Fermented unripe plantain *(Musa paradisiacal)* peel meal as a replacement for maize in the diet of Nile tilapia *(Oreochromis niloticus)* fingerlings

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Abstract

A feeding trial was conducted to investigate the effect of fermented unripe plantain peel meal (FUP) on growth performance, nutrient digestibility and economic indices of production of Nile tilapia, *Oreochromis niloticus*, fingerlings. A total of 150 Nile tilapia fingerlings (mean 1.70±0.1g) were stocked at 10 fingerlings per plastic tank. Five iso-nitrogenous diets containing 40% crude protein in which maize meal was replaced by FUP at 0% (FUP0), 25% (FUP25), 50% (FUP50), 75% (FUP75) and 100% (FUP100) were formulated and prepared. The fingerlings were fed at 5% body weight per day for 56 d. There was no significant difference (p> 0.05) in all growth parameters among the treatments. Feed conversion ratio of 1.35 in fish fed diet FUP25 was not significantly different (p>0.05) from 1.42 of fish fed diet FUP0. Apparent protein digestibility of 86.94% in fish fed diet FUP100 was significantly higher (p<0.05) than 70.37% in fish fed diet FUP0 while apparent carbohydrate digestibility of 88.34% in fish fed diet FUP0 was significantly different (p<0.05) from 70.29% of FUP100. Red blood cell (4.30 ml/mm^3) of fish fed diet FUP100 was not significantly different from 4.13 ml/mm^3 of fish fed diet FUP50. The highest percentage profit of 88.85% in fish fed diet FUP100 was significantly higher than 66.68% in fish fed diet FUP0 while the profit index of 1.89 in fish fed diet FUP100 was significantly different from 1.67 in fish fed diet FUP0. Therefore, fermented unripe plantain peel meal can completely replace maize in the diet of *O. niloticus* fingerlings.

Keywords: Unripe plantain, Nutrient digestibility, Nile tilapia, Maize, Fingerling.

Introduction

Fish culture production is on the increase in developing countries and the problems of the sector include lack of nutritionally balanced and low-cost feeds (Avnimelech et al., 2008). Fish feed accounts for about 60-70% of the variable cost in fish culture. This is due to high cost of feed ingredients especially maize which is the conventional source of dietary energy in fish and livestock feeds. Maize is also a staple for humans in many developing countries. In view of the scarcity and escalating costs of most conventional animal feed ingredients, it has become necessary to evaluate alternative nutrient sources to improve feed and also reduce the cost of aquaculture production. Previous attempts include cassava *(Manihot esculentus)* root tuber meal (Olurin *et al.*, 2006), plantain *(Musa paradisiacal* peels (Falaye and Oloruntuyi, 1998), tiger nut (*Cyperus esculentus*) meal (Alatise *et al.*, 2006) and African breadfruit *(Treculia africana)* seed (Obasa *et al*,. 2013).

Plantain (*Musa paradisiaca*) also known as Ogede (Hausa), Agbagba (Yoruba) and Ogadejoku (Igbo) is a tropical plant with more than 50% produced in Africa (Akyeampong, 1999). Nigeria is one of the largest plantain producing countries in the world; available data show that Nigeria produced 2.103 million tons of plantain, harvested from 389,000 ha in the year 2004 (FAO, 2005). Akinyele and Agboro (2007) reported over 2,000 small scale plantain chips processing companies in Lagos metropolis alone that discard the peels after utilizing the starchy fruit, hence, constituting environmental and disposal problems. Locally, plantain peels are used for "local" soap production. Recently, plantain peels have been used as composite feedstuff for growing snails (Omole *et al*., 2004).

Fermentation is one of the oldest methods of applied biotechnology, having been used in food processing and preservation as well as beverage production for over 6,000 y (Motarjemi, 2000). The fermentation processes of staple food serve as a means of providing a major source of nourishment for large rural populations and contributing significantly to food security by increasing the range of raw materials which can be used in the production of edible products (Adewusi *et al*., 1999). Fermentation increases the nutrient contents of food through the biosynthesis of vitamins, essential amino-acids and proteins. It improves protein quality and fiber digestibility. It also enhances the availability of micro nutrients to organisms for utilization and aids in the degradation of anti-nutritional factors (Achinewhu *et al*., 1998).

