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PERFORMANCE OF LOCALLY FORMULATED FEEDS FOR REARING OF AFRICAN CATFISH IN TANZANIA

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ABSTRACT

Fisheries is an important food production sub-sector, providing almost 20% of the world's protein supply; however, the trend in fish production from capture fisheries has reached its limits due to overfishing. A study was conducted to evaluate the performance of two locally formulated feeds as possible replacements for an imported costly commercial feed (CMF) commonly used in rearing of African catfish (*Clarias gariepinus* Burchell) in Tanzania. Two feed types, namely TAF 1 and TAF 2, denoting TAFIRI feed type 1 and 2 were formulated from fish meal (*Rastrineobola argentea*) and soybean (*Glycine max* L.), respectively. Nine concrete tanks of 12 m3 each were stocked with 320 catfish fry each, and fed with formulated feeds at 5% of their mean body weight for four months. Water in the tanks was wholly flushed out on a weekly basis and fish sorted for the fast growers to reduce cannibalism. On a monthly basis, fish were randomly sampled for body length and weight. The mean values for temperature, dissolved oxygen and pH ranged from 21.62±0.04 to 25.16±0.05 oC, 5.43±0.05 to 5.7±0.07 mg O2 L-1, and 6.5±0.05 to 6.61±0.03, respectively. Feed TAF 1 was the best performer with weight gain of 33.72±0.89, average daily gain of 0.28±0.01, FCR of 1.35±0.05 and specific growth rate of 4.61±0.04. Fish fed on the commercial feed performed the poorest, with weight gain of 6.17±4.8, average daily gain of 0.05±0.004, FCR of 1.56±0.11 and specific growth rate of 2.98±0.05. Results from this study suggest that locally formulated feeds can cost effectively be used for the rearing of African catfish in Tanzania.

Key Words: *Clarias gariepinus,* dissolved oxygen, *Glycine max*

RÉSUMÉ

La pêche et l'aquaculture constituent un sous secteur important de production alimentaire, fournissant environ 20% des besoins en protéines mondiales ; par ailleurs, la tendance de la production des poissons à partir de la pêche dans les lacs et les océans a atteint ses limites par suite d'une trop forte pression sur les resources halieutiques. Une étude était menée pour évaluer la performance de deux aliments locaux formulés afin de remplacer les aliments commerciaux chèrement importés couramment utilisés dans la nutrition des poissons (*Clarias gariepinus* Burchell) en Tanzanie. Deux types d'aliments TAF 1 et TAF 2, aussi appelés aliments TAFIRI type 1 et 2 étaient formulés à partir des aliments de poissons (*Rastrineobola argentea*) et du soja (*Glycine max* L.), respectivement. Neuf réservoirs de 12 m^3 chacun étaient approvisionnés chacun avec 320 clarias, et nourris avec des aliments formulés sur base de 5% de leur poids corporel moyen pendant quatre mois. L'eau dans les réservoirs était renouvelée une fois la semaine et ainsi le triage des grands poissons pour réduire le cannibalisme. Chaque mois, les poissons étaient aléatoirement échantillonnés pour les mesures de la longueur du corps et du poids corporel. Les valeurs moyennes de la température, de l'oxygène dissous et du pH variaient de 21.62±0.04 à 25.16±0.05oC, 5.43±0.05 à 5.7±0.07mg O_2 L^{-1}, et 6.5±0.05 à 6.61±0.03, respectivement. L'aliment TAF 1 était le meilleur et a induit un gain de poids de 33.72±0.89, un gain quotidien moyen de 0.28±0.01, un FCR

de 1.35±0.05 et un taux de croissance spécifique de 4.61±0.04. Les aliments de poissons importés ont induit une performance inférieure à celle des aliments locaux avec un gain de poids de 6.17±4.8, un gain de poids quotidien moyen de 0.05±0.004, un FCR de 1.56±0.11 et un taux de croissance spécifique de 2.98±0.05. Les résultats de cette étude montrent que les aliments localement formulés peuvent remplacer efficacément et de manière économiquement compétitive les aliments importés pour l'élevage du poisson-chat en Tanzanie.

