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Performance of Nile Tilapia (*Oreochromis niloticus*) Fed Diets Containing Blood Meal as a Replacement of Fish Meal

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Abstract

A 100 days experiment was conducted to determine the effect of feeding blood meal (BM) as a replacement of fish meal (FM), as the main source of animal protein, on growth rate and economic performance of Nile tilapia in fertilized pond. Three isonitrogenous diets (35% crude protein) were formulated using either FM as the main source of animal protein (Diet 1); 50% replacement of FM with blood meal (Diet 2); or 100% replacement of FM with BM (Diet 3). Three hundred Nile tilapia fingerlings (12±3 g) were randomly distributed into three groups of four replicates of 25 fingerlings per cage. The groups were randomly assigned the 3 diets which were fed at 2% of their biomass at 10 am and 4 pm every day. Percentage daily weight gain (DWG), relative growth rate (RGR), specific growth rate (SGR), survival rate and feed utilisation efficiency were measured. Fish fed diet 1 were larger (50.69 g) ($P < 0.05$) than those fed diet 2 (48.47 g) and 3 (40.37 g). Replacement of FM with 50% and 100% BM reduced the incidence cost (45.55, 37.83 and 31.88, respectively). The profit index was highest with 100% (9.42) replacement of FM, compared to 50% (7.95) and 0% (6.69). Although replacing FM with BM was associated with reduced growth, the economic return was better ($P < 0.05$). Based on the present results, it was economical to use BM as a major protein source instead of FM in formulating fish feed.

Keywords: blood meal, crude protein, growth performance, Nile tilapia

1. Introduction

A major determinant of successful growth and intensification of aquaculture production is aqua feed. According to Higgs, Prendergast, Dosanjh, Beames, and Deacon (1994), research in fish nutrition is focused on reducing the cost of feeds which accounts for 40-60% of the running cost of intensive system. Dietary protein is the major and most expensive component of formulated aqua feeds (Wilson, 2002) and the commonest source is fish meal, which is often scarce and expensive. Fish meal is considered the most desirable animal protein ingredient in aqua feeds because of its high protein content, balanced amino acid profile, high digestibility and palatability, and as a source of essential n-3 polyenoic fatty acids (Hardy & Tacon, 2002). There is a growing concern to substitute fish meal with less expensive protein sources. However, attempts to partially or completely replace fish meal component with alternative protein sources have resulted in variable success notably reduced feed efficiency and growth at higher dietary inclusion levels (Jackson, Capper, & Matty, 1982; Viola, Mokady, Rappaport, & Arieli, 1982; Tacon & Jackson, 1985; NRC, 1993; Sogbesan, 2006).

The future of aquaculture in Kenya will depend on development of nutritionally sound and cost-effective feeds based on non conventional feedstuff that can support increased production levels in both intensive and especially semi-intensive systems. Utilization of non-conventional feedstuffs of plant origin has been limited by presence of anti-nutritive compounds like alkaloids, glycosides, oxalic acids, phytates, protease inhibitors, haematoglutinin, saponins, mimosine, cyanoglycosides, linamarin to mention a few despite their nutrient values and low cost implications (Sogbesan, 2006). The non conventional feed stuff of animal origin are high quality feed ingredients that could compare to some extent with the conventional types (Gabriel, Akinrotimi, Bekibele, Onunkwo, & Anyanwu, 2007). They are cheaper by virtue of the fact that there is no competition for human consumption. Also according to NRC (2011), processed animal protein ingredients such as blood meal, feather meal and poultry by-product meal, are comparable with many other protein sources used in fish feeds on protein cost basis. However, the only problem with these feedstuffs is their unavailability in large commercial quantities for the sustenance of aquaculture industry (Gabriel et al., 2007).

