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Growth and economic performance of fingerlings of *Oreochromis niloticus* fed on different non-conventional feeds in out-door hapas at Akosombo in Ghana

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The study was conducted at the Aquaculture Research and Development Centre at Akosombo in Ghana to observe the growth and economic performance of the fingerlings of *Oreochromis niloticus* fed on diets prepared using different agro-industrial by-products. Four isonitrogenous (30% CP) and isoenergetic (GE 18 MJ/kg) diets were formulated: Wheat bran (WB) (Diet 1); Pito mash (PM) (Diet 2); Rice bran (RB) (diet 3); and groundnut bran (GB) (Diet 4). They were fed to fingerlings of *O. niloticus* of average weight 7.0 ± 0.23 g stocked at 20 fish m^{-3} in out-door hapas for a period of 24 weeks. The study revealed that fish which were fed on Diet 1 grew significantly ($P < 0.05$) faster than those fed on the other diets. Fish growth was least on those fed on Diet 4. The incidence cost (IC) was highest ($P < 0.05$) in fish fed Diet 4 and lowest ($P < 0.05$) for fish fed Diet 2. The profit index was highest ($P < 0.05$) for fish fed diet 2 and lowest ($P < 0.05$) for fish fed Diet 2. *O. niloticus* fingerlings fed WB based diet produced the fastest growth while fingerlings fed PM based diet was the most cost-effective diet.

Key words: Growth, economic, performance, fingerlings, *Oreochromis niloticus,* non conventional feeds, Akosombo Ghana.

INTRODUCTION

In the development and management of an aquaculture enterprise, fish feed plays a vital role in its growth and expansion (Gabriel et al., 2007). The high cost of feeding has affected the development and expansion of aquaculture enterprises in most African countries contributing in no small way, to the low protein intake in many developing African countries (Abu et al., 2010). Non conventional feed resources are credited for being non competitive in terms of human consumption, very cheap by-products or waste products from agriculture, (Iluyemi et al., 2010). The main source of carbohydrate in many farm-based fish diets in Ghana is Wheat bran (WB)

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and maize. However, the widespread uses of WB and maize in livestock including poultry feed production is causing a price increase in these feed ingredients. This puts it in a situation that is, subjected to global market shocks and votility should there be shortage of supply of any of the aforementioned commodities. However, a fair proportion of industries in Ghana are agriculture-based and produce a range of by-products which could be rich ingredients for the formulation of fish feed as they already contribute to livestock and poultry feed.

There is the need to look for alternative sources of carbohydrates that are nutritionally rich and locally available. Pito mash (PM), a by-product obtained from sorghum used in the production of a local drink known as "pito", rice bran (RB) and groundnut bran (GB), are agro-industrial by products that are of great importance for developing more nutritive and economical fish diets in developing countries like Ghana. However, information available on the nutritive value of some of these agro-industrial wastes/by-products (that is, PM, RB and GB) in the formulation of fish feed is rather scanty in Ghana. PM, RB and GB are ideal for use as a good plant feed ingredient for the development of fish feed in Ghana. This is because these by-products do not suffer severe competition as human food, livestock (including fish) and poultry feed as it may be with other sources, e.g. WB or maize. Availability of these agro-industrial by-products is a significant step towards more efficient utilization of plant by-products. It will also help to boost the income generated by the local industries involved, hence raising the standard of living of the persons involved. This research therefore closely examined and evaluated the nutritional quality and economic feasibility of PM, RB and GB as ingredients that would be used as feed for fingerling production.

MATERIALS AND METHODS

Site description

The study was conducted at the Aquaculture Research and Development Centre (ARDEC) which lies East of Akosombo in the Eastern Region of Ghana between October 2010 and March 2011.

Procurement of ingredients

PM was purchased from pito brewers at the Akosombo community and RB from a rice milling factory at Akuse all in the Eastern Region of Ghana. GB was obtained from Kumasi in the Ashanti Region of Ghana. Other ingredients such as broiler premix, palm oil, WB and fish meal (FM) were purchased from Ashaiman timber market in the Greater Accra Region of Ghana. The feedstuffs were transported to ARDEC and processed into feed for use during the trial experiment.

