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Processed Cocoyam Tuber as Carbohydrate Source in the Diet of Juvenile African Catfish (*Clarias Gariepinus*)

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Abstract

One hundred and forty seven juveniles of *Clarias gariepinus* of mean weight 50.00g were randomly stocked at 7 juveniles per tank of dimension 52.5cm x 33.5cm x 21cm and fed six iso-nitrogenous diets containing graded level of raw and differently processed cocoyam tuber at 25% and 50% substitution levels for maize meal over a period of 56 days.

The result of the experimental treatment showed mean weight gain, relative growth rate (RGR) and the specific growth rate (SGR) had the highest values recorded for the control diet (72.3±2.67, 82.1±2.34 and 0.6±0.11), then 25% boiled cocoyam diet (54.4±3.67,73.6±2.36 and 0.49±0.13) and the least values for the 50% fermented cocoyam diet (24.0±1.32, 41.1±1.76 and 0.27±0.06). The best feed conversion ratio (FCR) andprotein efficiency ratio (PER) were recorded for the control diet while the least values were recorded for the 50% fermented diet. The boiled cocoyam when compared to the raw and fermented cocoyam at both 25% and 50% level resulted in better mean weight gain, FCR and PER. The highest feed cost ($1.144±0.07) was recorded for the control diet and as observed cost of feed decreases with cocoyam inclusion level (0.98-1.00$). Heamoglobin(Hb) and packed cell volume (PCV) increased as a result of processing of the cocoyam meal, converse trend was observed for the lipid protein and cholesterol. All blood parameters measured were significantly lower in the unprocessed cocoyam meal diet in comparism to the control diet.

Keywords: Cocoyam, maize feed utilization, growth.

Introduction

Carbohydrates are used in fish diet primarily as energy source and for their binding properties. It can be added in excess of the amount that can be efficiently utilized for energy by the fish (Krogdahl *et al*, 2005). Carbohydrates are important in formulated diets because they are cheaper than lipids and protein and a knowledge of the optimal level of protein and protein sparing effect on dietary carbohydrate may be useful in reducing the cost of fish feed.

Diets used in fish farming contain highly variable amounts of carbohydrates depending on the cultivated species. Fish species differ greatly in their ability to digest carbohydrates; this variability reflects anatomical and functional differences of the gastrointestinal tract and associated organs. Even within fish species we find carbohydrate content of diets vary substantially.

Although grains and grain products are the main carbohydrate sources in the diets of cultivated fishes and other livestocks {Darunna 2000}, an attempt at fulfilling the energy requirement of livestock through the use of root and tubers could probably ameliorate the stiff competition with cereals and grains (Agbede *et al* 2002). Furthermore to meet up with annual increase of fish production, research should be targeted towards the use of alternative or unconventional feed ingredients such as root and tubers which could probably improve the feed water stability and nutrient retention, increase efficiency of digestibility and reduce cost of fish feed production (Falayi, *et al*., 2003 and 2004).

The production of cocoyam otherwise called Taro is low compared to the other roots and tubers (Fagbenro and Adebayo, 2002) but its superiority in terms of digestibility of starch (98.8%), the size of starch grain (1/10th of potato), the sulphur amino acid and price per tonne makes it a better choice than cereals in fish feed production (Hahn 1984, Ezedinma 1987). Cocoyam has been found to contain calcium oxalate crystal, phytate, tannins and saponins (Agwunobi *et al* 2002) which effect could be minimize by boiling, baking and fermentation to make cocoyam an excellent source of carbohydrate, vitamins and minerals.(Abdulrashid and Agwunobi 2009)

Clarias gariepinus (Burchell, 1822) is one of the most suitable aquaculture species in Africa. This catfish has been credited for being hardy, resistance to handling stress, omnivorous, better growth and feed conversion abilities (Eyo *et al*., 2004). The high quality and better taste of its flesh makes it a highly demanded fish; hence there is a need to increase the local production of this species at cheaper production cost (Sogbesan and Ugwumba 2008).

