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The Effect of Replacing Maize with Whole Cassava Root Meal on the Nutrient Utilization of Hybrid Cat Fish

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Abstract: The effect of replacing maize (*Zea mays* L) with whole cassava root meal (*Manihot esulata* crantz) in the diet of hybrid catfish (*Heterobranchus bidorsalis*, *Clarias gariepinus*) on the nutrient utilization parameters namely feed conversion, ratio, Gross feed conversion and nitrogen metabolism protein intake and protein efficiency ratio of the fish were assessed. The result from the study indicated that the best Feed Conversion Ratio (FCR) 1.1-10.04. Gross feed conversion efficiency GFE 68.95±314.12 g kg^{-1} were observed in the diet $C_{66.}$ However, the nutrient utilization variable varied significantly ($p<0.05$) within the treatment period. From the result obtained in this study, it could therefore be concluded that whole cassava root meal can replace maize in the diet of hybrid catfish without any negative effect on its ability to utilize nutrient needed for proper metabolism and growth.

Key words: Maize, nutrient, utilization, protein, efficiency ratio, hybrid cat fish, metabolism, feed conversion

INTRODUTION

The essential nutrient requirements of fish are proteins, lipids, carbohydrates, vitamins and minerals. It should be noted that knowledge of the protein requirement of fish is essential for the formulation of a well-balanced artificial diet for economical fish feeding (Lovell, 1989; De Silva, 2001; Omoniyi and Fagade, 2003). Protein requirement is linked with the general energy requirement of the fish at a given water condition and the ability of the fish to gain weight at its inherent capacity (Eyo, 2003). According to Gabriel and Keremah (2003), protein and energy levels significantly influence food conversion effect of Heterobranchus bidorsalis however, the efficiency was not high enough to influence carcass composition and condition of fish. According to Falaye (1992), the nutrient requirements of fish depend on the age, species, production function and environmental condition. In fish feed formulation protein and energy requirements of the species under culture is highly considered above all other nutrients (Otubusin, 1987; Olufeagba *et al*., 2002).

Fish have a lower dietary energy requirement because they do not have to maintain a constant body temperature, as they exert relatively less energy to maintain position and to move in water than do mammals and birds on land (Hardy, 1999; Jiang, 2001). Also they excrete most of their nitrogenous wastes as ammonia instead of urea or uric acid, thus losing less energy in protein catabolism and excretion of nitrogenous wastes (Williams *et al*., 2003).

Providing the optimum energy level in diets for fish is important because an excess or deficiency of useful energy can result in reduced growth rates. This is because energy needs for maintenance and voluntary activity must be satisfied before energy is available for growth; dietary proteins will be used for energy, when the diet is deficient in energy in relation to protein (Thomas and Vanderpoel, 2001). On the other hand, when fish are fed for maximum growth rate, a diet containing excess energy can prevent the utilization of the necessary protein and other nutrients, the fishes like mammals and birds eat primarily to satisfy their energy requirements (Vilhelmission *et al*., 2004).

Energy requirement for fish may be determined by measure of calorie or by growth response. Suguira *et al*. (2000) determined energy expenditure for weight increment and maintenance for rainbow trout by direct calorimetric measure. Energy required for growth, when determined can be added to these values to derive Metabolisable Energy (ME). Warm water fish utilize protein, carbohydrates (sugars, dextrin and starches) and

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triglycerides effectively as energy sources (Andrew *et al*., 1978; Watanabe *et al*., 1996; Sorenson *et al*., 2002). Concentrated-protein feedstuffs are higher for fish than for farm animals (Hybourne and Carter, 1999) because of the lower energy loss in excretion of nitrogenous wastes. Evidence that common carp and channel catfish are more efficient in utilizing high levels of carbohydrates has recently been presented by Francis *et al*. (2001) and Glencross *et al*. (2007). Channel catfish fed a high carbohydrate diet exhibited marked stimulation of several lipogenic enzyme activities in both liver and mesenteric adipose tissues (Hardy, 1999; Glencross *et al*., 2006; Eyo, 2003), evaluated the ability of catfish *Clarias gariepinus* to use starch as an energy source, which gave rise to protein sparing effect and allowed the fish to use a higher percentage of the protein component to meet the amino acid requirements. In addition to energy supply, carbohydrates have the physical functions of texturizing manufactured feeds and acting as a binder in the formulation of both compressed and expanded diets (Fabenro *et al*., 2003).

In Nigeria, like most parts of the world Eyo (2003), observed that cereal such as maize is a major source of carbohydrates in fish feed formulation. Their shortages have therefore, resulted in astronomical increases in the price of grains in the last decades. Therefore, there is the need to source for a cheaper, reliable source of energy in formulating fish feeds.

