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Cost Implications of Feeding *Clarias gariepinus* (Burchell) Processed Sweetpotato (*Ipomoea batatas*)

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Abstract. Maize is an expensive energy source of feedstuff in fish management especially during the off-season, hence the need to source and utilize other cheaper and non-conventional energy sources. This study investigated the growth performance of *Clarias gariepinus* fry fed processed sweetpotato meal as an energy source and its effect on the haematological and economic values. Three experimental diets were compounded such that maize was 100% energy source in Diet 1 (Control). In Diets 2 and 3, maize was replaced with sweetpotato tuber (SPT) and sweetpotato peel (SPP), respectively at 25 % inclusion level. The diets were fed at 5 % body weight to the *C. gariepinus* fry (0.21 ±0.03 g) in polystyrene net cages suspended in 3 concrete tanks (2 x 3 x 1.2 m^3) for 42 days in triplicates. Growth, nutrient utilization, haematological parameters were measured and cost evaluations were calculated. The mean weight gain (MWG) of the fry fed the maize-based diet (1.96) was significantly higher (P< 0.05) than the fry fed SPT (1.37) and SPP (1.27) respectively. The MWG of fry fed Diets 2 and 3 were not significantly different from each other. The feed conversion ratio (FCR) of the control and the SPT-based diets were not significantly different from each other but both were significantly different (P<0.05) from fish fed the SPP diet. The Growth Efficiency Feed Conversion

(GEFC) values of the 3 diets were 0.50, 0.51, and 0.40 respectively and were not significantly different from each other. However, the protein efficiency ratio (PER) and the survival rates were significantly better in fry fed the SPT-based diet (0.51; 95 %) than in fry fed the maize-based diet (0.50; 92 %) and the SPP-based diet (0.40; 82 %) respectively. The haematology results showed that the fry fed the control diet had the lowest MCV and WBC counts while the fry fed sweetpotato-based diets manifested moderately severe normocyctic normochromic anaemia and leucocytosis, which means that the maize diet showed better haematological indices. The economic evaluation revealed the need to produce SPT and SPP at low costs value to reduce the overall fry production cost. This study showed that sweetpotato-based diets have potential as substitute replacement for maize. In addition, it is recommended that sweetpotato replaces maize at less than 25% inclusion for maximum growth, economic and haematological performance in catfish diets.

Key-words: Growth performance; nutrient utilization; processed sweetpotato; *Clarias gariepinus*; haematology.

Introduction

The processing and utilization of sweetpotato (*Ipomoea batatas*) has been the focus of several researches in Nigeria (Oyenuga 1968; Tewe *et al.* 2000; Ojeniyi and Tewe 2001) and outside Nigeria (Woolfe 1992). These works have demonstrated the agronomic potentials of sweetpotato, in the humid zone of Africa, its nutritional value, the processing and utilization of sweetpotato in human cuisine, livestock feed and its industrial usage.

In Nigeria, sweetpotato is regarded agriculturally as a minor root crop but it is classified as a major crop in the developing world (Woolfe 1992). It does not feature as a main food in Nigerian dishes quite unlike yam and rice. Most farmers in humid Africa grow sweetpotato for their family's consumption (Odebode 2004). Moreover, in Nigeria, very little processing of sweetpotato is being done; it is usually added to yam, cassava or millet to prepare different Nigerian dishes (Odebode 2004). Other sweetpotato products such as chips, starch, puff-puff, chin-chin, buns, bread, jam and crisps (Table 1), when introduced into the food industry will enhance the demand for new sweetpotato varieties (Odebode 2004). However, very limited use of sweetpotato, if any, has been reported in fish diet. Since it is not a major food crop in Nigeria, there will be limited competition for its usage in human food if found appropriate for fish. Its cultivation should be encouraged on a larger scale. Hence, the objective of this study was to determine the nutrient utilization of *C. gariepinus* fry fed sweetpotato meal and peel as a cheaper source of energy and its effect on some haematological parameters.

