Agro-Science Journal of Tropical Agriculture, Food, Environment and Extension
Volume 9 Number 3 September 2010 pp. 176 -183
ISSN 1119-7455

PERFORMANCE AND SURVIVAL OF HYBRID CATFISH (HETERO X CLARIAS) FED WITH WHOLE CASSAVA ROOT MEAL AS A REPLACEMENT FOR MAIZE

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ABSTRACT
This trial was conducted to assess the possibility of replacing maize (Zea mays L) with varying levels of whole cassava (Manihot esculent crantz) root meal (WCRM) in the diet of hybrid catfish (Heterobranchus, bidorsalis x Clarias gariepinus). The effect of replacement on growth variables and nutrient utilization of the WCRM as a replacement for maize were also determined. Four practical diets with varying replacement levels of maize at 0 (A_o), 33 (B_{33}), 66(C_{66}), and 100% (D_{100}) were formulated and fed to hybrid catfish fingerlings for 32weeks. Fish were fed twice daily at 5% body weight/day. Optimum growth, nutrient utilization of the fish were assessed. The results obtained from the study indicated that WCRM can completely replace maize with the best result at 66% inclusion. The highest values of growth performance were: final weight 12,782±601.21g, mean weight gain 12041.43±312.66g, and daily weight gain 78.78±10.28g. The nutrient utilization indicated the best feed conversion ratio (FCR) 1.71±0.40; Gross feed conversion efficiency (GFCE), 68.95±5.161; protein intake (PI), 12975.88±306.11g, protein efficiency ratio (PER) 1.98±0.11; and nitrogen metabolism (NM) 10782.98±314.12g/100g were recorded in diet C_{66}. However, growth and nutrient utilization variables varied significantly ($p<0.05$) within the treatment period. The mean final weight, FCR and PER of the fish fed trial diets were not significantly different ($p>0.05$) from the control value. Dietary WCRM at 100% inclusion produced similar results in the mean weight gain (MWG), mean daily weight gain (MDWG), Gross Feed Conversion Efficiency (GFCE), Protein Intake (PI), and survival as the control diet. It could therefore be concluded that WCRM can replace maize in the diet of hybrid catfish effectively up to 100% with the optimal performance at 66% level of inclusion. Fish farmers can therefore explore the use of WCRM as an alternative to maize meal in hybrid catfish diet with better profit margins.

Keywords: Feed, cassava, maize, hybrid, catfish, aquaculture

INTRODUCTION
Over the past decades aquaculture has grown in leaps and bounds in response to an increasing demand for fish as a source of protein globally (Akinrotimi *et al.*, 2007a). This is because production from capture fisheries has reached its maximum potential possible, as the catch is dwindling with each passing day (Gabriel *et al.*,2007). According to FAO (2006), fish supplies from capture fisheries will therefore, not be able to meet the growing global demand for aquatic food. Hence, there is the need for a viable alternative fish production system that can sufficiently meet this demand, and aquaculture fits exactly into this role.

As aquaculture production becomes more and more intensive in Nigeria, fish feed will be a significant factor in increasing the productivity and profitability of aquaculture (Akinrotimi *et.al.*, (2007b). Jamiu and Ayinla (2003) opined that feed management determines the viability of aquaculture as it accounts for at least 60 percent of the cost of fish production. The need to intensify the culture of the fish, so as to meet the ever increasing demand for fish has made it essential to develop suitable diets either in supplementary forms for ponds or as complete feed in tanks (Olukunle, 2006). For the purpose of nutritional and economic benefits, previous researchers have made attempts at increasing the use of non-conventional plant and animal materials to replace conventional feed ingredients like maize and fish meal in fish feed ration (Falaye, 1988; Fagbenro, 1992; Olatunde, 1996, Baruah *et al*., 2003; Eyo, 2004). According to Olurin *et al.* (2006), maize is the major source of metabolisable energy in most compounded diets for catfish species. This is because it is readily available and digestible. However, the increasing prohibitive cost of this commodity has necessitated the need to search for an alternative source of energy. Recently, FAO (2006), reported shortages in the production of cereals, a serious issue in many countries including Nigeria. The use of cereal products, especially maize in fish feeds is becoming increasingly unjustified in economic terms (Tewe, 2004), because of the ever increasing cost. There is therefore, the need to exploit cheaper energy sources to replace expensive cereals in fish feed formulation. To relieve the food feed competition between man and animal and for profit maximization, cassava is very appropriate for this purpose.