Mots Clés: *Clariasgariepinus,* oxygène dissous, *Glycine max*

INTRODUCTION

Fisheries is an important food production sub sector, providing almost 20% of the world's protein supply. However, trends have shown that fish production from capture fisheries has reached its limits, which calls for an increase for fish supply from aquaculture (FAO, 2012). It is hoped that aquaculture production will increase fish supply and bridge the ever increasing gap between fish supply and demand. Aquaculture currently produces about 50% of the world supply of fisheries products for direct human consumption (Boyd, 2012). However, the contribution of aquaculture from Africa to the global aquaculture production was only 2.2% in 2010, of which 39.9% came from freshwater fish farming (FAO, 2012).

Tanzania, like other east African countries, has identified aquaculture as an alternative livelihood for fish supply, which requires special development consideration to reduce national dependency on the capture fisheries. African catfish (*Clarias gariepinus*) is one of the commonly cultured species in Lake Victoria basin in east Africa. The demand for the African catfish as food, for control over-population in tilapia ponds (''police fish'') and as bait for the Nile perch fishery poses a threat on its stocks in the water bodies.

Although farming of fish in east Africa started during the colonial *era* (i.e. since 1940s), it has remained undeveloped ever since. The major obstacles in this respect is the unavailability of quality feed for the different fish production systems (Adebayo and Popoola, 2008; Ndimele *et al*., 2011; Shoko *et al.,* 2011a). This problem has driven most fish famers into making their own feeds, by using some locally available food materials like maize (*Zea mays* L.) and rice (*Oryza sativa*) bran, food remains and garbage from their farms. Nevertheless, commercial feeds are recognised for their high value, although they are expensive for most local fish farmers (Bureau *et al.*, 2009; Marithumu *et al.*, 2011). Most fish farmers who use imported commercial feeds incur more than 60% of the total farm production investments in these feeds (Gabriel, 2007; Aderolu, 2010; Himadri *et al.,* 2012).

The most important barrier towards fish feed development in Tanzania is lack of simple technology for developing feed from locally available ingredients. The objective of this study was to evaluate the performance of two locally formulated feeds as possible replacements for an imported costly commercial feed commonly used on rearing of African catfish.

METHODOLOGY

The experiment was carried out from April to August, 2013 in nine concrete tanks of 2 m x 4 m x 1.5 m (12 m^3 capacity), located at Tanzania Fisheries Research Institute (TAFIRI), Mwanza centre. The tanks were filled with fresh water flowing by gravity from a filtration overhead tank which received water from Lake Victoria. The chemical and biological qualities of the water were determined for suitability to fish prior to stocking with fish fry, and the same was repeated after stocking fish before water replacement. Each tank was stocked with 320 catfish fry of three weeks old obtained from TAFIRI hatchery, stocked in replicates of three tanks per feed treatment. Prior stocking, the fry were treated with 1mg L^{-1} potassium permanganate ($KMnO_4$) to remove external parasites.

Even though the fry were from a single batch, they varied much in size (0.17 - 0.56 g), thus necessitated sorting into three size categories to reduce cannibalism. Therefore, the mean initial weights of fry used in the experiment were 0.30±0.01, 0.29±0.03 and 0.24±0.02 g for CMF (commercial feed), TAF 1 (TAFIRI made feed one)

and TAF 2 (TAFIRI made feed two) feed treatments, respectively. TAF 1 and TAF 2 were made at TAFIRI - Mwanza centre; while the commercial feed was imported from Uganda. All the three feeds contained 35% crude protein. The feed ingredients for TAF 1 comprised of fish meal "Dagaa" (*Rastrineobola argentea*), cotton seed cake, maize bran, multivitamins and fish oil; while TAF 2 feed comprised of soybean, rice bran, fish oil and multivitamin. Fish meal and cotton seed cake were used as sources of protein for TAF 1 and soybean for TAF 2. The CMF was made up of fish meal as the source of protein. Maize and rice bran were locally available in the study area and were commonly used in animal feed formulation in the country. The proximate analysis of TAF 1, TAF 2 and CMF feeds were done at Sokoine University of Agriculture in Morogoro, Tanzania.

