Development of Organic Fish Feeds: Case Study of Poultry Droppings and Pig Feces as Replacement for Soybean Meal in Practical Diets for Nile tilapia, *Oreochromis niloticus* (L.)

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Abstract

There have been persistent increases in the cost fish feeds and organic fish feeds are practically non-existent in Nigeria. This study was conducted to investigate the effects of replacement of soybean meal (SBM) with dried pig feces (DPF) and poultry droppings (PD) on growth performance, nutrient utilization and carcass composition of Oreochromis niloticus fingerlings. O. niloticus weighing 5.29 ± 0.02g and standard length 5.35 ± 0.07cm were fed seven iso-nitrogenous diets containing 40% crude protein in which the SBM protein was replaced with DPF and PD meals each at 0% (control diet, D7), 15% (Diets DPF1and PD4), 30% (Diets DPF2 and PD5) and 45% (Diets DPF3 and PD6) levels for 12 weeks in plastic aquaria measuring 52x33x33 cm^3(Length x Breadth x Height). Each treatment was in triplicate. At the end of the feeding trial, data obtained were analyzed statistically using one-way analysis of variance; and means were separated using Duncan's multiple range test, DMRT. Water quality parameters measured during the study period were within the range for tilapia production, except for dissolved oxygen. Weight gain of 11.0 ± 0.27g was highest in fish fed PD5, while PD4 had the lowest (6.99 ± 0.27 g);and was significantly different ($p<0.05$) from other diets. Feed conversion ratio of 1.79 in fish fed PD5 was not significantly different ($p>0.05$) from 1.81 and 1.83 recorded for fish fed D7 and PD6 respectively. Apparent net protein utilization was highest (62.57%) in fish fed PD5 and lowest (35.85%) with a significant differences ($p<0.05$) in fish fed diet PD4. Apparent protein digestibility was highest in fish fed PD5 (91.86%) and lowest in fish fed PD4 (78.98%). Percentage survival was similar (100%) in fish fed DPF3 and PD6 (93.33%) but was significantly higher ($p<0.05$) than values obtained in fish fed D7, DPF1, DPF2, PD4 and PD5 with an equal value of 90% respectively. This study revealed that poultry droppings could replace 30% of soybean meal in practical diets of O. niloticus without any adverse effects on growth and with concomitant reduction in aquaculture feed costs.

Introduction

The rapid increasing cost of fish feed has prompted research to focus on reducing the cost of the most expensive ingredients by using alternative protein sources. Most research has been conducted for replacing fish meal with either plant protein sources or other un-conventional animal protein sources (Faturoti *et al*., 1998) such as poultry offal (Fasakin, 2008), fermented shrimp head waste meal (Nwanna, 2003), maggot meal (Faturoti *et al.,* 1995; Fasakin *et al*., 2004) and water hyacinth meal (Sotolu*,* 2008). On the contrary fewer works have been reported on the replacement of soybean meal which is the costliest and the most utilized plant protein source in most fish feed in developing countries (Lovell, 1988, Alexis, 1990). To reduce the production costs of growing fish, the usefulness of locally available agricultural wastes which may serve as substitutes for the conventional feedstuffs should be examined; such agricultural wastes could be pig feces and poultry droppings.

Nigeria is considered to be the largest producer of pig in Africa. Available data showed that there were about seven million pigs in the country, reared in total confinement production systems. The wastes produced in these confinement systems present both an odor and an organic matter pollution problem; however, these wastes may possess untapped feeding value (Kornegay *et al.,* 1977). Also, poultry droppings abound in Nigeria because chickens are capable of excreting about 20% undigested feed in addition to about 10% wastes generated during normal feeding of poultry birds, thus making available up to 10-30% total protein in dried chicken wastes representing 1100-1400 kcal kg^{-1} energy and soluble synthesized vitamins in poultry manure (Tuleun, 1992; Musa *et al*.,2011). Animal wastes often become a nuisance to livestock farmers – as farmers expend energy, time and money to dispose of them so as to control diseases and have a clean environment, free from organic pollution. The use of these wastes as feed ingredients offer potential for salvaging some of the nutrients and for reducing the pollution problem (Kornegay *et al.,* 1977).

