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Chemical Composition and Cyanide Levels of Hybrid Catfish Fed Whole Cassava Root Meal in Replacement of Maize

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Abstract: The chemical composition and cyanide levels of hybrid catfish fed with whole cassava root meal as a replacement for maize were analyzed and evaluated. Four different diets with varying levels of replacement of maize meal with whole cassava root meal were formulated and designated A_0, B_{33}, C_{66} and D_{100} with 0, 33, 66 and 100% of whole cassava root meal inclusion, respectively. The fish were fed for a period of 32 weeks. The result from the study indicated there was no significant different in chemical composition of the experimental diets except in their cyanide levels, A_0 (control) had 0.00 mg kg^{-1}; diets B_{33} (0.02), C_{66} 0.04 and D_{100} had 0.09 cyanide levels. The chemical composition of the experimental fish shown that the there were no significant different in the proximate level of the fish fed with different diets. The cyanide levels increased as the level of whole cassava root meal inclusion in the diets increased. Diet A_0 (control), had 0.02 mg kg^{-1}; diet B_{33} 0.03 mg kg^{-1}; while diet C_{66} 0.05 mg kg^{-1} and diet D_{100} 0.08. These values are within tolerable range for the normal metabolism of the fish. Therefore, it can be concluded from the results obtained in this trial that whole cassava root meal can replace maize successfully without any adverse effect.

Key words: Chemical, composition, proximate, cyanide, hybrid catfish, whole cassava root meal, maize

INTRODUCTION

It is widely known that cassava root products are rich in carbohydrates but low in protein, amino acid and all other nutrients (Presston, 2004). Cassava therefore is used mainly as a source of energy (Essers *et al*., 1995). In using cassava root products as cereal substitutes, approximately 15-20% extra protein source is needed. Ernesto *et al*. (2000) observed that cassava root meal contains 2.50% crude protein, 3.50% crude fibre and 3145 kcal kg^{-1} metabolisable energy compared to maize which has corresponding values of 8.5% crude protein, 2.00% crude fibre and 3524 kcal kg^{-1} metabolisable energy. According to Cliff (1999), the nutritive and energetic values and hydrogen cyanide of cassava products in some researches varied widely especially where these were obtained by biological testing. This was mainly caused by inaccurate definition of tested products. Besides, this is also influenced by varieties, age at harvest, ecological conditions under which the plant was grown and processing method. Studies on cassava are aimed at establishing the optimum levels of inclusion, types and levels of supplementation of cassava based rations to precisely meet the nutritional needs of animals at the most economical cost (Idufueko, 1984; Cardoso *et al*., 1999; Iheukwumere *et al*., 2007).

Although, cassava tuberous roots has a high production potentials and can be used in different forms in tropical Africa, but this maybe limited by the presence of anti-nutrients such as Linamarin. Lanamarin is cyanogenic glycosides (2-B-D-glucopyranosy 1-oxy-isobutryo-nitrite) found in leaves and tuberous roots of cassava, which releases Highly toxic Cyanide (HCN) during hydrolysis at the time of digestion (Preston, 2004). These cyanogens are distributed widely throughout the plant, with large amounts in the leaves and the root cortex and generally smaller amounts in the root parenchyma. However, in sweet cassava, the parenchyma contains

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only a small amount of cyanogens so that after peeling, these roots can be safely boiled and eaten as occurs in most of the rural areas of the country (Bradbury and Holloway, 1995).

Consumption of cassava and its products by farm animals that contain large amount of cyanogens may cause cyanide poisoning with symptoms of dizziness, pains, weakness, diarrhea and occasionally death in farm animals (Mlingi *et al*., 1992; Akintonwa *et al*., 1994). Cyanide intake from cassava increases goiter and cretinism in human, especially in iodine deficient areas (Delange *et al*., 1994). Tropical Ataxic Neuropathy (TAN) is a chronic condition of gradual onsets that occurs in older people who consume monotonous cassava diet. It leads to loss of vision, ataxia of gait, deafness and weakness (Osuntokun, 1994; Onabolu *et al*., 2001).

