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Journal of Fisheries Science
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ARTICLE

Effects of Dietary Replacement of Maize with Sweet Potato Peel in the Diet of African Catfish *Clarias gariepinus* (Burchell, 1822)

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ARTICLE INFO

Article history
Received: 7 May 2022
Revised: 30 May 2022
Accepted: 9 June 2022
Published Online: 28 June 2022

Keywords:
Sweet potato peel
Clarias gariepinus
Nutrient utilization
Growth performance

ABSTRACT

This study was carried out to evaluate the effects of dietary replacement of maize with sweet potato peel in the diet of *Clarias gariepinus* juveniles. The levels of the SPP inclusion in the experimental diets were 0%, 25%, 50%, 75% and 100%. All the diets were iso-nitrogenous. One hundred and fifty (150) *C. gariepinus* juveniles (33 g ~ 35 g) were randomly distributed to five treatments with three replicates each and 5% of their body weight for 12 weeks. Fish carcass proximate compositions analyzed before and after feeding with the experimental diets shows that CP and EE differed significantly ($p<0.05$) among the experimental fish and the control, except the percentage CP of the fish fed SPP0% and SPP50% in which there was no significant difference ($p>0.05$). Highest MWG of 207.70±25.95 g was obtained in the fish fed SPP100% followed by 191.30±16.15 g obtained in the fish fed SPP75%. The least MWG of 149.83±16.01 g was recorded in fish fed SPP25%. The highest FCR of 3.61±0.45 g was recorded in the fish fed SPP100%. A steady decrease in FCR was observed with decreasing inclusion levels of SPP meal. However, higher FW, FL, SGR and PER were observed in the experimental fish as from 50% inclusion levels of the SPP. The cost of feed per kg was reduced and the NP and WG increased with increasing levels of SPP and the profitability was enhanced at 100% SPP inclusion level. The results revealed that *C. gariepinus* juvenile could tolerate up to 50%, 75% and 100% inclusion levels of SPP. The best growth performance was recorded in the fish fed SPP100%, therefore, sweet potato peel can replace maize in the diet of *C. gariepinus* without any inauspicious effect on the growth performance and nutrient utilization.

1. Introduction

The increasing prohibitive cost and scarcity of maize necessitated the need to search for underutilized energy feed ingredients [1]. FAO [2] reported that shortage of maize in Nigeria caused a hike in its price up to 89%. Aside the cost, its use in feed formulation cuts down its availability as food for man. Large quantities of sweet potato peels are

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DOI: https://doi.org/10.30564/jfs.v4i2.4705

generated which represent a severe disposal problem to the processing industries. Sweet potato peel can serve as a good source of energy due to its high carbohydrate level of about 77.36% which is comparable to the carbohydrate level of maize of about 77.46% [3]. Incorporating sweet potato peels as a replacement for maize in fish feed would not only help to get rid of waste from environment, it will also serve as source of revenue to local farmers. In view of the high cost of conventional feed ingredients, the increasing demand for fish, the competition for maize by both human beings and animals and the international concern for conservation of resources, it is necessary to look into the possibility of using SPP as a replacement for maize in *C. gariepinus* diet. Therefore, this study aimed to evaluate the effects of dietary replacement of maize with sweet potato peel in the diet of *Clarias gariepinus* juveniles.

2. Materials and Methods

2.1 Experimental Site

The experiment was carried out in the Fisheries Research Laboratory of Biology, Ahmadu Bello University, Zaria which is located at Latitude: 11º 03' 60.00" N and Longitude: 7º 41' 59.99" E in Kaduna state of Nigeria.

2.2 Experimental Fish

One hundred and fifty mixed-sex juveniles of *C. gariepinus* were obtained from Umfatas Ventures Farm, Dam Road, Dagace Zaria, Nigeria for the investigation.

2.3 Collection and Preparation of the Sweet Potato Peel

The sweet potato peels were obtained from restaurateurs in ABU Zaria main campus. The fresh sweet potato peels were washed and sun-dried properly under hygienic conditions, the peels were winnowed and sieved to get rid of any unwanted materials, after which were milled into a fine powder and sieved through a mesh screen of 0.5 mm.

2.4 Determination of Nutrient Contents

The proximate composition of sweet potato peels and carcass composition of the fish were determined using the methods of the AOAC (2019) [4].