Cassava production has been rising steadily in many African countries and its availability can only be matched with competitive pricing to make its use in animal feeds feasible. It has been estimated that between 5 and 10% of annual cassava production in Nigeria is used in commercial feed milling, while the bulk of the residues from human food processing goes into feeding of livestock kept as homestead (Tewe *et al*., 2002). Cassava is now being used in various forms in Nigeria's livestock and food industry.

This study therefore, is aimed at assessing the effects of replacing maize with whole cassava root meal on the nutrient utilization of hybrid cat-fish, a popular fish for culture in Nigeria, which hitherto has not been reported.

MATERIALS AND METHODS

Feed formulation: Fresh whole cassava root sweet specie (Manihot esculenta crantz) were harvested from cassava mosaic disease resistant farms at International Institute for Tropical Agriculture (IITA), Onne, Rivers State. They were washed and blanched for 5 min in boiling water at 100°C to remove cynogenic glycoside of cassava. The blanched cassava roots were chipped, dried and blended to a meal. The meal was then incorporated in the diets at various level of maize replacement. These diets were formulated and designated A_0, B_{33}. C_{66} and D_{100} (Table 1). Diet A_0, 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.

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 (₦ 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

Experimental set up: The experimental fish were obtained from Ellah lakes fish farm Obrikom, Rivers State, Nigeria. The initial average weight of fish ranged from 4.35-4.63 g. A total of 900 fingerlings of Hybrid catfish were randomly distributed into 8 tanks (45 fish per bowl) after which acclimation was done 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 2 weeks. Initial proximate composition of fish samples were determined according to AOAC (1990) methods.

Experimental procedure: At the end of acclimatization, fish in each bowl were weighed to determine the initial mean weight of fish in each bowl. The test diets were introduced after the mean body weight of the fish had been determined. Feeding was done at 8:00 am and 6:00 pm (i.e., twice daily) at a rate of 5% of the total body weight of the fish in each tank per day. While the excess feeds that were not fed to the fish were extrapolated and deducted from the initial quantity of feed weighed out on a daily basis. Fish in each tank were weighed weekly and the readings obtained were used to compute the Feed Conversion Ratio (FCR), Gross Feed Conversion Ratio (GFCR) Nitrogen Metabolism (NM), protein intake and Protein Efficiency Ratio (PER).

At the end of the experiment, two fish were randomly taken from each tank for final proximate analysis of the fish for crude protein, either extract (fat), crude fibre, ash and moisture using the AOAC (1990) methods.

Monitoring of physico-chemical parameters: Some physico-chemical factors monitored on weekly basis during the experiment period include temperature in °C, pH, Dissolved Oxygen (DO) in mg L^{-1} using the methods of APHA (1985). Ammonia, total hardness and nitrite.

Nutrient utilization parameters: The following nutrient utilization parameters were calculated to monitor the effectiveness and utilization of nutrients in the diets by hybrid cat-fish as maize was gradually replaced with whole cassava root meal.

Protein Efficiency Ratio (PER): This was calculated from the relationship between the increase in the body weight of fish (i.e. the weight gain of fish) and protein consumed according to the methods of Zeitoun.

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

$$PPV = \frac{\text{Increment of body protein}}{\text{Protein intake}}$$

Feed Conversion Ratio (FCR):

$$FCR = \frac{\text{Feed intake}}{\text{Wet weight gain}}$$

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

Gross Efficiency of Food Conversion (GEFC):

$$\text{Gross effiiciency of food conversion} = \frac{\text{Daily rate of growth}}{\text{Daily rate of feeding}}$$

Gross Food Conversion Efficiency (GFCE%): This was calculated as the reciprocal of the food conversion ratio, expressed as a percentage (Stickey, 1980).

$$\text{Gross Food Conversion Efficiency (GFCE\%)} = \frac{1}{FCR} \times \frac{100}{1}$$

Protein Intake (PI): This was determined from the proportion of protein content in the total feed.

$$\text{Consumed PI} = \frac{\text{Total feed consumed} \times \text{Percentage protein}}{100}$$

Statistical analysis: Analysis of Variance (ANOVA) was carried out to test significance of the treatments on the fish growth rate pattern within the study period and level of significance was determined using the Duncan Multiple range test according to statistical methods of Wahua (1999).