Cyanide is believed to be responsible for many of the poor results obtained when using cassava to feed livestock although, only scanty information on the effective incidence of the Hydrogen Cyanide rate on the performance of animals is available (Gomez, 1985). Experiments conducted using cassava flour give conflicting results, which were influenced by processing methods. Muller and Chou (1974) and Stevenson and Jackson (1993) reported that an inclusion rate of up to 50% cassava in the diet did not impair growth performance of poultry. But Longe and Oluyemi (1977), Willie and Kinabo (1986) observed a linear decrease in the weight of poultry resulting from the increase in the quantity of cassava included in the rations. These symptoms can be prevented in both man and animals by processing cassava roots before consumption, to reduce the cyanogens to a safe level. The World Health Organization (WHO) has set the safe level of cyanogens in cassava flour at 10 ppm (FAO/WHO, 1991).

Some researches have been done on cyanide levels of some farm animals fed whole cassava rot meal include that of pig (Phansurin *et al*., 2002), Poultry (Longe and Oluyemi, 1977; Gomez, 1985; Iheukwumere *et al*., 2007).

Cattle Oke (1994) and Preston (2004) but none is available on the cyanide levels of Hybrid catfish fed with whole cassava root meal as a replacement for maize thus, necessitating the need for this research.

MATERIALS AND METHODS

Fingerlings of hybrid catfish with an average weight of 5.12±2.1 g were fed with four different diets with varying replacement levels of maize with whole cassava root meal.

Fresh whole cassava roots, sweet specie (*Manihot esculenta*) where harvested from cassava mosaic disease resistant farms at I.I.T.A., Onne, Rivers State, Nigeria. They were washed and blanched for 5 min in boiling water at 100°C to remove cyanogenic glycoside of cassava. The blanched cassava roots were chipped dried and blended to a meal. These diets were formulated and designated A_o, B_{33}, C_{66}, D_{100} (Table 1).

Table 1: Percentage composition of experimental diets

Ingredients	A_o (control)	Diets B_{33}	C_{66}	D_{100}
Maize meal	13.18	8.49	4.11	-
Whole cassava root meal	-	4.25	8.21	11.94
Fish meal	27.75	27.90	27.00	27
Soya bean meal	41.64	41.00	42.07	42.26
Groundnut cake	13.88	14.81	15.06	15.25
Bone meal	2	2	2	2
Fish premix*	0.25	0.25	0.25	0.25
Methoionine	0.2	0.2	0.2	0.2
Lysine	0.3	0.3	0.3	0.3
Palm oil	0.3	0.3	0.3	0.3
Vitamin C	0.3	0.3	0.3	0.3
Common salt	0.2	0.2	0.2	0.2
Total (kg)	100	100	100	100
Cost (N kg^{-1})	183	182	178	176
Cost reduction (N ton^{-1})	0	1000	5000	7000
Energy (Kcal kg^{-1} Me)	3183	3097	3090	3079

Subscript in the diets indicate level of replacement of maize with whole cassava root meal. Fish premix, Each 2.5 kg contains, *Vitamin 8,000,000 IU, Vitamin D_3 1,600,000 IU, Vitamin E 6,000 IU, Vitamin K 2,000 mg, Thiamine B_1 1,5000 mg, Riboflavin B $_2$4,000 mg, Pyriodoxine B_6 1,5000 mg, Niacin 15,000 mg, Vitamin B_{1210mg}, Pantothenic acid 5,000 mg, Folic acid 500 mg, Biotin 20 mg, Choline chloride 200 g, Antioxidant 125 g, Manganese 80 g, Zinc 50 g, Iron 20 g, Copper 5 g, Iodine 1.2 g, Selenium 200 mg, Cobalt 200 mg

Diet A_o, which is the control had maize as the main source of energy. In diets B_{33}, C_{66}, D_{100} maize was substituted with whole cassava root meal at graded levels of 33, 66 and 100%, respectively. The experimental fish were reared in 12 different tanks of dimension (2.5×2×1.3 m). The tanks were labeled basis on treatment levels and replicated with coli diet having three tanks each.

