DEVELOPMENT OF LOCALLY AVAILABLE FEED RESOURCE BASE IN TANZANIA

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ABSTRACT

Soybean meal has been recommended as a substitute for fishmeal in fish diets because of its high protein content and relatively low price. However, small-scale fish farmers in sub-Saharan Africa have not adopted it because soybean meal is pricey and supply is limited. Thus, there is a need to look for cheap alternative protein sources from locally available feed resources. This study was carried out to evaluate the effects of substituting soybean meal with either *Moringa oleifera* leaf meal (MOLM) or *Leucaena leucocephala* leaf meal (LLLM) in feed and the effects on pond water quality and growth performance of tilapia. The study also assessed whether the replacement of soybean meal with leaf meals increases profitability in tilapia farming. Nine diets were formulated and all of them contained 40% protein (soybean meal, MOLM, LLLM and mixtures of the three), 58% energy source (maize bran) and 2% mineral mix. Diet 1, diet 2 and diet 3 contained, respectively, LLLM, MOLM and soybean meal as sole protein sources. In diet 4, diet 5 and diet 6 LLLM replaced soybean at the levels of 25, 50% and 75%, respectively. In diet 7, diet 8 and diet 9, soybean meal was replaced with MOLM at the levels of 25, 50% and 75%, respectively. The fish were fed daily on the respective diets at a rate of 10% of body weight for 90 days. Body weights and length of the fish were measured at the start of the experiment and then at day 30, 60 and 90. Pond water temperature, dissolved oxygen (DO) and pH were measured at weekly intervals for the whole experimental period. Water temperature ranged from 27.7 to 28.5^{0}C, DO was between 8.7 and 11.3 mg/l and pH ranged between 7.68 and 8.18. The growth of fish was significantly ($P \leq 0.001$) influenced by the diets. Fish on diet 3 showed the highest average growth rate (GR) (0.76 ± 0.07 g/d), lowest average feed convention ratio (FCR) (2.7) and highest mean body weight (72.06 ± 1.25 g) and length (11.83 ± 1.90 cm) at 90 days. These were followed by the fish on diet 7 (GR = 0.57 ± 0.06 g/d, FCR = 2.8, mean body weight at 90 days = 47.43 ± 1.17 g and length = 11.25 ± 1.7 cm). Fish on diet 1 had the lowest GR (0.37 ± 0.03 g/d), mean body weight (37.79 ± 1.13 g) and length (9.60 ± 1.4 cm). Fish on diet 2 had the next lowest values (GR = 0.38 ± 0.03 g/d, body weight = 41.92 ± 1.21 g and length = 10.30 ± 1.4 cm).The economic analysis indicated that the diets which contained MOLM and LLLM as sole sources of protein resulted in more profits while the diet which had soybean meal resulted into a loss. The profits decreased as the proportion of soybean meal increased in the diets because of the costs. The use of MOLM and LLLM in place of soybean can result in profitability in tilapia farming, although the yield of Nile tilapia would be low. MOLM is found to be relatively better as a protein source in tilapia diets than LLLM.

INTRODUCTION

In Tanzania, fish farming provides vital animal protein to human population residing in areas, which are located far away from the major fishery resources. It is also an important enterprise to the economic wellbeing of households in rural areas. The most cultured species is the Nile tilapia (*Oreochromis niloticus*). The aquaculture industry is dominated by freshwater fish farming in which small-scale farmers practice both extensive and semi-intensive fish farming. Fish ponds of an average size of 10m x 15m (150 m^2) are the predominant production system (URT, 1997). These ponds are usually integrated with other agricultural activities such as gardening, livestock and poultry production on small pieces of land. The ponds are commonly fertilized with the droppings of domesticated animals or tender leaves as compost manure.

The fish farmers use naturally available feeds to feed the cultured fish. The most frequently used feed are rice and maize bran, kitchen leftovers, and garden remains. These are of low quality and fish reared on these feeds are unable to meet their maintenance and production requirements, especially for protein. This prolongs the time to reach the market weight and consequently leads to production of poor quality fish and low profitability of fish farming.

