes (jack bean, cottonseed meal, soybean meal, cajanus, chaya, duckweed, maize bran, rice bran, palm kernel cake, groundnut cake, brewers waste etc.) and wastes from animal sources and processing of food for human consumption such as animal dung, offal, visceral, feathers, fish silage, bone, blood) (Devendra, 1988; Oyelese *et al*., 1999; Fasakin *et al*., 2000; Omitoyin and Faturoti, 2000). All these can be recycled to improve their value if there are economically justifiable and technological means for converting them into useable products.

The nutrient quality of feed ingredient is one of the major prerequisite apart from availability (which sometimes is a function of cost and season) for production of good quality feeds. The basic nutrient that cannot be compromised in the choice of ingredients for feed formulation and preparation is protein (Zeitler *et al.*, 1984). Hence it becomes imperative to research into the nutrient composition of some of the easily culturable animal protein sources.

The aim of this experiment is to analyse chemical composition of earthworm, garden snail, termite and tadpole meals so as to provide information which will help in incorporating any of these non-conventional animals into fish feed ingredients during the feed formulation by fish nutritionist and fish farmers who may want to use them as on-feed ingredients.

Materials and Methods

The culture of the non-conventional animals took place in the hatchery premises of National Institute for Freshwater Fisheries Research (NIFFR), New-Bussa, Niger-State from May to August, 2005. Earthworm, *Hyperiodrilus euryaulos* was cultured according to the method of Sogbesan and Ugwumba (2006). Garden snail, *Limicolaria aurora* was cultured according to Sogbesan *et al* (2007) Termite, *Macrotermes subhyalinus* meal were collected during nuptial flight as reported by Sogbesan (2006) and tadpole, *Bufo maculata* were cultured in outdoor concrete tanks using the method reported in Sogbesan and Ugwumba (2007).

Processing of the Non-Conventional Animal Feed Ingredients

Earthworm Meal: At the end of the culture period, the harvested worms were thoroughly rinsed in water and kept in a bowl for 30 minutes to evacuate the residual undigested contents in their guts (Akpodiete and Okagbare, 1999). The worms were then weighed, blanched in hot water, re-weighed and oven-dried at 80°C for 3 hours. After drying, the worms were weighed, then milled with Hammer milling machine into powdered form, packed as dried earthworm meal in an airtight plastic bowl and stored in a refrigerator till used.

Snail Meat Meal: The snails harvested were boiled for 30 minutes for easy removal of the foot and viscera from the shell. The shells were removed manually using knife. The snail meat was weighed and steamed for 10 minutes. They were oven dried at 80°C for 9 hours then weighed and milled into powdered form. The snail meal was packed in an airtight plastic bowl and stored in a refrigerator till used.

Termite Meal: Reproductive termites were collected during swarm activity from a termitarium outside the Hatchery Complex of NIFFR. They were weighed and then oven-dried at 80°C for 3 hours. The wings were blown off. The dried termites were weighed, milled, packed in plastic bowl and stored in a refrigerator till used.

Tadpole Meal: The harvested tadpoles were weighed and divided into three equal halves. First halve was oven dried at 80°C for 6 hours while the second was boiled before oven dried and the third halve was skinned before oven dried. They were separately weighed, milled into powdered form, packed in three airtight plastic bowls and coded as dry-unskinned, boiled-dry unskinned and skinned tadpole meals then stored in a refrigerator till used.

Proximate Composition and Mineral Salts Analysis of the Non-Conventional Animal Samples

The proximate composition, mineral salts and amino acids profile of the processed animal meals were carried out at NIFFR Chemical Laboratory and National Institute for Veterinary Research, Vom, Plateau State. The earthworm, garden snail meat, termites, tadpole and fish (clupeid) meals were analysed for moisture content, dry matter content, crude protein, crude lipid, nitrogen free extracts, crude fibre, ash, mineral salts, gross energy, digestible energy, and metabolizable energy according to Association of Official Analytical Chemist Methods (A.O.A.C. 2000). A mean of three samples for each nutrient was recorded.

