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Evaluation of Sweet Potato (Ipomea batatas) Peel as a Replacement for Maize Meal in the Diet of Clarias gariepinus Fingerling

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Abstract: The study seeks to investigate the suitability of sweet potato peel (SPP) as an energy source in replacing increasingly expensive conventional Yellow Maize Meal (YMM) in the diet of African catfish fingerlings. Result obtained reveals that SPP can completely replace Maize meal (at 33.35 level of inclusion). However growth parameters were maximum at 16.68 and 25.01 level of inclusion in the diet (i.e., at 50 and 75% substitution level respectively). Carcass of fish fed experimental diets also shows higher protein and lipid content for dietary inclusions of SPP compared to the initial and fish fed the control diet. Use of cassava peels to replace conventional energy source is therefore advice so as to reduce production cost and consequently recycling of waste to wealth at no cost.

Keywords: African catfish; Unconventional feedstuff; Growth performance; Proximate composition.

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Introduction

Artificial feeding is one of the principal methods of increasing production of fish cultivation. Its importance varies according to the intensity of aquaculture practice. Similarly, the importance of feed in aquaculture can not be over-emphasized. It promotes faster growth, allows higher stocking density, shorter cultivation period among others (Tiamiyu et al., 2007). However, feed account for at least 60% of the total cost of production in fish farming business. The high cost of fish feed is one of the problems hampering aquacultural development in Nigeria (Gabriel et al., 2007). This marginalize or even nullify the profitability of fish farming thereby incapacitating the expansion of farms and lowering yield, thus resulting in the scarcity of the commodity (fish) and eventually high cost of the few available ones to the disadvantage of the populace (Adikwu 1992). Hence, considerable efforts have been channeled to evaluate the suitability of several unconventional feed stuffs in replacing conventional feed ingredients bearing in mind their low cost and ready availability.

Fish nutrition trials in the past with tuber crops and their by-products have included wild variegated cocoyam (Agbabiaka et al., 2006), cocoyam corm (Omorege et al., 2009, Aderolu and Sogbesan, 2010), Cassava peels (Solomon et al., 1996) etc. However, there is paucity of information on the utilization value of sweet potato peel in the nutrition of African catfish; FAO (1970) had revealed that sweet potato peels contain adequate amount of calories in form of vitamin B and C as well as useful amount of other micronutrients such as Iron. The carbohydrate of sweet potato peels is highly digestible and soluble. It consists predominantly of starch with 4-7% occurring as sugar. However, the amino acid is observed to be short in tryptophan and total sulphur when compared to the amino acid profile of other crops (FAO 1970). It is also moderately high in ascorbic acid, carotene and other vitamins such as thiamine, riboflavin and niacin. Anti-nutritional factors so far identified includes phytins, oxalates and solamines, however, they can be reduced to the barest minimum in feed by processing (Oyin 2006). This study is therefore designed to evaluate the suitability of sweet potato peels in replacing maize in the diet of African catfish.

Materials and Methods

Diet formulation and preparation

Fish meal, yellow maize, dried sweet potato peels, soybean meal, salt, vitamin and mineral premix were obtained from North bank market Makurdi, Benue State and used to formulate five isonitrogenous, isolipidic and isoenergetic diets containing 35% crude protein as shown in Table 1 using Pearson's square method. The feedstuffs were processed to improve digestibility and eliminate any anti-nutritional factor that may be present. The sweet potato peels were sundry to eliminate anti-nutritional factor such as tannins phytins and oxalates while the soybeans was toasted to eliminate trypsin. All ingredients were finely ground and sieved before weighing and were mixed uniformly. In the five diets, fish meal, soybean meal, maize meal, vitamin and mineral premix and salt were kept constant for all the diets. While sweet potato peels meal was substituted for yellow maize meal at varying percentages (at 33.35 level of inclusion) and designated as Diet 1 (SPP0%: YMM100%), Diet 2 (SPP25%: YMM75%), Diet 3 (SPP 50%: YMM 50%), Diet 4 (SPP 75%: YMM 25%), and Diet 5 (SPP 100%: YMM 0%). Water was added (20%) to the mixture with continuous stirring until dough was formed. A Pelleting Machine was used to pellet the diets using a 2 mm die after which they were sun dried, packaged, and stored in a cool dry place until the commencement of feeding.