For several decades, fishmeal and soybean meal have been used as the main sources of protein in fish feeds (El-Sayed 1999). However, supplies are limited due to competition from humans and livestock. Also, the continuous rise in prices of fish meal and soybean meal make them too expensive and affordable by small-scale fish farmers in developing countries. In order to enhance aquaculture production, improve food security and reduce the level of poverty in rural areas, a search for cheap and locally available feedstuffs is required. There is a need to identify alternative cheap sources of protein from locally available feed resources and to select protein sources that do not conflict with human food security interests (El-Sayed 1999; El-Saidy and Gaber, 2002), as is the case with fish meal and soybean. Leguminous tree leaves and their pods seem to be appropriate alternative protein sources to fishmeal and soybean meal (Fernandes et al., 1999; El-Saidy and Gaber, 2003; Richter et al., 2003; Kaushik et al., 2004). *Moringa oleifera* and *Leucaena leucocephala* are the most useful trees as feed supplements to animals. The leaves of *Leucaena leucocephala* are highly nutritious with excellent palatability, digestibility and balanced chemical composition of protein, minerals and amino acids (Hughes, 1998). Protein concentration in *Leucaena leucocephala* is usually high i.e. 23.5-31.5% (Kimbi, 1997; Ndemanisho et al.,1998; El-hassan et al., 2000; Kimoro, 2003). *Moringa oleifera* is a multipurpose tree of significant importance with several industrial and medicinal uses. All parts of the plant are used in various ways; young leaves, mature leaves, pods and seeds (Becker and Makkar, 2000).The leaves of *Moringa oleifera* are rich in protein and have been used as feed for animals such as goats (Aregheore, 2002; Sarwatt et al., 2002; Manh et al., 2005), for fish (Richter et al., 2003) and for cattle (Sarwatt et al., 2004). According to the Gidamis et al. (2003) the leaves of *Moringa oleifera* contain high concentrations of crude protein, essential vitamins, calcium, iron and proteins.

However, there is limited information on the feeding value of *Moringa oleifera* and *Leucaena leucocephala* leaf meals for use as protein supplements in tilapia feeding. Hence, there is a need to find out the extent to which these leguminous tree leaves can replace fishmeal or soybean in small scale fish production. In this study it was hypothesized that the replacement of soybean meal with *Leucaena leucocephala* leaf meal and *Moringa oleifera* leaf meal as protein sources in fish diets would lower feed costs and hence increase the profitability of fish farming enterprises. This study was, therefore, carried out with the major objective of evaluating the feeding value of *Leucaena leucocephala* leaf meal and *Moringa oleifera* leaf meal as protein supplements in tilapia diets.

The objectives of the study were;

1. To evaluate the feeding value of *Moringa oleifera* and *Leucaena leucocephala* leaf meals in terms of their chemical composition.
2. To evaluate the effect of feeding *Moringa oleifera* and *Leucaena leucocephala* on growth performance, feed conversion ratio and survival rate of cultured tilapia.
3. To examine the effects of *Moringa oleifera* and *Leucaena leucocephala* leaf meals on the quality of pond water.
4. To assess the economic profitability of using *Moringa oleifera* and *Leucaena leucocephala* as feed supplements for tilapia.

MATERIALS AND METHODS

Location of study area

The study was carried out at Kingolwira Fishery Centre, Morogoro, Tanzania. Morogoro lies at latitude 600 20' south and longitude 370 39' East. Morogoro is located at an altitude of about 525 m above sea level. Morogoro region has bimodal rainfall pattern, with short rains starting in November and ending in December and long rains starting in March and ending in May, with an average rainfall of 800 mm per annum. The relative humidity at the location of study is about 81%, while the monthly mean minimum and maximum temperatures are 14.8^{o}C and 32.4^{o}C, respectively.