Chemical analysis of feed items

Proximate analyses of the feed ingredients for the experiment were carried out at the Animal Nutrition Laboratory of the School of Agriculture of the University of Cape Coast following the procedures that broadly adhere to Association of Official Analytical Chemists [AOAC] (1990). The protocol was used in determining the percentage (%) dry matter (DM), Crude protein (CP), Ash in percentage, Crude lipids (CL) in percentage also known as the Ether Extract (EE) of fat, Crude fibre (CF) in percentage and moisture in percentage. Nitrogen-free extract (NFE) was computed using the formula: % NFE = (100 - % CP + % CF + % EE + % Ash). The nutritional characteristics of feed ingredients were used in formulating experimental diets. Formulated diets were also analyzed to ascertain their nutritional characteristics and to see if they conform to the desired protein and energy requirements of the species under study based on the formulation.

Diet formulation and preparation

The trial and error method was use to formulate four different is nitrogenous (30% CP) and isoenergetic diets (GE, 18 MJ/kg). Feedstuff were sun dried and finely ground at the corn mill and sieved with a nylon mesh (420 μ/cm^2) to remove stones and larger sized particles (dissimilar sizes results in unstable pellet). The ingredients were weighed using a top pan balance according to the proportion based on the formulation for various treatments and mixed together in a large basin. Broiler (vitamin/mineral) premix, lysine and methionine and palm oil were added and the mixture further mixed thoroughly. In preparing pelleted feed, a little quantity of water was added to moisten the mixed proportions of the prepared feed to enable pelleting using a pelleting machine. Pelleted feed were sun dried, bagged and stored in dry and cool environment for use throughout the study.

Experimental set-up and fish

Twelve (12) fine mesh hapas (size 1 mm) each of capacity 10 m^3 (5 × 2 × 1 m) were installed in a 0.2 ha pond such that three quarters (¾) of the height of the hapas were submerged and one quarter (1/4) above the water surface to prevent the fish from escaping. The hapas were suspended by means of nylon ropes tied to bamboo poles, inserted into the bed of the pond.

Sex reversed fingerlings of *O. niloticus* of average weight 7 ± 0.23 g were obtained from ARDEC and stocked at 20 fish per meter cube for about 3 days for the fish to get them acclimatized before the start of the actual feeding trial experiment. The weight of fish were measured using a dry celled digital balance (model: Tanita KD 160) to the nearest 1 g and the standard and total lengths measured using a fish measuring board to the nearest 0.1 cm before being transferred to the experimental hapas. The 4 treatments, each in triplicate groups, were randomly assigned to the hapas installed in the pond to reduce biasness. The fish were reared and observed for 24 weeks during which fortnight body measurement (weight and length) were taken to evaluate their growth and response to the feeding on the diets administered.

Feeding regime

Fish were fed by hand-casting twice daily between 0830 to 0930 GMT and between 0300 to 0400 GMT at 10% for 6 weeks, 7% following another 6 weeks, 4% for another 6 weeks and 2% for the last 6 weeks making 24 weeks in all. The fishes were fed for 6 to 7 days a week and the daily ration equally divided between feeding times. Daily feed intakes were recorded and feed adjustments made fortnightly by sampling 25% of the fishes from each replicate of the various treatments and weighed to provide a good significant estimate of the average weight. The lengths and weights of fishes from each replicate were pooled for each treatment and based on these measurements (weights), the ration was adjusted accordingly.

Analysis of experimental data

Experimental data gathered during the growth trial for fingerlings of *O. niloticus* were used to determine various biological parameters such as:

(1) Mean weight gain (MWG) was computed as(Adewolu, 2008):

$$\text{MWG} = \text{Final mean weight of fish} - \text{Initial mean weight of fish}$$

(2) Specific growth rate was computed (SGR) as:

$$\text{SGR} = \frac{\text{In}\,W_2 - \text{In}W_1}{t} \times 100$$

where, W_1 = initial weight (g) at stocking, W_2 = final weight (g) at the end of experiment. $\text{In}W_2 - \text{In}W_1$ = Natural logarithms of both the final and initial weight of fish and T = duration (in days) of trial (Adewolu, 2008),