In Kenya, among the animal byproducts, blood meal, a byproduct after slaughter of cattle, is readily available in abattoirs and offer alternative cheaper protein source to fishmeal. According to Agbebi, Otubusin, and Ogunleye (2009), much can be achieved by intensifying research on blood meal inclusion in fish feed for better balanced diets.To develop a feed for sustainable fish production, the evaluation of proximate, amino acid composition, digestibility and performance efficiency as well as cost implications and conditions of application is necessary (Watanabe, 2002). According to Jobling (2001), Bunda, Tumbokon, and Serrano Jr. (2015), Kirimi, Musalia, and Munguti (2016), chemical analysis of feeds and feedstuffs provides information on their major nutrient, gross energy and amino acid composition. Although BM was found to be a good substitute of FM in terms of crude protein requirement and amino acid profile (Kirimi et al., 2016), there is need to conduct a feeding trial to determine the performance of animals (Salim, Aziz, Sultan, & Mustafa, 2004). The current study therefore was designed to evaluate the growth performance and economics of replacing fishmeal with blood meal on Nile tilapia in fertilized pond.

2. Materials and Methods

2.1 Study Site

The experiment was conducted at the National Aquaculture Research Development & Training Centre, Sagana, altitude 1230 m above sea level, latitude 0°39′S and longitude 37°12′E, and 90 km north of Nairobi. The fish were raised in net cages, of dimension 3 m × 2 m × 1 m that were fitted with six wooden sticks and stuck in earthen pond.

2.2 Preparation of Diets

The feed ingredients were obtained from commercial sources in the local market and their prices recorded. Bovine blood was collected from the local Sagana abattoir and processed according to Kirimi et al. (2016). Three isonitrogenous diets (35% CP) were formulated using wheat bran, soybean meal, cotton seedcake and either fishmeal as the main source of animal protein (Diet 1); 50% replacement of fishmeal with blood meal (Diet 2); and 100% replacement of fishmeal with blood meal (Diet 3) (Table 1).

Table 1. Ingredient composition and calculated chemical composition (%) of supplement fed to growing fish in a fertilized pond (as fed basis)

	Diet 1	Diet 2	Diet 3
Ingredient			
Fishmeal	36.6	18.4	0
Blood meal	0	12.5	25.5
Wheat bran	48.4	53.8	59.5
Soybean meal	10	10.3	10
Cotton seedcake	5	5	5
Total	100	100	100
Calculated chemical composition (%)			
Crude protein	35%	35%	35%

The ingredients were ground using hammer mill to be uniform and mixed thoroughly by hand in desired proportion. Some water was added to form dough and pelleted using a pelleter machine particle size 4.5 mm diameter. The pellets were then dried under shade and packed in water impermeable bags to prevent attacks by moulds and other pests.

2.3 Experimental Treatments

Three hundred, sex-reversed, Nile tilapia fingerlings from Sagana fish farm of average weight 12±3 g were selected and acclimatized for two weeks in the experimental pond during which time they were fed on a commercial ration. Using a completely randomized design (CRD), the fingerlings were picked and transferred into twelve net cages at a rate of 25 fingerlings per net cage. The net cages were further divided randomly into three groups of four replicates. The three groups were randomly assigned to three diets to form 3 treatments (Diet1, Diet 2 and Diet 3).

2.4 Feeding and Data Collection

After the adaptation period, the initial weight was measured and the fish were offered the experimental rations. Feed was given at a rate of 2% of body weight throughout the experimental period, twice daily i.e. morning (10 am) and evening (4 pm) in two equal meals. The amount of supplementary feed provided was adjusted accordingly after weighing the fish fortnightly. Water parameters were monitored weekly (dissolved oxygen, pH and temperature) using multiparameter water quality meter, model H19828 (Hanna Instruments Ltd., Chicago, IL., USA). At the end of every two weeks, fish from each net cage were weighed (g) for the entire experimental period of 100 days. The amount of feed consumed daily was also recorded.