The fish were fed at the same feeding frequencies twice daily (0.8 oocal 17.00 h) at 5% body weight. They were fed for a period of 32 weeks where they were raised to adult size.

The water in the experimental tanks were changed every week and the following parameter namely pH, Ammonia, Dissolved Oxygen (DO), temperature, nitrite and total hardness were evaluated every week. Water temperature was determined by mercury in glass thermometer. The pH was determined in situ in each of the tanks with pH meter (Hanna products, Portugal). The dissolved oxygen were estimated using the Winklers method as described by APHA (1985). Nitrite, Ammonia and water hardness were determined by using fish farmers water quality kit model FFI-A.

The experimental feed ingredients and fish were sampled from different treatment levels (A_o, B_{33}, C_{66} and D_{100}) and taken for chemical evaluation in the laboratory using the AOAC (1990) method. Five grams of each sample was weighed separately and placed in a known weight of aluminum dish. This was placed in a Galenkamp oven, preset at 105°C for 24 h. The sample was then dried to a constant weight and moisture content calculated as percentage (AOAC, 1990).

$$\text{Moisture content (\%)} = \frac{\text{Weight of fresh sample} \times \text{Weight of dried sample}}{\text{Weight of fresh sample}} \times 100$$

Crude protein content was by titration method in which the value of nitrogen content were determined. The nitrogen content of the sample was calculated as:

$$\text{Nitrogen content (\%)} = \frac{\text{(mL acid} \times \text{normality of standard acid} \times 0.014 \times 100}{\text{Weight of sample (g)}}$$

$$\text{Crude protein content (\%)} = \text{Nitrogen content} \times 6.25$$

This method assumes that protein in the sample approximately consists of 16% nitrogen. To determine the value of crude fat residue from the moisture content was transferred to a extraction thimble, making sure that any hard lumps formed during drying were carefully broken into small pieces before the transfer. The sample was then analyze using petroleum ether. The crude fat was then calculated AOAC (1990) and expressed as percentage.

$$\text{Crude fat (\%)} = \frac{\text{Weight of fat}}{\text{Weight of sample}} \times 100$$

Total ash was analyzed by placing 2 g each of the sampled fish and feed in all dietary treatments were weighed into a dry porcular dish and was placed in a mupple furnace set at 600°C for 6 h. After cooling the ash content was calculated AOAC (1990) and expressed as percentage.

$$\frac{W_2}{W_1} \times 100$$

Where:

W_1 = Weight of sample (g)

W_2 = Weight of ash (g)

The crude fibre (%) were estimated with the formula:

$$\frac{\text{(Weight of crucible dried residue)} - \text{(Weight of crucible + ashed residue)}}{\text{Weight of sample}} \times 100$$

The carbohydrate content was estimated by the difference method that is by subtracting value of the measured moisture ash, protein, fat and crude fibre from the total weight.

The data obtained were analyzed based on the methods described by Wahua.

RESULTS

The results of the water quality variable moisture during the study (Table 2) indicated the mean values of pH ranged between 6.60-8.55, which dissolved oxygen ranged from 4.99-7.10 mg L^{-1}. Temperature ranged from 27.11-29.14°C, nitrite ranged from 0.0010-0.0054 mg L^{-1}, ammonia ranged from 0.30-0.46 mg L^{-1} and total hardness ranged from 46.05-80.08.

The proximate composition values of experimental diets are as follows: moisture content ranged from 10.10-10.86%, fat ranged from 7.57-8.03%, nitrogen from 6.54-6.68% and phosphorus ranged from 0.63-0.70%. Ash ranged from 10.91-11.10% and Nitrogen Free Extract (NFE) ranged from 6.51-6.08%. for the minerals, the highest level of calcium (1.54%) was observed in diet C_{66} and the lowest (1.46) in the control diet (A_o). The magnesium (Mg) value ranged from 0.87-0.91%, while potassium (K) ranged from 1.62-1.70% and sodium value ranged from 241.75- 302.90 ppm in the experimental diets (Table 3).