(3) Protein efficiency ratio (PER) as:

$$\text{PER} = \frac{\text{total weight gained by fish}}{\text{total protein fed to fish}}$$

Where, protein intake per fish is total feed given multiply (x) by the CP percentage in feed (Adewolu, 2008),

(4) Feed conversion ratio (FCR) (Sawhney and Gandotra, 2010) as:

$$\text{FCR} = \frac{\text{total feed given}}{\text{total weight gained by fish}}$$

(5) Survival rate (SR) (Charo-Karisa et al., 2006) as:

$$\%\text{SR} = \frac{\text{Initial number of fish stocked} - \text{mortality}}{\text{Initial number of fish stocked}} \text{ x } 100.$$

(6) Condition factor (K) computed as:

$$\text{K} = \left(\frac{\text{W}}{\text{SL}^3}\right) \text{x } 100.$$

Where: K = condition factor, W = weight of fish in grammes and SL = the standard length of the fish in centimeters (Charo-Karisa et al., 2006).

A simple economic analysis was used to assess the cost effectiveness of diets used in the feed trial. The cost of feed was calculated using market prices taken into consideration the cost of feed and the transport fare with the assumption that all other operating costs remained constant (e.g. cost of constructing hapa, cost of fingerlings and labour). Indices for economic evaluation included:

(1) Incidence cost (IC) (Abu et al., 2010) as:

$$\text{IC} = \frac{\text{cost of feed}}{\text{weight of fish produced}},$$

(2) Profit index (PI) as:

$$\text{PI} = \frac{\text{Weight or value of fish produced}}{\text{cost of feed}}.$$

Biological and economic data were subjected to a one-way analysis of variance (ANOVA) using the SPSS version 16 at 5% ($P < 0.05$) significant level. Variance of data was presented as standard error of means. Where significant differences occurred, treatment means were compared using Fisher's least significant difference (LSD).

RESULTS

Chemical composition of feedstuff

Results of the proximate analysis of the feed ingredients expressed on a dry matter basis (that is, to help standardize information on the ingredients) are shown in Table 1. Among the test by-products, PM recorded the highest CP (28.77%) and RB recorded the lowest CP (6.68%). In terms of EE, GB had the highest (9.00%) and WB had the least (4.59%). The CF content of RB was the highest with 31.47% and lowest in WB with 10.48%. The calculated NFE was and highest in WB (64.29%) and lowest in RB (36.25%).

Inclusive levels and chemical composition of diets for fingerlings of *O. niloticus*

Table 2 shows the composition and chemical analysis of diets for fingerlings of *O. niloticus*. Among the test agro-industrial by-products, Diet 3 had the highest amount of FM (56%) and palm oil (2.58%) and Diet 2 had the lowest amount of FM (16%) and palm oil recorded the least (1.14%). The amount of FM in Diet 1 (45.5%) was higher than in diet 4 (34%). Methionine, lysine and broiler premix were the same for all the diets, because specific quantities were needed in all diets to supplement those naturally occurring in the diets.

All the 4 prepared diets had similar ($\times^2 < 0.35$, $P > 0.05$) CP levels. Diet 4 had the highest amount of EE (18.74%) and Diet 2 had the lowest EE (8.68%). Crude CF levels in the diets was in the following descending order Diet 2 > Diet 3 > Diet 1 > Diet 4. Ash content was highest in Diet 3 (22.32%) and lowest in diet 2 (13.94%). Diet 2 (41.05%) had the highest NFE and diet 3 (28.64%) had the lowest. Although the gross energy (GE) was highest in Diet 4 (19.98 MJ/kg) and lowest in Diet 3 (17.11 MJ/kg), there was no significant differences ($\times^2 < 0.35$, $P > 0.05$) among all the diets.