Experimental Set up

The study was conducted at the University of Agriculture Makurdi Fisheries Research farm, Benue state, Nigeria. Two hundred and fifty (250) Fingerlings of *Clarias gariepinus* were purchased from the research farm and acclimatized in plastic bowls for two weeks before the start of the experiment. 15 fish were weighed and stocked randomly in duplicate hapas of 1 m^3 (i.e., 1 m × 1 m × 1 m) partially submerged in 48 m^3 earthen pond. Water quality were monitored during the study using thermometer, pH meter and multiparameter water checker and parameters were observed to be within the recommended range (dissolved Oxygen-7.5-11.5 mg/l; pH 7.1-8.5; water temperature 25-30ºC) for the culture of tropical fishes (Boyd 1981). Fish were hand-fed twice a day (08:00 am, and 6:00 pm) at a rate of 5% of their body weight daily. Feeding rates were adjusted weekly for 8 weeks based on the weight gain of each group of fish per week. The Feed Ingredients, diets formulated as well as initial and final carcass of *Clarias gariepinus* fingerlings fed the experimental diets were analyzed for proximate composition using standard methods stated by AOAC (1990).

Performance in growth and feed utilization were determined as shown below

Weight gain calculated as;

$$(\text{Final weight - initial weight})$$

Growth rate was determined by calculating according to the method described by Brown (1957)

$$\frac{\text{Weight gained}}{\text{Duration of the Experiment}}$$

Specific growth rate (SGR) was calculated according to Brown (1957):

$$\frac{\text{Ln Final Weight - Ln Initial Weight}}{\text{Duration of the Experiment (Days)}}$$

Feed conversion ratio (FCR) was measured according to (Halver 1972):

$$\frac{\text{Feed Intake}}{\text{Body Weight Gain}}$$

Feed conversion efficiency was measured according to method described by (Halver 1972):

$$\frac{\text{Weight Gained} \times 100}{\text{Feed Intake}}$$

Percentage Survival:

$$= \frac{N_t \times 100}{N_o}$$

Where N_t and N_0 are the number of fish at the end of the experiment and the initial number of fish stocked at the start of the experiment respectively.

Each experimental diet was fed to two groups of fish in a completely randomized design. Statistical analyses in the present study included descriptive statistics as well as analysis of variance (ANOVA $P<0.05$) using a computer software GENSTAT Discovery edition 3 from Lawes Agricultural Trust Rothamsted.

Results

The proximate composition of sweet potato peel meal used for this study was found to be composed of 8.91% moisture, 5.64% crude protein, 4.71% ether extract, 3.56% crude fibre, 6.02% ash and 71.16% NFE (Table 2). The moisture content of the formulated diet as shown in Table 2 varies from 5.51 ± 0.01% to 6.81 ± 0.00%, Diet 4 had the highest value while Diet 1 had the lowest. Similarly, crude protein content varied from 39.02 ± 0.02% to 39.74 ± 0.01% however Diet 3 had the highest value while Diet 1 recorded the lowest value. Ether extract also varies from 4.38 ± 0.01% to 5.69 ± 0.09% with Diet 3 recording the highest value while the lowest value was recorded in Diet 1. Crude fibre varies from 10.88 ± 0.00% to 11.62 ± 0.03%, Diet 5 had the highest value. Furthermore, ash varies from 17.52 ± 0.00% to 17.95 ± 0.52% with Diet 1 recording the highest values while Diet 4 recorded the lowest values.

The mean weight gain as shown in Table 3 ranged from 10.67 ± 0.02% in Diet 1 to 11.14 ± 0.02% in Diet 3. Similarly, the specific growth rate ranged from 1.63 ± 0.04%day^{-1} (Diet 1) to 2.06 ± 0.05%day-1 (Diet 3). Also, Diet 3 was found to be the highest in value (1.12 ± 0.01%day^{-1}) for protein efficiency ratio (PER), while Diet 1 with 0.96 ± 0.03 had the least value. Feed conversion ratio (FCR) ranged from 2.24 ± 0.01-2.62 ± 0.07 with Diet 3 having the lowest value while Diet 1 had the highest value. The apparent net protein utilization also ranged from 48.00 ± 0.00 in Diet 3 to 43.14 ± 0.06 Diet 2. Fish fed Diet 1 had the highest percentage survival (90.00 ± 0.00) while mortality was recorded more in fish fed Diet 5 (Survival of 63.34 ± 3.34%).