For the two main ingredients used in the formulation of the experimental diet; the amount of crude protein (cp)

Table 2: Mean values of physicochemical parameters of water in the experimental tanks

Parameters	Mean±SD	Range Min./Max.
pH	6.56±0.41	6.60-8.55
Dissolved oxygen (mg L^{-1})	5.71±1.74	4.99-7.10
Temperature (°C)	28.14±0.11	27.11-29.14
Nitrite (mg L^{-1})	0.0039±0.01	0.0010-0.0054
Ammonia (mg L^{-1})	0.35±0.01	0.30-0.46
Total hardness (mg L^{-1})	50.11±10.12	46.05-80.08

Table 3: Proximate mineral and cyanide levels of experimental diets

	Experimental diets			
Parameters	A_o (control)	B_{33}	C_{66}	D_{100}
Proximate				
Moisture (%)	10.86^a	10.10^a	10.35^a	10.35^a
Crude protein (%)	40.90^a	41.71^a	40.87^a	41.74^a
Fat (%)	7.67^a	7.57^a	8.03^a	7.80^a
N (%)	6.54^{a-}	6.67^a	6.51^a	6.68^a
P (%)	0.63^a	0.69^a	0.67^a	0.70^a
Ash (%)	11.01^a	11.10^a	11.09^a	10.91^a
NFE (%)	6.54^a	6.67^a	6.51^a	6.68^a
Mineral				
Calcium (%)	1.46^a	1.49^a	1.54^a	1.47^a
Magnesium (%)	0.87^a	0.87^a	0.91^a	0.87^a
Potassium (%)	1.70^a	1.64^a	1.68^a	1.62^a
Sodium (ppm)	302.90^a	300.07^a	273.50^b	241.75^c
Total cyanide (mg kg^{-1})	0.00	0.02	0.04	0.09

Means within the row with the same superscript are not significant ($p<0.05$)

Table 4: Proximate and mineral compositions of whole cassava root meal and maize

Parameters	Maize	Cassava rot meal
Proximate		
Moisture content (%)	10.23^{a}	10.51^{a}
Crude protein (%)	8.55^{a}	4.58^{b}
Fat (%)	5.84^{a}	2.59^{b}
Ash (%)	1.37^{a}	2.16^{b-}
Crude fibre (%)	16.51^{b}	21.18^{a}
Total cyanide (mg kg^{-1})	0.00^{a}	0.10^{b}
Mineral		
Nitrogen (%)	1.37^{a}	0.73^{a}
Phosphorus (%)	0.19^{a}	0.58^{a}
Calcium (%)	0.19^{a}	0.15^{a}
Magnesium (%)	0.15^{a}	0.12^{a}
Potassium (%)	0.53^{a}	0.82^{a}
Sodium (ppm)	55.07^{a}	56.48^{b}

Means in the row with the same superscript are not significant ($p<0.05$)

and fat in the maize were higher than that in the whole cassava root meal, the cassava also had higher ash and crude fibre values compared with that of maize. As should be expected cyanide was completely absent in the maize meal.

The proximate composition of the experimental fish indicated that the values of carbohydrates ranged from 3.59% in fish fed diet with 66% inclusion (C_{66} to 4.88% in fish fed diet A_0 (control). The highest values 6.40% of ash was obtained in fish fed diet with 33% inclusion (B_{33}) and lowest (1.50%) was recorded in fish fed control diet (A_0) (Table 4). The Crude Protein (CP) value ranged from 50.62-56.08%. The highest value (56.08%) was recorded in fish fed diet 100% WCRM (D_{100}). The lowest value 50.62% was recorded in fish fed diet 100% maize (A_0) control diet. The value of fat obtained also ranged from 20.75-20.85%, while moisture content ranged from 63.77-71.75%. The highest value of cyanide 0.08 mg kg^{-1} was observed in fish fed diet D_{100}, while the lowest 0.02 mg kg^{-1} was recorded in fish fed diet A_0 (control diet).