Essential Amino Acid Indices

The essential amino acids indices were calculated according to Abdullahi (2001) and Wilson (2002), using whole hen egg crude protein and essential amino acids composition documented in FAO/WHO (1973) and Cudderfold (1983). The essential amino acids indices determined were:

(a) Chemical score (%) = [Essential amino acid of the sample / Essential amino acid of the whole hen egg] x 100

(b) Chemical score to protein score ratio (CSPS) (%) = [Total essential amino acid of the sample / Total essential amino acid of whole hen egg] x 100

(c) Total essential amino acid to crude protein content ratio (EAA: CP) (%). = [Total essential amino acid / (Crude protein of the animal meal /100 g of diet)] x 100

Statistical Analysis

All data collected were subjected to analysis of variance (ANOVA). Comparisons among treatment means were carried out by one-way analysis of variance followed by Tukey's multiple tests and Dunnet test. Standard deviation and standard error were calculated to identify the range of means and error respectively. Least significance differences (LSD) were used to determine the level of significance among treatments.

Results

Proximate Compositions of the Cultured Animal Meals and Fishmeal

Table 1 shows the proximate, gross energy and mineral composition of the cultured animal and fishmeal. Fishmeal had the highest crude protein followed by garden snail meat meal while unskinned-dry tadpole meal had the lowest and these were significantly different (P<0.05). Termite had the highest crude lipid and garden snail the lowest value. Termite meal recorded the highest gross energy followed by fishmeal while the lowest was from tadpole meal. The highest sodium and potassium were from garden snail meal while termite meal had the lowest sodium and unskinned-dried and skinned tadpole meal the lowest potassium. There were significant differences (P<0.05) between the highest and the lowest minerals for the animals studied.

The essential amino acids of the tested animal meals and fishmeal are shown in Table 2. Profile of all the tested animals had ten essential amino acids analysed. Garden snail meal recorded the highest arginine value while the lowest was from earthworm meal. The least isoleucine value was in termite meal while the highest value was in garden snail meal. Leucine and lysine were the highest in fishmeal while the lowest values were from termite meal. The lowest methionine was obtained in garden snail meat meal while the highest was obtained in earthworm meal. Fishmeal had recorded significantly higher (P<0.05)

Table 1. Proximate, mineral composition (% dry matter) and energy content (kJ/100g) of the cultured animal protein sources and fishmeal

	Animal Proteins						
	Earthworm meal	Garden snail meal	Termite meal	Unskinned-dried tadpole meal	Unskinned-boiled tadpole meal	Skinned tadpole meal	Fishmeal (clupeid)
Crude protein (%)	63.0±4.5^{b}	66.8±3.6^{b}	46.3±3.2^{c}	43.5±3.4^{c}	45.9±2.5^{c}	47.8±4.1^{c}	71.5±4.6^{a}
Crude lipid (%)	5.9±1.1^{d}	7.9±2.3^{c}	30.1±5.1^{a}	11.3±2.4^{b}	10.7±2.5^{b}	11.6±1.8^{b}	8.0±1.4^{c}
Crude fibre (%)	1.9±0.2^{d}	4.1±0.9^{d}	7.3±1.2^{a}	3.8±2.1^{b}	3.8±1.8^{b}	3.0±1.9^{bc}	1.2±0.8^{d}
Ash (%)	8.9±2.1^{c}	6.5±0.5^{d}	3.6±0.6^{e}	26.5±4.3^{a}	26.1±2.3^{a}	27.7±3.1^{a}	7.3±1.2^{b}
Nitrogen free extract (%)	11.8^{b}	5.8^{d}	19.0^{a}	8.2^{c}	7.6^{c}	3.4^{e}	3.2^{e}
Moisture (%)	8.6^{a}	9.0^{a}	3.7^{c}	6.8^{b}	6.6^{b}	6.5^{b}	8.9^{a}
Gross energy(kJ/100g)	1943.0±1.15^{c}	2006.0±3.46^{c}	2458.0±60.1^{a}	1640.0±17.32^{d}	1640.0±23.1^{d}	1661.0±^{d}	2075.0^{b}
Calculated E:P	32.0^{c}	29.97^{c}	53.06^{a}	37.69^{b}	36.15^{b}	34.73^{bc}	29.03^{c}
Metabolizable energy (kJ/100g)	1476.00^{b}	1504.95^{b}	1843.21^{a}	1229.72^{c}	1280.40^{c}	1289.45^{c}	1556.05^{b}
Digestible energy (kJ/100g)	1638.20^{c}	1732.10^{c}	2134.90^{a}	1373.40^{d}	1387.78^{d}	1433.59^{d}	1812.70^{a}
Sodium (g/100g)	0.43±0.02^{d}	2.32±0.06^{a}	0.20±0.06^{e}	0.61±0.006^{c}	0.59±0.05^{c}	0.63±0.02^{c}	0.91±0.006^{b}
Calcium (g/100g)	0.53±0.05^{d}	1.13±0.08^{c}	0.23±0.04^{e}	2.51±0.02^{b}	2.43±0.03^{b}	2.59±0.02^{b}	3.53±0.15^{a}
Potassium (g/100g)	0.62±0.02^{c}	2.23±0.06^{b}	0.38±0.06^{d}	0.21±0.003^{d}	0.79±0.05^{c}	0.21±0.01^{d}	0.96±0.006^{b}
Phosphorus (g/100g)	0.94±0.03^{b}	0.15±0.02^{e}	0.38±0.08^{d}	0.57±0.001^{c}	0.42±0.06^{cd}	0.50±0.02^{c}	2.4±0.006^{a}
Magnesium (g/100g)	------------	0.28±0.04^{b}	0.15±0.02^{b}	0.58±0.005^{a}	0.56±0.06^{a}	0.61±0.05^{a}	0.08±0.002^{c}