2.4.1 Moisture Content

A clean crucible was dried to a constant weight in an air oven at 110 °C, cooled in a desiccator and weighed (W_1). 2 g of finely pulverized sample was weighed in the crucible and then re-weighed (W_2). The crucible and its content were dried in an oven to a constant weight (W_3). The percentage moisture was calculated thus

$$\% \text{ Moisture content} = \{(W2–W3)/(W_2–W_1)\} \times 100$$

2.4.2 Ash Content

The porcelain crucible was dried in an oven at 100 °C for 10 minutes, cooled in a desiccator and weighed (W_1). 2 g of finely pulverized sample was weighed (W_2) into the previously weighed clean crucible which was ignited in the muffle furnace at 550 °C for 1 hour and cooled in a desiccator. The crucible and its content were transferred into the muffle furnace and the temperature was gradually increased until it reached 550 °C. The sample was left in the furnace for 8 hrs to ensure proper ashing. The crucible containing the ash was allowed to cool to 200 °C, the crucible was removed and cooled in a desiccator until constant weight is obtained (W_3).

$$\% \text{ Ash content} = \{(W_2–W_3)/(W_2–W_1)\} \times 100$$

2.4.3 Crude Lipid Content

Four grams of sample was weighed (W_1) into a clean, dried 500 mL round bottom flask containing few anti-bumping granules was weighed (W_2) and 300 mL of petroleum ether (40 °C-60 °C) for the extraction was poured into the flask fitted with soxhlet extraction unit. The round bottom flask and a condenser were connected to the soxhlet extractor, and cold water circulation was put on. The heating mantle was switched on and the heating rate adjusted until the solvent was refluxing at a steady rate. Extraction was carried out for 6 hours. The solvent will be recovered and the oil was dried in the oven at 70 °C for 1 hour. The round bottom flask and oil were cooled and then weighed (W_3).

$$\% \text{ Crude Content} = \{(W_2–W_3)/(W_2–W_1)\} \times 100$$

2.4.4 Crude Fibre

Two grams of finely pulverized sample was weighed into an extraction apparatus, fat was extracted with liquid petroleum spirit (40 °C-60 °C) the extracted was removed and dried at 105 °C for 30 minutes. Two grams of the defatted sample was weighed into a dry 600 cm round bottom flask. 100 cm^3 of (0.023M) sulphuric acid was added and the mixture boiled under reflux for 30 minutes. The hot solution was quickly filtered under suction. The insoluble matter was washed several times with hot water until it is acid free. This was quantitatively transferred into the flask and 100 cm^3 of hot (0.312) sodium hydroxide solution was added and the mixture boiled under reflux for 30 minutes and quickly filtered under suction. The insoluble residue was washed with boiling water until it was base free. It was dried to constant weight in the oven set at 100 °C, cooled in a desiccator and weighed (C_2). The weighed residue was incinerated in a muffle furnace at 550 °C for 2 hours, cooled in a desiccator and reweighed (C_3).

The loss in weight on ashing (incineration) = $C_2 – C_3$

Weight of original sample = W

% Crude Fibre = $\{C_2–C_3)/W\} \times 100$

2.4.5 Crude Protein

Two grams of the sample was weighed into 100 cm^3 Kjeldahl digestion flask and about l g of catalyst mixture (K_2SO_4 and $CuSO_4$) was added to speed up the reaction. 25 mL of concentrated sulphuric acid was added into the flask. The content in the Kjeldahl digestion flask was heated slowly at first in Kjeldahl heating unit frotting subsides and then more vigorously with occasional rotation of the flask to ensure even digestion and avoid over heating of the content. The heating continued until a clear solution is obtained. After cooling, the solution was transferred into 100 cm^3 volumetric flask and diluted to mark with distilled water. 10 mL aliquot of the diluted solution or digest was pipette into Markham semi macro nitrogen steel and 10 cm^3 of 40% sodium hydroxide solution was added. The liberated ammonia was trapped in a 100 cm^3 conical flask containing l0 cm^3 of 40% boric acid and 2 drops of methyl red indicator. Distillation was allowed to continue until pink colour of the indicator turn green. The content of the conical flask was titrated with 0.1M HCl, with end point indicated by a change from green to pink colour. The volume of the acid used for the distillate as well as the blank was noted.

$$\% \text{ Nitrogen} = \{(0.014 \times M \times (V_1–V_0)\}/\{\text{weight of test sample}\} \times 100$$

where M = actual molarity of acid; V_1 = volume of HCl required for 10 mL sample solution, V_0 = volume of HCl required for the blank.