The fish in tanks were fed at 5% of their body weight per day. The feeds were divided into two rations as fish were fed twice a day at 10.00 a.m. and 4.00 p.m. The amount of feed was adjusted monthly basing on the total weight of the fish calculated from the mean weights. Water quality was monitored for pH and temperature twice a week at 09.00 a.m. and 03.00 p.m. using portable pH-Temperature meter (HI 991300 pH/EC/TDS/ Temperature, USA). Concurrently, dissolved oxygen was monitored using an Oxygen meter (HI 9143 Microprocessor Oxygen meter HANNA, USA). Debris at the bottom of the tanks was washed out while replacing water with fresh water from the filtration tank on weekly basis.

For the purpose of measuring growth parameters, 30 fish were taken from each experimental tank and measured for total length and weight. The length was measured using 30 cm ruler; while weight was measured using 220 g capacity weighing balance (model Scout Pro SPU 2001, China). After each sampling, survival (%), specific growth rate (SGR), food conversion ratio (FCR) and growth rate (GR) of the fish were calculated by using the formula given by Aderolu *et al.* (2010):

$$Percentage\ Survival = \frac{N_h}{N_s} x100 \quad \text{.... Eq. 1}$$

Where:

N_h = Total number at harvested; and

N_s = Total number of fish stocked.

$$SGR = \frac{\ell n\, W_f - \ell n\, W_i}{t} x\,100 \quad \text{..... Eq. 2}$$

Where:

W_f = Final mean weight (g); and

Wi = Initial mean weight (g).

$$FCR = \frac{TFC}{TWG}$$

Where:

TFC = Total feed consumed (dry) (g); and
TWG = Total weight gained by fish (wet) (g).

Two-way analysis of variance (ANOVA) was used to evaluate any significant differences in growth performance among different feeds tested. All statistical analyses were performed using SPSS 13 for Windows (Landau and Everit, 2004). Post hoc Turkey's pairwise multiple comparisons were used to detect significant differences between the means (Zar,1999). Significant differences were judged at a probability level of $P<0.05$.

RESULTS

Composition of the feeds. The chemical composition of the selected locally available feed ingredients is presented in Table 1. Fish meal had the highest crude protein, followed by soybean and lastly cotton seed cake. The lowest values were recorded in maize and rice brans. For the crude fibre, the highest values were recorded in rice bran and cotton seed cake; while the lowest was in fish meal. Ether extract was the highest in cotton seed cake and lowest in rice bran. Ash content varied greatly among the ingredients, with the highest values recorded in the fish meal.

The proportions of different ingredients and the proximate analysis of the formulated TAF 1 and TAF 2 feeds are as shown in Tables 2 and 3, respectively. Both feeds had 35% crude protein

TABLE 1. Proximate composition of selected feed ingredients (% dry matter) formulated to TAF 1 and TAF 2 feeds used in the experimental study

Feed ingredient	Dry matter (DM)	Crude protein (CP)	Crude fibre (CF)	Ether extract (EE)	Ash
Fish meal	90.53	61.86	0.75	13.00	22.51
Soybean	91.44	32.35	4.18	6.84	5.52
Cotton seed cake	92.44	33.12	16.44	12.40	7.55
Maize bran	91.60	12.20	8.94	6.63	5.16
Rice bran	92.43	5.50	20.21	1.23	19.91

TABLE 2. Proportions of ingredients (%) of the formulated TAF 1 and TAF 2 feeds used in an aquaculture study

Feed ingredients	Percentage in diet	
	TAF 1	TAF 2
Fish meal	32.21	-
Soybean	-	59.57
Cotton seed cake	32.21	-
Rice bran	-	39.71
Maize bran	35.43	-
Vitamin/mineral premix	0.08	0.37
Oil	0.07	0.36

TABLE 3. Proximate analysis (%) of the formulated TAF 1 and TAF 2 feeds used in the experimental study.

Feed type	Dry matter	Crude protein	Crude fibre	Ether extract	Ash
TAF 1	93.0	35	7.6	12.4	10.0
TAF 2	93.0	35	7.0	13.2	6.6

with almost, the same values of crude fibre and ether extract. The exception was with ash content whereby a higher value was recorded in TAF 1.

Bio-physical conditions of the tanks. Mean temperature, pH and dissolved oxygen in the rearing tanks are presented in Table 4. There was significant ($P<0.05$) increase in temperature from morning to the evening in the three treatments. On the other hand, dissolved oxygen decreased significantly ($P<0.05$) from the morning to the evening. There was no significant variations in pH level ($P>0.05$).

