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DIETARY EFFECTS OF RIPE AND UNRIPE BANANA PEELS ON THE GROWTH AND ECONOMY OF PRODUCTION OF JUVENILE CATFISH (*Clarias gariepinus* Burchell, 1822)

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Abstract: Six diets were produced using graded levels of banana peels (5, 10 and 15% for both ripe (RBP) and unripe (UBP) banana peels) which were compared with the control diet (CTR) containing maize in the diet of *C. gariepinus* juveniles. Feeds were fed to triplicate groups of ten fish each to satiation thrice daily for ten weeks. There were significant differences ($p<0.05$) in Mean Weight Gain (MWG) and Specific Growth Rate (SGR) across diets. The CTR had the highest MWG (58.40 ±5.27g) and SGR (1.877±0.09%) while the least values of MWG (25.03 ±1.85g) and SGR (1.106 ±0.05%) were recorded in Diet3 (15% UBP). The Feed conversion ratio, Protein efficiency ratio and Protein intake recorded significant differences ($P<0.05$) between the CTR and other diets. Similar results were recorded for Profit Index, Incidence of Cost and Economic Investment Cost Analysis. Likewise, analysis of fish organs recorded significant differences ($P<0.05$) between the CTR and other diets. Though the CTR had the best growth performance, it had the least Profit Index (1.87) while Diet2 (10% RBP) had the highest Profit Index (3.11). Thus, plantain peel is a profitable alternative energy source for partial substitute of maize up to 10% RBP and UBP in diet of *C. gariepinus*.

Keywords: Catfish, Energy source, Growth indices, Economy of production

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Öz:

Diyete Olgunlaşmış ve Ham Muz Kabuğu Eklenmesinin Juvenil Kuzey Afrika Yayin Balığı (*Clarias gariepinus* Burchell, 1822)'Nin Gelişmesi ve Yetiştiriciliğinin Ekonomisi Üzerine Etkileri

Farklı oranlarda muz kabuğu içeren 6 adet diyet grubu (hem olgunlaşmış, hem de ham muz kabuğu için % 5, 10 ve 15) üretilmiş ve jüvenil *C. gariepinus* 'un beslenmesinde mısır içeren kontrol diyet grubu (CTR) ile karşılaştırılmıştır. Yemler 10'ar adet balıktan oluşan 3 tekrarlı deney gruplarına 10 gün boyunca günde 3 kez balıklar doyana kadar verilmiştir. Diyet grupları arasında Ortalama Ağırlık Artışı (OAA) ve Spesifik Büyüme Oranı (SBO) bakımından gözle görülür farklılıklar ($p<0.05$) tespit edilmiştir. En yüksek OAA (58.40 ± 5.27 g) ve SBO (1.877 ±0.09) kontrol grubunda ölçülürken en düşük OAA (25.03 ± 1.85 g) ve SBO (% 1.106 ±0.05) 3 numaralı diyet grubunda (%15 ham muz kabuğu) tespit edilmiştir. Yem dönüştürme oranı, protein etkinliği ve protein alımı bakımından da kontrol ve diğer gruplar arasında gözle görülür farklılıklar ($P<0.05$) kayıt edilmiştir. Benzer sonuçlar karlılık indeksi, maliyet etkisi ve ekonomik yatırım maliyet analizinde de gözlemlenmiştir. Aynı şekilde balık organlarının incelenmesinde de kontrol ve diğer diyet grupları arasında önemli farklılıklar ($P<0.05$) görülmüştür. En iyi büyüme performansı kontrol grubunda görülmesine rağmen en düşük karlılık indeksi (1.87) bu grupta ve en yüksek karlılık indeksi 2 numaralı diyet grubunda (3.11) görülmüştür. Böylelikle olgunlaşmış ve ham muz kabuğunun, *C. gariepinus* diyetinde mısırla %10'a kadar yer değiştirilebilecek karlı bir alternatif enerji kaynağı olduğu belirlenmiştir.

Anahtar Kelimeler: Yayın balığı, Enerji kaynağı, Büyüme indeksleri, Yetiştiricilik ekonomisi

Introduction

African catfish (*C. gariepinus*) appears as the major fish species cultured in sub-Saharan Africa, followed by tilapia. This is obviously related to continual improvement in mass propagation techniques and the development of quality water management along with quality feed development. Further growth in fish culture on the continent may however be hampered by the failure to meet the dietary requirements of the fish. The dietary requirements of cultured fish are probably the most important factor influencing the success of any fish farming enterprise. The goal of any successful fish culture operation is to achieve maximum production of fish in the shortest time possible at the least cost. Fish feed are sourced from various classes of food especially protein and carbohydrates. Other sources of food include fats and oil (lipids), vitamins (synthetic) and minerals (Aderolu et al., 2009).