Atomic weight of nitrogen = 0.014

% Crude = % Nitrogen (N_2) × 6.25

2.4.6 Nitrogen Free Extract

The total carbohydrate content was determined by different methods. The sum of the percentage moisture, % ash, %crude lipid, % crude protein and % crude fibre was subtracted from 100.

NFE = 100–(ash+ crude lipid + crude protein + crude fibre)

2.5 Formulation of Experimental Diets

Five iso-nitrogenous diets were formulated at a CP level of 35% using Pearson Square Method in a way that sweet potato peel was use to replace maize progressively at 0%, 25%, 50%, 75% and 100% respectively. The feed ingredients that were used in the experiment include; fish meal (Clupeid), soya bean meal, sweet potato peel, white maize, bone meal, palm oil, salt, vitamin premix, methionine and lysine (Table 1). All the ingredients were separately processed and milled to fine particle size and mixed together for pelleting, the feed was dried after pelleting, and it was stored in a cool dry place.

Table 1. Feed Composition

Ingredients	SSP0%	SSP25%	SSP50%	SSP75%	SSP100%
Maize	15.15	11.36	7.58	3.79	-
Sweet potato peel	-	3.79	7.58	11.36	15.15
Fish meal	24.95	24.95	24.95	24.95	24.95
Soya bean meal	49.90	49.90	49.90	49.90	49.90
Bone meal	1	1	1	1	1
Palm oil	3.5	3.5	3.5	3.5	3.5
Salt	0.8	0.8	0.8	0.8	0.8
Min/Vit premix	0.7	0.7	0.7	0.7	0.7
Methionine	2	2	2	2	2
Lysine	2	2	2	2	2

2.6 Experimental Design

Fifteen plastic tanks with a water holding capacity of 200-litre were utilized for the experiment and a constant water volume of 133 litres was maintained in each tank. The experimental tanks were assigned to five treatments which were allocated as SPP0%, SPP25%, SPP50%, SPP75% and SPP100%, respectively with three replications each. For the experimental trails, 10 *Clarias gariepinus* fingerlings were weighed and introduced into each of the experimental tanks.

2.7 Feeding Trials

The fish were fed at 5% body weight twice daily at 8:00 a.m. (morning) and 5:00 p.m. (evening) throughout the experiment. Fish in each experimental tank was collectively weighed and both the total and standard lengths were measured biweekly using weighing balance and measuring board respectively, throughout the experimental period. The experimental period lasted for 12 weeks.

2.8 Determination of Growth Performance and Nutrient Utilization Parameters

Data collected was processed to determine the fish growth performance.

2.8.1 Mean Weight Gain

This is the difference between the final weight and the initial weight of the fish that is been cultured. The difference between the final weight and the initial weight was determined as

$$MWG = W_2 - W_1$$

where W_1 = Initial weight; W_2 = Final weight

2.8.2 Specific Growth Rate

It is an index showing the best growth in a set of growth. This will be determined to observe the best growth in a set of growth. It was obtained using the method of Brown [5].

$$SGR\ \% = \frac{\log \text{ of } W_2 - \log \text{ of } W_1}{T_2 - T_1} \times 100$$

where W_1 = Initial weight; W_2 = Final weight; T_1 = Initial time; T_2 = Final time

2.8.3 Protein Efficiency Ratio

It is described as live weight gain per gram of protein fed. This was estimated from the relationship between the increment in weight and the protein consumed by fish.

$$PER = \frac{\text{Total weight gain (g)}}{\text{Crude protein fed (g)}}$$

2.8.4 Feed Conversion Ratio

It is a numerical value used to measure the gross utilization of feed for growth in fish and other animal. It is assuming that weight gain in fish and other animals is due to increase in body weight. A lower FCR therefore implies efficient food utilization by the animal. This was measured as gross utilization of food for growth in fish as described by Olukunle [6].

$$FCR = \frac{\text{Total Weight of diet fed (g)}}{\text{Total weight of fish (g)}}$$

A lower level of feed conversion ratio therefore implies efficient food utilization by fish.