Cassava is one of the most important energy sources in the diet of people in the tropics. Recent estimates suggest that its storage roots provide eight percent or more of the minimum calorie requirement of more than 750million people. Its starchy root produces more calories per unit of land than any other crop in the world (Presston, 2004). According to Pedrosa (2002), cassava roots are generally rich in calcium and ascorbic acid and contain significant amounts of thiamine, riboflavin and niacin. Its starchy, thickened, tuberous roots are a valuable source of cheap calories and its use in animal feed is increasing because of its high energy content and low price (Salami, 2000). In recent times, the use of cassava as a substitute for cereals in livestock and fish feeds has been under investigation. Inclusion of cassava in the diet of white Fulani herds in Nigeria has been reported to increase milk production by 22% (IITA, 1990). Oke (2007), reported that cassava products are good energy feed ingredients for both monogastric and ruminant animals. As reported by Talthawan *et al* (2002), the starch in cassava is highly digestible when compared to that of maize due to the high content of amylopectin. Cassava can then be used as a source of energy in fish feed, but attention should be paid to the protein, metabolisable energy and Hydrogen Cyanide (HCN) contents in cassava products. Studies on the use of cassava meal in animal feed (Khajarem, *et. al.*, 1986; Oresegun and Alegbeleye, 2001; Faturoti, *et. al.,* 2002; Eyo, 2003) indicate a great potential for cassava to replace the conventional energy feed ingredients such as maize, broken rice and sorghum, which are commonly used in animal diet in most parts of Africa (Akinfala and Tewe, 2001).

Few works available in literature on the replacement of maize with cassava in fish diets include those on mirror carp, *Cyprinus carpio* (Ufodike and Matty, 1983), Rainbow trout, *Salmo trutta* (Ufodike and Matty, 1984). Tilapia, *Oreochromis niloticus* (Faturoti and Akinbote, 1986). *Oreochromis mossambicus* (Wee and Ngi, 1986); *Clarias gariepinus* fingerlings (Olurin *et al.*, 2006); *C. garieipinus* advanced fry (Olukunle *et. al.*, 2006). But none is available on the use of whole cassava root meal in raising hybrid catfish from fingerlings to table size. This is the premise on which the project study was carried out.

MATERIALS AND METHODS

Feed Formulation

Fresh whole cassava roots of sweet cassava species (*Manihot esculanta*) resistant to cassava mosaic disease were harvested from farms at the International Institute for Tropical Agriculture (I.I.T.A.), Onne, Rivers State, Nigeria. They were washed and blanched for 5minutes in boiling water at (100^{o}C) to remove cyanogenic glycoside. Thereafter, they were chipped dried and blended to powder. The cassava flour was then used to formulate the experimental diets designated A_0, B_{33}, C_{66}, D_{100} (Table 1).

Diet A_o, which is the control had maize as the main source of energy. In diets B_{33}, C_{66}, and D_{100} maize was substituted with whole cassava root meal at graded levels of 33%, 66% and 100%, respectively.

Experimental fingerlings

The experimental fish (fingerlings) were obtained from African Regional Aquaculture Centre, Port Harcourt, Rivers State, Nigeria. The initial average weight of the fingerlings ranged from 4.35-4.63g. A total of 900 fingerlings hybrid catfish were randomly distributed into 12 tanks (75 fish per tank) and allowed to acclimatize for about two days. During this period, the fish were not fed with any artificial diets, but were starved to allow total digestion of any food in their stomach. The experiment was carried out for a period of 32 weeks (244 days).