The aim of the present study was to evaluate the effect of substitution of maize with differently processed cocoyam tuber on growth, nutrient utilization and economic benefits of *C. gariepinus* juvenile.

Materials and Methods

Purchase and Processing of Feed Ingredients

The red cocoyam tuber (*Colocasia spp.)* used for this experiment was purchased from a local market located at Bariga market, Lagos state, Nigeria. Enough quantity was purchased at the start of the experiment to avoid problems associated with different batches of ingredients. Other feed ingredients were purchased from Sabina Pad Nigeria Limited, opposite Lagos State Abattoir, Oko-Oba, Agege, Lagos state, Nigeria.

Cocoyam tubers were peeled, sliced and divided into three different portions, the first portion was washed and sundried,the second portion was boiled and sundried, while the third portion was soaked for 4-5 days and then sundried for 3-4 days. Each of them were separated into different polythene bags and labeled Raw(R), Boiled (B) and Fermented (F) respectively. Each portion of processed cocoyam and other ingredients were ground separately into powder and stored for future use.

Graded levels of the differently processed cocoyam meals were substituted at 0% (control), 25% and 50% graded levels respectively for maize as shown in Table 1. Measured quantities of each ingredient were mixed and blended together and thereafter compressed using a pelletizing machine to

3mm size. It was then sundried to about 90% dry matter and stored for feeding.The seven diets are shown in Table 1.

Table 1: Feed composition of experimental diet (kg)

Diet	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6	Diet 7
	CWC	RC	BC	FC	RC	BC	FC
		25%	25%	25%	50%	50%	50%
Fish meal (72%)	25.0	25.0	25.0	25.0	25.0	25.0	25.0
SBM	35.6	35.6	35.6	35.6	35.6	35.6	35.6
Maize	35.0	26.2	26.2	26.2	17.4	17.4	17.4
Cocoyam	-	8.74	8.74	8.74	17.4	17.4	17.4
Methionine	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Premix	0.40	0.40	0.40	0.40	0.40	0.40	0.40
Oil	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25
DCP	2.0	2.0	2.0	2.0	2.0	2.0	2.0

Key: CWC=Control without Cocoyam, RC = Raw Cocoyam,BC=Boiled Cocoyam, FC=Fermented Cocoyam,SBM = Soybean meal , DCP=Dicalcium Phosphate

Values are the mean of triplicate groups of fish. Mean values with different letters in column were significantly different in the Ducan test ($p<0.5$).

Experimental Fish, Water Supply and Feeding

One hundred and fourty seven juvenile of *C. gariepinus* were brought to the nutritional laboratory of the Deparment of Marine Sciences, University of Lagos Nigeria, allow to acclimatise for a period of two weeks before the commmencement of the experiment. Fish were randomly allocated on the basis of body weight (50g) into twenty one plastic tanks (dimension 52.5cm x 33.5cm x 21cm) for the growth trials. Before the commencement of the feeding trial fish were starved for 24 hours to empty their gastro intestinal tract and each of the diets was fed thrice daily (9:00h, 1:00h and 17:00h) to satiation. Excess feed was siphoned an hour after every feeding, dried and weighed to estimate the actual feed intake per week. All the fish in each tank were weighed weekly interval after which the mean body weight was determined and feed intake adjusted accordingly. At the end of the experimental period, 2ml of blood was collected from the caudal peduncle of 2 fishes each per experimental diet according to the method of Joshi *et al.,* (2002a). The blood samples were then dispensed into heparinised bottles to prevent coagulation. The capillary tubes were micro-centrifuged to determine the percent hematocrit value and the hemoglobin (Joshi 2002a). Other blood parameters measured from the decanted plasma included plasma protein and cholesterol.

Data Computation

The weight gain record and feed consumed were computed every 7days and later used to calculate the growth, feed utilization and economic parameters.