Experimental Procedure

The experiment was carried out at Federal University of Agriculture, Abeokuta (FUNAAB). The culture media were plastic aquaria with dimensions of 52cmx33cmx33cm (length, breadth and height) respectively. The water source was from a dug-out well. The poultry droppings were obtained from caged adult broilers from a poultry farm located at Alanco, Osiele, while the pig feces was collected from the piggery unit of the Federal University of Agriculture, Abeokuta. The fresh poultry droppings and pig feces were sun-dried for five days at temperatures ranging between 33^0C and 38^0C. The proximate composition of the animal wastes was determined thereafter following AOAC (2005).*Oreochromis niloticus* fingerlings*weighing* 5.29 ± 0.02 g and standard length 5.35 ± 0.07 cm were sourced from Choice Farm Isolo, Lagos State; and transported in oxygenated nylon bags to the project site in the early hours of the day. On arrival, they were acclimated for 72hours and later fed with 2mm commercial diet (Coppens feed, CP 45%) for a week before being randomly assigned to the experimental diets. The acclimated fish were weighed individually with an electronic digital counting balance (GOLDEN-METTLER U.S.A, Model: HC-D, Max: 2000g, d: 0.1g, e: 1g).Twenty-one plastic aquaria were thoroughly washed, filled with 30 liters of water and 10 *Oreochromis niloticus* fingerlings were randomly allotted to each aquarium. At the beginning of the feeding trial, composite samples of eleven whole fish were analyzed for proximate composition and a random sample of three fish per treatment at the end of the 84days (12weeks) experimental period. Each treatment had three replicates. The fish were fed at 3% body weight daily for six days and weight gain was measured on the seventh day on weekly basis; and the quantity of feed fed adjusted accordingly. The quantity of feed fed to each group of fish was recorded. The water was partially changed on daily basis, while fecal matter and left- over feed were siphoned every morning and afternoon 30 minutes before feeding, using a hose. Bicycle pump was used in aerating the water in the experimental units twice daily.

Experimental diets

Seven iso-nitrogenous diets (40% CP) were prepared. The feed ingredients comprised fish meal (72% CP), soybean meal (44% CP), poultry droppings (36.8% CP), pig feces (21.02% CP), maize (10%), palm oil, vitamin C, vitamin premix, methionine, lysine, salt and Oyster shell. Balance of mineral was achieved by using oyster shell at 0.5%. Salt (NaCl) was added as mineral source and for palatability at 0.5%. Vitamin premix was added at 1.0% inclusion to fortify the diets. The soybean meal was substituted with poultry droppings and pig feces at 0%, 15%, 30% and 45% levels of inclusion.

Feed preparation

The sun-dried pig feces, poultry droppings, maize and soybean meal were grounded (separately) into powdery form. For specific formulation, the calculated weight of each ingredient was measured into plastic bowl and thoroughly dry-mixed. Thereafter cold water (25^0C) was added at the rate of 30cl per 5000g of the feed to enable pelleting. Pelleting of the feed was done to maximize utilization of the feed by the fish as the fish may select only the desirable components of such ingredients, reduce water pollution emanating from un-eaten components of the feed and to reduce cost that may come from feed wastage. The pelleted feeds were sun-dried for six hours with ambient temperature between 33^0C- 38^0C. The dried feeds were allowed to cool and packed in air-tight polythene bags and labeled. The feeds were subjected to proximate analysis following the Association of Analytical Chemists Method (AOAC, 2005).

Water quality analyses

Physicochemical parameters such as; water temperature (^{0}C) was measured using mercury-in-glass thermometer, water pH was measured using Hanna COMBO pH-meter model CE-HI98129 after standardization with two buffers of known pH at 25^0C on every occasion and dissolved oxygen (mg/l) was measured using the Winkler's method.