The following parameters were used to determine the growth response of the fish:

(1) Survival Rate

Survival rate (SR) is the number of fish that survive during the experimental period expressed as a percentage of the stocked fish. It was calculated by substracting the number of fish dead during the culture period from the fish stocked and then expressing it as percentage (Charo-karisa et al., 2006).

$$SR (\%) = (\text{Initial number of fish stocked} - \text{mortality})/\text{initial number of fish stocked} \times 100 \quad (1)$$

(2) Daily Weight Gain

Daily weight gain (DWG) was calculated as the difference between the final body weight and the initial body weight of fish over a period of 100 days.

$$DWG\% = [(\text{final body weight} - \text{initial body weight})/(\text{Initial body weight} \times 100 \text{ days of experiment})] \times 100 \quad (2)$$

(3) Relative Growth Rate

Relative growth rate (RGR) was calculated as the change in weight of fish expressed as a percentage of the final average weight (Otubusin, Ogunleye, & Agbebi, 2009),

$$RGR (\%) = (Wf - Wi)/Wf \times 100 \quad (3)$$

Where,

Wf = final average weight at the end of experiment; Wi = Initial average weight at the beginning of experiment.

(4) Specific Growth Rate

Specific growth rate (SGR) is the instantaneous change in weight of fish expressed as the percentage increase in body weight per day over any given time interval. It was calculated by taking natural logarithms of body weight change expressed as percentage per day (Khalafalla & El-Hais, 2013),

$$SGR (\% \text{ per day}) = [(\text{Ln final body weight} - \text{Ln initial body weight})] \times 100/\text{Experimental period} \quad (4)$$

Where,

Ln = natural logarithm.

(5) Feed Utilisation Efficiency

Feed utilisation efficiency (FE) is the live weight gain (g) per feed consumed (g). It often serves as a measure of efficiency of the diet. The more suitable the diet for growth, the less food is required to produce a unit weight gain (Guroy, Emrah, Kut, & Adem, 2005),

$$FE (\%) = [\text{Weight gain (g)}/\text{Feed intake (g)}] \times 100 \quad (5)$$

2.5 Economic Analysis

A simple economic analysis was conducted to assess the cost effectiveness of diets used in the feed trial. Only the cost of feed was used in the calculation with the assumption that all other operating costs remained constant. Cost of the feed was calculated using market prices of ingredients in Kenya as per June 2014 (Table 2).

Table 2. Cost of ingredients used in formulating the diets

Ingredient	Price (Kshs*) per kg
Fishmeal	100
Wheat bran	20
Cotton seed cake	80
Soy bean meal	70
Blood meal	20

Note. *: 1 US Dollar = 104 Kshs.

The following parameters were used to determine the economic performance:

(1) Incidence Costs

Incidence cost (IC) was the cost of feed used to produce a kg of fish (relative cost per unit weight gain) and the lower the value, the more profitable using that particular feed (Nwanna, 2003; Abu, Sanni, Erondu, & Akinrotimi, 2010).

$$IC = \text{Cost of feed/weight of fish produced} \quad (6)$$

(2) Profit Index

Profit index (PI) was calculated according to Abarike, Attipoe, and Alhassan (2012),

$$PI = \text{Value of fish produced/cost of feed} \quad (7)$$

2.6 Data Analysis

Data on growth performance parameters and economic analysis were subjected to analysis of variance (ANOVA) using statistical package for social science version 17.0 at P = 0.05 confidence level, to determine whether there were significance differences and where the differences occurred, mean separation was done by least significance difference (LSD). The basic linear model for the completely randomized design (CRD) was:

$$Y_{ij} = \mu + \alpha_i + e_{ij} \quad (8)$$

Where,

Y_{ij} = is the observation on the j^{th}fish and i^{th} treatment; μ = is the overall population mean; α_i= is the effect due to level of blood meal {0%, 50% and 100%}; e_{ij}= is the random error term.