RESULTS

The results of the physico-chemical parameters of water in the experimental tanks indicated that the pH ranged between 6.60-8.55, Dissolve oxygen 4.99-7.10 mgIl, temperature 27.11-29.14, while the nitrite values ranges between 0.0010-0.0054, ammonia ranges between 0.30-0.46 and total hardness 46.05-80.08 (Table 2). The proximate and mineral compositions of experimental diets were within the same range in all the

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

Parameters	Mean±SD	Range minimum maximum
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 composition of experimental diets

	Experimental diets			
Parameters	A_0 (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

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

formulated diets. There was no significant difference in all the proximate and mineral parameter, except in the value of sodium, which tend to decrease as the level maize replacement with whole cassava root meal in the diets increased (Table 3).

The FCR for the various diets were very variable particularly from the 2nd to the 14th week and became less variable from the 15th week. Diets 1 and 4 appeared to do better than 2, 3 up to the 10th week. However, from the 16th week the FCR of diets 1 and 4 generally declined below that of 2 and 3. After which also diet 2 did better than all, followed by C_{66} (Fig. 1). The effect of dietary treatment on Gross feed conversion efficiency in hybrid catfish is shown in Fig. 2. The graph indicated that

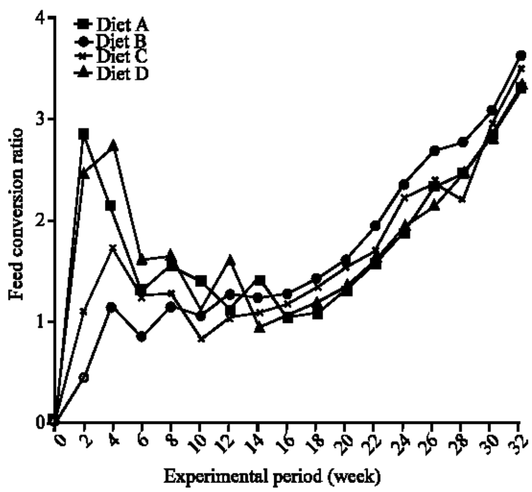

Fig. 1: Effects of replacement of maize with whole cassava root meal on the feed conversion ratio of hybrid catfish

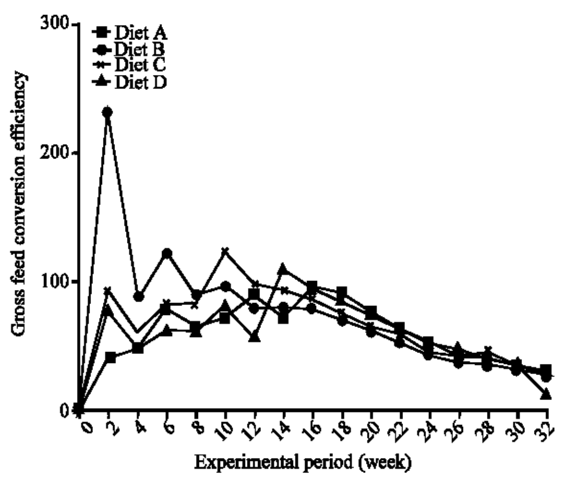

Fig. 2: Effects of replacement of maize with whole cassava root meal on the gross feed conversion efficiency of hybrid catfish

diet B_{33} had the highest value in week 2 and diet A_0 and D_{100} both had the lowest. The graph indicated a pattern in which all the dietary treatments decreased towards the right hand side, with the lowest value obtained in diet D_{100} (Fig. 2).

Protein intake: In all the diets, the protein intake by the experimental fish improved with time (Fig. 3). The pattern of PER for diets 1, 4 and 2, 3, respectively were very close during the feeding period.

Protein Efficiency Ratio (PER): The effects if dietary treatment on PER in hybrid catfish is shown in Fig. 4. The graph indicated weekly variation in all the four diets, with the trend of decreasing as the number of weeks increased.

At week 2 the highest value was observed in diet B_{33} and the lowest value in diet D_{100}. The lowest value in all the four diets were observed in week 32 (Fig. 4).

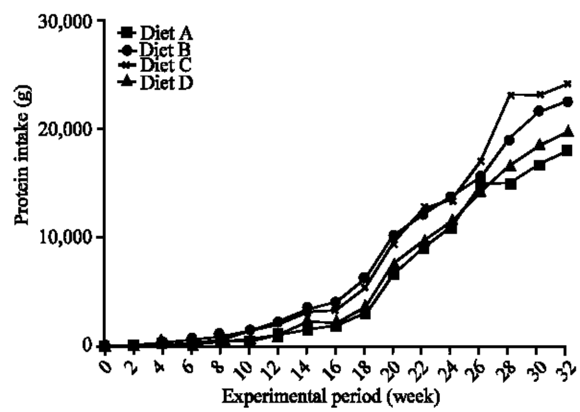

Fig. 3: Effects of replacement of maize with Cassava on the protein intake of hybrid catfish