Experimental procedure

At the end of acclimation, fish in each tank were weighed to determine their initial mean weight. Thereafter, the experimental units were randomly assigned to the experimental diets (3 tanks to a diet) to form four (4) treatments (3 replicates per treatment). Feeding was done at 8.00am and 5.00pm (i.e., twice daily) at a rate equivalent to about 5% of the total body weight of the fish in each tank.

Fish in each bowl were weighed weekly and the readings obtained were used to compute parameters like mean weight gain (MWG), Specific Growth Rate (SGR), Protein Efficiency Ratio (PER) and other growth and nutrient utilization parameters. At the end of the experiment (32 weeks) the feed from each treatment were analyzed for proximate, mineral and cyanide following the procedure of A.O.A.C. (1990).

Monitoring of physio-chemical parameters

Physiochemical factors like temperature, pH, dissolved oxygen (DO) nitrite, ammonia and total hardness were monitored on a daily basis according to the methods of APHA (1985).

Growth and nutrient utilization parameters

The following growth and nutrient utilization parameters were calculated as measures of the effectiveness of utilization of cassava meal as a replacement of maize in the diet of hybrid catfish. This was done in accordance with the method of Brown (1975).

Specific Growth Rate (SGR)

SGR (%W/D)=

$$\frac{Log\ W_2 - Log\ W_1 \times 100}{T_2 - T_1 \times 1} \times \frac{100}{1}$$

W_2 = weight at time T_2 (days)
W_1 = weight at time T_1 (days)

Protein Efficiency Ration (PER)

This was calculated from the relationship between the increment in the body weight of fish (i.e. the weight gain of fish) and protein consumed according to the methods described by Booth and Allan (2003).

$$PER = \frac{\text{Mean weight gain}}{\text{Protein intake}}$$

Nitrogen metabolism (N_m)

This was calculated from the following

$$N_m = \frac{(0.549)\ (a+b)h}{2}$$

a = Initial weight of fish
b = Final weight of fish
h = experimental period in days
(Zeitoun *et al.*, 1973)

Daily Growth Rate (DRG)

$$DRG = \frac{\text{Mean increase in weight per day}}{\text{Initial Body Weight of Fish}}$$

(Oyelese, 2007)

Gross Efficiency of Food Conversion (GEFC)

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$$= \frac{\text{Deily rate of growth}}{\text{Daily rate of feeding}}$$

(Sticknay, 1969)

Mean weight of fish (MWOF)

Mean weight of fish (MWOF)

$$= \frac{\text{Total weight of fish}}{\text{Number of fish}} \quad \text{(Lovell, 1977)}$$

Mean weight gain per day (MWGD)

Mean weight gain per day (MWGD) = Final mean weight gain per day (FMWGD) – Initial mean weight gain per day (MWGD)

Percentage weight gain per week (PWGW)

Percentage weitht gain week (PWGW

$$\frac{\text{Mean weight gain per week}}{\text{Mean weight}} \times \frac{100}{1}$$

(Halver, 1976)

Gross food conversion efficiency (GFCE%)

This was calculated as the reciprocal of the food conversion ratio expressed as a percentage (Stickney, 1980). Gross food conversion efficiency

$$GFCE\ (\%) = \left(\frac{1}{FCR} \times \frac{100}{1}\right)$$

Protein intake (PI)

This was determined from the proportion of protein content in the total feed

$$P1 = \frac{\text{Total feed consumed x \% proterin in feed}}{100}$$

Feed input

The feed inputs were calculated based on the amount of feed fed to the fish at a particular stage or the other. The feeds were weighed out weekly as 5% of the weekly body weight of the fish using a weighing balance.

Survival

This was done by counting the number of fish in the tanks forth-nightly. The number of mortality observed were recorded.

Statistical analysis

Analysis of variance (ANOVA) was carried out to test the effects of the treatments on the fish growth rate within the study period and significant mean were seperated using the Duncan Multiple range test (Duncan, 1995).

RESULTS

Table 2 presents the mean values for the physicochemical parameters of the water in the experimental tanks. The results of the water quality variables indicated that mean values of pH ranged from 6.60 to 8.55, while concentration of dissolved oxygen ranged from 4.99 to 7.10mg/l. water temperature ranged from 27.11 to 29.14^{o}C, nitrite ranged 0.0010 to 0.0054mg/l, ammonia 0.30 to 0.46mg/l and total hardness, 46.05 to 80.08.