Catfish growth rates. African catfish fed on Feed TAF 1 attained the highest growth rate (33.72±0.89 g), followed by TAF 2 (22.43±5.58 g) (Table 5, Fig. 1). Catfish fed on CMF resulted in the lowest growth rate (6.17±0.48 g). Food conversion ratios among the three feed treatments were not significantly different ($P>0.05$).

Survival rate. The highest percenatge survival was recorded in fish fed on the commercial feed (Table 5). There was no natural mortality in all the tanks and it was noticed that all the mortalities were due to cannibalism.

DISCUSSION

Bio-physical conditions of the tanks. The levels of temperature, pH and DO recorded from the culture tanks in the present study were within the appropriate range for catfish culture (Ayinla

TABLE 4. Water quality parameters (pH, temperature and dissolved oxygen) as measured in the tanks used in the experimental study

Parameter	Feed type	Morning	Evening
pH	CMF	6.56±0.03	6.61±0.03
	TAF 1	6.51±0.05	6.60±0.03
	TAF 2	6.59±0.04	6.61±0.03
T (°C)	CMF	21.62±0.04	25.16±0.05
	TAF 1	21.63±0.04	25.14±0.08
	TAF 2	21.67±0.04	25.10±0.09
DO (mg L^{-1})	CMF	5.59±0.06	5.44±0.07
	TAF 1	5.57±0.04	5.43±0.05
	TAF 2	5.70±0.07	5.60±0.08

TABLE 5. Growth and survival rates of African catfish (*C. gariepinus*) fed with different feeds used in the experimental study

Growth parameters	Feed treatments		
	CMF	TAF 1	TAF 2
Initial average weight (g)	0.30±0.01^a	0.29±0.03^a	0.24±0.02^a
Final weight (g)	6.42±0.48^a	34.19±0.89^b	22.43±5.58^c
Weight gain (g)	6.17±0.48^a	33.72±0.89^b	22.86±1.92^c
Initial length(mm)	35.92±0.65^a	34.95±0.44^a	32.63±0.88^c
Final length(mm)	105.23±6.52^a	180.62±34.39^b	146.53±2.00^c
Average daily weight gain	0.05±0.004^a	0.28±0.01^b	0.21±0.01^c
Specific growth rate (%)	2.98±0.05^a	4.61±0.04^b	4.47±0.08^b
Food conversion ratio	1.56±0.11^a	1.35±0.05^a	1.45±0.08^a
Survival rate (%)	69.1	52.2	49.1

Values with the same superscripts in the rows are not significant different ($P<0.05$)

et al., 1994). The findings imply that there was no influence of these parameters on catfish growth. Monitoring water quality parameters in culture systems is very important as the variables influence fish physiological processes. Feed wastes may lead to water deterioration, thus bringing significant changes in ecosystem structure and functioning (Da, 2012). However, in African catfish, negative impacts of low water quality are quite rare, as adults are quite tolerant to a range of environmental parameters as opposed to its juveniles.

Composition of the feeds. It is clear that fish meal had higher crude protein content than cotton seed cake and soybean based feeds (Table 1). The fact that fish meal had high crude protein favours its use in the manufacture of most animal feeds; however, its increased use poses a challenge due to competition by alternative human needs for the same (Shoko *et al*., 2011b). Worldwide, it is highly discouraged to use feeds needed by humans for making animal feeds, and thus the move is on the use of animal protein. Currently, there is increased search for various plant sources for the purpose of replacing the use of fish protein and fish oil. In this regard, any effort towards using plant by-products as a replacement on the use of fishmeal and fish oil will be appreciated. From this study, locally available materials such as cotton seedcakes and soybean have a potential for replacing fish meal