Carbohydrate is used in fish diet primarily as energy source and for its binding property. It can be added in excess of the amount that can be efficiently utilized for energy by fish (Krogdahl et al., 2005). Carbohydrates are important in formulated diets because they are cheaper than lipids and proteins. Diets used in fish farming contain highly variable amounts of carbohydrates depending on the cultivated species. Maize, Sorghum, Potatoes, Cassava, Yam, Cocoyam, Wheat, Guinea Corn amongst others are energy sources commonly used in feed formulation of fish nutrition which have regular changes in price and are consumed by both man and animals resulting to competition. Since feeding represents the single most expensive production cost (Uys, 1988), scientists have resulted into introducing by-products/wastes such as biscuit waste, yam peels, plantain peels and banana peels amongst others as an energy source, which is less competed for, abundant, and less expensive.

Banana peel is a by-product utilized in the nutrition of livestock around the world. The peel has anti-nutritional factors, which are Hydrogen cyanide, Oxalate, Phytate and Saponins. These anti-nutrient contents of the peel indicate generally low values except Saponins (Adeniji et al., 2007; Anhwange et al., 2009). The objective of this research is to investigate the effects of substituting maize with graded levels of ripe and unripe banana peels on the growth performance, nutrient utilization and economy of production of *C. gariepinus* juveniles.

Materials and Methods

Experimental design

The experiment was a complete randomized design with seven experimental diets in triplicates for a period of ten weeks, at the Nutrition Unit of the Department of Marine Sciences, Faculty of Science, and University of Lagos, Nigeria.

Experimental feed preparation

The banana peels used in the experiment were got from ripe and unripe bananas, sun dried and ground to powder, while other feed ingredients (fish meal, soybean meal, groundnut cake, maize, fish premix, dicalcium phosphate, vitamin C, palm-oil and salt) were bought from Sabina Pad Enterprises Ltd., Oko-Oba, Agege, Lagos. The ingredients were milled individually at the feed mill. Ingredients were measured using digital scale, and thoroughly mixed manually with hands in a bowl with hot water added to form homogenized dough. Each experimental diet was manually pelletized with 2mm die. The proximate analysis of sun dried ripe and unripe banana peels were analyzed at the Department of Animal Science, University of Ibadan. The crude protein, ash, ether extract, crude fibre and dry matter were determined according to the Association of Analytical Chemists Method (AOAC, 2004) (Table 1).

Feed formulation

Six test and a control diets were formulated. The experimental diets were formulated with graded inclusion replacement of maize with ripe and unripe banana peels at 5, 10 and 15% respectively (Table 2).

Table 1. Proximate composition of Ripe and Unripe banana peels

Parameters	Dry matter	Crude protein	Ash	Ether extract	Crude fibre
Ripe banana peels (RBP)	60.17	8.51	12.96	11.00	9.88
Unripe banana peels (UBP)	60.01	6.85	11.72	5.00	8.00

Table 2. Composition of experimental diets (kg)

INGREDIENT	CONTROL DIET	DIET 1 RBP5%	DIET 2 RBP10%	DIET 3 RBP15%	DIET 4 UBP5%	DIET 5 UBP10%	DIET 6 UBP15%
MAIZE	30	24.5	19	14	24	19	13
RBP	0	5	10	15	0	0	0
UBP	0	0	0	0	5	10	15
SBM	27	25	23	22	26	27	26
GNC	15	17	19	20	15	14	14
FISH MEAL	25	25	25	25	26	26	27
FISH PREMIX	0.5	0.5	0.5	0.5	0.5	0.5	0.5
DCP	1	1	1	1	1	1	1
SALT	0.5	0.5	0.5	0.5	0.5	0.5	0.5
PALM-OIL	1	1.5	2	2	2	2	3
CALC. CP %	39.09	39.02	38.96	38.91	38.96	38.94	38.98
CALC. EE %	5.17	4.56	4.95	5.32	4.21	4.21	4.26
CALC. ENEGRY (KCAL/KG)	2948.78	2927.21	2904.89	2809.99	2904.80	2812.08	2767.19
FEED COST (₦)/KG	174.72	106.59	101.5	92.6	125.11	119.5	110.32

Experimental fish

Two hundred and ten (210) of African mud catfish, *C. gariepinus* juveniles were procured from Latia Global Investment. They were transferred in 50 litre kegs to the Nutrition Unit of the Department of Marine Sciences in the early hours of the day to avoid heat stress. The fish were acclimatized for two weeks in 1000L plastic container during which they were fed with 2 mm commercial feed (Coppens from Holland). After acclimatization, the fish were weighed (21.40±0.01g) and distributed into 21 plastic tanks (52.5× 33.5 ×21cm) at the rate of 10 juveniles per tank.