Table 1. Product types, processing steps and utilization of sweetpotato

Product Type: Sun-dried chips (milled into flour).
Product name: a) Sweetpotato Cake
Processing steps: Fresh roots, peeling, chipping, sun-drying (2days), and milling
Description: Sun-drying chips, milled, product is usually white in colour, and can store for 3-6months
Utilization: Serve as snack, use dish to entertain visitors.

Product name: b) Other products: Puff-puff, Buns, Bread, and Chin-chin
Utilization: Served as snack, used to entertain visitors, and use for income generation

Product Type: Sweetpotato leaves
Processing steps: Wither fresh leaves in the sun to get soft, boil for 20-30minutes, and squeeze to drain water.
Description: For making soup. Narrow leaves are preferred to broad leaves.
Utilization: Vegetable soup. Serve with pounded yam, eba or amala

Product Type: Sweetpotato toasted granules ("sparri")
Product name: "Sparri"
Processing steps: Peeling, grating, de-watering, sieving, and toasting
Description: Can store for more than 6 months. Vulnerable to storage pests, so put in refrigerator
Utilization: Soak in water, add groundnuts, and drink as a snack, or stir into boiled water and serve with soup

Product Type: Boiled sweet sweetpotato tuber
Product name: Sweetpotato Ketchup
Processing steps: Boil sweetpotato tuber, chop and mix with tomato, sugar, onions, vinegar, salt and water
Description: Put in refrigerator
Utilization: Serve with bread as breakfast

Product Type: Sun-dried chips
Product name: Sweetpotato chips
Processing steps: Peel, trim, chip, and deep fry
Description: Shed and deep fry. It is better to avoid breakage
Utilization: Serve as a snack

Product Type: Sweetpotato tuber
Product name: Sweetpotato Jam
Processing steps: Peel (450g) tuber, simmer for 20minutes, add 3 lemons + 3 oranges and boil in 750 ml water + 6 g Citric acid, and cook for 25minutes at 92^0C till mixture is thickened.
Description: Put in refrigerator
Utilization: Serve with bread as breakfast

Source: Odebode 2004.

Problem description. The pressure on the utilization of maize for energy in human food and for livestock causes the price of maize to fluctuate especially during the off-season. This phenomenal increase affects the cost of fish feed, which represents over 60 % of the cost of inputs on a fish farm. Sweetpotato is a minor crop in Nigeria and the pressure for its use in human food and livestock feed is not as great as that for maize. In addition, there is a dearth of research on the utilization of sweetpotato tubers or peels.

Sweetpotato, especially the peels, are products for the waste-bin because research has not highlighted the potential for their utilization in livestock feed. In the tropics, sweetpotato has a 5-month growth cycle, which implies that it can be grown twice a year. In calorie deficient diets, Woolfe (1992) reported two significant advantages of sweetpotato over most staple crops. As a crop, it has the highest useful energy production rate among the major tropical food crops (e.g., sweetpotato 194 MJ ha^{-1} day^{-1} ; rice 149; maize 145; cassava 138; banana 113; sorghum 101; yam 94; millet 82). Hence, sweetpotato can provide significantly more calories on a given unit of land per unit of time. It is a nutritious food, providing a good supply of Vitamin C, calcium and iron and can be an excellent source of pro-vitamin A (Tsou and Hong 1992). Many Asian countries such as China are utilizing sweetpotato as an industrial starter product for manufacturing starch and alcohol and as a replacement for conventional energy crops, which constitute major energy sources for humans, such as maize, Irish potato and rice (Woolfe 1992). The usage of the sweetpotato peels needs to be encouraged to reduce the pressure on conventional sources of energy food like maize for livestock feed, especially for fish, if research highlights its potentials. The carotene content in the orange variety of sweetpotato and its influence on the pigmentation of catfish fry will be another potential point for the utilization of sweetpotato in its nursery management.