Blood is a good indicator to determine the health of an organism (Joshi *et al.,* 2002). It also acts as a pathological reflector of the whole body. Hence haematological parameters are important in diagnosing the functional status of an exposed animal to toxicants (Joshi *et al.*, 2002). Previous haematological studies of nutritional effects, infectious diseases and pollutants (Rehulka, 2002) brought knowledge that erythrocytes are the major and reliable indicators of various sources of stress (O'Neal and Weirich 2001). Changes from the effect of pollutants in the biochemical blood profile mirror changes in metabolism and biochemical processes of the organism. They therefore, make it necessary to study the mechanisms of the effects of these substances (Kori-Siakpere *et al*., 2011). Hence, this feeding trial was conducted to evaluate the utilization of dietary fermented unripe plantain peel in the diet of Nile tilapia, *O. niloticus,* fingerlings.

Materials and Methods

A total of 160 Nile tilapia *Oreochromis niloticus* fingerlings (mean 1.70±0.1g) were kept in a 250 L fibre glass tank fed with a commercial feed twice daily to acclimatize for 1 wk, starved for 24 h before feeding commenced to empty their guts. The fingerlings were randomly distributed into 5 treatments of 10 fish each in triplicates and stocked in net hapa (0.5m x 0.5m x 1.0m). The 15 net hapa were suspended in an outdoor concrete tank (8m x 5m x 1.5m) to three quarter of their volume with No.15 kuralon twine tied to bamboo poles. The concrete tank was filled to 5/6 of its volume (40 m^3) and was continually supplied with fresh water to sustain an optimal environment and to preclude primary productivity.

Unripe plantain peel was obtained locally from markets in Abeokuta, Ogun State, Nigeria. The peels were sundried, milled to powder. They were therefore kept in a plastic container at room temperature. Fermented unripe plantain peel meal was prepared by mixing the peel meal with water in a ratio 1:1 (wt. /vol.) and allowed to ferment at room temperature (28-30^oC) for 72 h, after which the pH decreased to a stabilized level of 3.7. The fermented meal was sundried, milled and sieved using a 595µm sieve. The resultant meal was packed in air tight containers and stored in a cool dry place at room temperature.

Five iso-nitrogenous (35% crude protein) and approximately iso-energetic (3200 ME Kcal/kg) diets in which yellow maize (10.81% crude protein) was substituted with fermented unripe plantain peel meal (FUP) of 12.09% crude protein content at varying levels of 0% FUP (Control diet /FUP0), 25% FUP (FUP25), 50% FUP (FUP50), 75% (FUP75) and 100% FUP (FUP100) were formulated and prepared (Table 1). Chromium III oxide (Cr_2O_3) was used at 0.50% in the diets as the external digestibility marker. The feed ingredients were milled, weighed, mixed, pelleted, sun dried, packed in labelled air tight polyethylene bags and stored in a dry place at room temperature.

The experimental fish were fed the diets twice daily at 5% of total biomass, at 0700 h and 1600 h for 56 d. Fish were batch-weighed weekly with a sensitive electronic balance (METTLER TOLEDO, PB602). Mortality was monitored daily. Water temperature (^0C) was monitored daily using mercury-in glass thermometer; dissolved oxygen (DO) was measured using Jenway DO meter model 9071 while the pH was measured using a glass electrode pH meter (E520) Metrolin model. Ammonia was determined by the methods described by Thomas and Lynch (1960) while conductivity was measured using a model CMD 80 TYPEWPA conductivity metre (WPA, Cambridge, UK).