Production data for fingerlings of *O. niloticus*

Data on the growth performance of fingerlings of *O. niloticus* (Table 3) indicate that, the average initial weights (AIW) of the test fish were found to vary slightly but not significantly ($P > 0.05$) among the four treatments. However, at the end of the trial, the average final weights (AFW) were significantly ($P < 0.05$) different among the treatments. Fish fed on Diet 1 (88.0 ± 1 1.43 g) were the heaviest. The AFW of other diets took the following descending order Diet 3 > Diet 2 > Diet 4. Among the treatments, Diet 1 supported the best mean weight gain [MWG] (80.80 ± 3.48 g) and the Diet 4 supported the

Table 1. Chemical composition of feed ingredients.

Type of analysis	Fish meal	Pito mash	Rice bran	Groundnut bran	Wheat bran
Dry matter (%)	94.09	92.93	91.78	93.96	92.68
Crude protein (%)	48.95	28.77	6.68	21.69	15.46
Ether extract (%)	12.54	7.81	8.76	9.00	4.59
Crude fibre (%)	0.88	12.77	31.47	17.51	10.48
Ash (%)	27.93	4.42	16.89	4.78	5.18
Nitrogen-free extract (%)	9.70	46.23	36.25	47.02	64.29
GE (MJ/kg)	18.19	17.82	11.26	16.75	16.50

Table 2. Inclusion levels and proximate analysis of diets for fingerlings *O. niloticus.*

Ingredient	Diets			
	1	2	3	4
Fish meal	45.5	16	56	34
Pito mash	-	80.27	-	-
Rice bran	-	-	39	-
Groundnut bran	-	-	-	62
Wheat bran	50.4	-	-	-
Methionine	0.1	0.1	0.1	0.1
Lysine	1.9	1.9	1.9	1.9
Broiler premix	0.5	0.5	0.5	0.5
Palm oil	1.5	1.14	2.58	1.45
Total	100	100	100	100
Proximate analysis				
Dry matter (%)	88.54	91.22	91.52	91.45
Calculated crude protein (%)	30.06	30.22	30.02	30.24
Actual. crude protein (%)	30.42	30.36	30.14	30.25
Ether extract (%)	8.68	9.98	12.84	18.74
Crude fibre (%)	5.86	8.07	6.06	3.54
Ash (%)	14.95	13.94	22.32	16.76
Nitrogen-free extract (%)	40.09	41.05	28.64	30.71
Gross energy (MJ/kg)	17.67	18.15	17.11	19.98

Table 3. Harvest data for fingerlings *O. niloticus* fed on different dietary treatments.

Parameter	Diets (mean ± standard error)			
	1	2	3	4
Average initial weight	$7.19^{a} \pm 1.68$	$7.18^{a} \pm 1.66$	$7.10^{a} \pm 1.75$	$7.04^{a} \pm 1.56$
Average final weight	$88.01^{a} \pm 1.43$	$64.53^{c} \pm 0.86$	$75.27^{b} \pm 1.18$	$51.35^{d} \pm 1.07$
Mean weight gain	$80.80^{a} \pm 3.48$	$57.33^{b} \pm 4.30$	$67.93^{b} \pm 4.19$	$44.30^{c} \pm 5.41$
Specific growth rate	$1.49^{a} \pm 0.02$	$1.30^{bc} \pm 0.09$	$1.38^{ab} \pm 0.05$	$1.17^{c} \pm 0.06$
Protein efficiency ratio	$0.71^{a} \pm 0.02$	$0.67^{a} \pm 0.14$	$0.75^{a} \pm 0.05$	$0.51^{a} \pm 0.14$
Feed conversion ratio	$4.74^{b} \pm 0.15$	$5.32^{a} \pm 1.03$	$4.46^{b} \pm 0.28$	$8.60^{a} \pm 3.49$
Survival rate	$68.33^{a} \pm 0.88$	$71.50^{a} \pm 7.50$	$81.00^{a} \pm 4.48$	$62.17^{a} \pm 16.85$
Condition factor	$3.28^{a} \pm 0.01$	$3.09^{a} \pm 0.10$	$3.23^{a} \pm 0.0.02$	$2.38^{b} \pm 0.48$

Similar superscript alphabets in the rows denote homogeneous means (LSD, P > 0.05).