At the end of the experiment, data representing growth indices and nutrient utilization were calculated as follows:

a) Mean weight gain calculated after Obasa and Akinyemi (2009) and expressed as

$$MWG = \frac{W_f - W_i}{N}$$

Where Wf = final body weight
Wi = initial body weight
N = number of fish.

b) Food conversion Ratio (FCR) calculated after Wee and Shu, (1989) and expressed as

$$FCR = \frac{Quantity\ of\ feedfed\ (g)}{Weightgain\ (g)}$$

c) Protein efficiency Ratio (PER) calculated after Millikin, (1982) and expressed as

$$PER = \frac{Liveweightgain\ (g)}{Proteinfed\ (g)}$$

d) Specific Growth Rate calculated after Obasa and Akinyemi (2009) and expressed as

$$SGR = \frac{(\ln Wf - \ln Wi)}{T} \times 100$$

Where:
Wf = final body weight
Wi = initial body weight
T = duration of experiment in days
ln = Natural Logarithm

e) Apparent Protein Utilization (APU) calculated after Millikin, (1982) and expressed as

$$APU = \frac{Proteingain}{Proteinfed} \times 100$$

f) Survival (%) calculated after Obasa and Akinyemi (2009) and expressed as

$$S = \frac{F_2}{F_1} \times 100$$

Where:
$F2$ = number of fish at the end of the experiment
F_1 = number of fish at the beginning of the experiment

g) Gross Feed Conversion Efficiency (GFCE) calculated after Stickney, (1979) and expressed as

$$GFCE = \frac{1}{FCR} \times 100$$

Results

Table 1. **Gross Composition and proximate analyses of the experimental diets (g/100g)**

Ingredients	D7	DPF1	DPF2	DPF3	PD4	PD5	PD6
Fish meal	31.90	33. 10	34.40	35.80	32.30	32.60	33.00
Soybean Meal	31.90	28.20	24.10	19.70	27.50	22.90	18.20
Poultry droppings	0.00	0.00	0.00	0.00	4.80	9.80	14.90
Pig feces	0.00	5.00	10.30	16.10	0.00	0.00	0.00
Maize	29.70	27.20	24.70	21.90	28.90	28.20	27.40
Palm oil	3.00	3.00	3.00	3.00	3.00	3.00	3.00
[1]Vitamin Premix	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Methionine	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Lysine	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Oyster shell	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Salt	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Vitamin C	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**
%Moisture	10.52	9.22	9.40	9.82	12.28	12.37	8.98
Lipid (%)	5.34	5.37	5.42	5.47	5.37	5.40	5.43
Ash (%)	13.12	15.29	17.66	18.23	14.82	16.34	17.81
Crude fiber (%)	2.51	3.21	3.95	4.76	3.08	3.68	4.29
Crude protein (%)	39.88	39.51	39.81	39.43	39.10	39.63	39.30
NFE (%)	28.71	27.40	23.76	22.29	25.35	22.58	24.33

[1]Vitamin premix (Radar) supplies per 100 g diet: Palmitate (A) 1000 IU; cholecaciferol (D) 1000 IU; a- tocopherol acetate (E) 1.1 mg; Menadione (K) 0.2 mg; Thiamine (BI) 0.63 mg; Riboflavin (B2) 0.5 mg; pantothenic acid, 0.9 mg; Pyridoxine (B6) 0.15 mg; Cyanocobalamine (B12), 0.001 mg: Nicotinic acid 3.0 mg; Folic acid 0.1 mg; Choline 31.3 mg; Ascorbic acid (C), 2.5 mg; Fe, 0.05 mg; Cu 0.25 mg, Mn 6.0 mg; Co, 0.5 mg; Zn 5.0 mg; I, 0.2 mg; S, 0.02 mg.