Materials and Methods

Preparation of SPT and SPP flours. Mature tubers (11.0 kg) of white-fleshed sweetpotato variety were harvested from 4 rows (4.0 x 1.0 m^2) of a homestead garden. The tubers were peeled and immediately the peels were soaked for 1 hour to reduce the concentration of sugar. Finally, the peels were drained and dried. The peeled sweetpotato tubers (SPT) were sliced and soaked for 1 hour and sun-dried to constant weight within 3 days with at least 5 hours daily. The dried slices of SPP and SPT were ground to flour separately and incorporated in experimental diets as source of energy to partially replace maize in Diets 2 and 3, while Diet 1 had maize as the main source of energy.

Experimental diets. Three experimental diets were formulated as follows: Diet 1 is the control and had 0 % sweetpotato inclusion; Diets 2 and 3 had 25 % maize replaced by SPP and SPT respectively (Jackson *et al.* 1982; Olukunle 1996; Olukunle and Agboola 2005). The dietary energy content of the feed was calculated by using the conversion factors of 4, 9, and 4 for protein, carbohydrate and lipids, respectively. The crude protein level of the diets was a mean of 46.9 $\pm$ 0.57 %. Previous research recommended between 45 % and 50 % protein inclusions in the diet of fry/fingerling stages of catfish (Viveen and Huisman 1985; Adekoya *et al.* 2004). The three diets were iso-calorific (3.47 kcal/100 g). The experimental ingredients were weighed, thoroughly mixed, moistened, pelleted, sun-dried for 6 hours and stored in polythene bags until used.

Experimental tanks. Three concrete tanks with dimensions 2.0 x 3.0 x 1.5 m^3 were used as experimental tanks. Three net-cages were suspended on bamboo stakes, with each tank representing each treatment. The tanks were impounded with tap water to a depth of 1.2 m in all the tanks and allowed to fallow for 14 days. Subsequently, fresh water was supplied from connected municipal tap at 0.25 ml/min to replace water loss by evaporation. The water quality parameters such as temperature, dissolved oxygen, pH, and alkalinity were weekly taken and blood samples were monitored at the initial, mid-way (at 3 weeks) and at the end (6 weeks) of the experiment using standard methods (Boyd 1982).

Experimental fish. A batch of 100 advanced fry of *C. gariepinus* with mean weight of 0.21$\pm$ 0.03 g were allotted per cage, and were fed 5 % of total body weight per day at 10.00 hr, 14.00 hr, and 18.00 hr daily. Biweekly weighing was done and the quantity of feed fed to the fish was adjusted relative to the weight gained. The experiment lasted 42 days. The diets and carcasses were analyzed for proximate composition using Standard Analytical Methods (AOAC 1991). At 21 days, and at the end of the experiment, blood samples were taken from the caudal peduncle of randomly selected fingerlings pooled from each treatment for haematological studies according to Falaye *et al.* (1999) and Olukunle *et al.* (2002).

The data obtained were analyzed using the analysis of variance (ANOVA) and standard error was used to estimate the probability of significant differences among the treatments.

Results and Discussion

Table 2 shows the composition of the ingredients used in the formulation of the experimental diets. The variation in the dry matter composition of processed sweetpotato in this study and those of other researchers like Oyenuga (1968), Ashida (1982) may be due to differences in variety, time of harvest, and/or length of storage. The sweetpotato used in this study was processed immediately after harvest. Table 3 shows the gross composition of the experimental diets used.

Premix composition (per kg). The composition of the premix used in this study was: Vitamin A 12,500,000 IU; Vitamin D_3 2,500,000 IU; Vitamin E 40,000 mg; Vitamin K_3 2,000 mg; Vitamin B, 3,000 mg; Niacin 5,500 mg; Calcium Panthothenate 55,000 mg; Vitamin B_6 11,500 mg; Vitamin B_{12} 25 mg; Chloride 500,000 mg; Folic Acid 1,000 mg; Biotin 80 mg; Mn 120,000 mg; Fe 100,000; Zn 80,000 mg; Cu 8,500 mg; I_2 1,500 mg; Co 300 mg; Se 120 mg; Antioxidant 120,000 mg.