worse MWG (44.30 ± 5.41 g) The growth curves of fish in response to the test diets over the 24 weeks (6 months) experimental period are shown in Figure 1. Fish fed on Diet 1 maintained the highest growth differentiating clearly

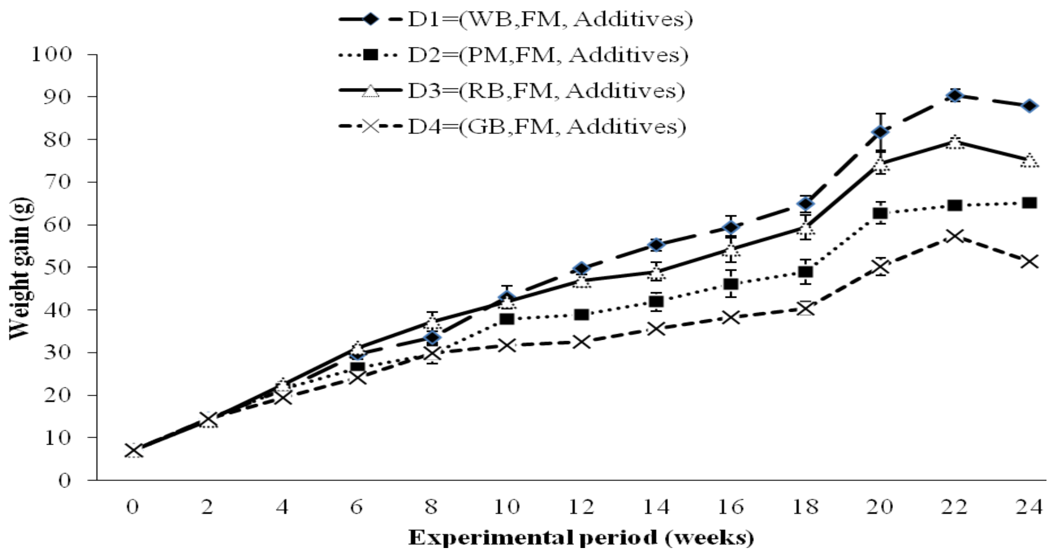

Figure 1. Growth curves for fingerlings of *O. niloticus* fed on different dietary treatments for 24 weeks (Vertical bars represent standard errors).

Table 4. Economic benefits of using different diets.

Diet	Cost /kg. of feed (GH¢)	Total feed input (kg)	Total cost of feed input (GH¢)	Harvested biomass (kg)	Assumed sales of biomass (GH¢)	[1]IC	[2]PI
1	0.71	121.24	86.09	30.02	90.05	8.62[a] ± 0.08	3.14[ab] ± 0.03
2	0.46	107.21	49.32	26.18	78.54	5.96[a] ± 0.33	4.82[a] ± 0.28
3	0.76	126.98	96.50	28.39	85.13	10.40[a] ± 0.23	2.62[b] ± 0.05
4	0.67	104.96	70.32	15.91	47.71	17.64[a] ± 2.43	2.02[b] ± 0.20

Similar alphabets in the columns denote homogenous means (LSD, P > 0.05), Cost price per kilogram of fish (that is. below 150 g) at the farm gate = GH¢ 3. Market price per kilogram of test diets was based on cost per kilogram of feed ingredients used in formulating the test diets. 1. Incidence cost = IC, 2. Profit index = PI.

after the 10th week of culture and Diet 4 maintained the least trend in growth.

Among the treatments, fish fed on diet 1 had the highest specific growth rate [SGR] (1.49 ± 0.02% day^{-1}) and fish fed on Diet 4 had the lowest SGR (1.17 ± 0.06% d^{-1}). However, the SGR were not significantly (P > 0.05) different among fish fed on Diet 1 and those feed on Diet 2. Also the SGR for fed on Diet 2 were not significantly (P > 0.05) different from fish fed on Diet 3. Although, PER as observed in study were not significantly (P > 0.05) different between treatments, PER was highest for fish feed Diet 3 (0.75 ± 0.05) and lowest for fish fed on diet 4 (0.51 ± 0.14). The best performing Diet in terms of feed conversion ratio (FCR) was lowest (that is, better utilization) for fish fed on Diet 3 (4.46 ± 0.28) and highest (that is, poor utilization) was for fish fed on Diet 4 (8.60 ± 3.49). However, the FCR were not significantly (P > 0.05) different for fish fed various diets. The condition factor (K) of fish fed on Diets 1, 2 and 3 were similar (P > 0.05). However, fish fed on Diet 4 was statistically (P < 0.05) different from the other treatments.