Feeding trials

Fish were fed to satiation by hand twice daily (09:30 and 17:30 hr) with the formulated diets. The average weight gain of fish was determined on weekly basis by bulk-weighing. The water for the experimental tanks was sourced from a borehole in the Department of Marine Sciences and was changed every two days to maintain good water quality. Fish were monitored daily for mortality, physical and behavioral changes throughout the experimental period.

Growth performance and Nutrient utilization

Growth and nutrient utilization were estimated in terms of Mean weight gain, Specific growth rate, Feed intake, Feed conversion ratio, Protein efficiency ratio and Protein intake following Morais et al. (2001).

(1) Mean Weight Gain (MWG)

MWG (g) = Mean final body weight – Mean initial body weight

(2) Specific Growth Rate (SGR)

$$SGR = \frac{(Log_e W_2 - Log_e W_1}{T_2 - T_1 \text{ (day)}} \times 100$$

Where e = natural logarithm

W_1 = Initial weight (g)

W_2 = Final weight (g)

$T_2 – T_1$ = Experimental period (day)

(3) Feed Intake (FI)

$$FI = \frac{\text{Feed intake during experimental period (g)}}{\text{No of days}}$$

(4) Feed Conversion Ratio (FCR)

$$FCR = \frac{\text{Dry feed intake (g)}}{\text{Wet weight gain (g)}}$$

(5) Protein Efficiency Ratio (PER)

$$PER = \frac{\text{Mean weight gain}}{\text{Protein intake}}$$

(6) Protein Intake (PI)

$$PI = \frac{\text{Total feed intake}}{\text{Protein content of feed}}$$

Cost analysis

Cost was based on the current prices of feed ingredients in the experimental locality (Nigeria) at the time of the experiment. The economic evaluations of the diet were calculated from the method of New (1989).

(1) Incidence of Cost (IC)

$$IC = \frac{\text{Cost of feed}}{\text{Kg of fish produced}}$$

(2) Profit Index (PIn)

$$PIn = \frac{\text{Value of fish}}{\text{Cost of feeding}}$$

(3) Estimated Investment Cost Analysis = Cost of feeding juvenile + Cost of stock

Histometry of fish organs

Fish were randomly picked from each tank and dissected using a dissecting kit; each organ was carefully traced and cut out. The organ was placed in a small transparent nylon bag and weighed (considering the weight of the nylon) using an electronic digital scale (KERN770, max.220g, d = 0.0001g) at the Department of Cell Biology and Genetics, Faculty of Science, University of Lagos. The percentage relative organ weight was calculated as stated below.

$$\% \text{ Relative organ weight} = \frac{\text{Organ weight}}{\text{Fish weight}} \times 100$$

Statistical analysis

Data were analyzed with one-way ANOVA using SPSS version 10.0 for windows. The Duncan’s multiple range test (Duncan, 1955) was used to determine the position of the difference in mean.

Results and Discussion

This study showed significant (P < 0.05) decrease in Mean weight gain (MWG) with increased inclusion of the test ingredients across the experimental diets (Table 3). The highest MWG (58.40 ±5.57 g) was recorded by the fish fed the control diet, while the the least values (25.03 ±1.85 g and 30.50 ±10.05 g) were recorded by 15 % inclusion of ripe and unripe banana peels respectively. The highest value (1.87 ±0.09 $\%day^{-1}$) of Specific growth rate (SGR) was recorded by the group fed the control diet while the least value (1.106 ±0.05 $\%day^{-1}$) was recorded by 15% inclusion of ripe banana peels (Diet 2). There was significant decrease (P<0.05) in the Feed intake (FI) between the control and other test diets. Though, no significant difference (P>0.05) was recorded among the UBP group. Feed conversion ratio, Protein efficiency ratio and Protein intake recorded significant differences (P<0.05) between the control and other diets.

There were significant differences (P<0.05) in the Profit index (PIn), Incidence of cost (IC) and Economic investment cost analysis (EICA) of feed (Table 4). Diet 2 (10% RBP) had the highest Profit index (3.11) while the control diet had the least value (1.87). The control diet had the highest values for the IC (0.370) and EICA (99.335 ±5.19) while the least values were recorded in Diets 2 (0.20) and 3 (31.85 ±1.91) respectively.