Tables 3 and 4 show the gross composition and the proximate composition of the experimental diets. The mean crude protein in the diets ranged from 45.58 % in Diet 2 to 48.13 % in the Control while the dietary energy values have a mean value of 3.47 ± 0.16 mg/l and were not significantly different from each other. The mean crude protein of the experimental diets ranged from 45–50 %, that is within the range recommended by Viveen and Hisman 1985; Adekoya *et al.* 2004.

Water quality. The water quality analysis for the experimental tanks is shown in Table 5. Temperature variations were limited in all the tanks to 27 ± 1.12^0C. All the parameters were within acceptable ranges as recommended by Boyd 1982 and Viveen *et al.* 1983.

The food conversion ratio (FCR) of the diets ranged from 1.97–2.5 (Table 6), which is an indication of the acceptability and good conversion of the diets by the experimental fish. The FCR of the SPT diet (1.97) and the control (2.0) were not significantly different from each other while that of the SPP (2.5) was higher and significantly different ($P < 0.05$) from the control. There were no significant differences ($P \leq 0.05$) within the values of GECF among the treatments. The PER values were however significantly different ($P \leq 0.05$) within the treatments. The PER values explain the fact that the crude protein in the SPT diet was better utilized than the SPP and the maize based diets. The higher fibre content of the SPT diet probably aided faster digestion of Diet 2. The MWG was highest in the maize-based diet (control), and it was significantly different ($P < 0.05$) from the two sweetpotato diets. However, the MWG of the sweetpotato-based diets were not significantly different from each other. A treatment using whole sweetpotato (tuber plus peels) flour would probably make little difference. However, using the peels while utilizing the tuber for human consumption will be a better economic option. Peels are products meant for the garbage heap so finding use for them will be environmentally friendly. The maize-based diet (control) elicited a significantly ($P < 0.05$) better growth performance and utilization than the sweetpotato-based diets. The SPT-based diet was not much different in the MWG and GEFC values from the SPP statistically but in the other parameters the SPT fed fish performed better than the fish fed the SPP diet.

The haematological result (Table 7) indicated that in all the blood parameters analyzed, the fry fed the control diet were significantly different ($P < 0.05$) from fry fed sweetpotato diets. This observation is similar to those reported by Olukunle *et al.* (2002) and Taiwo *et al.* (2003) in the examination of the nutritional values of cow blood meal and grasscutter faeces in the diets of hybrid catfish and *C. gariepinus* bloodstock, respectively. However, the sweetpotato-based diets were not significantly different from each other, except in the WBC counts and the MCHC values. The high WBC counts in the sweetpotato-based diets may be an indication of a defence reaction by the experimental fry in Diets 2 and 3 which were compounded with 25 % sweetpotato replacement. The 25 % inclusion level may not elicit the optimal performance level in the experimental fish. Similar observations were reported by Olukunle (1996); Falaye and Oloruntuyi (1998) where high concentrations of sesame seed cake (SSC) and plantain peel meal respectively suppressed fish growth in *Clarias* fingerlings. The latter authors made the suggestion that further research should be made to obtain the optimal inclusion levels of SSC and plantain peel meal in the diets of *C. gariepinus* fingerlings.

Tables 8 and 9 show the cost analysis of the feed ingredients used in the experiment. The average cost of the energy inclusion is highest in the SPT-based diet (244.1), while that of the SPP diet was lowest (213.40). There are three assumptions: (1) a fry diet should be rich in protein component. This explains the low level of maize (E) inclusion and the protein component; (2) the size of the diet should be as small as the mouth size of the fry, hence, the attempt to reduce the fibre (wheat offal) rather than the already small maize (E) inclusion and the utilization of SPT and SPP; and (3) the sweetpotato would cost the farmer next to nothing since it is expected to be used as a cover crop but an arbitrary cost had to be assigned for the sake of cost analysis. If a nil value is used to do the analysis the cost of sweetpotato-based diets will be cheaper than the maize based diet.