The proximate composition of fish before and after the experiments are shown in Table 4 result revealed that moisture content of fish which was 5.03 ± 0.02% before feeding ranged from 4.14 ± 0.00% in Diet 2 to 5.11 ± 0.01% in Diet 4 after the experiment. On the other hand, crude protein content was found to increase from the initial value of 43.97 ± 0.02% before feeding to 61.23 ± 0.02% in Diet 1, 61.22 ± 0.01% in Diet 2, 63.17 ± 0.02% for Diet 3,

Table 1: Formulation of the Experimental Diets.

Ingredients (%)	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
Fish meal	35.15	35.15	35.15	35.15	35.15
Soyabean meal	21.50	21.50	21.50	21.50	21.50
Yellow maize meal	33.35	25.01	16.68	8.34	0.00
SPP Meal	0.00	8.34	16.68	25.01	33.35
Salt	5.00	5.00	5.00	5.00	5.00
Vitamin/mineral premix	5.00	5.00	5.00	5.00	5.00
Total	100	100	100	100	100

Vitamin premix contain (as mg kg-1 of diet): Thiamine (B_1), 85.00; Riboflavin (B_2), 60.00; Pyridoxine (B_6), 25.00; Pantothemic acid, 105.00; Inositol, 500.00; Biotin, 1.80; Folic acid, 20.00; Ethoxyquin, 4.00; Choline, 1481.00; Nicotinic acid (Niacin), 250.00; Cyanocobalamin (B_{12}), 0.03; Retinol palmitate (A), 20.00; Tocopherol acetate (E), 140.00; Ascorbic acid (C), 750.00; Menadione (K), 30.00; Cholecalciferol (D_3), 0.08 (Manufacturer's label).

Mineral premix contain (as g kg-1 of diet): $MgSO_4$,$7H_2O$, 20.40; NaCl, 8.00; KCl, 6.04; $FeSO_4$,$7H_2O$, 4.00; ZnSO4, $4H_2O$, 0.88; $MnSO_4$.$4H_2O$, 0.41; $CuSO_4$,$5H_2O$, 0.13;$CoSO_4$,$7H_2O$, 0.08; $CalO_3$, $6H_2O$, 0.05; $CrCl_3$,$6H_2O$, 0.02 (Manufacturer's label).

Table 2: Proximate composition of sweet potato peel and experimental diets.

Parameters (%)	SPP	Diet 1	Diet 2	Diet 3	Diet 4	Diet 3	P-value
Moisture	8.91±0.2	5.51±0.01^{b}	6.47±0.02^{a}	6.74±0.01^{a}	6.81±0.00^{a}	6.19±0.01^{a}	0.01
crude protein	5.91±0.1	39.02±0.02^{a}	39.37±0.01^{a}	39.74±0.01^{a}	39.51±0.01^{a}	39.89±0.01^{a}	0.11
Crude fat	4.71±0.1	4.38±0.01^{b}	5.03±0.02^{a}	5.69±0.09^{a}	5.45±0.01^{a}	5.59±0.00^{a}	0.01
Crude fibre	3.56±0.2	11.15±0.01^{b}	10.88±0.00^{b}	11.16±0.02^{b}	11.47±0.02^{a}	11.62±0.03^{a}	0.01
Ash	6.02±0.01	17.95±0.52^{a}	17.55±0.01^{a}	17.75±0.11^{a}	17.52±0.00^{a}	17.82±0.02^{a}	0.12
NFE	71.16±0.1	22.03±0.52^{a}	20.71±0.01^{b}	15.92±0.19^{e}	19.25±0.02^{c}	18.89±0.01^{d}	0.01

NFE=Nitrogen free extract obtained by Difference, Mean in the same row with different superscripts differ significantly ($P<0.05$).

Table 3: Growth evaluation of experimental fish fed diets containing increasing inclusion levels of sweet potato peel meal.