Preparation of feed materials

Moringa oleifera and *Leucaena leucocephala* leaves were harvested in Morogoro District in September 2008.These leaves were dried in a shaded area to avoid nutrient degradation by direct sunlight. The dried leaves were chemically analyzed and used as plant protein sources in feed compounding. Soybean, maize bran and mineral mix were also purchased in Morogoro municipality. Soybean was boiled for 30 minutes, dehulled, then sun dried for three days. These feed ingredients were chemically analyzed to determine their chemical composition. *Moringa oleifera*, *Leucaena leucocephala* leaves, soybean and maize bran were crushed to enable uniform mixture during feed compounding process.

The chemical composition (dry matter (DM), ether extract (EE), crude fibre (CF), crude protein (CP) and ash) of *Moringa oleifera*, *Leucaena leucocephala* leaves, soybean and maize bran were determined using the proximate analysis scheme (AOAC, 1990). Mineral contents (Ca, Mg, P and K) were determined by using an Atomic absorption spectrophotometer. Extractable condensed tannins were measured by using the method of Makkar (2000). The concentrations of mimosine in diets were determined by using the procedure described by Matsumoto and Sherman (1951) with the modification of Okot (1998).

Feed formulation

Nine diets were formulated. Diet 1, diet 2 and diet 3 contained *Leucaena leucocephala* leaf meal (LLLM), *Moringa oleifera* leaf meal (MOLM) and soybean, respectively, as sole source of protein. In diet 4, diet 5 and 6 soybean was substituted with LLLM at the levels of 25, 50 and 75% while in diet 7, diet 8 and diet 9 MOLM replaced soybean at the levels of 25, 50 and 75%, respectively. All diets contained 40% protein source, 58% energy source and 2%. The proteins sources were soybean, LLLM and MOLM while maize bran was used as energy source.

Experimental procedure

Two concrete tanks were allocated for each diet and 40 fingerlings were stocked in each tank at a rate of 2 fingerlings/m^2. The fingerlings were of mixed sex and had mean (± se) weight of 3.1 ± 0.24 g. A total of 18 round concrete tanks with surface area of 7.06m^2 and depth of 1m were used in the study. The fish were fed twice a day at 0900 h and 1600 h for a period of 90 days. The amount of feed provided was 10% of the body weights, and was adjusted upwards according to monthly body weights. The data were collected in the months of November, December 2008 and January 2009. Body weights of 40 fingerlings stocked in each tank were measured by using an electronic balance at the start of the experiment and then at day 30, 60 and 90 of the experiment and growth rates were computed. Fork length and body width of 10 fish randomly selected from each tank were measured using a measuring board and vernier caliper, respectively, at day 30, 60 and 90 of the experiment. Death was recorded as it occurred and survival rate was computed. In addition, temperature was determined using a digital thermometer, dissolved oxygen (DO) concentration was determined using a digital DO meter (Jennway 2001) and pH was determined using a digital pH meter (Portmass 911), at weekly intervals during the experiment.

Data analysis

The data collected were analyzed using General Linear Model procedure of Statistical Analysis System (SAS, 1998). The diets were used as fixed effect and the initial body weights were used as the covariates. The dependent variables were body weight, growth rate, dissolved oxygen, pH, and temperature. The chi-square test was used to analyze the data on mortality rate. In addition, gross margin (GM) analysis was used to estimate the profit margin. Gross margin (GM) =Total revenue (TR) – Total variable costs (TVC). The main input costs used in the calculation were prices of fingerlings, prices of feeds, and labour costs. The revenue was obtained from the sales of fish.

RESULTS

Chemical composition of feed ingredients

The analysis for chemical composition of feed ingredients indicated that average DM ranged from 96.52 to 97.13%. The CP content was highest in soybean meal (52.72 %) and lowest in maize bran (11.23%).The CF was highest in LLLM (17.23%) and lowest in soybean (5.85%).The ash content was highest in LLLM (10.63%) and lowest in soybean (4.3%). The Ca content ranged from 0.23% in LLLM to 0.61% in maize bran. The content of Mg was highest in soybean meal (0.32 %) and lowest in LLLM (0.10%).The K content was highest in maize bran (0.13%) and lowest in MOLM (0.05%).The P content was highest in soybean (0.55%) and lowest in LLLM (0.21%).