Table 2. Proximate composition (per 100 g) and gross energy content of ingredients fed to *Clarias gariepinus*

	Maize[1]	SPP[1]	SPP[2]	SPT[1]	SP[1] whole	SP[2] whole
Dry matter	90.38	28.72	30.00 (25.45)[3]	11.70 (36.36)[3]	28.08	86.80
% Crude Protein	10.65 (9.00)[4]	5.24	1.50	6.33	5.36	3.30
% Crude Fibre	0.06	0.41	0.40	0.34	0.33	N.A.
Lipid	4.09	0.46	0.30	1.34	0.54	0.60
% Ash	2.13	2.96	N.A.	4.18	3.21	2.70
% NFE	83.20	91.49	78.30	87.44	90.56	79.20
Gross Energy (Kcal/100 g)	409.65	391.06	111.00	N.A.	N.A.	337.00

Sources: (1) Oyenuga (1968); (2) Ashida (1982) p. 48; (3) Present work; and (4) FAO (1983).
SP: sweetpotato; SPP: sweetpotato peels; SPT: sweetpotato tuber; NFE = Non-fat extract

Table 3. Gross composition of experimental diets for *Clarias* fry

Ingredients	Treatments		
	Maize	SPT	SPP
Fish meal	50.86	51.26	49.43
Soya bean meal	33.90	34.17	32.95
Maize	3.00	3.00	3.00
Wheat offal	3.24	0.23	1.42
SPT	-	2.34	-
SPP	-	-	4.20
Palm oil	3.00	3.00	3.00
Premix (growers)	2.00	2.00	2.00
Lysine	1.00	1.00	1.00
Methionine	1.00	1.00	1.00
$Ca_3(PO_4)_2$	1.00	1.00	1.00
Salt	1.00	1.00	1.00
Total	100.00	100.00	100.00

Table 4: Proximate composition of experimental diets for *Clarias* fry

Diets	Treatments			Mean
	1	2	3	
% Moisture	10.03	8.83	9.84	9.57±1.03
% Crude protein	48.13	45.58	46.32	46.67±1.21
% Crude lipid	6.78	9.28	7.57	7.88±1.42
% Crude ash	8.64	9.33	9.33	9.10±0.41
% Crude fibre	3.81	4.87	3.98	4.22±0.23
% NFE	21.32	22.80	22.36	22.16±0.11
Dietary energy (kcal/100g)	3.57[a]	3.57[a]	3.42[a]	3.47±0.16

Table 5: Water quality parameters during the study at mean temperature of 27 °C

	Alkalinity (mg/l)	Dissolved oxygen (mg/l)	pH
Initial	10	6.2	7.2
Tank 1	10	7.4	7.4
Tank 2	7	8.4	7.2
Tank 3	5	9.2	7.1
Tank 4	10	7.0	6.9

Table 6: Growth performance and nutrient utilization of *C .gariepinus* fed processed SPT and SPP

Growth parameters	Treatments			Mean
	1	2	3	
Total No. of fish stocked	100	100	100	100
Mean initial weight (g)	0.23a	0.23a	0.19a	0.21 ±0.05
Mean final weight (g) (MFW)	2.19a	1.59b	1.46b	1.75 ±0.15
Mean weight gained (g) (MWG)	1.96a	1.37b	1.27b	1.53 ±0.14
Mean daily weight gain (g/day)	0.05a	0.04a	0.03a	0.04 ±2.02
Total percent weight gained (%)	852a	623c	668b	714.3 ±2.97
Specific growth rate (g/day)	0.70a	0.33b	0.25c	0.45 ±0.07
Total feed intake SGR (g)	362.2	256.8	264.4	294.5 ±0.18
Mean feed intake/fish (g)	3.94	2.70	3.22	2.55 ±1.91
Average No. of survivals	92.0a	95.0a	82.0c	90 ±1.05
Feed conversion ratio (FCR)	2.0a	1.97a	2.5b	2.2 ±0.16
Gross efficiency feed conversion (GEFC)	0.50a	0.51a	0.40a	0.45 ±0.7
Daily protein intake (g/day)	8.62a	6.11b	6.30b	7.01 ±0.29
Protein efficiency ratio (PER)	0.50b	0.59a	0.39c	0.49 ±0.07