The NFE and fat of all treated fish fell below that of the control, whereas the reverse was the case with ash, CP, moisture and cyanide (Table 4). There was defined trend in the values of variables among the treated fish relative to the rate of inclusion of WRCM (Table 4).

DISCUSSION

The proximate composition of the experimental diets fall within the range expected to support good growth of fish (Arts *et al*., 2001).

Chemical and mineral composition of the experimental feed across the dietary treatments did not differ ($p>0.05$) as was observed by Jauncey (1982) and Keshavanath (2002), in similar diets where maize was replaced with CRM and fed to *Cyprinus carpio*. However, the slight variations observed may be due to different factors such as processing methods, analytical techniques and environmental factors (Eyo, 2001). Whole cassava root meal and maize as sources of energy in the experimental diets, generally had low crude protein, fat, crude fibre and total ash, but high in NFE. The high NFE coupled with low crude fibre has made these ingredients very suitable as a ready source of available energy in fish feeds (Eyo, 1992). Furthermore, the crude protein and crude fat in whole cassava root meal was lower than that of maize, as was reported by Hoangkim *et al*. (2001) in cassava roots meal fed to poultry. NRC (2002) attributed the low values of these nutrients in CRM to tannin content and poor amino acid availability. The mineral composition of whole cassava root meal and maize in the experiment were within the range of those reported in the literature (NRC, 1983; Fetuga *et al*., 1988). The crude fibre and ash contents of whole cassava root meal depended very much on the quality of fresh roots and the processing techniques. According to Fasuyi (2005), good quality fresh cassava roots which are clean and have minimal or no stems or woody parts will produce cassava root meal with low crude fiber and ash contents. This is because Metabolisable Energy (ME) of cassava root meal is inversely related to the levels of crude fibre in the feed ingredients (Phansurin *et al*., 2002).

The proximate composition and cyanide content of experimental fish showed no significant ($p>0.05$) changes in all the experimental diets. The carcass quality of experimental fish approximates that of the Rainbow trout in the studies of Ufodike and Matty (1984) in which the increased level of cyanide in fish increased with inclusion of CRM in the diet. The level of cyanide in the diets and fish were within the tolerable range reported in literature (Lundquist *et al*., 1988; Oke, 1994; Onabolu *et al*., 2001).

Nutritional significant of dietary cyanide derives from several observations (Tewe, 2004; Frake and Sharma, 1986; Aletor and Fetoga, 1988; Aletor, 1993) and indicate that cyanide retention in the systems of organisms either in synthetic or organic forms, can cause marked changes in the weight gain nutrient utilization enzyme activities and thiocyanate concentrations in serum of animals. The low levels of cyanide observed in fish or diet in this study was due to the species used and the processing methods. This research also corroborates the reports of Adindu *et al*. (2003) in cassava root meal fed to swine in Port Harcourt.

CONCLUSION

The serum metabolites and whole cassava root meal of the fish fed were within the range reported for normal fish, showing that the inclusion whole cassava root meal did not increase metabolites (wastes) in the blood. The blood enzymes were consistently reduced in all dietary treatments, which vary in relation to types of and level of cassava replacement of maize.

Hence, for the study is needed in this area to confirm this result. The level of cyanide in the diet and the fish at the end of the trial were within tolerable range for normal fish metabolism indicating that whole cassava root meal did not alter the functional metabolism of hybrid fish. Therefore, it can be said in conclusion that cassava can replace maize successfully without any adverse effect.

REFERENCES

Adindu, M.N., F.F. Olayemi and O.U. Nze-Dike, 2003. Cyanogenic potential of some cassava products in Port Harcourt markets in Nigeria. J. Food Comp. Anal., 16: 21-24.