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

Note: Subscript in the diets indicate components of fish premix

Fish premix (each 2.5kg contains)

* Vitamin 8,000,000IU	Vitamin D_3 1,600,000 I.U
Vitamin E 6,000 I.U	Vitamin K 2,000 mg
Thiamine B_1 1,5000mg	Riboflavin B_2 4,000 mg
Pyriodoxine B_6 1,5000mg	Niacin 15,000mg
Vitamin B_{12} 10m_g	Pantothenic Acid 5,000mg
Folic Acid 500mg	Biotin 20mg
Choline Chloride 200g	Antioxidant 125g
Manganese 80g	Zinc 50g
Iron 20g	Copper 5g
Iodine 1.2g	Selenium 200mg
Cobalt 200mg	

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

Parameters	Mean ± S.D	Range minimum maximum		
		Minimum	-	Maximum
pH	6.56 ± 0.41	6.60	–	8.55
Dissolved oxygen (mg/l)	5.71 ± 1.74	4.99	–	7.10
Temperature (^oC)	28.14 ± 0.11	27.11	–	29.14
Nitrite (mg/l)	0.0039 ± 0.01	0.0010	–	0.0054
Ammonia (mg/l)	0.35 ± 0.01	0.30	–	0.46
Total hardness (mg/l)	50.11 ± 10.12	46.05	–	80.08

Table 3 presents the proximate composition and other chemical contents of the experimental diets. The proximate composition values are as follows: moisture content ranged from 10.10 to 10.86%, crude protein, 40.84 to 41.74% fat ranged from 7.57 to 8.03%, nitrogen (N) from 6.54 to 6.68% and phosphorus (P) ranged from 0.63 to 0.70%. Ash ranged from 10.91 to 11.10% and nitrogen free extract (NFE) ranged from 6.51 to 6.08%. For the minerals, the highest level of calcium (1.54%) was observed in diet C_{66} while the lowest value (1.46) was obtained in the control diet (A_o). The values for magnesium (Mg) ranged from 0.87 to 0.91%, potassium (K) from 1.62 to 1.70% and sodium from 241.75 to 302.90ppm.

Table 4 contains the mean values of growth, nutrient utilization parameters and survival of the experimental hybrid catfish. The table show that the level of inclusion of whole cassava root meal (WCRM) impacted significantly ($p<0.05$) on the final weight of the fish fed the diets with the highest value (12,782.76±601.21g) being observed in diet C_{66} and the least value (9008.42±601.21g) observed in diet (A_o). Although treated fish did better than the control (A_0), however, (diet D_{100}) which is 100% replacement of maize with WCRM had the least final weight (9524.08±601.21g) compared with the other treatment levels (Table 4). Substitution with WCRM significantly enhanced ($p<0.05$) the weight gained by hybrid catfish above the control (A_0). Diet C_{66} had the highest value (12,641.43±312.66g), while diet D_{100} substitution, recorded the lowest (9,396.95±312.66g). The feed intake for the treatments indicate that diet B_{33}, had the highest value (30172.20±306.14g), while the lowest value (20182.74±306.14g) was recorded in diet A_0.

The highest daily weight gain (DWG) of 75.83±10.78 was recorded in diet B_{33} and the lowest (52.61±10.28) in diet A_0. The DWG of control diet and that of D_{100} were almost similar, but significantly different ($p<0.05$) from that of B_{33} and C_{66} . However, there was no significant difference ($p>0.05$) between diet B_{33} and diet C_{66}.

The response of absolute growth rate to dietary treatments was best in diet B_{33}, followed by diet C_{66}, A_o and least in diet D_{100} giving the following trend, $B_{33}>C_{66}>A_o>D_{100}$ (Table 4). The 33% and 66% replacement level increased the Absolute Growth Rate (AGR) of experimental fish better than the control diet.