Economic benefits of using the different diets

Shown in Table 4, the cost per kilogram of feed was highest for fish fed on Diet 3 (GH¢0.76) and lowest for fish fed on Diet 2 (GH¢ 0.46). Feed administered was highest for fish fed on Diet 3 (126.98 kg) and lowest for fish fed on Diet 4 (104.96 kg). The total biomass harvested was highest for fish fed on Diet 1 (30.02 kg) and lowest for fish fed on Diet 4 (15.91 kg). Among the treatments, Diet 4 had the highest (that is, highest cost per kilogram of feed) IC of 5.88 and Diet 2 had the lowest (lowest cost per kilogram of feed) IC of 1.99. However, there were no significant (P > 0.05) differences among all the treatments in terms of IC. The profit index (PI) was highest for fish fed on Diet 2 (4.82 ± 0.28) and lowest for fish fed on Diet 4 (2.02 ± 0.02). However, fish fed on Diet 2 were similar (P > 0.05) to fish fed on Diet 1. Also fish fed on the Diets 1, 3 and 4 were similar (P > 0.05).

DISCUSSION

Characteristics of feedstuff

The variability in the composition of agro-industrial by-products and diets formulated and prepared is reflected in growth and development of *O. niloticus.* This is because, growth of fish fed on various diets tended to differ, although not significantly among the tested diets. The ability of *O. niloticus* to utilize various diets could be attributed to wide spectrum of preference for foods. This is in agreement with Gonzalez and Allan (2007) and Audu et al*.* (2008) who, reported that, *O. niloticus* readily adapts to eating a wide variety of feeds, and that they have very long intestines necessary to digest plant materials.

Acceptance of diets of fingerlings of *O. niloticus*

Palatability is defined as acceptable to the taste or sufficiently agreeable in flavour to be eaten. While it may be difficult to ascertain whether or not a fish 'likes' some flavour or not, it is certainly possible to determine differences in the amounts of feed eaten (Glencross et al*.,* 2007). The acceptability of the diets containing PM, RB, and WB is a good indication of the palatability of the experimental diets, hence the feasibility of using these agro-industrial by-products in formulating feed for fingerlings *O. niloticus*. Similar results have been reported for *O. niloticus* by Liti et al*.* (2006) and Attipoe et al*.* (2009), and for Florida Red Tilapia, (*O. niloticus* crossed with *O. mosambicus*) by El-Dakar et al*.* (2008). In these reports, the acceptance of feed rations containing various agro-industrial by-products such as cocoa husk, brewery waste, RB, WB, MB and fig Jam by-product by the tilapias demonstrates the opportunistic nature of tilapia in their feeding habits. This provides an advantage to farmers because the fish can be reared in intensive systems that can be operated with lower cost feeds.

Growth performance of fingerlings *O. niloticus*

In this experiment, the results from proximate analysis demonstrate that, the test Diets (1, 2, 3 and 4) differed both in nutritional quality and efficiency in promoting the growth of fingerlings of *O. niloticus*. Fish which were fed on Diet 1 (WB-based diet), grew significantly faster than those fed on the other diets. The best performance by the fish fed on WB-based diet, as observed in this study are similar to the reports by Liti et al*.* (2006) and Attipoe et al*.* (2009) that WB-based diets improved the growth performance of tilapia compared with other brans. The good performance of fish fed on Diet 3 (RB-based diet) as observed in this study is at variance with the reported works of Liti et al*.* (2005, 2006) and Solomon et al*.* (2007). According to these authors, rice bran-based diets gave the worse performance among other treatments. Though diet 3 (rice bran-based diet) performed well, Diet 1(WB-based diet) demonstrated the best growth because the crude fibre levels were lower. In addition, the NFE a measure of the carbohydrate level in diets (Mohanta et al., 2007; Tran-Duy et al., 2008) was higher in Diet 1 than in Diet 3 suggesting a greater the protein sparing effect (that is, the use of carbohydrate to spare the use of protein for energy purposes). This is because, more energy in the form of NFE was available in Diet 1 than it is in Diet 3 to spare the use of protein as an energy source.