Numbers along the same row followed by the same letter are not significantly different ($P < 0.05$)

Table 7. Haematology of *Clarias gariepinus* fingerlings fed the experimental diets

	Treatment		
Parameters	Maize (1)	SPT (2)	SPP (3)
PCV (%)	31.8 ± 0.3a	28.3 ± 0.3b	28.3 ± 0.5b
HbC (mg/dl)	10.0 ± 0.1a	8.7 ± 0.2b	8.5 ±0.3b
RBC counts ($x10^6$/ml)	2.6 ± 0.1a	2.3 ± 0.2b	2.2 ±0.2b
WBC counts ($x10^3$/ml)	17.8 ±2.4b	23.2 ± 0.8a	24.1± 1.5a
MCV (fl)	122.3 ±2.2b	123.2 ± 3.2b	128.6 ±3.1a
MCHC (%)	31.4 ± 0.6a	30.7 ±3.1b	30.1±2.2b

HbC: Hb concentration; Numbers along the same row followed by the same letter are not significantly different ($P < 0.05$)

Table 8: Cost analysis of feed ingredients (₦ : K)

Diets Feed Ingredients	Maize	SPT	SPP
Maize inclusion	50.86	51.26	49.40
(₦ : K)	(15.77)	(15.87)	(15.31)
Plant Protein Inclusions			
Soybean meal	33.90	34.17	32.95
(₦ : K)	(4.07)	(4.00)	(3.98)
Average Cost of Protein Inclusion (₦ : K)	19.84	19.99	19.26
Feed ingredients			
% Energy inclusion			
- Maize	3.00	3.00	3.00
(₦ : K)	(195.00)	(195.00)	(195.00)
- Wheat offal	3.24	0.23	1.42
(₦ : K)	(32.40)	(2.30)	(14.2)
- SPT	-	2.34	-
(₦ : K)	-	(40.80)	-
- SPP	-	-	4.20
(₦ : K)	-	-	(42.00)
Average cost of Energy	217.40	244.1	213.40

Conclusions

This study highlighted the potential of sweetpotato-based diets in fattening catfish fry in its nursery management. However, the haematological analysis does not appear to support using sweetpotato processed products at above 20 % level, probably due to microbial contamination. More hygienic preparation and less of sweetpotato tuber or peels in diets of catfish fry may be more beneficial and will reduce cost of diet and profit index. Other modes of processing sweetpotato are suggested, such as applying dry or moist heat to kill pathogens so as to elicit better growth and utilization comparable to maize-based diets for the catfish fry. Hence, there may be need to include the SPP and SPT at lower levels (e.g. 5–20 %) to obtain optimal performance in the diet of advanced fry of *Clarias gariepinus.*

Table 9: Economic evaluation of three *Clarias* fry diets

Index of evaluation	Diets			Mean
	Maize (1)	SPT (2)	SPP (3)	
Incidence	217.40	244.1	213.40	
of Cost	1.96	1.37	1.24	
	110.92a	178.18c	168.03b	152.38 ±1.37
Profit	1.96x8.52	1.37x8.69	1.27x8.76	
Index	217.40c	244.1b	213.40	
	0.077a	0.049b	0.050b ± 8.061	
Productive	0.05	0.04	0.03	
Protein Value	8.62	6.11	6.30	
Protein	0.0058	0.0065	0.00496	
intake (g)	$5.8x10^3$	$6.5x10^3$	$4.76x10^3$	
Dietary energy (Kcal/ 100g)	3.57a	3.57a	3.40b	3.51 ±0.36

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