The values of feed conversion ration (FCR) in dietary treatment indicated that diet A_o, and D_{100} had the highest value of 1.85±0.04 while the lowest value was recorded in diet C_{66}. The trend for FCR was $A_o > D_{100} > B_{33} > C_{66}$. However, the values presented did not show any significant differences.

Responses of GFCE to dietary treatment in experimental fish followed a particular trend, diets B_{33}>C_{66}>D_{100}>A_{10} with the highest value 76.69±5.61 in B_{33} and lowest value 62.05±5.6 recorded in diet A_o.

The protein intake by hybrid catfish indicated that diet B_{33} had the highest value (12259.85±366.11) while the lowest value (8271.60±306.11) was observed diet A_o. The responses of protein efficiency ratio (PER) to dietary treatments in hybrid catfish fed whole cassava root meal at different levels showed that there was no significant difference (p>0.05) between the four diets and are within the range 1.54-1.91. Among the dietary treatments the highest survival (87.45±2.11%) was recorded in diet C_{66}, while the lowest (75.80±2.11%) was observed in diet D_{100}. However, there was no significant difference (P > 0.05) between diets C_{66} and B_{33}.

Table 3: Proximate Composition mineral content and cyanide levels of the experimental diets

Parameters	Experimental diets			
	A_o(control)	Diets 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)	0.00	0.02	0.04	0.09

Mean within the row with different superscripts are significantly different (p<0.05)

Table 4: Responses of Growth, Nutrient Utilization and Survival Parameters to Dietary Treatments in *C gariepinus* fed Cassava Meal at Different Levels. (Mean ± s.e)

Growth Parameters	Experimental diets			
	A_0	B_{33}	C_{66}	D_{100}
Initial weight (g)	141.66±4.15[a]	141.66±4.15[a]	141.66±4.15[a]	141.66±4.15[a]
Minimum weight (g)	1.92±0.56[a]	1.92±0.56[a]	1.92±0.56[a]	1.92±0.56[a]
Final weight (g)	9008.42±601.21[d]	12226.25±601.21[b]	12782. ±601.21[a]	9524.08 ±601.21[c]
Mean final weight (g)	191.52±6.12[a]	210.41±6.12[a]	217.33±6.12[a]	201.38±6.12[a]
Weight gain (g)	8866.75±312.66[d]	12057.75±312.66[b]	12641.43±312.66[a]	9396.95±312.66[c]
Mean weight gain (g)	188.92±30.12[a]	207.38±30.12a[a]	213.41±30.12[a]	188.37±30.12[b]
Feed input (g)	29182.74±306.14[a]	30172.20±306.14[a]	29470.68±306.14[a]	21125.95±306.14[a]
Daily weight gain (g)	52.61±10.28[b]	75.83±10.28[a]	75.78±10.28[a]	53.94±10.88[b]
Mean daily weight gain (g)	1.09±0.12[a]	1.58±0.12[a]	1.55±0.12[a]	1.12±0.12[b]
Feed conversion ratio (FCR)	1.85±0.04[a]	1.74±0.04[a]	1.71±0.04[a]	1.85±0.04[a]
Gross feed conversion Efficiency (GFCE)	62.05±5.161[c]	76.69±5.161[b]	68.95±5.161[b]	62.78±5.161[c]
Protein intake	8271.60±306.11[c]	12259.85±306.11[b]	12975.88±306.11[c]	8633.80±306.11[c]
Protein efficiency ratio (PER)	1.54±0.11[a]	1.91±0.11[a]	1.98±0.11[a]	1.63±0.11[a]
Survival	76.26±2.11[b]	84.84±2.11[a]	87.45±2.11[a]	75.80±2.11[b]
Nitrogen Metabolism (NM)	9602.78±314.12[c]	10247.24±314.12[b]	10782.98±314.12[a]	10060.08±314.12[b]

Means within the row with different superscripts are significantly different (p<0.05)

DISCUSSION

Carbohydrate either of cereal or tuber in fish feed acts as both structural and energy component (Burret *et al.,* 1997), which have some influence on the rate of growth of fish provided all other physiological requirements are satisfied (Carter *et al.,* 2003).