Key: DPF = Pig feces- based diet, PD = poultry droppings- based diet and D7 = control diet, 1 liter of Palm oil at 25^0C is equal to 0.89kg, NFE = Nitrogen Free Extract

Table 2. **Growth performance and nutrient utilization of *O. niloticus* fed varying levels of pig feces and poultry droppings**

Parameters	D7	DPF1	DPF2	DPF3	PD4	PD5	PD6	SEM
SD	10	10	10	10	10	10	10	
IW (g)	5.29	5.27	5.30	5.29	5.27	5.29	5.30	0.016
FW (g)	15.31^{b}	14.31^{c}	13.78^{c}	14.38^{c}	12.26^{d}	16.29^{a}	15.31^{b}	0.28
WG (g)	10.02^{b}	9.04^{c}	8.45^{d}	9.08^{c}	6.99^{e}	11.00^{a}	10.01^{b}	0.27
SGR	1.27^{b}	1.19^{c}	1.14^{d}	1.19^{c}	1.00^{e}	1.34^{a}	1.26^{b}	0.05
FI (g)	18.20^{bc}	17.62^{c}	16.77^{d}	17.83^{bc}	16.33^{d}	19.70^{a}	18.35^{b}	0.24
FCR	1.81^{c}	1.95^{b}	1.98^{b}	1.96^{b}	2.33^{a}	1.79^{c}	1.83^{c}	0.04
M (%)	10.00^{a}	10.00^{a}	10.00^{a}	0.00^{b}	10.00^{a}	10.00^{a}	6.67^{ab}	1.30
S (%)	90.00^{b}	90.00^{b}	90.00^{b}	100.00^{a}	90.00^{b}	90.00^{b}	93.33^{ab}	
GFCE (%)	55.36^{a}	51.28^{b}	50.57^{b}	50.57^{b}	43.93^{c}	55.89^{a}	54.54^{a}	0.47
APD (%)	88.54^{b}	83.64^{c}	83.51^{c}	85.19^{c}	78.98^{d}	91.86^{a}	88.60^{b}	1.10
NPU (%)	61.74^{a}	62.20^{a}	47.23^{b}	54.84^{ab}	35.85^{c}	62.57^{a}	50.64^{ab}	2.71
PER (%)	1.39^{a}	1.30^{b}	1.27^{b}	1.29^{b}	1.10^{c}	1.41^{a}	1.39^{a}	0.02

Mean values with different superscripts along rows are significantly different (P>0.05).
Key: SD = Stocking density, IW = initial weight, FW= final weight, WG= weight gain, SGR= specific growth rate, FI = feed intake, FCR = feed conversion ratio, M = mortality, S= survival, GFCE = gross feed conversion efficiency, NPU = net protein utilization, APD apparent protein digestibility and PER = protein efficiency ratio, SEM = Standard error of the mean.

Table 3. **Carcass composition *O. niloticus* fed diets containing varying levels of pig feces and poultry droppings**

Parameters	Initial	D7	DPF1	DPF2	DPF3	PD4	PD5	PD6	SEM
Moisture (%)	7.30	8.53^{b}	9.24^{ab}	10.37^{a}	9.29^{ab}	8.68^{b}	9.04^{b}	8.95^{b}	0.18
CP (%)	59.00	63.46^{ab}	63.34^{ab}	62.17^{c}	62.95^{bc}	61.27^{d}	63.90^{a}	62.65^{bc}	0.24
Lipid (%)	10.50	8.34^{a}	5.49^{d}	6.47^{c}	6.61^{c}	6.39^{c}	6.91^{b}	6.65^{bc}	0.22
Ash (%)	9.38	10.15^{d}	11.75^{bc}	12.50^{ab}	12.85^{a}	11.43^{c}	12.25^{abc}	12.93^{a}	0.26
Fiber (%)	3.08	2.50^{bc}	3.15^{a}	2.15^{cd}	1.95^{d}	3.25^{a}	2.65^{b}	3.32^{a}	0.15
NFE (%)	10.74	7.03^{ab}	7.11^{ab}	6.35^{a}	6.36^{a}	9.00^{a}	5.25^{a}	5.51^{a}	0.36

Mean values with different superscripts along rows are significantly different (P>0.05)
WhereSEM = Standard error of the mean, CP = crude protein, NFE = nitrogen free extract