Values on the same row with the different superscripts are significantly different (P<0.05).
Mean±SE

Table 2. Essential amino acids composition (g/16gN) of the tested animal protein sources

	Animal Protein Sources						
	Earthworm meal	Garden snail meal	Termite meal	Unskinned-dried tadpole meal	Unskinned-boiled tadpole meal	Skinned tadpole meal	Fishmeal (clupeids)
Arginine	2.83±0.12^{d}	11.99±0.11^{a}	2.87±0.12^{c}	3.63±0.02^{c}	3.79±0.09^{c}	4.01±0.06^{c}	5.34±0.17^{b}
Histidine	1.47±0.23^{d}	1.77±0.12^{c}	1.28±0.12^{e}	2.65±0.03^{b}	2.31±0.006^{b}	2.96±0.05^{b}	4.19±0.06^{a}
Isoleucine	2.04±0.012^{d}	6.23±0.32^{a}	1.70±0.02^{e}	2.32±0.04^{c}	2.30±0.005^{c}	2.74±0.05^{b}	2.62±0.07^{b}
Leucine	4.11±0.11^{c}	6.79±0.12^{b}	3.11±0.013^{d}	3.26±0.04^{d}	3.72±0.08^{cd}	3.38±0.05^{d}	8.31±0.09^{a}
Lysine	6.35±0.23^{b}	5.10±0.20^{c}	2.82±0.06^{d}	6.97±0.26^{b}	6.72±0.32^{b}	7.05±0.05^{b}	10.96±0.09^{a}
Methionine	5.30±0.05^{a}	1.33±0.06^{d}	1.68±0.02^{d}	2.08±0.01^{c}	1.74±0.08^{d}	3.14±0.009^{b}	2.26±0.05^{c}
Phenylalanine	6.26±0.06^{a}	5.04±0.005^{ab}	1.97±0.013^{d}	3.98±0.09^{c}	4.36±0.081^{b}	3.96±0.03^{c}	5.52±0.05^{a}
Threonine	4.43±0.2^{ab}	5.91±0.2^{a}	1.67±0.9^{d}	3.73±0.5^{c}	3.41±0.2^{c}	3.64±0.2^{c}	5.28±0.6^{a}
Valine	4.43±0.6^{b}	5.90±0.8^{a}	2.26±0.06^{d}	3.86±0.03^{c}	3.89±0.1^{c}	3.43±0.5^{c}	5.88±0.05^{a}
Total Essential amino acids	37.11±2.31^{b}	50.06±2.89^{a}	19.36±0.58^{c}	32.48±1.15^{b}	32.24±1.18^{b}	34.69±2.31^{b}	50.36±2.31^{a}
Crude Protein %	63.04±4.5^{b}	66.96±3.6^{b}	46.32±3.2^{c}	43.50±3.4^{c}	45.38±2.5^{c}	47.81±4.1^{c}	71.64±4.6^{a}

Values on the same row with the different superscripts are significantly different (P<0.05).
Mean±SE

total essential amino acids than all the other animal meals except garden snail meal.

The overall highest chemical score was from arginine for garden snail meat meal followed by histidine from fishmeal as illustrated in Figure 1. The least chemical scores were from termite meal for all essential amino acids except arginine in earthworm meal and methiohine in garden snail meat meal. The highest chemical score for the ten essential amino acids was recorded for fish meal while the least was recorded for termite meal (Table 3).