2.8.5 Net Nitrogen Retention

$$NNR = \frac{\text{Initial body protein}}{\text{Final body protein}} \times 100$$

2.8.6 Survival Rate (%)

$$SR = \frac{\text{Number of fish remain at the end of experiment}}{\text{Initial number of fish stocked}} \times 100$$

2.8.7 Mortality

$$M = \frac{\text{Number of fish dead at the end of experiment}}{\text{Initial number of fish stocked}} \times 100$$

2.8.8 Condition factor

$$CF = \frac{\text{Weight gain}}{(\text{Final Length})^3}$$

2.9 Cost Benefit Evaluation

The feed production cost was based on current market prices of ingredients at Zaria, Kaduna, Nigeria. The economic evaluations were calculated employing the methods described by New [7]; Sogbesan and Ugwumba [8]. Feed Cost (N/kg) = Total Cost of ingredients required to produce a kilogram of each diet

$$\text{Profit Index} = \frac{\text{Value of fish (N)}}{\text{Cost of feed (N)}}$$

$$\text{Incidence Cost} = \frac{\text{Cost of feed (N)}}{\text{Weight of fish produced (kg)}}$$

$$\text{Benefit Cost Ratio} = \frac{\text{Total cost(N)}}{\text{Total sales (N)}}$$

Where Total Cost = Total Fixed Cost (N) + Total Variable Cost (N)

2.10 Data Analysis

T-test and one-way Analysis of Variance (ANOVA) were used to test for significant differences between the various treatment means. Least significant difference (LSD) test was used to rank and separate means where ANOVA shows significant differences. SPSS Version 23 was adopted (statistical package) to show mean deviation and standard errors, at 0.05 significant level ($P<0.05$).

3. Results

3.1 Proximate Composition of the Sun-dried Sweet Potato Peel

The mean proximate composition of the sundried sweet potato peel is presented in Table 2.

Table 2. Proximate Composition of Sun-dried Sweet Potato Peel (g/100gDM)

	Moisture	Ash	CP	EE	CF	NFE
SSPP	4.05±0.50	7.63±0.88	5.61±0.58	2.30±0.40	3.05±0.59	77.36±0.51

Key: SSPP= Sun-dried Sweet Potato Peel; CP= Crude Protein; EE=Ether Extract; CF= Crude Fiber; NFE= Nitrogen Free Extract

3.2 Proximate Composition of Experimental Diets

The proximate composition of the experimental diets is shown in Table 3. The diets were iso-nitrogenous as there was no significant difference (p>0.05) in the protein composition of the diets at 38% crude protein and they all met the dietary requirement for the experiment.

3.3 Growth Performance of *Clarias gariepinus* Juveniles Fed Experimental Diets

The results of growth performance in terms of FW, FL, MWG, SGR, CF and SR of *Clarias gariepinus* juveniles fed experimental diets are presented in Table 4.

3.4 Carcass Composition (g/100g DM)

Fish carcass proximate compositions analyzed before and after feeding with the experimental diets are presented in Table 5.

3.5 Nutrient Utilization of *Clarias gariepinus* Juveniles Fed Experimental Diets

The results of nutrient utilization in terms of PER, FCR, ANPU, NNR, PPV and FCE of *C. gariepinus* fed experimental diets are presented in Table 6.

3.6 Cost and Benefit Analysis of Experimental Diets

Cost and benefit analysis of experimental diets are presented in Table 7. The cost of the diets decreased with dietary inclusion levels of SSP Table 7.