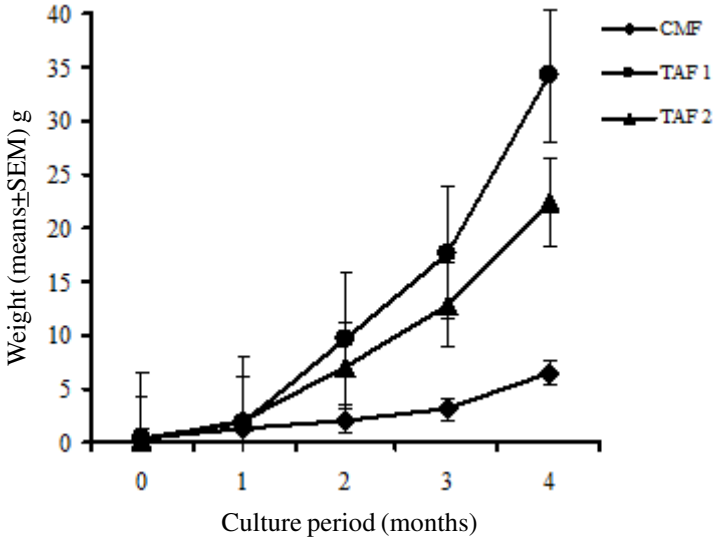

Figure 1. Growth trends showing change in mean weights of *C. gariepinus* fed on CMF, T AF 1 and TAF 2 feeds used in the study. (Error bars show ±SE).

in feeding African catfish. This finding is supported by Shoko *et al*. (2011) who reported similar findings on Tilapia *O. variabilis*.

Cost of production of the feeds. The cost of producing 1 kg of the formulated TAF 1 feed (US$ 1.00 kg^{-1}) and TAF 2 feed (US$ 1.70 kg^{-1}) was much lower than the imported commercial feed (US$ 2.00 kg^{-1}). The use of locally available materials is advantageous in that it reduces the costs of production of the feeds and it impacts on the economy of the country. The use of local ingredients also has a possibility to impact on the innovations and growth of micro-technologies as most farmers had already indicated making different trials on their farms for increased outputs. For example, some catfish fry producers used boiled chicken egg yolk to feed fry, the phenomenon which inspired researchers to conduct search on the same. Currently, there is an increasing number of catfish growers, who use bi-products from poultry industry as feed, and in fact, their farms are doing quite good.

Catfish growth rates. TAF 1 fed showed the highest weight gain and average daily gain, followed by TAF 2 feed (Table 5). The better performance of TAF 1 than TAF 2 could mainly be attributed to the inclusion of fish meal in the feed, which might have led to the acceptability and efficient utilisation by fish. Generally, fish meal bears high nutritional quality and biological value, and is well-balanced in amino acid profile, yet lacks anti-nutritional factors. As such, it is the most loved protein source by most aqua feed producing industries (El-Sayed, 1998; 2005; FAO, 2010; Aanyu *et al.,* 2012). Fish meal is a more readily digested and assimilated ingredient than the plant source ingredients (Tacon *et al*., 2008). The fiber in plant ingredients is known to reduce feed intake, decrease the time the feed spends in the gut and, consequently diet digestibility and nutrient bio-availability (Espe *et al*., 1998; Cheng and Hardy 2002; Nyina-wamwiza *et al*., 2007). However, the heat processing method employed in soybean in the present study could be partly the cause of the digestibility of TAF 2 feed as there were no significant difference in the specific growth rate and the food conversion ratios on treatment of the two locally formulated feeds. This is in concurrence with some studies which revealed that partial or complete replacement of fish meal, with plant ingredients, did not inhibit growth performance (Lee *et al*., 2002; El-Saidy and Gaber, 2003, Amisa *et al*., 2009).

Contrary to our expectation in this study, the CMF feed performed the poorest. This can be

attributed to the possibility that the feed was a floating pellet, while African catfish are dermesal fish spending most of the time in the bottom. Although most catfish would have been expected to come and compete for food in the surface, most fish did not come. This was because African catfish tend to express different behavours depending on variation on stocking density. Generally, African catfish, when stocked in high densities tends to efficiently utilise the feed due to intra-competition (Kohinoor *et al*., 2012). Fish when stocked at lower densities tend to express territorial behaviour than competition for food. Thus, it is probable that most of the CMF dissolved completely in the surface of the waters before it could be taken by fish. Thus, it is important at all times to consider all the necessary precautions on the behavior of the cultured animal and properties of the feed used.

Survival rate. The survival percentages of both feed treatments were generally low (Table 5). This could be due to cannibalism behavior of the catfish. Cannibalism in catfish is quite significant regardless of its stage in life, and normally it is recommended that sorting of fish is done to fast growers as any differences in fish size would cause cannibalism. Water quality, to some extent, impaired on the survival of the fish at their earliest life (Table 4); however this was immediately corrected and water replacement was changed on weekly intervals.

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