Mean Weight Gain (g) = Mean Final Weight – Mean Initial Weight

Specific Growth Rate (SGR %/day) = $(\text{Log}W_2 - \text{Log}W_1) \times 100 / T_2 - T_1$,

where W_2 and W_1 = final and initial weight; T_2 and T_1 = final and initial time respectively.

Feed Conversion Ratio (FCR) = Feed fed (Dm) / Fish weight gain

Protein Efficiency Ratio (PER) = Mean weight gain per protein fed

Protein Intake (PI) = Feed intake x crude protein of feed.

Economic Estimates

Based on the price of each raw material ($) and the amounts that were required to make the different diets, we calculated the cost/kg of each diet. The raw material prices used were average prices during the experimental period, due to the fact that there may be significant changes throughout the year. The economic conversion ratio (ECR) was determined using the following equation, ECR = Cost of diet x Feed conversion ratio (Piedecausa *et al*., 2007).

Statistical Analysis

All the results were subjected to analysis of variance (ANOVA). Duncan multiple range test (Duncan, 1955) was used to evaluate the mean differences among individual diet at 0.05 significant level.

Results

The feed composition of experimental diets is shown in Table 1.The diets prepared from differently processed cocoyam and maize were isocalorific and isonitrogenious.Mean intial weight of the experimental fish were not significantly different (P>0.05) and no mortality was noticed throughout the experimental period. The feeding trials revealed that *C. gariepinus* responded to all the diets, the mean weight gain, relative growth rate (RGR) and the SGR had the highest value recorded on the control diet (72.3±2.67, 82.1±2.34 and0.6±0.11), which is only next to the 25% boiled cocoyam diet (54.4±3.67, 73.6±2.36 and 0.49±0.13) and the least significant value was recorded on the 50% fermented cocoyam diet (24.0±1.32,41.1±1.76 and 0.27±0.06). The best FCR and PER were recorded for the control diet while the least value of FCR and PER were recorded for the 50% fermented diet. The boiled cocoyam when compared to the raw and fermented cocoyam at both the 25% and 50% level had better mean weight gain, FCR and PER. The highest feed cost (1.144±0.07) was recorded for the control diet and as observed cost of feed decreases with cocoyam inclusion level (0.98-1.00$). Difference in cost of feed was also noticed among diet within same inclusion level of cocoyam as a result of variation in method of processing.Economic conversion ratio was lowest on control diet and highest on the 50% fermented diet.While heamoglobin(Hb) and packed cell volume (PCV) increased as a result of processing of the cocoyam,the converse was observed for the lipid protein and cholesterol. Between the 25% and 50% diets,cholesterol was found to increase at higher level of cocoyam inclusion while the PCV decreased along the same trend. All blood parameters measured were significantly lower in the unprocessed cocoyam meal diets in comparism to the control diet.

Discussion

The nutritional quality of cocoyam meal as determined by growth and economic indices observed in this study showed the adequacy of the diets at meeting the nutritional requirement of the fish under study.This is evident as a result of no mortality and improved weight gain in all the experimental fish during the feeding trial.

Processing conditions have great impact on starch digestibility (Allan *et al* 2000; Booth *et al* 2001). Beneficial effects of heat treatment are apparent even for the herbivorous fish (Erfanullah and Jafri 1998). Processing conditions vary widely, and comprise dehulling, concentration, heat treatment in pellet press or extrusion, heating under wet or dry conditions and fermentation among others. From the study it may be concluded that starch treated with heat could be better digestibled by both carnivorous and herbivorous species.