3. Results

3.1 Water Quality

Water temperatures ranged from 23.06 °C to 29 °C with a mean of 26.8 °C in the cage and 21.19 to 28.92 mean of 26.6 °C outside the cage (Table 3). The pH ranged from 8.93 to10.62 mean of 10.1 in the cage and 8.96 to 10.52, mean 10.08 outside the cage, dissolved oxygen ranged between 0.9 to 2.98 mean 2.19 mg/litre while outside the cage ranged between 0.9 to 2.78 with a mean of 2.12 mg/litre.

Table 3. Range and average of physico-chemical parameters of the water during the experiment

Parameter	Range		Average	
	Inside cage	Outside cage	Inside cage	Outside cage
Temperature (°C)	23.06-29.0	21.19-28.92	26.78	26.6
Dissolved oxygen (mg/litre)	0.9-2.98	0.9-2.78	2.19	2.12
pH	8.93-10.62	8.96-10.52	10.11	10.08

3.2 Survival and Growth Performance

Survival rate was high and similar for the three diets (98%) (Table 4). Fish fed on control diet had the highest ($P < 0.05$) daily weight gain (0.4 g/d) followed by group 2 (0.37 g/d) and Diet 3 (0.28 g/d) (Table 4). Likewise, the highest final average weight per fish (50.69 g) was recorded under treatment 1 while the least (40.37 g) was under treatment 3. The highest specific growth rate was recorded in fish fed the control ration (0.62%) followed by those fed diet 2 (0.61%). The least specific growth rate of 0.50% was recorded among fish fed diet 3. Relative growth rate was highest for group 1 and least for group 3.

Table 4. Growth performance of *Oreochromis niloticus* fed on blood meal as a replacement of fish meal in concentrate supplement*

Parameter	Treatment		
	Diet 1	Diet 2	Diet 3
Initial average body weight (g)	12.07±0.14^{c}	12.24±0.17^{bc}	12.83±0.15^{a}
Final average body weight (g)	50.69±1.68^{a}	48.47±1.40^{ab}	40.37±1.12^{c}
Daily weight gain (g/d)	0.4±0.02^{a}	0.37±0.01^{ab}	0.28±0.01^{c}
Specific growth rate (%)	0.62±0.02^{a}	0.61±0.02^{ab}	0.50±0.01^{c}
Relative growth rate (%)	76.48±1.04^{a}	75.15±1.18^{ab}	68.18±0.53^{c}
Survival rate (%)	98±1.16	98±1.16	98±2.00
Feed conversion efficiency	0.03±0.00	0.03±0.00	0.02±0.00

Note. *: Values are expressed as mean ± SE; ^{ab}: values in the same row having different superscript letters are significantly different (P < 0.05).

3.3 Economic Analysis

The quantity of feed and cost per kilogram of feed offered and total biomass harvested with the estimated value reduced with the level of substitution of FM (Table 5). Similarly the incidence cost and profit index fell with the level of substitution of FM.

Table 5. Economic analysis of *Oreochromis niloticus* fed on the supplements*

Treatment	Diet 1	Diet 2	Diet 3
Cost per kg of feed (Kshs†)	46.3	37.14	28
Feed input (kg)	1.27±0.08	1.24±0.03	1.15±0.04
Costs of feed (Kshs)	58.87±3.906^{a}	46.17±0.99^{b}	32.17±1.07^{c}
Harvested biomass (kg)	1.29±0.06^{a}	1.22±0.05^{ab}	1.00±0.03^{c}
Estimated value of biomass (Kshs)#	387.60±17.42^{a}	367.28±14.809^{ab}	302.70±8.10^{c}
Incidence cost	45.55±3.07^{a}	37.83±1.12^{ab}	31.88±0.55^{bc}
Profit index	6.69±0.49^{c}	7.95±0.23^{b}	9.42±0.16^{a}

Note. *: Values are expressed as mean ± SE; ^{abc}: values in the same row having different superscript letters are significantly different (P < 0.05); #: Estimate was based on a market value of Kshs 300 per kg of fish; †: 1 US Dollar = 104 Kshs.

