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GROWTH PERFORMANCE AND BIOCHEMICAL PARAMETERS OF THE AFRICAN CATFISH (*CLARIAS GARIEPINUS*) FINGERLINGS FED DIETS WITH VARYING LEVELS OF ORANGE FLESHED SWEET POTATO (*IPOMEA BATATAS)* PEEL

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ABSTRACT

The present study examined the growth and biochemical performance of Clarias gariepinus fingerlings fed experimental diets containing different percentages of orange fleshed Ipomea batatas peel meal. Experimental diets were prepared with differing levels of incorporation of Ipomea batatas peel meal (0%, 20%, 40%, 60%, 80%, and 100%) as replacement for traditional feed ingredients. Fish were fed for 16 weeks and the growth performance, feed consumption, and biochemical variables were measured. The results indicated that the treatment and control groups exhibited significant variations (p<0.05) in growth performance, and maximum weight gain (117.91±0.80 g) and feed consumption (271.43±2.14 g) were achieved for the control diet (0% orange fleshed Ipomea batatas peel meal). Minimum weight gain (92.65±0.28 g) and feed intake (197.19±11.33 g) were recorded for the diet containing 100% orange fleshed Ipomea batatas peel meal. Biochemical parameters indicated significant alteration in serum parameters (p<0.05), i.e., reduction in creatinine, total protein, and albumin, and electrolytes (sodium and potassium) with increased intake of Ipomea batatas peel meal. Creatinine fell from 1.18±0.09 mg/dL in control to 0.85±0.02 mg/dL for the 100% peel meal diet. Protein content fell from 2.59±0.09 g/dL for the control to 1.72±0.03 g/dL for the 100% peel meal diet. Albumin reduced from 0.88±0.01 g/dL to 0.72±0.01 g/dL with the treatments. Sodium concentration reduced from 40.86±0.93 mg/dL in control to 36.21±0.11 mg/dL in the 100% peel diet, and potassium concentration reduced from 17.65±0.05 mg/dL to 17.12±0.64 mg/dL, respectively. These results indicate that although orange fleshed Ipomea batatas peel meal is a cheaper substitute feed ingredient, increased use of it may have a negative impact on growth and biochemical indices of protein metabolism and electrolyte balance.

Keywords: Orange fleshed sweet potato peel, Clarias gariepinus, fingerlings, Growth, Biochemical.

INTRODUCTION

One of the biggest challenges of global food security is the nutritional requirement of a growing population, which is projected to be 10 billion by 2050 (FAO, 2017). Sustainable Development Goal 2, ending hunger and malnutrition by 2030, can be achieved only through dietary changes, particularly in low- and middle-income countries (Karolina, Andrew & Michael, 2020). With the growth of population, there is an immediate need for enhancement in food production systems, especially in developing countries, to ensure a uniform and sustainable supply of food. Fish has been a critical animal protein source for long, particularly in nations where it is part of the staple diet. Fish contributes significantly to animal protein consumption in some parts of the Global South, and it is crucial to the nutritional well-being of the vulnerable population (FAO, 2022). Fish such as *Clarias gariepinus* (African catfish) contributes good protein, omega-3 fatty acids, and minerals like calcium, iron, and zinc, all of which are required in human development where other proteins may be inaccessible (Neumann et al., 2014).

Aquaculture is a key part of world food supply, but expensive feed is a key problem, especially where access to conventional fish feed ingredients is impractical (FAO, 2022). Fish feed in Africa accounts for up to 60% of the cost of fish production (Igoche et al., 2019). Other feed ingredients such as local crop by-products may be utilized in order to contribute towards lower costs of feed and improved aquaculture sustainability. orange fleshed *Ipomea batatas* peels are by-product that is rich in dietary fibre and carbohydrates and therefore form a cost-effective alternative feed ingredient for aquaculture. The aim of this research was to determine the growth rate, feed conversion, and biochemical efficiency of *Clarias gariepinus* fingerlings fed with diets that have varying percentages of orange fleshed *Ipomea batatas* peel meal.