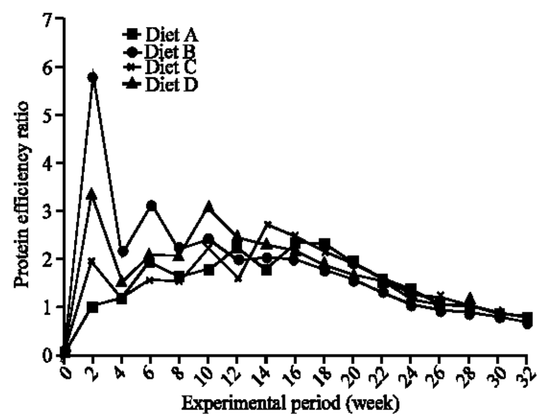

Fig. 4: Effects of replacement of maize with whole cassava root meal on the protein efficiency ratio of hybrid catfish

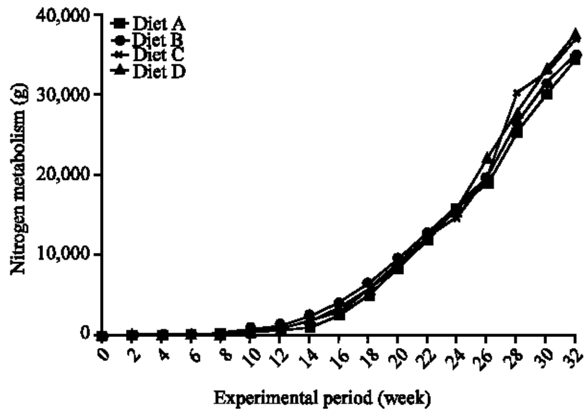

Fig. 5: Effects of replacement of maize with whole cassava root meal on the nitrogen metabolism of hybrid catfish

Nitrogen Metabolism (NM): The responses of nutrient metabolism to dietary treatment in hybrid catfish fed whole Cassava Root Meal (WCRM) at different levels indicated a trend in which diet of $C_{66}>B_{33}>D_{100}>A_0$ indicating a significant difference ($p<0.05$) between treated diets and control (Fig. 5).

DISCUSSION

The decrease in the rate of feed input relative to the increase, in the inclusion levels of whole cassava root meal in the experimental diet is in line with the findings of Charlorklany *et al.* (2002) in channel catfish, Italurus punctatus fed with varying levels of cassava root meal as replacement of maize. This seems to suggest that increasing amount of WCRM affected palatability negatively which in turn leads to low feed intake. This may be as a result of low fat in the diet, which reduces the palatability as the inclusion levels of cassava root meal increases. The poor palatability generally associated with high tannin diets (Cassava products) are ascribed to its astringent property, which is a consequence of its ability to bind with proteins of mouth fluid (saliva) and mucosal membranes (Mehansho *et al.*, 1987).

Viola *et al.* (1988) reported similar FCR values in Rainbow trout and common carp (*Cyprinus carpio*) at about the same level of inclusions (33 and 66%). The values obtained in this study were higher than those obtained by Faturoti and Akinbote (1986) in Oreochromis niloticus fed at varying levels of cassava root meal but lower than that obtained by Jinyasatapom *et al.* (2000) in *C. gariepinus*. These variations observed may have risen from differences in species, inclusion levels and culture systems. Gross feed conversion efficiency, which is a basis for assessing feed utilization i.e. the conversion of feed into body tissues was best in diet B_{33} and C_{66}. This result agrees with earlier report by Tacon (1990) to Pacu (*Piaractus mesopotamicus*).

The utilization of protein corresponded positively with protein intake suggesting that the higher the protein intake the higher the protein utilized since protein consumed in excess of requirement would be deaminated and voided in feaces. This observation confirms an earlier report by Mantaldo (1977) in Coho Salmon fed with varying levels of cassava meal.

The nitrogen metabolism values for the treatment increased significantly in the treatment diets but declined in diet 4, an indication that WCRM as a nitrogen source had good digestibility index and if properly consumed with veritable protein sources, may produce comparable nitrogen utilization with conventional nitrogen sources of acceptable standards.

CONCLUSION

From the results obtained in this study, it can be concluded that whole cassava root meal can completely replace maize effectively in the diet of hybrid catfish with no negative effect in protein utilization. It could therefore, be recommended that fish farmers can use whole cassava root meal to replace maize for optimal performance at 66% level of replace for the growth and expansion of aquaculture industry.

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