The crude protein of cassava root meal reported in this study was in line with the one reported by Olurin *et. al,* (2006). The lipid content of the cassava root meal used in this work is also close to the range 7.00 - 8.20% for cassava and rice grain meal employed by Ufodike and Matty, (1984) in the diet of rainbow trout.

The growth pattern revealed that hybrid catfish performed in diet C_{66} than al other diets. It has been documented that 50% replacement of maize with cassava meal in broiler diet showed no depression in growth or unfavourable feed conversion ratio (Essers *et al.,* 1995) and that the best growth performance was recorded in layers fed 10% cassava meal. This work indicated that hybrid catfish can utilize cassava meal better than broiler because even at 100% replacement of maize higher weight gain was observed over the control without cassava. Olurin *et. al.* (2006) reported a replacement level of 50% cassava meal for maize without a depressing growth in *Claria gariepinus*. In the present study the best growth performance and nutrient utilization was recorded in fish fed 66% level of whole cassava root meal. This implies that high inclusion levels of whole cassava root meal in the diet of hybrid catfish favours enhanced growth rate. This is unlike in broiler and tilapia that had the best growth performance at 25%, and 50% cassava root meal inclusion levels respectively (Ernersto, et al., 2000).

The differences in growth observed between the experimental diets are indication of the variation in the feed utilization. The reports of Carter *et al.* (2003) for Atlantic salmon (*Salmon salar*) and Ernesto *et. al,* (2002) are at variance (that is contrary) to the report of this study. These workers recorded better feed conversion ratio and feed acceptability in the control diet (without cassava). The acceptance of cassava by hybrid catfish, indicate that replacement of maize with cassava could be more profitable to fish farmer as maize is more expensive than cassava.

Ability of an organisms to convert nutrients especially protein will positively influence its growth performance. This was justified by the best protein efficiency ratio and growth performance in 66% whole cassava root meal inclusion diets lower feed conversion ratio indicates better utilization of the feed by the fish. According to DeSilva (2001) feed conversion ratio is between 1.2-1.8 for fish fed carefully prepared diets, and the results from the present study falls within this range. Also, Davis (2004) observed that protein efficiency ratio, is a measure of how well the protein sources in a diet could provide the essential amino acid requirement of the fish fed. Furthermore, this index has been associated with fat deposition in fish muscle. The nitrogen metabolism recorded in the study corroborates the report of Sugiura *et. al.,* (2000) on rainbow trout, to the effect that replacement of maize with cassava does not impair the functional metabolism of the fish and hence results in enhanced growth.

The high survival rates recorded in this study indicate that feeding hybrid catfish with cassava root meal does not leads to mortality of the fish. This may probably be due to the substantial reduction in the cyanide content, (by boiling and drying) of the whole cassava root meal. Cardoso *et al.,* (2005) observe that good processing of cassava enhance survival and healthy state of fish at all stages of their life.

CONCLUSION

Based on the results obtained in this study, inclusion of whole cassava root meal in the diet of hybrid catfish enhanced growth and survival of the fish. Hence fish farmers can therefore take advantage of this ingredient as a replacement for more expensive maize when formulating feed for fish in aquaculture.

REFERENCES

Akinfala, E. O. and Tewe, O. O. (2001). Utilization of whole cassava plant in the diets of growing pigs in the tropics. *Livestock Res. Rural Development.* 13:5-12.

Akinrotimi, O. A., U. U. Gabriel, P. E. Anyanwu, and A. O. Anyanwu (2007b). Influence of sex, acclimation methods and period on haematology of *Sarotherodon melanotheron*. Res. J. *Biol. Sci.* 2(3):348-352.

Akinrotimi, O. A., U.U. Gabriel, N.K. Owhonda, D. N. Onukwo, J. Y. Opara, P. E. Anyanwu and P. T. Cliffe (2007a). Formulating an environmentally friendly fish feed for sustainable aquaculture development in Nigeria. *Agric. Journal.* 2(5):606-612.