Akintonwa, A., O. Tonwashe and Onifade, 1994. Fatal and non-fatal acute poison attributed to cassava-based meal. Acta Hortic., 375: 285-288.

Aletor, V.A., 1993. Cyanide in garri. Distribution of total, free and bound Hydrocyanic acid (HCN) in commercial garri and the effect of fermentation time on its residual cyanide content. Int. J. Food Nutr., 44: 281-287.

Aletor, V.A. and B.L. Fetuga, 1988. Dietary interaction of lima bean (*Phaseolos lunatus*) trypsin inhibitor and cyanide effect on an growth performance, nitrogen utilization and physiopathology in growing rats. J. Amin. Physiol. Anim. Nutr., 60: 113-122.

AOAC (Association of Official Analytical Chemist), 1990. Official Methods of Analysis, Vol. II. Washington, USA, pp: 1234.

APHA, 1985. Standard Methods for the Examination of Waste Waters. 16th Edn. Washington, American Public Health Association, pp: 360.

Arts, F., A. Maage and G. Julshamik, 2001. An estimation of dietary feed requirement on biochemical profile of fish. Int. J. Cell. Biol., 101 (33): 940-959.

Bradbury, J.H. and W.D. Holloway, 1995. Chemistry of Tropical root crops: Significance for Nutrition and Agriculture in the pacific. Australian Centre for International Agricultural Research, Monograms, Canberra, Australia, pp: 305.

Cardoso, A.P., M. Ernesto, J. Cliff and J.H. Bradbuy, 1999. High levels of total cyanide to drought in Mozambique. Foots, 6: 4-6.

Cliff, S.J., 1999. Nutritional bioenergetics and estimation of waste production in salmonds. Aquat Living Resour., 11: 311-318.

Delange, F., L.O. Ekpechi and H. Rusling, 1994. Cassava cyanogenesis and iodine deficiency disorders. Acta Horticulture, 375: 284-293.

Ernesto, M., A.P. Cardosso, J. Cliff and J.H. Bradsury, 2000. Cyanogesis cassava flour and roots and urinary thiocyanate concentration in Mozambique J. Food Comp. Anal., 13: 1-12.

Essers, A.J., C. Ebong, R.M. Vander Grift, M.J.R. Nout, W. Otim-Nape and H. Rosling, 1995. Reducing cassava toxicity by heap fermentation in Uganda. Int. J. Food Sci. Nut., 46: 125-136.

Eyo, A.A., 2001. Chemical Composition and Amino Acid Content of the Commonly Available Feed Stuffs Used in Fish Feed in Nigeria. In: A.A. Eyo (Ed.). Proceedings of first national symposium on fish nutrition and fish feed technology, NIOMR, Lagos, pp: 14-25.

Eyo, A.A., 1992. Biochemical composition of clupeids Rellonula apseluisi and Saerrathrissa leonensis. Nig. Feed. J., 10: 111-115.

FAO/WHO, 1991. Joint FAO/food standards programme. Codex Alimentary xii supplement 4, FAO. Rome, pp: 30.

Fasuyi, A.O., 2005. Nutrient composition and processing effects on cassava leaf (*Manihot esculenta*) anti-nutrients. Pak. J. Nutr., 4 (1): 37-42.

Fetuga, B.L., G.M. Babatunde and V.A. Oyenuga, 1988. Some Nigeria protein concentrates as foods and feeds. Nig. J. Anim. Prod., 8: 132-142.

Frake, R.A. and E.P. Sharma, 1986. Comparative metabolism of linamarin an amaygdalin in cassava, Food Chem. Toxicol., 24: 417-420.

Gomez, G., 1985. Cassava's chemical composition cyanide content and effect of drying on cyanide elimination. J. Food Agric., 36: 433-441.