Discussion

One of the benefits of earthworm cultured is the production of a valuable protein source (Lieberman, 2002). The crude protein of earthworm reported in this study (Table 1) for *H. euryaulos* is lower than 69.8% for *P. excavatus* (Guerrero, 1983) and 67.68% for *E. foetida* (Reinecke and Alberts, 1987) but higher than 56.4% and 61.8% for *E. foetida* reported by Tacon (1994) and Medina *et al*. (2003), respectively. The lipid content of *H. euryaulos* analysed from this study is similar to 5.8% by Guerrero (1983) for *P. excavatus* and higher than 5.15% by Reinecke and Alberts (1987) but lower than 7.8% by Tacon (1994) and 9.88% by Dynes (2003) for *E. foetida*. The quantity of sodium, calcium and potassium reported from this study for earthworm meal is within the required level for catfish and all tropical fish (NRC, 1993). The 0.62 g/100 g of phosphorus reported in *H. euryaulos* is lower than the recommended phosphorus, 0.8 g/100 g for natural diets but higher than 0.42 g/100 g for chemically refined diets. Since earthworm meal is a natural diet, feeding it as whole ingredient to catfish may result into poor growth, feed efficiency and bone mineralization (NRC, 1993).

The crude protein for garden snail meat meal from this study is higher than crude protein of 62% for golden snail and 60-70% for African giant snails

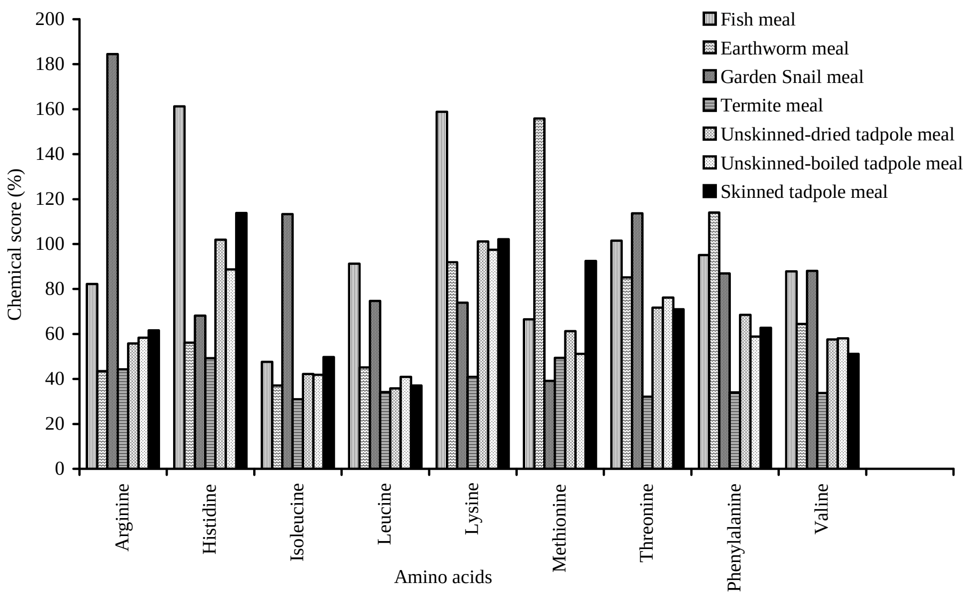

Figure 1. Chemical score value of the essential amino acids of the of the animal protein meals.

Table 3. Essential amino acids indices of the tested animal protein sources

	Animal protein sources		
	Chemical score (%)	Cs/Ps (%)	EAA:CP
Earthworm meal	71.5±0.58[b]	54.5±0.58[b]	0.60±0.05[b]
Garden sail meat meal	95.9±0.52[a]	68.9±0.50[a]	0.76±0.08[a]
Termite meal	37.5±0.58[d]	38.9±0.60[c]	0.43±0.06[c]
Unskinned-dried tadpole meal	62.6±0.35[c]	69.1±0.30[a]	0.76±0.03[a]
Unskinned-boiled tadpole meal	62.1±0.06[c]	65.7±0.09[a]	0.72±0.008[a]
Skinned tadpole meal	66.3±0.17[c]	66.6±0.24[a]	0.73±0.02[a]
Fishmeal (clupeids)	96.7±0.4[a]	64.9±0.36[a]	0.72±0.02[a]