MATERIALS AND METHODS

Preparation of orange fleshed (*Ipomea batatas*) peels meal

Fresh orange fleshed *Ipomea batatas* were collected from local farmers. The peels were washed, sun-dried for two weeks, and then milled into fine powder using a hammer mill. The powdered peels were sieved to remove coarse particles, and a fine uniform powder was produced. The dry orange fleshed *Ipomea batatas* peel powder was subsequently incorporated into experimental diets at varying inclusion levels.

Formulation of Experimental Diets

Six experimental diets were formulated using fish meal, orange fleshed *Ipomea batatas* peel meal, soybean cake, maize, cassava flour, palm oil, blood meal, mineral and vitamin mix, and chromic oxide (for digestibility analysis). The diets included different levels of orange fleshed *Ipomea batatas* peel meal: 0%, 20%, 40%, 60%, 80%, and 100%. These diets were prepared by thoroughly mixing the ingredients in a stainless-steel pot and pelleting the mixture using a meat mincer (Omoregie et al., 2009). The pellets were made with a diameter of 2mm to suit the size of the fingerlings.

Experimental Design

Eighteen 20-liter plastic tanks were used in a completely randomized design, with three tanks per diet treatment. Each tank contained ten fish. The fish were fed their respective diets at 5% of their body weight, twice a day. Growth performance (mean final weight and mean weight gain) and feed utilization (feed intake) were measured bi-weekly. Water quality factors such as temperature, pH, dissolved oxygen, and ammonia were checked from time to time, and excess feed and feces were removed daily for water quality maintenance.

Feeding and Management

Fish were fed twice a day at 5% of body weight for 16 weeks. Feeding was regulated weekly on the basis of average body weight of fish. Water quality factors such as temperature, pH, dissolved oxygen, and ammonia were checked from time to time, and excess feed and feces were removed daily for water quality maintenance.

Growth and Feed Utilization Assessment

After the end of the feeding trial, fish growth performance was assessed on the basis of the following parameters:

Growth Indices

A. Percentage Weight gain

Weight Gain (g)=<u>Initial weight</u> (g) x 100

Initial weight (g)

(Ahmad, 2012).

Specific Growth Rate (SGR)

This the percentage increase in body weight per day over any given time interval. The Specific Growth Rate (SGR) was calculated using the formula below:

$$SGR = \frac{\log_e w2 - \log_e w1}{T2 - T1} \times 100$$

Where,

W2= Final weight of fish at time T_2

W_1- Initial weight of fish at time T_1

e= Base of natural logarithm

(Samuel, Ayanwale & Mohammad, 2021).

Survival rate (SR%) = 100 x (fish No. at the end÷ fish No. stocked at the beginning) Equation 3

Food Utilization Parameters

Food conversion ratio (FCR)

This is a measure of the quantity of feed required for a unit weight gained by the fish. Thus, the higher the FCR value the better the feed.

$$FCR = \frac{\text{Weight of food consumed (g)}}{\text{Weight gain by the fish}}$$

Where:

$$\textbf{Feed intake (FI) (g)} = \frac{5\%\ \text{Body weight} \times \text{Experimental period}}{\text{Number of fish stocked}} \quad \ldots\ldots\ldots\ldots$$

(Afe & Omosowone, 2019).

B. Protein efficiency ratio (PER)

$$PER = \frac{\text{Live weight gain (g)}}{\text{Protein fed (g)}}$$

Where,

$$\textbf{Protein fed (g)} = \frac{\text{Protein (\%) in feed x Total weight (g) of diet consumed}}{100}$$

Apparent Net Protein Utilization (ANPU)

This indicates the efficiency of transforming the dietary protein into tissue protein by the fish. It was calculated thus:

$$ANPU\ (\%) = \frac{\text{Final carcass protein} - \text{Initial Carcass Protein}}{\text{Protein Fed}} \times 100$$

Biochemical Analysis

At the end of the trial, blood samples were collected from two fish per treatment for serum biochemical analysis. Parameters assessed included creatinine, glucose, total protein, albumin, globulin, electrolytes (sodium and potassium), and liver enzymes (ALT, AST, and ALP).