At the beginning of the feeding trial, composite samples of 10 whole fish were analysed while a random sample of 5 fish per net hapa were analyzed for proximate composition at the end of the feeding period. Nitrogen content, fat, fibre, ash and moisture content of the diets and composite fish samples were analyzed using A.O.A.C. (1990) method. Blood samples were taken with 2-ml syringes and needles from the caudal vein of a set of 3 *O. niloticus* fingerlings from each treatment and put separately into EDTA bottle. The boold samples were taken to the laboratory for determination of haemoglobin (Hb), white blood cells (WBC), red blood cells (RBC) and packed cell volume (PCV) using the methods of Roberts, (1978), Mgbenka et al. (2003) and Shah and Altindag (2004). Mean corpuscular volume (MCV), mean corpuscular haemoglobin concentration (MCHC) and mean corpuscular haemoglobin (MCH) were determined using the method described by Blaxhall and Daisely (1973). Diet performance and fish yield were evaluated on experimental fish according to Olivera *et al* (1990) and Obasa and Faturoti (2001).

Statistical comparisons of growth performance and protein utilization values were made by using analysis of variance of SAS (SAS, 1988). Differences among means were also tested for significance ($p<0.05$) using Duncan Multiple Range Test.

Table 1: Percentage Composition of Experimental Diets

Feedstuff	FUP0	FUP25	FUP50	FUP75	FUP100
FUP	0.00	7.33	14.68	22.03	29.41
Maize	29.27	21.93	14.68	7.34	0.00
Fishmeal	20.98	20.96	20.95	20.94	20.93
Soybean meal	20.98	20.96	20.95	20.94	20.93
Groundnut cake	20.98	20.96	20.95	20.94	20.93
Palm oil	5	5	5	5	5
Dicalcium phosphate	0.5	0.5	0.5	0.5	0.5
Vitamin C	0.5	0.5	0.5	0.5	0.5
Vitamins premix	1	1	1	1	1
Chromic oxide	0.5	0.5	0.5	0.5	0.5
Common salt	0.3	0.3	0.3	0.3	0.3
Total	100	100	100	100	100

Radar Vitamin. Premix. Supply /100g Diet. Palmat A: 1000Iu; Cholecalcifero (D): 1000Iu; G-Tocopherolacetate (E): 1.1mg; Menacilione (K): 0.02mg; Thiamine B1: 0.63mg; Riboflavin (B2): 0.5mg; Panthothenic Acid: 1.0mg; Phyridoxine (B6): 0.15mg; Cyanocobalamine (B12): 0.001mg; Nicotinic Acid: 3.0mg; Folic Acid: 0.1mg; Ascorbic Acid (C): 0.1mg; Iron (Fe): 0.05mg; Cu: 0.25mg; Mn: 6.00mg; Co: 0.5mg; Zn: 5.0mg; Sn: 0.02mg.

Results and Discussion

The proximate composition of the experimental diets is presented in Table 2. Crude protein was around 35%. Popma and Lovshin (1995) maintained that maximum growth of tilapia is achieved at dietary crude protein levels of 35-50%, but economically optimum levels in commercial diets for juveniles and adults are usually 25 - 35%. Crude fibre increased as FUP increased in the diets while ash ranged 12.06 in diet FUP0 to 12.37 in diet FUP50. The crude protein content of the experimental fish (Table 3) was lowest in fish fed diet FUP25 and highest in fish fed diet FUP75, fat was lowest in fish fed diet FUP25 and lowest in fish fed diet FUP75 while ash increased as FUP increased in the diets.