Parameters	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	P-value
Mean initial weight (g)	1.70±0.01	1.72±0.02	1.71±0.01	1.73±0.01	1.75±0.01	0.21
Mean final weight (g)	12.37±0.02 ^{b}	12.68±0.01 ^{b}	12.85±0.02 ^{a}	12.73±0.03 ^{a}	12.410±0.01^{b}	0.01
Mean weight gain (g)	10.67±0.02^{b}	10.92±0.01^{b}	11.14±0.02^{a}	11.00±0.03^{a}	10.69±0.01^{b}	0.01
SGR(% day^{-1})	1.63±0.04^{b}	1.79±0.01^{b}	2.06±0.05^{a}	1.96±0.01^{a}	1.72±0.03^{b}	0.01
FCR	2.62±0.07^{a}	2.52±0.04^{a}	2.24±0.01^{bc}	2.38±0.01^{b}	2.45±0.09^{ab}	0.02
PER	0.96±0.03^{c}	0.99±0.02^{bc}	1.12±0.01^{a}	1.06±0.01^{ab}	1.03±0.04^{cb}	0.02
ANPU	43.17±0.02^{c}	43.14±0.06^{c}	48.00±0.00^{b}	46.91±0.03^{b}	33.19±0.01^{d}	0.01
Survival (%)	90.00±0.00^{a}	70.00±3.33^{e}	80.00±0.00^{b}	76.67±3.34^{c}	63.34±3.34^{e}	0.03

Mean in the same row with different superscripts differ significantly (P<0.05).

Table 4: proximate composition of fish before and after experiment.

Parameters (%)	Initial	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5	P-value
Crude protein	43.97±0.02^{e}	61.23±0.02^{c}	61.22±0.01^{c}	63.17±0.02^{a}	62.73±0.01^{b}	57.24±0.01^{d}	0.01
Moisture	5.03±0.02^{c}	4.16±0.01^{e}	4.41±0.00^{d}	5.01±0.01^{a}	5.11±0.01^{b}	5.09±0.02^{b}	0.01
Crude fat	5.32±0.02^{e}	6.56±0.01^{d}	7.82±0.01^{c}	8.18±0.01^{a}	7.98±0.02^{b}	7.81±0.01^{c}	0.01
Crude fibre	3.41±0.02^{a}	2.19±0.01^{e}	2.11±0.01^{c}	2.12±0.02^{c}	2.06±0.01^{d}	1.99±0.01^{e}	0.01
Ash	13.33±0.03^{a}	10.86±0.01^{e}	12.03±0.02^{d}	12.04±0.01^{c}	12.19±0.01 ^{e}	12.61±0.01^{b}	0.01
NFE	28.95±0.05^{a}	15.01±0.03^{c}	12.42±0.00^{d}	8.78±0.04^{f}	9.94±0.01^{e}	15.27±0.01^{b}	0.01

Mean in the same row with different superscripts differ significantly (P<0.05).

62.73 ± 0.01% obseved in Diet 4 and 57.24 ± 0.01% was recorded in Diet 5. Crude fibre, however, decrease from the initial 3.41 ± 0.01% to 2.19 ± 0.01% in Diet 1, 2.11 ± 0.01% in Diet 2, 2.12 ± 0.02% in Diet 3, 2.06 ± 0.01% in Diet 4, and 1.99 ± 0.01% in Diet 5. Furthermore, the ether extract (fat) which was initially 5.32 ± 0.02% before feeding increased with 8.18 ± 0.01% being the highest recorded in Diet 3 and lowest 6.56 ± 0.01% observed in Diet 1. The initial ash values recorded before feeding was 13.33 ± 0.03% however, final values observed in the study were 10.86 ± 0.01% (Diet 1), 12.03 ± 0.02% (Diet 2), 12.04 ± 0.01% (Diet 3), 12.19 ± 0.01% (Diet 4) and 12.16 ± 0.01% (Diet 5).