Values on the same column with the different superscripts are significantly difference ($p<0.05$).
Mean±SE
Keys: Cs/Ps = ratio of the chemical score to crude protein.
EAA: CP: ratio of the essential amino acid to crude protein.

as reported by Seira (1998) and Odaibo (1997) respectively. The lipid content presented in this study is lower than 8.3% reported by Seira (1998). High level of sodium reported from this ingredient could have been positively influenced by the table salt used during processing of the meal. Higher level of sodium has been reported to adversely affect growth and feed efficiency (Shiau and Hseih, 2001).

The crude protein of termite meal in this work is higher than 37% reported by Aduku (1993) for *Macrotermes* spp and corroborate to 48.80% reported by Fadiyimu *et al*. (2003) also for *Macrotermes* spp. and 44.12% reported by Oyarzum *et al*. (1996) for *Nasutitermes* spp. The lipid content analysis of this animal is aligned with the work of Oyarzum *et al*. (1996) and Aduku (1993) that termites have high lipid content. Feeding catfish with this type of high lipid diet exposes them to a risk of fat deposition in the organs (Tacon, 1987) though dietary lipids that have been reported to be well digested by fish and serve as better energy source for protein sparing than carbohydrate (Okoye *et al*., 2001). Termite meal is poor in mineral composition. This result is in accordance with the report of Barker *et al*. (1998) that insects are low in major mineral compositions, especially calcium and phosphorus.

The crude protein and lipid composition of the unskinned-dried tadpole in this present study is similar to 43.50% crude protein and 11.30% crude lipid of dry weight reported by Ayinla *et al*. (1994) (for *Bufo* sp.). This simply implies that there may not be variation in tadpoles of bufonidae family. The sodium, 0.61 g/100 g, calcium, 2.51 g/100 g, and magnesium, 0.58 g/100 g were within the required amount for catfish (NRC, 1993). The low phosphorus, 0.57 g/100 g may need to be supplemented with other higher sources if needed by *H. longifilis* because this fish along with other catfish has been reported to utilize 60% of phosphorus in its diet since it has enough gastric juices to digest this mineral (Lovell, 1978).

The fact that the crude protein content of the earthworm meal and garden snail meal were close to that of fishmeal and those of termite and that they tadpole still fall within range of the protein required by the culturable tropical fish (Eyo and Olatunde, 2001) indicated that feeding any of these fish with any of these animal protein supplements will not pose the problem of malnutrition to the fish. Eyo (2003) reported that the value of animal products used in aquaculture diets will be high if the protein content is high and ash is low and results of the proximate compositions of the animals' protein in this study corroborate this. Allan *et al* (2000) reported that aquaculture diet is expected to contain higher protein-to-energy ratios than diets for pig and poultry. Since protein content is usually between 35-50% for aquaculture diets compared with 15-22% for poultry and pig diet.

The result of the essential amino acids indicated that these animal supplements could substitute fishmeal in fish feed (Table 2) since they all contain the required essential amino acids needed by fish for protein metabolism (DeSilva and Anderson, 1995). This result showed that earthworm meal is richer in methionine (Figure 1) than other animal protein sources studied which agreed with the observation of Finke (2003) when he compared the nutrient values in some invertebrates. Methionine has been credited as growth promoting essential amino acid, which is highly needed by cultured fish and limited in most plant and many animal supplements (Wilson, 2002).

The nutritive value of protein depends on its capacity to produce nitrogen and amino acids in adequate amounts to meet the requirements of culture fish (Wilson, 1989; Eyo and Olatunde, 2001). The lowest total essential amino acids and highest crude fibre from termite meal could have resulted from the fact that high proportions of fibre has been associated with reduction in total essential amino acid since it is a non-protein nutrient and has nothing to do with sparing of protein like lipids and nitrogen-free extract (Van der Meer and Verdegem, 1996).

The essential amino acid, protein and lipid value of the animal supplements from this study could satisfy the requirement of catfish at all ages for both somatic and reproductive development. These nutrients were comparable to the quality and quantity of what are obtained in the conventional fishmeal used in this study (Table 2) and similar reports were generated by Van der Meer *et al*. (1995), Dynes (2003) and Okoye (2003).