AOAC, (1990). Official methods of the Association of Official Analytical Chemist. Vol. II Washington, USA 1434pp.

APHA, (1985). Standard Methods for the examination of waste water (16^{th} Edition), Washington, American Public Health Association, 360pp.

Baruah, K. Sahu N. P. and Debnath D. (2003). Dietary phytase: An ideal approach for a cost effective and low polluting aquafeed. NAGA, 27(3):15-19.

Booth, M.A. and Allan, G.L (2003). Utilization of digestible nitrogen and energy from four agricultural ingredient by juvenile silver perch. *Aqua Nutr.* 9:317-326.

Brown, M.E (1975). Experimental Studies on Growth. The physiology of fishes. In: Brown M.E. (ed). Vol. I Academic Press, London 401pp.

Burret, C., Robin, J and Boujard, T. (1997). Can turbot., *Psetta maximum* be fed with self-feeders? *Aquat. Living Resour:* 10:381-384.

Cardoso, A. P., Mirione, E, Ernesto, M. Massazer, F., Cliff J., Haque, R. M. and Bradbun, H. J. (2005). Processing of cassava roots to remove cyanides. *J. Food Comp. Analysis* 18:451-460.

Carter, C. G., Lewis T. E. and Nicholas, P. D. (2003). Comparison of cholesterol and sodium oxide as digestibility markers for lipid components in Atlantic salmon (*Salmon salar*) diets. *Aquaculture* 225:341-351.

Davis, A.R. (2004). Correlation of plasma IGF-I concentrations and growth rate in aquacultured finfish: a tool for assessing the potential of new diets. *Aquaculture* 236:583 – 592.

De Silva, S. S. (2001). Performance of *Oreochromis niloticus* fry maintained on mixed feeding schedules of different protein levels. Aquac. Fish. 16:621-633.

Duncan, D.B (1995). Multiple range and multiple f-test *Biometrics.* 11:1-42

Ernesto, M., Cardoso, A.P., Nicala, D. Mineone E., Massasa F., Cupp, J., Haque, R. M. and J. H. Brasubry (2002). Persistent Konzo and cyanogens toxicity from cassava in Northern Mozambique. *Acta. Tronica,* 82:357-360.

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

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

Eyo, A. A. (2003). *Fundamentals of fish nutrition and diet development* in: A. A. Eyo (eds) National workshop on fish feed development and feeding practices. 80pp.

Eyo, A. A. (2004). Fundamentals of fish nutrition and diet development an overview. Pp. 1-33. In A. A. Eyo (ed). National workshop on fish feed development and feeding practices in aquaculture NIFFRI, Newbussa 15th to 19th September, 2003. 65pp.

Fagbenro, O. A. (1992). Utilization of Cocoa pud husk in low diets cost by *Clarias isheriensis,* (Syhenham). *Aquaculture.* 4:175-182.

Falaye A. E. (1988). Utilization of cocoa husk in the nutrition of tilapia (*Oreochcromis niloticus*). Ph.D. Thesis University of Ibadan, Nigeria. 260pp.

FAO (2006). *State of world aquaculture* FAO *Fisheries Technical paper,* No. 500. Rome, 134pp.

Faturoti, E. O. and Akinbote, R. E. (1986). Growth responses and nutrient utilization in Oreochromis niloticus fed varying levels of dietary cassava peel. *Nig. J. Appl. Fisheries* and *Hydrobiol.* 1:47-50.

Faturoti, E. O., Balogun, A. M. and Ugwu, L. L. C. (2002). Nutrient utilization and growth responses of clarias (*Clarias lazera*) fed different dietary protein levels. Nigeria *Journal of Applied fisheries and Hydrobiology* 1:41-45.

Gabriel, U. U., A. O. Akinrotimi, P. E. Anyanwu, D. O., Bekibele and D. N. Onunkwo (2007). Locally produced fish feed; potential for aquaculture development in Africa. *J. Agric.* 20(10):536-540.

Halver, (1976). Formulating Practical diets for fish. *Fish Res. Board Canada.* 33:1032 – 1039.