RESULTS

Growth Performance:

The growth performance of *Clarias gariepinus* fingerlings (table 1) significantly varied across the different dietary treatments. The control group (0% orange fleshed *Ipomea batatas* peel meal) exhibited the highest weight gain, with a value of 117.91±0.80 g, followed by the 20% inclusion diet (110.82±1.10 g). Conversely, the lowest weight gain was observed in the 100% orange fleshed *Ipomea batatas* peel meal diet (92.65±0.28 g). The specific growth rate (SGR) also followed a similar trend, with the control group achieving the highest SGR of 2.37±0.02%/day, while the 100% peel meal diet showed the lowest SGR (1.87±0.03%/day). Feed intake decreased progressively with increasing inclusion of sweet potato peel meal, with the control group recording the highest feed intake (271.43±2.14 g) and the 100% peel meal diet showing the lowest feed intake (197.19±11.33 g). The feed conversion ratio (FCR) was best in the 20% peel meal diet (1.60±0.08), while the highest FCR was observed in the 100% peel meal diet (2.14±0.11).

Table 1: Mean growth performance and feed utilization indices of *Clarias gariepinus* fingerlings fed diets with varying levels of orange fleshed sweet potato peels

Treatments Indices	D1	D2	D3	D4	D5	D6	p-value
Mean Initial Weight (g)	2.67±0.00	2.67±0.00	2.66±0.01	2.67±0.01	2.66±0.01	2.66±0.01	1.000
Mean Final Weight (g)	120.58±0.07	114.43±0.43	111.65±0.19	100.06±1.88	96.98±2.45	95.31±2.40	0.000
Mean Weight Gain (g)	117.91±0.80	111.76±0.36	108.98±0.19	97.39±1.88	92.66±2.40	84.63±0.28	0.000
Mean Feed Intake (g)	271.43±2.14	256.53±0.43	251.34±2.20	224.99±4.15	208.87±1.95	197,19±11.33	0.000
SGR (%/day)	1.38±0.005	1.36±0.005	1.35±0.005	1.31±0.005	1.30±0.01	1.26±0.005	0.997
Feed Conversion Ratio	2.30±±0.01	2.30±0.01	2.31±0.02	2.31±0.00	2.27±0.08	2.33±0.01	1.000
Protein Efficiency Ratio	1.11±0.01	0.78±0.48	1.12±0.00	1.11±0.00	1.14±0.04	1.10±0.01	0.476
ANPU (%)	0.02±0.005	0.02±0.005	0.02±0.005	0.02±0.005	0.02±0.005	0.02±0.005	0.956
Survival (%)	100.00	100.00	100.00	100.00	96.67±4.71	96.67±4.71	0.571

Means within a column and effect that lack common superscripts differ significantly (Tukey's multiple comparison test, $P \leq 0.05$).

Legend:

SGR= Specific Growth Rate

ANPU=Apparent Net Protein Utilization

Biochemical Parameters:

The biochemical parameters (Table2) indicated significant differences between the control and treatment groups, particularly with increasing levels of orange fleshed *Ipomea batatas* peel meal inclusion. Creatinine levels significantly decreased from 1.18±0.09 mg/dL in the control group to 0.85±0.02 mg/dL in the 100% peel meal diet ($p<0.05$). Similarly, total protein levels showed a significant reduction, declining from 2.59±0.09 g/dL in the control group to 1.72±0.03 g/dL in the 100% peel meal diet ($p<0.05$). Albumin levels also significantly decreased, from 0.88±0.01 g/dL in the control to 0.72±0.01 g/dL in the 100% peel meal diet ($p<0.05$). Regarding electrolytes, sodium levels significantly decreased from 40.86±0.93 mg/dL in the control group to 36.21±0.11 mg/dL in the 100% peel meal diet ($p<0.05$). Similarly, potassium levels showed a slight but significant reduction from

17.65±0.05 mg/dL in the control group to 17.12±0.64 mg/dL in the 100% peel meal diet ($p<0.05$) (Table 2).