Kaur and Saxena (2004) reported higher mean weight gain (MWG) in diets in which RB was replaced with brewery waste in a feed trail with *Catla catla* and *Labeo rohita*. This was attributed to better absorption and utilization by these fishes. However, in the current study, though with *O. niloticus*, the Diet 3 (rice bran-based diet) exhibited higher MWG than Diet 2 (PM-based diet). The superior growth of fish fed on the rice bran-based diet observed in this study could be a manifestation of the higher proportion of FM used in compounding Diet 3. Attipoe et al*.* (2009) concluded that, diets with higher proportion of FM exhibited better growth because of their excellent biological value in enhancing growth. Though the weight gain of fish fed on Diet 2 (PM-based diet) in this study did not exhibit the best growth, the higher proportion of PM in the Diet 2 suggests that, PM can enhance the growth of *O. niloticus* by reducing drastically the quantity of FM (reducing the cost of feed in the process) in diets. This is in accordance with earlier findings of Webster et al*.* (1992) and Wu et al*.* (1996). All these authors also found that, brewery waste could be used to completely or partially replace costly FM in the diets of tilapia.

According to Agbo (2008), crude fibre provides physical bulk to feed and may improve pelletability. However, fibre decreases the quantity of usable nutrients in a diet. Although the crude fibre was lowest in diet 4 (3.54%) suggesting better utilization, growth could have been impaired by the higher EE per cent (18.74%). This is consistent with several other research findings as in Manjapa et al*.* (2002) and Audu et al*.* (2008). These researchers explained that, EE levels in the diet of tilapia should range between 5 to 12%, or when in excess (above 12%), results in poor growth because of an imbalance of protein to fat ratio.

Solomon et al*.* (2007) using different grain sources (maize, wheat, rice, sorghum and millet) to assess the growth of tilapia in out-door hapas, reported that the best MWG for fish fed with maize grain > wheat grain > sorghum grain > millet grain > rice grain. However, as observed in this study, PM-based diet recorded a lower MWG than rice bran-based diet. This can be attributed to the high crude fibre (8.07%) levels in PM-based diet as compared to the low crude fibre (6.06%) content of the rice bran-based diet. This assertion agrees with several other researchers' findings (Gonzalez and Allan, 2007; El-

Dakar et al., 2008) that high fibre levels in the diet of tilapia resulted in poor weight gain and nutrient utilization.

The SGR as obtained in the current study was lowest for fish fed on Diet 4 (GB based diet) and highest for fish fed on the Diet 1(WB-based diet). Higher SGR values of fish fed on the WB-based diet is indicative of the fact that, the WB-based diet was better utilized than the other diets. This gives credence to the views of Iluyemi et al. (2010). For comparison, the SGR obtained in this study (1.17 to 1.49) are higher than the SGR values (0.43 to 0.53) reported by Attipoe et al*.* (2009).

Chatzifotis et al*.* (2010) demonstrated that growth can be reduced and PER lowered if fishes were fed with excessive dietary lipid levels. This is because, excessive lipids not only spare proteins, but can also result in higher fat deposits and impaired growth performance. Although PER values were highest for fish fed on the rice bran-based diet and lowest for fish fed on the diet 4 (groundnut bran-based diet) (Table 3), yet statistically, there were no significant (P > 0.05) differences among the fish fed on all the diets. However, this was at variance with the finding of Wu et al*.* (2000) that, diets with higher proportion of FM exhibited higher PER because of more efficient utilization of FM by fish, the results obtained in this study can be explained according to Drew et al*.* (2007) who reported that, digestion of plant materials by fish resulted in a lower PER because most plant materials had lower CP levels which are used as sources of energy in the form of carbohydrates. However, an imbalance of carbohydrate and lipids ratio can suppress the uses of protein even if the proportion of FM is high in a diet.