Table 2: Proximate Composition of Experimental Diets

Parameter	FUP0	FUP25	FUP50	FUP75	FUP100
Crude protein (%)	34.90	34.97	34.98	34.96	35.00
Fat (%)	3.54	3.47	3.59	3.56	3.61
Crude fibre (%)	3.82	4.76	4.94	5.12	5..39
Ash	12.06	12.15	12.37	12.08	12.23
Moisture (%)	9.24	9.56	8.18	9.11	8.62
NFE (%)	36.44	36.06	37.43	36.26	36.45
Calculated ME (Kcal/100g)	279.80	279.70	283.62	281.70	281.50

Table 3: Proximate Composition of Experimental Fish Carcasses

Parameter	Initial	FUP0	FUP25	FUP50	FUP75	FUP100
Crude protein (%)	41.5	56.64	55.89	57.68	59.21	58.47
Moisture (%)	9.03	6.72	7.82	7.41	6.21	7.07
Fat (%)	5.59	6.58	6.71	6.47	6.38	6.51
Crude fibre (%)	3.49	0.96	1.31	0.93	0.86	0.81
Ash	11.81	12.23	12.79	12.57	13.15	13.28

Table 4 shows the growth response, apparent nutrient digestibility and survival rate of *O. niloticus* fed various levels of FUP meal based diets. There were no significant differences ($p>0.05$) in the growth response parameters but there were in the apparent nutrient digestibility. Apparent protein digestibility was significantly higher ($p<0.05$) in fish fed diet FUP100 than in fish fed diet FUP0 while apparent carbohydrate digestibility presented an inverse relationship to apparent protein digestibility. This trend in the growth of *O. niloticus* observed in this work is in agreement with Obasa et al., (2013) on replacement of maize with fermented mango seed meal in the practical diet of *O. niloticus*.. This however could have resulted from the ability of the tilapias to digest complex carbohydrates. Popma and Lovshin (1995) stated that tilapia are similar to channel catfish in assimilating starch carbohydrate in cereal grains (corn, whole wheat, etc) but are significantly more efficient than channel catfish in the digestion of the more complex carbohydrates in highly fibrous feedstuffs. It could also be as a result of fermentation which could have improved the nutritional quality of the unripe plantain peel meal. Akinyele and Agboro (2007) reported that fermentation increases the nutrient contents of food through the biosynthesis of vitamins, essential amino-acids and proteins. It improves protein quality and fibre digestibility. It also enhances the availability of micro nutrients to organisms for utilization and aids in the degradation of anti-nutritional factors (Achinewhu *et al*., 1998).

Table 4: Growth Response and Digestibility of *O. Niloticus* Fed Various Levels of Fermented Unripe Plantain Peel Meal Based Diets

Parameter	FUP0	FUP25	FUP50	FUP75	FUP100
Initial mean weight, (g)	1.64±0.25	1.63±0.17	1.65±0.24	1.83±0.50	1.69±0.33
Final mean weight, (g)	9.42±0.17	9.29±0.54	9..67±0.68	9.75±0.66	9.77±0.49
Mean weight gain, (g)	7.78±0.12	7.65±0.93	8.02±0.26	7.92±0.16	8.08±0.72
Specific growth rate (%/day)	2.19±0.13	2.14±0.24	2.26±0.18	2.07±0.11	2.23±0.04
Feed intake, (g)	11.04±1.01	10.30±1.34	11.21±0.81	10.93±1.16	11.23±0.82
Feed conversion ratio	1.42±0.09	1.35±0.24	1.40±0.27	1.38±0.11	1.39±0.66
Protein efficiency ratio	1.99±0.04	2.12±0.09	2.05±0.10	2.07±0.04	2.06±0.03
ADC $_{protein}$	70.37±5.34^{b}	86.43±6.44^{a}	80.05±4.76^{b}	84.88±3.78^{a}	86.94±4.22^{a}
ADC $_{carbohydrate}$	88.34±5.45^{a}	72.82±4.37^{b}	76.92±6.11^{b}	73.36±5.13^{b}	70.29±4.65^{b}
ADC $_{Lipid}$	66.67±3.55	60.23±4.22	65.46±3.56	68.60±3.44	68.70±4.76
Survival rate, %	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00	100.00±0.00

^{ab}Means with in the same row with different superscripts are significant different at p<0.05