Table 3. Proximate Composition of Experimental Diets (g/100g DM)

Parameters (g/100g DM)	T1 SPP(0%)	T2 SPP(25%)	T3 SPP(50%)	T4 SPP(75%)	T5 SPP(100%)
Moisture	6.95±0.58^{a}	7.90±0.58^{a}	6.00±0.57^{a}	6.25±0.12^{a}	6.10±0.57^{a}
Ash	7.10±0.57^{a}	7.55±0.58^{a}	6.45±0.06^{b}	7.70±0.57^{a}	7.85±0.58^{a}
Ether Extract	5.81±0.52^{a}	4.50±0.57^{b}	5.30±0.17^{a}	5.95±0.57^{a}	4.95±0.58^{b}
Crude Protein	38.79±1.15^{a}	38.77±0.6^{a}	38.76±0.58^{a}	38.78±0.52^{a}	38.69±0.58^{a}
Crude Fibre	3.90±0.58^{a}	3.15±0.57^{a}	2.00±0.57^{b}	2.29±0.37^{b}	2.15±0.52^{b}
NFE	37.35±0.51^{c}	38.24±0.83^{b}	41.29±0.46^{a}	39.03±0.58^{b}	40.26±0.57^{a}

Means with the same superscripts across rows were not significantly different (P>0.05)
Key: T= Treatment; NFE=Nitrogen Free Extract

Table 4. Growth Performance of *Clarias gariepinus* Juveniles Fed Experimental Diets

Parameters	Inclusion levels				
	T1 SPP0%	T2 SPP25%	T3 SPP50%	T4 SPP75%	T5 SPP100%
IW (g)	35.60±1.22^{a}	35.53±1.17^{a}	35.47±0.81^{a}	35.43±1.01^{a}	35.43±0.88^{a}
IL (cm)	17.73±0.37^{a}	17.67±0.99^{a}	17.67±0.85^{a}	17.60±0.60^{a}	17.60±0.76^{a}
FW (g)	187.50±42.85^{c}	185.37±14.84^{c}	188.30±6.78^{c}	226.73±15.62^{b}	243.13±25.49^{a}
FL (cm)	29.67±2.59^{c}	29.67±0.60^{c}	29.83±0.60^{c}	31.83±1.01^{b}	32.00±0.87^{a}
MWG (g)	151.90±43.74^{c}	149.83±16.01^{c}	152.83±6.55^{c}	191.30±16.15^{b}	207.70±25.95^{a}
PWG (%)	81.01±1.37^{c}	80.87±3.73^{c}	81.16±3.07^{c}	84.37±4.62^{b}	85.43±5.41^{a}
SGR (%)	0.88±0.16^{c}	0.82±0.05^{c}	0.86±0.02^{c}	0.96±0.45^{b}	1.00±0.06^{a}
CF	1.81±0.05^{b}	1.91±0.07^{a}	1.89±0.03^{b}	1.91±0.01^{a}	1.91±0.06^{a}
SR (%)	96.67±3.33^{b}	96.67±3.33^{b}	100.00±0.00^{a}	100.00±0.00^{a}	100.00±0.00^{a}

Means with the same superscripts across rows were not significantly different (P>0.05)
Key: SPP=Sweet Potato Peel, IW=Initial Weight, IL=Initial Length, FW=Final Weight, FL=Final Length, MWG=Mean Weight Gain, PWG=Percentage Weight Gain, SGR=Specific Growth Rate, CF=Condition Factor, SR=Survival Rate.

Table 5. Carcass Composition of *Clarias gariepinus* juveniles Before and After Feeding with Experimental Diets (g/100gDM)

Parameters	Initial	Final Carcass Composition				
		T1 SPP0%	T2 SPP25%	T3 SPP50%	T4 SPP75%	T5 SPP100%
Moisture	8.70±0.64^{a}	4.15±0.06^{b}	4.85±0.52^{b}	4.55±0.56^{b}	4.50±0.58^{b}	4.75±0.06^{b}
Ash	6.50±0.58^{d}	10.04±0.55^{c}	14.20±0.12^{b}	15.90±0.58^{b}	16.10±0.57^{a}	16.30±0.40^{a}
EE	17.30±0.40^{a}	16.40±0.12^{b}	15.60±0.58^{c}	12.10±0.64^{d}	10.30±0.56^{e}	09.20±0.46^{f}
CP	46.57±0.12^{e}	61.03±0.58^{c}	58.95±0.58^{d}	61.69±0.57^{c}	63.36±0.64^{b}	65.29±0.58^{a}
NFE	20.93±0.57^{a}	8.38±0.06^{b}	6.40±0.56^{c}	5.76±0.55^{d}	5.74±0.58^{d}	4.46±0.64^{e}
Total	100.00±0.0	100.00±0.0	100.00±0.0	100.00±0.0	100.00±0.0	100.00±0.0