Hoangkim, B., P. Van Bian and R.H. Howeler, 2001. Status of Cassava in Vietnam: Implications for Future Research and Development. In: Howeler, R.H. (Ed.). Conference Proceeding of Cassava in Asia, held in Rome. Italy April 26-26, 2000, pp: 103-184.

Idufueko, A., 1984. Self-sufficiency in animal protein supply under changing economic fortunes. Nig. J. Anim. Prod., 11: 14-21.

Iheukwumere, F.C., E.C. Ndubuisi, E. Amasi and M.U. Onyekwere, 2007. Growth blood chemistry and carcass yien of broilers fed cassava leaf meal (*Manihot esculenta*). Int. J. Poult. Sci., 6 (8): 555-559.

Jauncey, K., 1982. The effect of varying dietary protein levels on the growth, food conversion, protein utilization and body composition of juvenile tilapia, Sarotherodon mossambicus. Aquaculture, 27: 34-54.

Keshavanath, M.O., 2002. Usage of enzyme to increase the amylase content of sago starch. Chem. J., 66 (3): 173-182.

Longe, O.G.L. and J.A. Oluyemi, 1977. Comparative use of cassava, maize and guinea corn as the major dietary source of carbohydrates for chicks. J. Assoc. Adv. Agric. Sci., 4: 47-52.

Lundquist, L., G. Kissil, D. Sklan and E. Preffer, 1988. Apparent digestibility coefficients of feed ingredients and their predictability in compounded diets for gilt heae (*Sparus avrata*). Aquc. Nutr., 3: 81-90.

Mlingi, N., N.H. Poulto and A. Rosliry, 1992. An outbreak of acute intoxication from consumption of insufficiently processes cassava in Tanzania. Nutr. Res., 12: 677-687.

Muller, Z. and K.C. Chou, 1974. Le maniuc: Product de remplacement des cereals dans les rations du betail et de la vovaille. Rev. Mon. Zool., 12: 19-24.

NRC, 1983. Nutrients requirements of warm-water fishes and shell fishes. Revised edition, National Academy Press, Washington DC, pp: 206.

NRC, 2002. Nutrients requirements of fish. National Academy Press, Washington, DC, pp: 114.

Oke, O.L., 1994. Eliminatory cyanogens from cassava through processing technology and trading. Acta Hortic., 10: 66-61.

Onabolu, A.O., O.S.A. Oluwole, M. Bokenga and H. Rosling, 2001. Ecological variation of intake of cassava food and dietary cyanide in Nigerian communities. Public Health Nutr., 4: 871-876.

Osuntokun, B.O., 1994. Chronic cyanide intoxication of dietary origin and a degenerative neuropathy in Nugeroas. Acta Hortic., 375: 311-321.

Phansurin, K.U. Kanto and S. Juttu-Pornpony, 2002. A Study on Metabolizable Energy of Cassava Chips in Growing Finishing Pig Diets. In: Howeler, R.H. (Ed.). Proc. 38th Kasetsant University Conference Kasetsort University Bangkock, Thailand, pp: 300.

Preston, T.R., 2004. Potential of cassava in integrated farming systems. Livest. Res. Rural Dev., 10 (8): 20-28.

Stevenson, M.H. and N. Jackson, 1993. The use of cassava meal in broiler diets. Paper presented to the progress in the use of cassava as animal feed. 12th International Congress of Nutrition. The town and country hotel, Sandiageo, Califonia, USA. Aug. 9-12, 16-21. Nairobi Kenya, pp: 36.

Tewe, O.O., 2004. Cassava for livestock feed in sub-saharan Africa, FAO Rome, pp: 64.

Ufodike, E.B.C. and A.J. Matty, 1984. Nutrient digestibility and growth responses of rainbow trout (*Salmo gairdineri*) fed different levels of cassava and rice. Hydrobiologia, 119: 83-88.

Willie, D. and A.A. Kinabo, 1986. Cassava or maize meal for Atlantic salmon and the effect of supplementation with methionine and sulphate in cassava based diets. Trop. Anim. Prod., 5: 182-190.