Table 2: mean biochemical parameters of *Clarias gariepinus* fingerlings fed diets with varying levels of orange fleshed sweet potato peels meal

Treatment Parameters	D1	D2	D3	D4	D5	D6	p-value
Creatinine	1.18 ± 0.09^{a}	1.04 ± 0.06^{ab}	0.95 ± 0.06^{bc}	0.90 ± 0.03^{bc}	0.86 ± 0.02^{c}	0.85 ± 0.02^{c}	0. 000
Glucose	54.19 ± 0.10^{a}	56.55 ± 0.10^{b}	59.63 ± 0.06^{c}	63.16 ± 0.05^{d}	66.52 ± 0.11^{e}	70.11 ± 0.18^{f}	0. 000
Total Protein	2.59 ± 0.09^{a}	2.55 ± 0.04^{a}	2.46 ± 0.04^{a}	2.24 ± 0.25^{a}	1.83 ± 0.04^{b}	1.72 ± 0.03^{b}	0. 000
Albumin	0.88 ± 0.01^{a}	0.86 ± 0.01^{a}	0.85 ± 0.01^{a}	0.75 ± 0.02^{b}	0.73 ± 0.01^{b}	0.72 ± 0.01^{b}	0. 000
Globulin	1.72 ± 0.11^{a}	1.69 ± 0.05^{a}	1.62 ± 0.04^{a}	1.49 ± 0.25^{a}	1.10 ± 0.04^{b}	1.00 ± 0.04^{b}	0. 000
Sodium	40.86 ± 0.93^{a}	40.62 ± 0.11^{a}	37.70 ± 0.78^{b}	36.56 ± 0.33^{b}	36.33 ± 0.01^{b}	36.21 ± 0.03^{b}	0. 000
Potassium	17.65 ± 0.05^{a}	17.42 ± 0.09^{a}	17.40 ± 0.04^{a}	17.31 ± 0.04^{a}	17.16 ± 0.05^{a}	17.12 ± 0.64^{a}	0.191
ALT	28.39 ± 0.02^{a}	28.30 ± 0.06^{ab}	28.17 ± 0.07^{bc}	28.14 ± 0.01^{bc}	27.99 ± 0.10^{c}	27.15 ± 0.01^{d}	0. 000
AST	46.62 ± 0.15^{a}	46.52 ± 0.09^{a}	46.40 ± 0.06^{ab}	46.19 ± 0.09^{b}	45.73 ± 0.05^{c}	45.53 ± 0.37^{c}	0. 000
ALP	12.20 ± 0.02^{a}	12.13 ± 0.01^{a}	12.05 ± 0.04^{ab}	11.67 ± 0.52^{ab}	11.15 ± 0.04^{ab}	10.95 ± 0.71^{c}	0.010

Means within a column and effect that lack common superscripts differ significantly
(Tukey's multiple comparison test, $P<0.05$).

Legend:
ALT=Alanine aminotransferase, AST=Aspartate aminotransferase, ALP= Alkaline phosphatase

Cost-Benefit Analysis

The cost of feed per kg of feed ranged from ₦1, 240 in D6(100%), to ₦1, 970 in D1(0%), with D1(0%) having the highest and D6(100%), the lowest (Table 14). The total input cost ranged from ₦6,040 in D6(100%) to ₦6,770 in D1(0%), with D1(0%) having the highest and D 6(100%) the lowest. Furthermore, the net profit ranged from ₦18,230 in D1(0%) to ₦18,960 in D6 (100%), with D6(100%) having the highest and D1(0%) having the lowest and the incidence cost ranged from 16.71 in D1(0%) to 14.30 in D6(100%), with D1 having the highest and D6(100%), having the lowest. In addition, the profit index ranged from 12.69 in D1(0%) to 20.16 in D6(100%), with D6(100%) having the highest and D1 the lowest. (Table3).