References

Aduku, A.O. 1993. Tropical feedstuff analysis table. Department of Animal science, Faculty of Agriculture, Ahmadu Bello University, Zaria, Nigeria.

Allan, G.L., Rowland, S.J., Misford, C., Glendenning, D., Stone, D.A.J. and Ford, A. 2000. Replacement of fishmeal in the diets of Australian silver perch, *Bidyanus bidyanus*. V. Least-cost formulation of Practical diets. Aquaculture, 186: 327-340.

Akpodiete, O.J. and Okagbere, G.N. 1999. Feed accessories from animal production. In: S.I. Omeje (Ed.), A compendium of ideas, fact and methods in the science and technology of Animal Agriculture Ran Kennedy. Animal Sciences, 71-82.

Association of Official Analytical Chemists. 2000. Official methods of chemical Analysis. 17th Edition. , Washington, D.C., U.S.A.

Ayinla, O.A, Kayode. O. Idonibuoye-obu, T.I.E., Oresegun, A. and Adindu, V.E. 1994. Use of Tadpole meal as substitute for fishmeal in the diet of *Heterobranchus bidorsalis* (Geofrey st, Hillaire, 1809). Journal of Aquaculture in the Tropics, 9: 25-33.

Barker, D., Fitzpatrick, M.P. and Dicrenfeld, E.S. 1998. Nutrient composition of selected whole invertebrates. Zoo. Biology, 17(2): 123-134.

De Silva, S. S. and Anderson, T.A. 1995. Fish Nutrition in Aquaculture. Chapmann and Hall Aquaculture Series, Tokyo. 319 pp.

Devendra, C. 1988. General approaches to Animal Nutrition research and their relevance to fish production in the Asian region. In: S.S. DeSilva (Ed.), Finfish Nutrition

Research in Asia. Heinemannn Asia Singapore, Singapore: 7-24.

Dynes, R.A. 2003. Earthworms – Technology information to enable the development of earthworm production. Publication No.03/085, 23 September, RIRDC, 1-33.

Fadiyimu, A.A., Ayodele, A.O., Olowu, P.A. and Folorunso, O.R. 2003. Performance of finishing broilers fed graded levels of termites meal as replacement for fish meal. Proceeding of the 28th Annual Conference of Nigerian society for Animal Production, 28: 211 -212.

Fasakin, E.A., Falayi, B.A. and Eyo, A.A. 2000. Inclusion of poultry manure in the diet for Nile Tilapia (*Oreochromis niloticus,* Linneaus). Journal of Fish. Tech., 2: 51-56.

Guerrero, R.D. 1983. The culture and use of *Perionxy excavatus* as protein resource in the Philippines. In: J.E. Satchell (Ed.), Earthworm Ecology, Chapman and Hall, London: 309-319.

Lieberman, S. 2002. Worms, beautiful worms. International worm digest, 11.

Lovell, R.T. 1978. Factors affecting voluntary consumption by channel catfish. Proceeding of the Annual conference of association of Fish and wild life agencies, 33: 563-571.

Madu, C.T., Sogbesan, O.A. and Ibiyo, L.M.O. 2003. Some Non-conventional fish feed resources in Nigeria. In: A.A. Eyo (Ed.), Proceeding of the Joint 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 held at National Institute for Freshwater Fisheries Research, 15th -19th Sept. 2003. New- Bussa: 73-82.

Medina, A.L., Cova, J.A., Vidna, R.A., Pujic, P., Carlos, M.P. and Toress, V. 2003. Immunology and chemical analysis of proteins from *Eisenia foetida*, earthworm Food and Agricultural Immunology, 15(3-4): 251-263

National Research Council 1993. Nutrient requirements of fish . National Academy press. Washington, 114 pp.

New, M.B. 1987. Feed and feeding of fish and shrimp. A manual on the preparation and presentation of compound feeds for shrimp and fish in aquaculture. FAO ADCP/REP/87/26. Rome, 275 pp

Odaibo, B.A. 1997. Snail and Snail farming, Nigeria. Edible land snail. Stirling-Horden Publishers (Nig.) Ltd. Lagos, 29 pp.

Okoye, F.C., Eyo, A.A. and Aminu, N.G. 2001. Growth of tilapia, *Oreochromis niloticus* hybrid fingerlings fed lipid-based diets. In: A.A. Eyo (Ed), Fish Nutrition and Fish feed technology. Published by Fisheries Society of Nigeria, Lagos: 52-57.