Table 2: Growth Performance and Nutrient Utilization of *Clarias gariepinus* Fish fed with Graded Levels of Processed Cocoyam Tubers

Parameters	Control (1)	Diet 2	Diet 3	Diet 4	Diet 5	Diet 6	Diet 7
Mean initial weight	50.0±2.43a	50.1±1.93a	50.0±2.71a	50.2±1.37a	50.2±1.56a	50.0±1.74a	50.0±1.65a
Mean final weight	122.3±3.94a	80.4±3.45b	104.4±4.67ab	99.7±2.57a	85.6±2.67ab	97.3±3.23ab	74.0±3.19b
Mean weight gain	72.3±2.67a	30.3±1.89b	54.4±3.67ab	49.6±2.34ab	35.4±1.89ab	47.3±2.19ab	24.0±1.32b
Average feed intake	114.5±5.65	81.3±3.79	103.5±3.56	97.0±3.76	104.4±4.36	105.8±5.21	91.4±3.43
RGR	82.1±2.34a	48.5±2.47ab	73.6±2.36ab	71.0±2.04ab	54.7±2.32ab	70.0±3.21ab	41.1±1.76b
SGR	0.60±0.11a	0.32±0.09b	0.49±0.13ab	0.47±0.15ab	0.37±0.13ab	0.46±0.12ab	0.27±0.06b
FCR	1.76±0.08b	3.29±0.45ab	2.58±0.34ab	2.23±0.14b	3.03±0.56ab	2.21±0.23b	4.12±.82a
PER	0.017417±0.0023	0.00949±0.0015	0.01322±0.0065	0.1383±0.0078	0.00961±0.0006	0.1316±0.0075	0.007481±0.0016
FC ($)	1.144±0.07	1.096±0.05	1.116±0.06	1.110±0.063	0.980±0.047	1.000±0.052	0.986±0.043
ECR	2.013	3.606	2.879	2.475	2.969	2.210	4.151

Values are the mean of triplicate groups of fish. Mean values with different letters in column were significantly different in the Ducan test (p<0.5).

Key:

Diet 1: Control
Diet 2: 25% Raw Cocoyam inclusion
Diet 3: 25% Boiled
Diet 4: 25% Fermented
Diet 5: 50% Raw
Diet 6: 50% Boiled
Diet 7: 50% Fermented, SGR= Specific Growth Rate, RGR =Relative Growth Rate, MWG= Mean Weight Gain, FCR=Feed Conversion Ration, PER=Protein efficiency ratio. FC=Feed cost ($) and ECR=Economic conversion ratio

Table 3: Result of Blood Analysis

DIETS	Haemoglobin (Hb)g/100ml	Packed Cell Volume (PCV) (%)	Protein g/l	Cholesterol
Diet 1	11.7±1.89^{a}	33.0±5.13^{b}	55.8±4.11^{a}	85.1±5.78^{a}
Diet 2	9.4±2.31^{b}	30.0±3.87^{b}	29.8±2.43^{c}	58.0±4.32^{b}
Diet 3	12.5±2.15^{a}	38.0±4.12^{a}	48.2±2.18^{a}	59.6±3.89^{b}
Diet 4	14.0±3.14^{a}	43.0±34^{a}	43.6±3.11^{ab}	75.4±4.13^{ab}
Diet 5	9.0±2.17^{b}	27.0±1.78^{bc}	13.6±1.11^{d}	98.6±5.09^{a}
Diet 6	6.6±1.68^{c}	20.0±1.58^{c}	36.0±3.54^{b}	60.4±2.91^{b}
Diet 7	12.5±2.34^{a}	38.0±3.45^{a}	14.2±2.16^{d}	109.9±6.43^{a}

The processing of cocoyam tubers resulted in a significant improvement over the raw in most of the measurement recorded as shown in Table 2. Fish fed with boiled cocoyam (BC) diet gained significantly *(P < 0.05)* higher weight than those fed RC diet. The improved weight gain of the fish fed BC may be associated with the beneficial effect of boiling which resulted into better nutritional value and digestibility. (Abdurashid Agumnobi 2009). The improved digestibility could be as a result of the inactivation of the anti-nutritional factors, which interferes with the digestive process (Ghazi *et al.*, 2002). The decreased weight gain observed in fish fed with RC both at 25 and 50% inclusion levels suggest that nutrients in the RC were not as available or probably abundant as in the BC diets. Tannins and trypsin inhibitors have been reported to affect nutrient availability and utilization by monogastric animals (Kocher *et al.*, 2002). Therefore, the poor body weight of the fish could be due to the poor digestibility and absorption of nutrients in raw cocoyam diets when compared to the processed cocoyam meal. Better growth performance and nutrient utilization was recorded for the control diet, this is similar to the findings of Omoregie *et al* (2009) when they fed graded levels of sweet potatoes peel in comparism to maize to Cichlid. There was no significant difference *(P > 0.05)* in feed intake among all treatments; one of the most common difficulties observed when alternative sources of feedstuffs are used in fish diets is acceptance and palatability by the fish (Domingues *et al* 2003). However, in this present study, the fish avidly consumed the experimental diets.