Utilization of feed measured by the feed conversion ratio (FCR) was lowest for fish fed on Diet 1 (that is, indicating better utilization) and highest for fish feed Diet 4 (that is, indicating poor utilization). Although the FCR values were not significantly (P > 0.05) different between fish fed on Diets 1, 2 and 3, the higher FCR of fish fed on Diet 4 may be explained by Manjappa et al*.* (2002) who reported that, growth of fish fed with diets which have higher lipid level (above 12%) is poorer, reflecting a negative impact of dietary fat beyond the optimum level. Though crude fibre was lowest in Diet 4, utilization of the diet might have been impaired by the higher EE level. Glencros et al*.* (2007) supported this fact when they found that, the FCR becomes lower as the efficiency of feed utilization increases. For comparison, the FCRs in this study were better than those obtained by Wu et al*.* (2000) and Liti et al*.* (2006).

In this study, the condition factor (K) recorded for fishes fed on Diets 1, 2 and 3 were similar (P > 0.05) and differed (P < 0.05) significantly from those of fishes fed on Diet 4. Ogunji et al*.* (2008) reported that, the higher the K the better the physiological state of the fish. This suggests that in the present study, fish fed on Diets 1, 2 and 3 were in a better condition than those fed on Diet 4. The poor K of fish fed on Diet 4 could be attributed to the poor utilization of supplemental feed (indicated by lower MWG and PER and a higher FCR). For comparison, the lower K in the present study than those recorded by Anene (2005) for Cichlids: *C. guntheri, C, cabrae* and *T. mariae* could be ascribed to poorer utilization of supplementary feed.

Economic benefits of different dietary treatments of fingerlings of *O. niloticus*

The cost-benefit analysis (Table 4) of using different feeds in terms of the IC turned out to be similar among all the four treatments. It therefore, points to the fact that, all the diets used in the study could be used for *O. niloticus* culture depending on the availability and prices of the agro-industrial by-products used in this study. However, it is important to note that, in areas where larger quantities of these by-products exist, the cost per kilogram of feed may be lower and significantly reduce IC. For comparison, El-Dakar et al*.* (2008) reported an IC of 2.26 for diets containing up to 50% fig jam by-product (FJB) replacing WB in the diet of red tilapia and recommended it as an economically efficient diet for red tilapia fry. However, the IC of fingerlings of *O. niloticus* fed on Diet 1 (WB-based diet) in this study was higher. This might be because, WB was the major source of carbohydrates and the use of FJB as a less expensive feed ingredient in their study reduced the cost of the diet hence lower IC reported.

In another study Attipoe et al*.* (2009) in evaluating three test diets prepared from agro-industrial by-products, fish fed on the Diet (F2) (compounded with RB and groundnut bran) were reported to be the cheapest among the other diets. On the contrary, Diet 4 (groundnut bran-based diet) was the most expensive in terms of IC in the current study. The variance in results might be because, Diet 4, was prepared with FM as the major source of protein which in itself is expensive (Falaye and Jauncey, 1999; Abu et al., 2010). Coupled with that, the poor performance of the fish fed on Diet 4, did not compensate for the rather high cost of feed in this study.

The profit index (PI) was highest in Diet 2 though not significantly different from Diet 1. It may be economical and beneficial to use Diet 2 for the culture of fingerlings of *O. niloticus*. However, due to better feed utilization, growth was better for fish fed on Diet 1. Comparing the performance of fish fed on Diet 1 (WB-based diet) in this study to the report in a closely related study by Liti et al*.* (2006) on the economic performance of *O. niloticus*, WB-based diet gave higher returns than the other test brans for example rice bran. This is because WB had lower fibre and higher levels of carbohydrates, NFE and than RB, hence, proving more energy to spare dietary protein for growth.

Conclusion

In this study, fish fed on Diet 1 produced the fastest growth of *O. niloticus* fingerlings among the other test diets and the worse growth was recorded for fish fed on Diet 4. The IC was lowest for fish fed on PM based diet (Diet 2) corresponding to a higher PI.

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