IITA (1990). *Cassava in tropical Africa. A reference manual.* International Institute of Tropical Agriculture. Ibadan. Nigeria. 176pp.

Jamiu, D. M., and Ayinla O. A. (2003). Potential for the development of Aquaculture in African *NAGA* 26 (3):9-13.

Khajarem, S; Hutanu W; Khajeres, J; Panit, N; Phalaraksh, R and Terapuntuwat, 3 (1986). The improvement of nutritive and economic value of cassava root products. 1985 Annual Report to IDRC, Ottawa, Canada. 30pp.

Lovell, R.T. (1972). Feeding practices for Channel Catfish. *Fish. Ann. Rep. Alg. Agric. Exp. Sta.* Ausson University. 37pp

Lovell, R.T. (1987). Nutrition and Feeding of Fish. AVI book published by Van M. Nostrand, Reinloll, New York, 260pp.

Oke, O. L. (2007). Problem in the use of cassava as animal feed. *Anim. Feed. Sci. Tech.*3:345-350.

Olatunde, A. A. (1996). Effect of supplementation of soyabean diet with L and D, L. methionine on the growth of mud fish *Clarias anguillaris Nig. J. Biotech.* 9(1):9-16.

Olukunle, O. (2006). Nutritive potential of sweet potato peel meal and root replacement value for maize in diets of Africa catfish (*Clarias gariepinus*) advanced fry. *J. Food Tech.* 4(4):289-293.

Olurin. K. B., E. A. A. Olujo and O. A. Olukoya (2006). Growth of African catfish *Clarias gariepinus* fingerlings, fed different levels of cassava. *W. J. Zool* (1):54-56.

Oresegun A. and Alegbeleye W. O. (2001). Growth response and nutrient utilization of Tilapia oreochromis niloticus fed varying dietary levels of cassava peels based on ratio supplemented with di-methinine Fish. *J. P.RH Murt.* 20(2): 120-126.

Oyelese, O.A. (2007). Utilization of Processed Snail meal and Supplementation with conventional fish meal in the diet of *Clarias gariepinus J. Fish. Intl.* 2(2):140 – 146.

Pedrosa, G. J. (2002). Evaluation of cassava as potential energy source in animal feed. *Livestock Res. Rural Dev.* 10(4):11-16.

Presston, T. R. (2004). Potential of cassava in integrated farming systems. *Livestock Res. Rural dev.* 10(8):20-28.

Salami, R. I. (2000). Preliminary studies on the use of parboiled cassava peel meal as a substitute for Maize in Layers. *J. Aquat Nut.* 10:20-30.

Stickney, R.R (1980). Role of nutrition in Channel catfish farming. *Southern Cooperative Series Bull.* 14:273-280.

Stickney, R.R. (1980). Lipid requirement of some warm water species. *Aquculture* 79:145-156.

Sugiura, S. H., Babbit, J. K. Dong. F. M. and Hardy R. W. (2000). Utilization of fish and animal by-product meals in low-pelleted feeds for rainbow trout. *Aquac. Res.* 31.585-593.

Talthawan. B. E., O. Lic and L. Froyland (2002). Lipid metabolism and tissue composition in Atlantic Salmon (*Salmo salar*) effects of capelin oil, palm oil and oleic enriched sunflower oil as dietary lipid sources. *Lipids* 35:653-664.

Tewe, O.O. (2004). Cassava for Livestock feed in sub-sahara Africa. F.A.O. Rome Italy. 64pp.

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

Ufodike, E. B. C. and Matty. A. J. (1983). Growth responses and nutrient digestibility in mirror carp (*Cyprinus carpio*) fed different levels of cassava and rice. *Aquaculture* 31:41.

Wee, K. L. and Ng. L. T. (1986). Use of cassava as an energy source in a pelleted feed for tilapia *Oreochromis nicoticus* L. *Aquaculture and fisheries management.* 17:129-138.

Zeitrun, I.H., Tack, I., Halver, J.E. and Ulrey D.F. (1973). Influence of Salinity on protein requirements. *J. Fish Res. Boane Can.* 30:1867 – 1873.