Discussion

The result of the proximate analysis of sweet potato peel shows that the crude protein, fibre, moisture and ash are similar to the reports of Abd El-Hakim et al., (2010), FAO (1992) and Oyin (2006) but at variance with the values obtained from Apata and Babalola (2012)'s experiment on cassava peel. Fish fed the five different diets responded well with no deleterious effect on growth when compared with the control diet, as significant (P>0.05) higher values where observed for MFW, MWG, SGR, FCR, PER and ANPU. However, fish fed Diet 3 and Diet 4 containing 50% and 75% inclusion of SPP meal replacement level with maize shows superior growth performance over Diet 1, Diet 2 and Diet 5 containing 100%, 75% and 25% maize meal (MM) respectively. Ramezani (2009) and Sotolu (2009); had earlier stated that high feeding rate of quality feed is directly related to fish growth performance hence, trend of growth observed in the study is an indication that the energy quality of sweet potato peel is better utilized in the diet of *Clarias gariepinus* fingerlings compared to yellow maize meal as growth responses were significantly affected by inclusion level of SPP in the diets. Olukunle (2006) reported that replacing yellow corn at 25%, 50% and 75% with SPP improved growth performance parameters of African catfish Fry compared to the control group however the author observed that growth was best at 25% replacement levels which was different from the outcome of this study. Also, Soltan et al., (2005) incorporated potato by-product meal (PBM) in the diets of common carp as replacement of yellow corn. The Authors reported that at higher replacing level of 50%, significant decreased in body weight, weight gain and specific growth rate were observed. Furthermore, Ghazalah et al., (2002) found that, replacing 25 or 50% of yellow corn with potatoes by-product meal did not significantly affect body weight, weight gain and specific growth rate of Nile tilapia *(O. niloticus)*. On the other hand, Shouqi et al., (1997) concluded that as dietary potato protein concentrate increased from 0 to 51% in rainbow trout (*Oncorhynchus mykiss*) diets, final BW and SGR significantly decreased and mortality increased. In this connection, Saleh (2001) reported that yellow corn can be substituted by either 25% date stone (DSM) or up to till 50% potato by-product meal (PBM) in Nile tilapia diets without harmful effect on the growth performance and feed utilization of fish. Omoregie et al., (2009) incorporated sweet potato peel (SPP) in Nile tilapia diets at levels of 0; 5; 10; 15; 20 and 25 percent in iso nitrogenous (31.22% crude protein) diets and found that the greatest increase in body weight of the fish was achieved with the control diet (p<0.05) and hence growth rate decreased as level of inclusion increase. The disagreement among results of this study and those of the above referenced authors may be due to factor which may include differences in experimental fish in relation to tolerance of increase level of plant protein, processing methods of the diet as it affects anti-nutritional factor, physiological age and stage of the fish etc.

However the growth performance of fish as reported in the present study were better than reports from the experiments conducted by Balagopalan et al., (1988); Omoregie et al., (1991); Solomon et al., (1996); Oresegun and Alegbeleye (2001) and Bichi and Ahmed (2010) who earlier evaluated the use of cassava and yam peel in the diet of *Clarias gariepinus*. The superiority of the energy quality and higher protein content sweet potato peels is the reason for the differences in the studies. Also the deleterious effect of cyanide may be a major cause of difference in the growth. The highest mortality record in fish fed diet with SPP at 100% inclusion level may be due to the presence of high fibre content owing to poor digestion of cellulose and increasing level of anti-nutritional factor.

Proximate composition of experimental fish shows significantly higher protein and fat values in fish fed diet 3 and diet 4 compared to others. Soltan et al. (2005) experiment had revealed that there was no significant effect on carcass of common carp raised with dietary inclusion of potato by-product meal (PBM) diets in replacement of yellow corn. Also, Soltan (2002) found that increasing the inclusion level of PBM up to 50% in tilapia diets did not significantly change the protein content but the higher inclusion levels (60, 70 or 80%) significantly decreased protein and ash contents of tilapia carcass. Shouqi et al., *(*1997) reported that, Crude Protein content of fish decreased ($p<0.05$) as dietary potato protein concentrate increased from 0 to 51% in rainbow trout (*Oncorhynchus mykiss*) diets. Xie and Jokumsen (1997) clearly stated that incorporation of potato protein concentrate in diets of rainbow trout significantly increased ash contents of fish body. Furthermore Omoregie et al., (2009) reported that carcass of Nile tilapia fed on diet containing SPP 25% replacing yellow corn had the lowest protein content, which was significantly different from the other diets except SPP15. However there was no significant difference in ash content among the six experimental diets. Fish fed diet SPP0 recorded the highest level of lipid deposit which was significantly different from the other dietary treatments. The differences in the outcome of the various studies are likely due to the differences in utilization levels of the test fishes. The present study has demonstrated that potatoes peel meal can completely replace yellow maize in the diet of African catfish; however growth is maximized at replacement level of 50 and 75%.

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