Discussion

Proximate composition of the test ingredients showed their great potential as feed resources for cultured fish. The high level of protein confirmed that they could be used to replace more expensive protein sources in aquaculture fish diets, thereby cutting costs (Smith, 1973; Dhawan and Kaur, 2002). Proximate composition of the diets were nutritionally adequate for the fish; and the crude protein content of the diets (39.10% - 39.88%) meet the requirement of *Oreochromis niloticus* as reported by Al-Hafedh (1999). The fiber content of the diets was also within the recommended limits for tilapias (Anderson *et al.,* 1984).As the quantity of pig feces and poultry droppings increased in the experimental diets, ash and fiber contents of diets also increased, probably due to the high fiber and ash contents of the animal wastes, which exceeded the level of fiber and ash in soybean meal. Obasa, *et al.* (2009), also observed increases in the fiber and ash contents of feeds as the quantity of dried poultry manure increased. However, contrary to Obasa, *et al.,* (2009), the lipid content of diets in this study was not influenced by increases in the inclusion level pig feces or poultry droppings in the diets.

The values of the temperature and pH observed in the experimental tanks during this study were within recommended levels for *O. niloticus* (Mires, 1995; Ross, 2000), although dissolved oxygen (DO) levels were below the recommended range (Ross, 2000). DO value was highest in the D7 experimental tanks. From this observation, it could be inferred that using animal wastes as feed ingredients could result in DO reduction; and may necessitate additional aeration.

Growth responses of fish fed PD5 (poultry droppings at 30% level of inclusion) showed that the fish utilized the feed better than other treatments. This confirmed that 30% inclusion level was optimal for poultry droppings as increases beyond this level resulted in decline in growth performance. The improved performance of fish fed PD5 could be due to higher intake of the test diet as observed in *Clarias gariepinus* when dietary soybean meal was replaced with dried poultry excreta up to 60% (Obasa *et al.,* 2009). The low values of FCR in fish fed PD5 and PD6 compared to fish fed the control diet (D7) showed that PD5 was better utilized, and resulted in the improved performance observed. The values recorded for mortality suggested that microorganisms in the test ingredients were not pathogenic and did not produce any lethal effects on the fish, thus they were considered safe.

Apparent protein digestibility (APD), net protein utilization (NPU) and protein efficiency ratio (PER) of PD5 and PD6 favorably compared with those of the control diet; and confirmed that *O. niloticus* was able to utilize available proteins in poultry droppings-based diets.

Carcass composition of *O. niloticus* at the end of the feeding trial showed increases in the carcass protein. This agreed with Obasa *et al.,* (2009) who reported increases in the carcass protein of *C. gariepinus* fed dried poultry excreta as replacement for soybean meal.

This study observed that feeding animal wastes to *O. niloticus* significantly reduced the total body fat content of the fish as compared to those fed the control diet. This was similar to the observation of Al-Asgah and Ali (1999) and Obasa *et al.,* (2009) in *O. niloticus* and *C. gariepinus* respectively.

The ash contents of fish carcass showed an increasing trend as animal wastes' inclusion increased in the test diets; confirming that this must have been due to the high ash contents of the animal wastes included in the diets. This agreed with earlier studies with *O. niloticus* (Al-Asgah and Ali, 1999). Fiber contents of the experimental fish did not follow any particular trend. While carcass fiber of fish fed D7, DPF2, DPF3, and PD5 showed a decrease in value when compared to the initial carcass composition, fish fed PD6, PD4 and DPF1 showed a slight increase in their carcass fiber.

Conclusion and recommendations

From this study, it can be concluded that Fish fed PD5 (30% dried poultry droppings) had the highest growth response. Percentage moisture, crude protein and ash contents of fish increased with fish age, while lipid content reduced with age. It is therefore recommended that dried poultry droppings at 30% inclusion level could replace soybean meal in the practical diets for *Oreochromis niloticus* without any deleterious effects. The issue of safety is of utmost importance in organic production systems. Some additives, including hormones, steroids, growth promoters and others are prohibited in organic production systems. In as much as these are used in conventional livestock production systems, issues of their possible accumulation in livestock wastes should be considered. It is therefore reasonable to recommend only the use of livestock wastes from organic production systems for use as substitutes for expensive components in organic fish feed production.

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