Omitoyin, B.O. and Faturoti, E.O. 2000. Effect of raw and parboiled chicken offal in the diet of *Clarias gariepinus*. Aquabyte, 1: 20-25.

Oresegun, A. and Alegbeleye, W.O. 2001. Serum and tissue thiocynate concentration in tilapia (*Oreochromis niloticus*) fed cassava peels based diets supplemented with D,L-methionine. In: AA. Eyo (Ed.), Fish Nutrition and Fish Feed. Published by FISON, Nigeria: 107-115.

Oyarzum, S.E., Grawshaw, G.J. and Valdes, E.V. 1996. Nutrition of the Tamandua: I. Nutrient composition of termites (*Nasutitermes* spp.) and stomach content from wild Tamandua (*Tamandua tetradactyl*) Zoo. Biology, 15: 509-524.

Oyelese, O.A., Taiwo, V.O., Ogunsanmi, A. and Faturoti, E.O. 1999. Toxicological effect of cassava peels on haematology, serum biochemistry, tissues pathology of *Clarias gariepinus* (Burchell, 1822) fingerlings. Tropical Veterinary, 17: 17-30.

Reinecke, A.J. and Alberts, J.N. 1987. The chemical and amino acid composition of the compost worm (*Eisenia foetida* Oligocheata) as potential source of protein for animal feed. S.A. Tydskrif Vir. Natuurwetenskap en Tengnologie, 6: 1-14

Seira, A.B. 1998. The use of golden snail (*Pomacea* sp.) as animal feed in the Philippines. Voedings Magazine, 11(6): 40-43.

Shiau, S. and Hseih, J. 2001. Quantifying the dietary Potassium requirement for juvenile hybrid Tilapia (*Oreochromis niloticus x O.aureus*). British Journal of Nutrition, 85: 213-218.

Sogbesan, O.A. 2006. Effects of different organic substrates on growth and survival of long winged termite (*Macrotermes subhyabrius*) under laboratory conditions. African J. of Gen. Agricult., 2(2): 37-44.

Sogbesan, O.A. and Ugwumba, A.A.A. 2006. Effect of different substrates on growth and productivity of Nigeria semi- arid zone earthworm (*Hyperiodrilus euryaulos*, Clausen, 1842) (Oligochaeta: Eudrilinae). World Journal of Zoology, 1(2): 103-112

Sogbesan, O.A, Adebisi, A.A., Falaye, B.A., Okaeme, B.N. and Madu, C.T. 2006. Some aspects of dietary protein deficiency diseases in semi-intensive cultured fishes. A review. J. of Arid Zone Fish., 2(1): 80-89.

Sogbesan, O.A. and Ugwumba, A.A.A. 2007. Growth performance and nutrient composition of *Bufo maculata* (Linneaus) tadpole fed different practical diets as fish meal substitute. African Journal of Biotechnology, 6: 2177-2183.

Sogbesan,O.A., Ugwumba, A.A.A. and Madu, C.T. 2007. Growth performance and productivity of *Limicolaria aurora* (Jay, 1989) (Mollusca: Achatinidae) cultured in two different substrates under laboratory condition. ANNALS Science Research 2(3) (In-press)}.

Tacon, A.G.J. 1987. The nutrition and feeding of farmed fish and shrimps - A training manual. 2. Nutrient sources and composition. Project GCP/RLA/075/ITA. Document No. 5, Brasilia, Brazil, 129 pp.

Tacon, A.G.J. 1994. Feed ingredients for carnivorous fish species. Alternatives to fishmeal and other fishery resources. FAO of United Nations, Fisheries Circular No.881. FIRI/C881, Rome, 35 pp.

Wee, K.L. 1988. Alternate feed sources for fin fish in Asia. In: S.S. De Silva (Ed.), Fin Fish Nutrition in Asia: Proceedings of the Second Asian Fish Nutrition Network Meeting. Tokyo: 25–41.

Wilson, R.P., Robinson, E.H., Gatlin III, D.M. and Poe, W.E. 1982. Dietary phosphorus requirement of channel catfish, *Ictalurus punctatus*. J. Nutr., 112(6): 1197-1202.

Zeitler, M.H., Kirchgessner, M. and Schwarz, F.J. 1984. Effects of different proteins and Energy supplies on carcass composition of carp (*Cyprinus carpio*, L.) Aquaculture, 36: 37-48.