4. Discussion

4.1 Survival Rate

Survival rate was comparable among the diets (98%). The high survival rate in this study could be attributed to good management procedures during the study i.e. proper handling and storage of feed to avoid mould growth and contamination by rodents, proper handling of fish during sampling and conducive physico-chemical parameters within the culture system. However, this high survival rate contradicts with the findings of Eyo and Olatunde (1999) where fish fed the highest levels of blood meal recorded the highest mortality in the cages. Whether this high mortality was caused by a nutritional defect in the diet was not clear.

In the present experiment, it is clear that inclusion levels of blood meal had no effect on the survival rate of fish which was in agreement with Agbebi et al. (2009) who reported that fish meal can be replaced completely (100%) by blood meal with no adverse effect on growth, survival and feed conversion of *Clarias gariepinus* juvenile. Aladetohun and Sogbesan (2013) also recorded no mortality and concluded that blood meal can perform very well as a feedstuff at inclusion rate of 100% and can replace fishmeal in Tilapia diet with no adverse effect on growth and survival of *Oreochromis niloticu*s fingerlings.

4.2 Growth Rate

Growth performance in this study decreased with high levels of blood meal in the diet (Figure 1). Diet 1 had the highest growth rate; this can be attributed to the use of high level of fishmeal as the major animal protein source. Fish meal is known to have balanced amino acid profile, high digestibility and palatability which promote good growth of fish (Hardy & Tacon, 2002). Poor performance of blood meal based diet in the present experiment agree with the study done by Otubusin (1987) in which the feed containing the highest amount of blood meal gave the poorest performance in terms of growth and feed conversion ratio. Huet (1994) reported that blood is known to be imbalanced in amino acids; however, he noted that it is good food for fish if mixed with vegetable meal.

Despite the comparable crude protein content of the three diets, diet 1 still performed better than the other diets in terms of growth performance and this implies that protein quality is important when considering fishmeal substitutes. This can be due to imbalance of essential amino acid composition of blood meal which was translated into the diet (Fasakin, Serwata, & Davies, 2005; Kirimi et al., 2016). Kirimi et al. (2016) observed that replacement of FM with 50% BM gave a useful protein diet whereas 100% an almost poor diet.

There was more deviation in the growth curve in the earlier days which tended to narrow later as the fish grew (Figure 1). This can be attributed to the reduced requirement of essential amino acids as the fish matured (NRC, 1993) resulting in a narrow gap between requirement and diets for the fish fed 50% replacement of FM and the control diet.

Summerfelt & Ketola, 1995; Abery, Gunasekera, & De-Silva, 2002; Agbebi et al., 2009; Bekibele et al., 2013), reported that optimum bone meal with blood meal could effectively replace up to75% of the fish meal in the diets fed to *Oreochromis mossambicus* fry. Good performance of fish have been observed for fish fed diets containing approximately 8 to 20 percent BM in conjunction with high (more than 20 percent) fish meal levels.

The method used to process blood meal i.e. cooking for 45 minutes in the present study may have denatured the amino acids leading to low growth rate (Cho, Slinger, & Bayley, 1982; McCallum & Hings, 1989; Pike, Andorsdottir, & Mundheim, 1990; Luzier et al., 1995; Bureau, Harris, & Cho, 1999). The fertilized earthen pond offered fish extra nutrition from natural food in the pond. However, this natural food could not compensate for what was deficient in blood meal based diets that led to low growth performance. Attention should therefore be paid to the amino acid profile of alternative protein sources and the resulting test diets.