Table 3: Cost and benefit analysis of experimental diet with varying level of orange fleshed sweet potato peels meal fed to *Clarias gariepinus* fingerlings

Parameters	Diets	D1	D2	D3	D4	D5	D6
Weight Gain (g)		117.91	111.76	108.98	97.39	92.66	86.63
Cost of Feed (₦)		1970	1740	1640	1470	1340	1240
Cost of Fingerlings (₦)		1300	1300	1300	1300	1300	1300
Cost of Water (₦)		2000	2000	2000	2000	2000	2000
Cost of Feeding (₦)		1500	1500	1500	1500	1500	1500
Total Input Cost (₦)		6770	6540	6440	6270	6140	6040
Number of Fingerlings		10	10	10	10	10	10

Unit price of Fish/Kg	2500	2500	2500	2500	2500	2500
Total value of Fish (₦)	25000	25000	25000	25000	25000	25000
Net Profit (₦)	18230	18460	18560	18730	18860	18960
Incidence Cost (₦)	16.71	15.57	15.05	15.09	14.46	14.30
Profit Index	12.69	14.37	15.24	17.01	18.66	20.16
Benefit Cost Ratio	0.27	0.26	0.26	0.25	0.25	0.24

Water Quality Parameters of Experimental Tanks

The mean water quality parameters of the experimental tanks for fingerlings revealed that, there were no significant differences (p>0.05) for all the parameters monitored between the control (D1) and the treatment groups. However, the temperature ranged from 25.21±0.08 to 25.54±0.58 with highest value in D1 and the lowest in D5. The dissolved oxygen ranged from 5.24±0.06 to 5.36±0.07 with D1 having the highest and D4 the lowest. The pH ranged from 6.10±0.11 to 6.27±0.20 with D6 having the highest and D4 the lowest. Free carbondioxide ranged from 7.48±0.11 to 7.68±0.07 with D1and D3 having the highest while D6 had the lowest value. Alkalinity ranged from 126.05±0.31 to 127.52±0.08 with D4 having the highest and D1 with the lowest (Table 4).

Table 4: Water Quality Parameters of Experimental Tanks for Fingerlings of *Clarias gariepinus* fed Diets with Varying Levels of Orange Fleshed Sweet Potato Peels Meal

Treatments								p-value
Parameters	D1	D2	D3	D4	D5	D6	p-value	
Temperature (°C)	25.54±0.58^a	25.22±0.26^a	25.31±0.08^a	25.22±0.05^a	25.21±0.08^a	25.29±0.40^a	0.791	
DO (mg/L)	5.36±0.07^a	5.28±0.12^a	5.31±0.01^a	5.24±0.06^a	5.28±0.05^a	5.32±0.08^a	0.541	
Ph	6.25±0.05^a	6.23±0.04^a	6.24±0.02^a	6.10±0.11^a	6.11±0.19^a	6.27±0.20^a	0.37	
Carbondioxide (mg/L)	7.68±0.07^a	7.55±0.18^a	7.68±0.19^a	7.57±0.13^a	7.53±0.15^a	7.48±0.11^a	0.986	

Means within a column and effect that lack common superscripts differ significantly (Tukey's multiple comparison test, $P \leq 0.05$).

Legend:

DO=Dissolved oxygen

pH=hydrogen ion concentration

DISCUSSION

Growth Performance

In the present study, growth rate and feed conversion reduced with increased levels of orange-fleshed sweet potato peel incorporation. Decrease in growth was most probably caused by the increase in carbohydrate content of the diets. Omoregie et al. (2009), Olukunle (2006), and Oshoke et al. (2019) also attained the same results, whereby growth performance of *C. gariepinus* fingerlings reduced with increased use of sweet potato peel meal. Samuel et al. (2022) also noted the same pattern in terms of exposing *C. gariepinus* to different levels of watermelon bark to substitute soy, while Ajiboye et al. (2019) noted stunted growth with dried pig feces at elevated inclusion levels in the diet and attributed the loss to high levels of microbes and phytochemicals in the diet. But this outcome is contrary to Abdurrazzaq et al. (2022), who reported enhanced growth and feed utilization when *C. gariepinus* fingerlings were provided with sweet potato peel meal at different inclusion rates (0%, 25%, 50%, 75%, 100%). Likewise, Baleta et al. (2022) reported that sweet potato hot-water extract in *Oreochromis niloticus* diets had a significant impact on growth performance. These discrepancies may be attributed to differences in sweet potato type, processing, weather, soil type, and duration of the study.