Means with the same superscripts across rows were not significantly different (P>0.05)

Key: SPP= Sweet Potato Peel; EE= Ether Extract; CP= Crude Protein; NFE= Nitrogen Free Extract

Table 6. Nutrient Utilization of *Clarias gariepinus* juveniles Fed Experimental Diets

Parameters	Inclusion levels				
	T1 SPP0%	T2 SPP25%	T3 SPP50%	T4 SPP75%	T5 SPP100%
WG (g)	151.90±43.74^{c}	149.83±16.01^{c}	152.83±6.55^{c}	191.30±16.15^{b}	207.70±25.95^{a}
FI (cm)	65.79±0.63^{b}	66.67±0.64^{b}	66.67±0.64^{b}	69.44±0.13^{a}	68.49±0.63^{a}
PER	3.90±1.12^{c}	3.85±0.41^{c}	3.93±0.17^{c}	4.92±0.41^{b}	5.30±0.67^{a}
FCR	3.28±0.28^{c}	3.61±0.45	2.77±0.12^{c}	2.75±0.79^{b}	2.71±0.50^{a}
ANPU (%)	65.47±1.36^{c}	60.12±1.79^{d}	67.16±1.19^{c}	71.46±1.35^{b}	76.42±1.78^{a}
NNR (%)	58.29±0.48^{b}	60.36±0.79^{a}	57.67±0.35^{b}	56.15±0.39^{c}	54.93±0.66^{d}
PPV	1.57±0.01^{c}	1.52±0.01^{d}	1.58±0.01^{c}	1.63±0.01^{b}	1.67±0.01^{a}

Means with the same superscripts across rows were not significantly different (P>0.05)

Key: SPP=Sweet Potato Peel, WG=Weight Gain, FI=Feed Intake, PER=Protein Efficiency Ratio, FCR=Feed Conversion Ratio, ANPU=Apparent Net Protein Utilization, NNR=Net Nitrogen Retention, PPV=Protein Productive Value, FCE=Feed Conversion Efficiency

Table 7. Cost and Benefit Analysis of Experimental Diets

Parameters	Inclusion levels				
	T1 SPP0%	T2 SPP25%	T3 SPP50%	T4 SPP75%	T5 SPP100%
Weight Gain (g)	151.90	149.83	152.83	191.30	207.70
Cost of Feed (₦)	2,200	2,100	2,000	1,900	1,800
Cost of Juvenile (₦)	2,250	2,250	2,250	2,250	2,250
Cost of Water (₦)	2,000	2,000	2,000	2,000	2,000
Cost of Feeding (₦)	900	900	900	900	900
Total Input Cost (₦)	7,350	7,250	7,150	7,050	6,950
Number of Juveniles	10	10	10	10	10
Unit Price of Fish/kg	1,000	1,000	1,000	1,000	1,000
Total Value of Fish (₦)	10,000	10,000	10,000	10,000	10,000
Net Profit (₦)	2,650	2,750	2,850	2,950	3,050
Incidence Cost (₦)	14.48	14.02	13.09	9.93	8.67
Profit Index	4.5	4.8	5.0	5.3	5.6
Benefit Cost Ratio	0.22	0.21	0.20	0.19	0.18

4. Discussion

The proximate composition of the SSPP indicates a high amount of NFE of 77.36%. The NFE obtained in this study is higher than 71.16% and 74.60% reported by Solomon *et al.* [9] and El-Nadi *et al.* [10] for SSPP, respectively. The difference obtained could be as a result of variety of the SPP used in this experiment. The CP obtained for the SSPP in this experiment is higher than 4.64% reported by Faramarzi *et al.* [11], but is lower than 5.91% reported by Solomon *et al.* [9]. The ash content (7.63%) obtained is higher than 4.56%, 6.02% and 4.53% reported by Faramarzi *et al.*; Solomon *et al.* and El-Nadi *et al.*, [9-11] respectively. The differences observed in this study may be as a result of differences in geographical location, harvesting time and the variety the sweet potato peel used.