Furthermore, significant differences (P<0.05) were in fish organs (heart, kidney, liver and intestine) between the control and other test diets (Table 5). The least values for kidney and liver (0.157 ±0.00% and 0.206 ±0.01% respectively) were recorded by the fish fed the control diet while the highest values (0.389 ±0.027% and 0.702 ±0.265% respectively) were recorded for fish fed Diet 1 (5% RBP).

The significant decrease recorded in the mean weight gain and specific growth rate with increased inclusion of the test ingredients was in contrary to Fagbenro and Davies (2001), who reported that fish fed diets containing similar levels of digestible protein and energy should be identical. However, the outcome of this study was similar to the report of Solomon et al. (2007), when they fed different grain sources to *Oreochromis niloticus* fingerlings. Also, Keembiychetty and De Silva (1993) reported decrease in mean weight gain at high fibre load when they fed diets containing Cowpea, *vigna catiang* and Black grain, *Phaseolus mungo* seeds to juvenile *O. niloticus*.

Table 3. Growth performance and nutrient utilization of *C. gariepinus* juveniles fed graded levels of ripe and unripe banana peels

Parameters	Control Diet	Diet 1(5%) RBP	Diet 2(10%) RBP	Diet 3(15%) RBP	Diet 4(5%) UBP	Diet 5(10%) UBP	Diet 6(15%) UBP
IWG ($g\ fish^{-1}$)	21.400 ±0.00	21.400 ±0.00	21.400± 0.00	21.367 ±0.05	21.400 ±0.00	21.367 ±0.05	21.367 ±0.07
FWG ($g\ fish^{-1}$)	79.800 ±5.57^{a}	62.067 ±5.06^{b}	61.800±4.78^{b}	46.400 ±1.90^{c}	58.833 ±7.20^{b}	53.200 ±6.35^{bc}	51.867 ±1.08^{c}
MWG ($g\ fish^{-1}$)	58.400 ±5.57^{c}	40.667 ±5.06^{b}	40.400±4.78^{b}	25.033 ±1.85^{c}	37.433 ±7.20^{b}	31.833 ±6.36^{bc}	30.500 ±10.05^{bc}
SGR ($\%day^{-1}$)	1.877 ±0.09^{a}	1.517 ±0.11^{b}	1.512±0.10^{b}	1.106 ±0.05^{c}	1.437 ±0.17^{b}	1.296 ±0.17^{bc}	1.249 ±0.26^{bc}
FI (g)	102.93 ±11.5^{a}	84.76 ±2.25^{ab}	83.83 ±19.4^{ab}	72.733 ±1.66^{b}	92.300 ±27.8^{ab}	75.000 ±2.38^{ab}	87.66 ±17.6^{ab}
FCR	0.568 ±0.02^{a}	0.479 ±0.05^{ab}	0.489 ±0.05^{ab}	0.344 ±0.02^{c}	0.419 ±0.09^{bc}	0.425 ±0.09^{bc}	0.348 ±0.06^{c}
PER	1.457 ±0.07^{a}	1.229 ±0.14^{ab}	1.255 ±0.13^{ab}	0.882 ±0.05^{c}	0.756 ±0.25^{bc}	1.091 ±0.24^{bc}	0.893 ±0.17^{c}
PI	40.144 ±4.50^{a}	33.059 ±0.89^{ab}	32.696 ±7.59^{ab}	28.366 ±0.64^{b}	35.997 ±10.8^{ab}	29.250 ±0.93^{ab}	33.352 ±6.23^{ab}

All values on the row with different superscript are significantly different (p<0.05)

Table 4. Economic analysis of *C. gariepinus* juveniles fed graded levels of ripe and unripe banana peels

Parameters	Control Diet	Diet1 (5%) RBP	Diet2 (10%) RBP	Diet3 (15%) RBP	Diet4 (5%) UBP	Diet5 (10%) UBP	Diet6 (15%) UBP
PIn	1.870±0.11^{d}	2.88±0.22^{ab}	3.11±0.43^{a}	2.89±0.08^{ab}	2.23±0.52^{a}	2.49±0.35^{ab}	2.28±0.31^{cd}
IC	0.378±0.01^{ab}	0.22±0.02^{bc}	0.20±0.02^{c}	0.26±0.01^{bc}	0.30±0.06^{ab}	0.29±0.06ab^{c}	0.32±0.06^{a}
EICA	99.335±5.19^{a}	51.12±6.01^{b}	49.70±5.25^{b}	31.85±1.91^{c}	52.48±12.49^{b}	50.87±11.24^{b}	38.43±7.50^{c}