Biochemical Parameters

Biochemical indicators have important roles in assessing the health of fish against dietary fluctuations (Ahmed & Ahmad, 2020). Reduction in levels of creatinine under increased inclusion of orange fleshed sweet potato peels (OFSP) in this study indicates that *Clarias gariepinus* accommodates high levels of the diet through enhanced excretory activities or decreased kidney stress, as explained by Adeshina and Abdel-Tawwab (2020). The rise in glucose with higher OFSP peel inclusion reflects either enhanced energy metabolism or disturbed glucose regulation, as discussed by Silva et al. (2021). The lower concentrations of total protein, albumin, and globulin in fish that were fed the higher OFSP peels may also reflect reduced protein synthesis or elevated breakdown due to fluctuations in nutrient metabolism, as also noted by Fayemi et al. (2020). This could be because of the amino acid makeup of the plant diet, which determines protein synthesis. Potassium and sodium used in fluid balance and muscle control lowered during this experiment and indicate an alteration in electrolyte homeostasis that likely took place as there was an alteration in the mineral content of OFSP peels from a traditional diet, as discussed by Khalil et al. (2019). This would reduce osmoregulatory ability with the result being stress or different function (Kpogue et al., 2021). Lastly, the reduction of liver biomarkers (ALT, AST, and ALP) with increased OFSP peel content indicates better liver function or alleviated liver stress, perhaps due to enhanced metabolic efficiency or lowered dietary toxin insult, as indicated by Hussein et al. (2018). The trend accords with Abdullahi et al. (2023), whose conclusion was that enzyme activity optimizes the feeding efficacy of *C. gariepinus* on sweet potato peels.

Cost-Benefit Analysis

Cost-benefit implication of feeding various percentages of orange-fleshed sweet potatoes peels meal to *C. gariepinus* fingerlings is that using OFSP peels as fish feed is cost-effective while at the same time enhancing profitability. Feed cost per kilogram was reduced in 100% OFSP peels meal diets compared to the control diet (D1), demonstrating the economies of OFSP as a replacement feed ingredient, as also noted by Adesina, Ajibare, and Ebimowei (2020). Likewise, overall input costs were lowered in the 100% OFSP peels meal diet compared to the control, and this indicates that OFSP can potentially lower overall cost of production, as indicated by a study by Ali et al. (2024), which was performed to investigate the use of maca root powder in *C. gariepinus* hatchlings. Maximum net profit was achieved in peels meal diet 100% OFSP peels (D6), which means that minimized feed cost did not affect fish growth and possibly could enhance it, as suggested by Abdurrazzaq et al. (2022). The cost incidence, as a measure of the ratio of costs to revenue, was lower in D6 compared to D1, in the sense that there was greater cost efficiency, as hypothesized by Abdurrazzaq et al. (2022). Profit index, a sign of return on investment, was higher in D6 than in D1, showing the higher profitable result using OFSP peels meal, as seen by Salisu et al. (2024) in *C. gariepinus* fingerling feeding on different levels of bambara groundnut meal. In summary, orange-fleshed sweet potato peels meal is inexpensive and lucrative as an ingredient of fish feed, and therefore a sustainable and viable means of aquaculture, particularly where conventional feeds are prohibitive or not readily available.

Water quality parameters of experimental tanks

Although there is variation in the water quality parameters of experimental tanks, The mean value obtained for the water quality parameter of the experiment showed that temperature (26.53 ±0.57), dissolved oxygen (5.37-5.57±0.03) and pH (6.22-6.50 ±0.03) fall within the optimal requirements for fish production. This conformed to the report of Anita and Pooja, (2013).

CONCLUSION

Inclusion of orange fleshed Ipomea batatas peel meal in *Clarias gariepinus* fingerling diet showed a potential use as an alternative feed ingredient. Nevertheless, the more extensive incorporation levels (80% and 100%) adversely affected growth performance and biochemical characteristics. This indicates that while sweet potato peel meal helps in minimizing feed cost, use up to 20% peel meal indicated an optimal balance between growth performance and feed cost saving. Future research must be aimed at the potential of improving sweet potato peel meal's nutritional value and digestibility to maximize its use in fish feed blends.

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