Table 5 shows the haematological parameters of *O. niloticus* fingerlings fed fermented unripe plantain peel. There were no significant differences (p>0.05) in all blood parameters among the treatments. Result obtained in this study is however similar to the result obtained by Brucka-Jastrzebska and Protasowicki (2005). They subjected common carp *(Cyprinus carpio)* to cadmium and nickel exposure for a prolonged period. Although, there was an initial erythrocyte system dysfunction as evidenced by haemolytic anaemia observed at the onset of the experiment, this was later followed by a return of homeostasis and levelling off of the haematological parameters at 14 or 30 d after injection. The same phenomenon might have taken place in this trial. This could be due to the presence of anti-nutritional factors in unripe plantain peel (Agbabiaka *et al.*, 2013) which might not have been removed by fermentation. Although, this did not adversely affect growth since the above phenomenon could have been compensated for by the improved nature of the unripe plantain peel by fermentation (Achinewhu *et al.*, 1998).

Table 5. Blood parameters of *O. niloticus* fed varying levels of fermented unripe plantain meal

Parameters	FUP0	FUP25	FUP50	FUP75	FUP100
PVC (%)	37.00±2.65	38.00±1.73	36.33±1.53	36.33±2.57	35.35±3.51
Hb (g/%)	12.40±0.96	12.67±0.55	12.17±0.47	12.17±0.85	12.90±1.15
RBC (ml/mm^3)	4.17±0.32	4.27±0.21	4.13±0.23	4.17±0.31	4.30±0.46
WBC(no/mm)	5533.33±305	5538.33±115	5200.00±200	5466.67±305	5600.00±400
Glucose(mg/di)	70.00±5.00	71.67±2.89	68.33±2.89	70.00±5.00	73.33±5.77
Total protein (mg/di)	59.00±4.36	61.00±2.65	58.67±3.06	59.00±4.00	61.33±5.13

^{ab}Means with in the same row with different superscripts are significant different at p<0.05

Table 6 shows the economic analysis of dietary fermented unripe plantain peel in the diet of *O. niloticus***.** There was generally higher economic gain with increasing levels of FUP in the diet of *O. niloticus*. This could be due to the low cost of the plantain peel which is an agro-industrial by-product which according to Williams (2001) is left behind after the edible portion of plantain has been processed into various food items by cooking, roasting or milling into flour. Locally, ripe or unripe plantain wastes may be used to feed livestock or in the production of local soap but in the areas where these are not feasible, these wastes end up polluting the environment.

Table 6: Economic analysis of fermented unripe plantain peel as a substitute for maize in the diet of *O. niloticus* fingerlings

Parameter	FUP0	FUP25	FUP50	FUP75	FUP100
Cost of feed/kg. (₦)	179.18	174.12	167.23	165.75	161.28
Weight of feed used (g)	110.4±3.12	103.0±5.11	112.10±1.12	109.30±2.88	112.30±2.36
Cost of feed used (₦)	19.78±2.33	17.93±1.56	18.75±2.65	18.12±1.55	18.11±3.02
Weight of fish produced (g)	94.2±1.22	92.9±3.26	96.7±2.87	97.5±1.56	97.7±3.28
Value of fish produced @ N350/kg	32.97±0.35	32.52±1.33	33.85±1.06	34.13±1.47	34.20±1.33
Profit (₦)	13.19±0.21^b	14.59±1.44^{ab}	15.10±1.35^a	16.01±1.64^a	16.09±1.98^a
% Profit	66.68±4.66^b	81.37±6.22^a	80.53±3.67^b	88.36±5.32^a	88.85±4.22^a
Profit index	1.67±0.11b	1.81±0.66a	1.81±0.54^a	1.88±0.23^a	1.89±0.58^a
Incidence of cost	0.21±0.05	0.19±0.08	0.19±0.01	0.19±0.02	0.19±0.22

^{ab}Means with in the same row with different superscripts are significant different at p<0.05

Conclusion

From the results of this feeding trial, it is concluded that fermented unripe plantain peel can completely replace maize as the main energy source without any negative effect on the growth, digestibility, health and economic indices in the diet of Nile tilapia, *O. niloticus* fingerlings.

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