All values on the row with different superscript are significantly different (P<0.05)

Table 5. Histometry analysis of fish organs

Parameters	Control diet	Diet1 (5%) RBP	Diet2 (10%) RBP	Diet3 (15%) RBP	Diet4 (5%) UBP	Diet5 (10%) UBP	Diet6 (15%) UBP
Heart	0.107±0.012[ab]	0.119±0.007[a]	0.072±0.005[b]	0.117±0.008[a]	0.119±0.003[a]	0.105±0.017[ab]	0.116±0.005[a]
Kidney	0.157±0.000[d]	0.389±0.027[a]	0.280±0.100[bc]	0.323±0.06[ab]	0.230±0.035[bcd]	0.317±0.080[ab]	0.199±0.012[cd]
Liver	0.206±0.01[c]	0.702±0.265[a]	0.492±0.101[ab]	0.396±0.129[bc]	0.327±0.040[bc]	0.481±0.119[ab]	0.282±0.091[bc]
Intestine	1.526±0.128[a]	1.501±0.071[a]	1.492±0.098[a]	1.361±0.229[ab]	1.384±0.254[ab]	1.153±0.138[b]	1.445±0.165[ab]

All values on the row with different superscript are significantly different ($p<0.05$)

Reasons for this observation could be due to high fibre level in the test ingredient which accumulates to increase cell wall materials and non-soluble polysaccharides which invariably limit the rate of digestion and nutrient absorption (Aderolu and Oyedokun, 2009). This was in agreement with Keembiychetty and De Silva (1993), who observed that high fibre diets result to increase in weight of excreta and poor nutrient absorption. It could also be due to the decrease in feed intake observed across the test diets. Since the experimental fish could not consume enough feed to take care of their growth therefore, rate of growth is expected to diminish. This observation also agreed with Ponigrahi and Powel (1991), who reported that for efficient growth rate, feed intake must correspondingly increase to meet up with the anticipated growth rate of the animal.

Accordingly, the observed reduction in feed intake with increased test ingredient inclusion could probably be due to poor diet palatability. This was corroborated by Glencross et al. (2007) who reported that feed intake in fish is a measure of ingredient palatability. Though, the poor palatability recorded may be due to the presence of anti-nutritional factors which include hydrogen cyanide, oxalate, phytate and saponins in banana peels (Anhwange et al., 2009). The presence of anti-nutritional factors in feed can reduce feed palatability, nutrient utilization or growth (Hardy and Kissil, 1996).

Besides that *C. gariepinus* showed better nutrient utilization and growth performance with ripe banana peel compared to unripe banana peel this could be as a result of the anti-nutritional factors that are higher in unripe banana peel. According to earlier reports the nutritional value of Banana (*Musa* spp.) fruits varies with cultivar, stage of ripeness, soil and climatic conditions under which the fruits were cultivated (Chandler, 1995; Baiyeri and Unadike, 2001; Adeniji et al., 2007).

Organ indices and condition can be used as indicators of change in nutritional and energy status of fish (Adams et al., 1996). Liver enlargement recorded in the catfish juvenile can be associated with increased detoxification by enzymes, as it was reported in rainbow trout (Oikari and Nakari, 1982) and white sucker (McMaster et al., 1991) exposed to bleached kraft mill effluent. The increase in size of liver may be as a result of increased functioning capacity of the organ, for example sequestration of red blood cell (Gabriel et al., 2010).

This study also recorded reduction of intestinosomatic index values after the inclusion of the test ingredient. This may probably be a result of loss of appetite due to the presence of anti-nutritional factors in banana peels and concomitantly resulted in reduction of total body weight (Abdel-Hamed, 2009). This result is also in agreement with several other works where changes in intestinosomatic index values were used as indicator of physiological conditions and body weight loss caused by reduced feed intake (Abdel-Tawwab et al., 2006, 2007).

The Control diet had the best growth performance compared with other test diets yet, it recorded the least profit index (1.87) while Diet 2 (10% ripe banana peel) had the highest Profit Index (3.11). Thus, the economic viability of replacement of maize with graded levels of ripe and unripe banana peels indicated a progressive reduction in the Diets costs as the quantity of maize was being replaced with different inclusion levels of banana peels.

Conclusion

Although with the increased rate of test ingredients in the diet, weight gain and specific growth rate of catfish were reduced however, the test diets had better profit index compared with the control diet. Hence from the results obtained in the present study it is recommended that graded levels of ripe and unripe banana peels are profitable alternative energy sources for partial replacement of maize up to 10 % ripe and unripe banana peels in the feed of catfish, *C. gariepinus.*

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