The growth performance of *C. gariepinus* juveniles fed varying inclusion levels of sweet potato peel indicates the mean initial weight (35.43 g ~ 35.60 g) was not significantly different (p>0.05) among the experimental treatments, showing uniformity in size at onset of the experiment as recommended by previous studies [12]. MWG generally increased with increasing inclusion levels of SPP in diets. The fish fed containing 100% inclusion level of SPP recorded the best WG (207.70 g) which was significantly different ($p<0.05$) from the WG of fish fed diet containing 25%, 50%, 75% SPP and the control. Similarly, the SGR also displayed an increasing trend with increasing levels of SPP in the diets. The best performance (1.00%/day) was obtained in fish fed 100% SPP followed by fish fed SPP75% (0.96%/day) while the lowest value (0.82%/day) was recorded in fish fed (SPP25%). Percentage weight gain, also revealed similar trend with those of FW and SGR.

The increasing trend in growth performance could be due to high mineral concentrations present in the SPP. However, minerals are component of hormones and enzymes, and they activate enzyme, as reported by Zaijie [13] which could also lead to the increased and better growth performance recorded with increasing inclusion levels of sweet potato peel in the diets. The increasing trend in growth performance observed in this study contradicts with findings of Olukunle [6] who replaced sweet potato peel with maize at 0%, 25%, 50% and 75% in diet of *C. gariepinus* advanced fry and stated that growth performance decreased with increase in the sweet potato peel meal inclusion. However, Solomon *et al.* [16] replaced sweet potato peel for maize in the diet of *C. gariepinus* fingerling at 0%, 25%, 50%, 75% and 100% inclusion levels and concluded that growth parameters were maximum at 50% and 75% inclusion levels of sweet potato peel in the diet. Faramarzi *et al.* [11] had also carried out a similar research on replacing maize with SPP at 0%, 5%, 10%, 15%, 20% and 25% inclusion levels in iso-nitrogenous diet (31.23% crude protein) of *Cyprinus carpio,* these authors concluded that *C. carpio* could tolerate up to 15% inclusion levels of sweet potato peel.

The condition factors (1.81 – 1.91) of fish fed the dietary treatments were not significant different ($p>0.05$) indicating that dietary inclusion of SPP did not influence the welfare of the experimental fish. Survival rate of *C. gariepinus* juvenile fed the experimental diets showed similar performances (96.67% - 100.00%) among the experimental treatments as no significant difference ($p>0.05$) was observed.

The nutrient utilization of *C. gariepinus* fed diets containing different dietary levels of SPP did not show significant differences ($p>0.05$) in PER, feed and ANPU among the experimental diets and the control except for the fish fed SPP75% and SPP100% which have higher values compared to the other treatments this could be as a result of activation of digestive enzymes by the high mineral concentrations present in the SPP. Protein efficiency ratio differed significantly ($p<0.05$) among the experimental fish and the control. The highest PER (5.30) was recorded in the fish fed SPP100% while the least PER of 3.85 was obtained in the fish fed SPP25%, this could be due high weight gain (207.70 g) obtained in the fish fed SPP100% and least weight gain (149.90 g) obtained in the fish fed SPP25%.

The feed conversion ratio recorded in this experiment (2.71-3.61) in which the fish fed SPP100% had the lowest and the fish fed SPP25% had the highest. The highest value of feed conversion ratio (3.61) obtained in this study was similar with the feed conversion ratio value (3.23) reported by David and Afia [14] for *C. gariepinus* fed locally formulated diet for eight (8) weeks.

The carcass crude protein in this experiment increased significantly ($p<0.05$) after the feeding trial. The mean initial crude protein (46.57%) was significantly lower than the values obtained after the feeding trial. High value (65.29) was recorded in fish fed SPP100% which is in line with findings of Cheng and Hardy [15]. However, moisture content did not differ significantly ($p>0.05$) among the fish fed experimental diets and the control. There was no significant difference in the ash content of the fish fed 75% and 100% sweet potato peel but it differed with the other treatments and the control. Ash ranged from 10.04% to 16.30% and moisture ranged from 4.15% to 4.85%. Soluble carbohydrate (nitrogen free extract) did not differ significantly ($p>0.05$) in the fish fed 50% and 100% as well as 25% and 75% sweet potato peel but they differed significantly ($p<0.05$) with the control (0%). The percentage of nitrogen free extract ranged from 5.46% to 8.38%. Moisture content, lipid and nitrogen free extract are significantly higher in the initial carcass composition than after feeding with the experimental diets, while crude protein and ash content are significantly higher after the feeding trial. The carcass crude protein and ash increased while lipid decreased with increasing level of sweet potato peel in the diet.