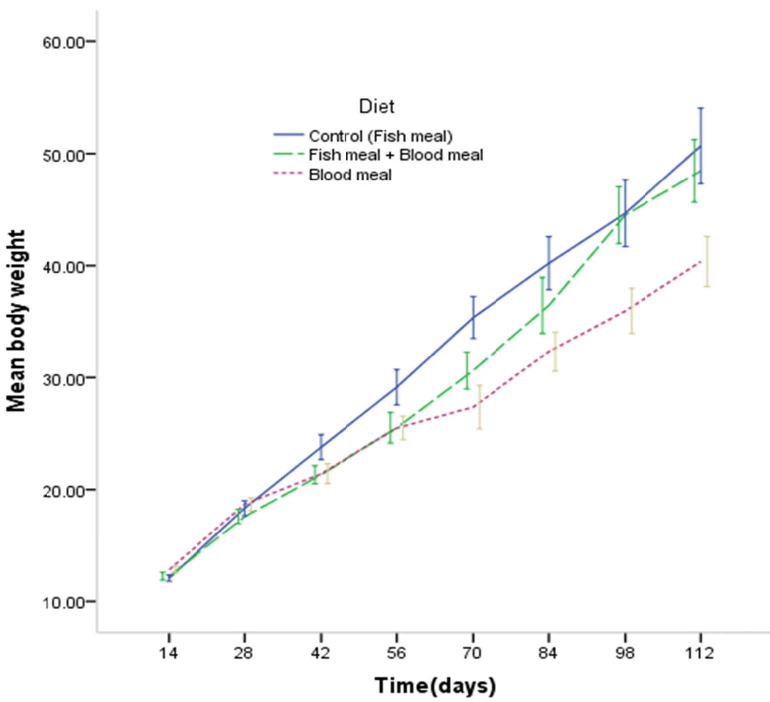

Figure 1. Growth response of *Oreochromis niloticus* fed on blood meal as a replacement of fishmeal

4.3 Economic Analysis

The costs of using the three diets is indicated by the incidence costs (IC), which is defined as the cost of feed used to produce a kg of fish (relative cost per unit weight gain) and the lower the value, the more profitable it is using that particular feed (Nwanna, 2003; Abu et al., 2010). In the present study data (Table 5), it was evident that it could be cheaper to raise Nile tilapia on diet 3 which contained blood meal as the major protein source with the incidence cost of (31.88). However, diet 1 which contained highest proportion of fishmeal as a major protein source had the highest Incidence cost (45.55), indicating that it is more costly to use fishmeal in formulating fish rations. Moreover, the less the incidence cost, the higher the profit index (PI) with diet 3 having the highest profit index (9.42) followed by diet 2 (7.95) and diet 1 (control) with the lowest profit index (6.69). These results agree with the experiment done by Aladetohun and Sogbesan (2013) where blood meal was used as protein ingredient in the diet for *Oreochromis niloticus* and the diet with 100% blood meal was cheapest.

In this experiment, high profit index in blood meal based (diet 3), arose from the fact that blood was free from the local slaughter house and the only cost incurred was that of transporting blood to the research station. More so, in this experiment, it is evident that use of non conventional protein sources of animal origin such as blood meal could be more cost effective for semi-intensive tilapia production systems since most are regarded as waste in our localities. The difference in economic performance for the three rations was due to the high cost of fishmeal which was used to formulate diet 1 and diet 2. To increase fish farm profits, the cost of feed must be reduced and considerable effort be focused on finding alternatives to fishmeal from both plant and animal protein sources (El-sayed, 1998; Fasakin, Balogum, & Fasuru, 1999; Hossain, Focken, & Becker, 2002).

In relation to culture period, Ogunji (2004) observed that when alternative protein sources are used in tilapia feeds, the rate of fish growth may be reduced leading to increased rearing time. However, the low cost of the protein sources would reduce the entire cost of raising the fish, compensating for the delayed growth and time lost, consequently, increasing profitability.

5. Conclusion

The results of the present study showed that fish fed on FM based diet performed better in terms of growth than those on BM. However, those on 50% (BM and FM) performed better than 100% BM hence blood meal can substitute fishmeal at 50%. However, although blood meal cannot compete with fishmeal in terms of growth performance, the economics of using it to replace fish meal is positive in the long run. The contradictory observations were due to the very low cost of BM that was obtained free of charge from the slaughter house. In conclusion, the results of the present study have revealed that it would be economically sustainable to use locally available blood meal to raise Nile tilapia in semi intensive system.

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