The result of the feed conversion ratio of *Clarias* fed RC, BC, FC and CWC diets showed that the FCR of fish fed BC and the CWC (control without cocoyam) diets were significantly *(P < 0.05)* superior to those fed 25% RC (raw cocoyam) and those fed 50% FC (fermented cocoyam) diets. This could be attributed to the improvement in the availability and utilization of nutrients in this particular diet that was boiled. The poor FCR of the fish fed 25% and 50% raw cocoyam inclusion may not be unconnected with the effect of age on the response to residual tannins and trypsin-inhibitor, which could be beyond the tolerable limit of the young *Clarias* juvenile fish.Poor FCR, PER and SGR were also recorded at higher inclusion level by Ofojekwu *et al* 2003 and Omoregie *et al* (2009). Fish fed CWC diets showed better protein efficiency ratio than those fed raw, boiled and fermented diets. This could probably have resulted in the improved weight gain of fish on the control diet.

Economic indices showed decreased in price of feed with the inclusion of cocoyam meal,especially at higher inclusion level of the test ingredient,this may be attributed to the higher cost of maize brought about by the keen competition for maize between man and other livestock (Arinjeniwa *et al* 2000).Despite the above stated point,the economic index was lowest on control diet as a result of the outstanding result obtained from the growth and nutrient utilization parameters.Cost of processing varies among the diets although this may not be significantly different.

Blood is a good indicator in determining the health of an organism (Joshi *et al.*, 2002c), it also acts as a pathological indicator of the whole body, and hence hematological parameters are important in diagnosing the functional status of an exposed animal to suspected toxicant (Omitoyin 2006). Haematological characteristics of most fish have been studied with the aim of establishing normal value range and any deviation from it may indicate a disturbance in the physiological process (Rainza-paiva *et al.,* 2000). The values obtained in this experiment for both the PCV and Hb (control diet) were within the normal ranges (37.0±2.18 and10.10±0.214 respectively) recommended for *Clarias gariepinus (*Sunmonu 2008 and Adedeji 2009*).* Since most of the heamatological values obtained in this study at 50% inclusion level fall significantly below that of the control, it could be suggested that the diets tested had major physiological stress on the health status of the fish studied. Previous haematological studies of nutritional effects brought knowledge that erythrocytes, PCV and Hb are major and reliable indicators of various sources of stress (Rainza-Paiva *et al*, 2000) and these parameters decreases in the present of antinutritional factors (Osuigwe *et al 2007*).Reduction in PCV and Hb value at high substitution rate and between control and raw test ingredient was also observed by Osuigwe *et al* (2007) when they fed different dietary level of raw and boiled jack bean to juvenile *Heterobranchus longifilis.* This result is in agreement with earlier reports that heat treatments reduced the level of anti-nutritional factors in jackbean seed (Udedibie and Carlini 1998).Values obtained for both the total lipid protein and cholesterol (55.8mg/l and 85.1mg/dl respectively) are within the range stated by Omitoyin *et al* 2005 (56.8 g/l) and 57.0g/l stated by Fagbenro *et al* (2000)for *Heterotis niloticus.*.Reduction in plasma protein as a result of handling stress was observed by Gbore *et al* (2006) following the same experience obtained in this study as higher inclusion level of cocoyam in test diets.

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