Cost of feed per kg of feed reduced from ₦2,200 in the control to ₦1,800 in Treatment5. The total input cost (₦7350) was higher in the control compared to the other treatments. Net profit had increased from ₦2650 to ₦3050 in the Control and Treatment5, respectively which was significantly ($p<0.05$) higher to the other treatments. Experimental diet containing 100% sweet potato peel which had lowest cost of feed per kilogram, lowest total input cost, highest net profit and highest profit index (5.6) was therefore more profitable than the other diets.

The economic superiority of Treatment5 (SPP100%)

could be as a highest level of sweet potato peel. The relatively higher cost factor of the control may be attributed to the high cost of maize in the diet. Moreover, the use of sweet potato peel in fish feed production may be economical taken into consideration its availability.

5. Conclusions

Growth and nutrient utilization of the experimental fish increased with increasing levels of sweet potato peel in the diet, suggesting that SPP may be suitable to replace maize in the diet of *C. gariepinus* juvenile from 50% to 100% as the fish fed containing 100% inclusion level of sweet potato peel had the best weight gain (207.70 g) while poor weight gain of 149.83 g and 151.90 g were observed in the diet fed 25% inclusion level and the control. The cost of feed per kg had reduced from ₦2,200 to ₦1,800 and the net profit had increased from ₦2,650 to ₦3,050, the weight gain had also increased (151.90 g-207.70 g) with increasing levels of SPP and the profitability was enhanced at 100% SPP inclusion.

Abbreviations

SPP= sweet potato peel; CP= crude protein; EE= ether extract; MWG= mean weight gain; FCR= feed conversion ratio; FW= final weight; FL=final length; NP= net profit; WG= weight gain

Authors' Contributions

Abdurrazzaq Ibrahim Abdullahi conceived the work, designed the experiment and carried out the experiment. Dr. Bolanle Silas Bawa and Prof. S. A. Abdullahi supervised the work and also read and approved the manuscript.

Conflict of Interest

The authors have declared no conflict of interest for this work.

Funding

This research received no external funding.

Acknowledgments

The authors acknowledge the support of laboratory Technologists who assisted in all the analyses carried out during this project.

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Appendix

Feed formulation

Fixed Ingredients (%):		
	Bone meal	1
	Salt	0.8
	Min/vit premix	0.7
	Palm oil	3.5
	Methionine	2
	Lysine	2
		10%

Maize = 8.75% CP

Sweet potato peel = $\frac{5.37\%\ CP}{\mathbf{14.12\%}} = \frac{14.12}{2}$ = **7.06%**

One (1) part Fish meal = 60% CP
Two (2) part SBM = 38% CP × 2 = 76%

$\mathbf{136\%} = \frac{136}{3}$ = **45.33%**

100% - 10% = 90%

35/90 × 100 = **38.89% CP**

Energy source 7.06 6.44

$\boxed{38.89}$

Protein source 45.33 31.88

38.27%

Energy source = $\frac{6.44}{38.27} \times 90$ = **15.15%**

Protein source= $\frac{31.82}{38.27} \times 90$ = **74.85%**

1 part Fish meal = **24.95%**

2 part SBM = **49.90%**

At 0% SSP = 0%

100% Maize= 15.15

At 100% SPP = 15.15%

0% Maize= 0%

At 25% SPP = 25/100 × 15.15 =**3.79%**

75% Maize = 75/100 × 15.15 = **11.36%**

At 50% SPP = 50/100 × 15.15 = **7.58%**

50% Maize = 50/100 × 15.15 = **7.58%**

At **75% SPP =** 75/100 × 15.15 = **11.36**%

25% Maize = 25/100 × 15.15 = **3.79**%

Plate 1. Watching of sweet potato peel

Plate 2. Side view of hand pelletizer

Plate 3. Sun drying of sweet potato peel

Plate 5. Sun drying of the experimental feed

Plate 4. Grinding of sweet potato peel

Plate 6: Treatment set up in the Lab.