The analysis for anti-nutritive factors showed that LLLM had higher levels of mimosine (28.50 g/kg DM), condensed tannin (18.50 g/kg DM) and lignin (36.5 g/kg DM) compared to MOLM, MB and soybean. *Moringa oleifera* did not contain mimosine and condensed tannin, but contained lignin (22.05 g/kg DM). Water temperature in the tanks ranged from 27.7 to 28.5 0C, DO was between 8.7 and 11.3 mg/l and pH ranged between 7.68 and 8.18.

Growth Performance

The diets had significant ($P < 0.05$) influence on weight gain of fish. The fish on the control diet 3 had the highest weight gain (68.25 ± 2.48 g) compared to the fish on the other diets. However, fish on *Moringa oleifera* based diets (diets 2, 7, 8 and 9) showed slightly higher weight gain (32.70 ± 2.39 - 51.52 ± 2.37g) compared to the fish on *Leucaena leucocephala* based diets (diets 1, 4, 5 and 6). The diets significantly influenced ($P < 0.05$) the growth rate of fish. The fish on the control diet (diet 3) had the highest growth rate (0.76 ± 0.07 g/d) compared to those on the other diets. Fish on

Moringa oleifera based diets (2, 7, 8 and 9) had slightly higher growth rate (0.38 ± 0.03 - 0.57 ± 0.06 g/d) compared to those on *Leucaena leucocephala* based diets (1, 4, 5 and 6) (0.37 ± 0.03 – 0.46 ± 0.05 g/d).

Body length also differed significantly ($p < 0.05$) among the fish fed different diets. The highest body value for body length was observed on fish fed diet 1 (11.83 ±1.9 cm), this was followed by those on diet 7 (11.25 ±1.7 cm) and fish on diet 1 had the lowest body length (9.60 ± 1.4 cm). Fish on diet 3 had the highest body width (4.28 ± 0.04 cm) while those on diet 7 (4.15 ± 0.04 cm) had the second highest body width and those on diet 1 had the lowest (3.60 ± 0.03 cm). Feed conversion ratios of the fish under different diets ranged from 2.67 ± 0.05 (diet 3) to 2.91±0.02 (diet 1).

The results for the chi-square test indicated that fish mortality in the ponds was not significantly ($P \geq 0.05$) influenced by the diets. However, fish under *Moringa oleifera* based diets showed slightly higher survival rate than those under *Leucaena leucocephala* based diets.

The economic analysis for the different diets showed that the production cost for fish fed diets which contained soybean meal at levels more than 25% was higher compared to the revenue obtained after selling the fish. The diets which contained leaf meals as sole sources of protein had high returns, despite the fact that the fish on these diets had lower body size compared to the diets which contained soybean meal protein supplements. Diet 2 which had 100% MOLM as sole source of protein supplement resulted in the highest profit (TSHs 158,303.14≈ US$ 121.8), followed by diet 1 (125,402.38 ≈ US$ 96.5) which had 100% LLLM as sole source of protein supplement. Diets 9 (25% MOLM) and 6 (25%LLLM) ranked third and fourth in terms of profitability. Generally, the gross margin decreased as the level of soybean meal increased in the diets, indicating that soybean meal is very expensive and that feeding fish with MOLM and LLLM as sole sources of protein alone can increase the profitability of fish farming.

CONCLUSIONS

Based on the findings obtained from the present study, the following conclusions were made: 1) The relatively higher weight gain, growth rate and survival rate observed on fish fed MOLM based diets, indicate that MOLM can be used as protein source in tilapia diets to replace soybean meal; 2) Fish fed MOLM based diets performed relatively better than those fed LLLM based diets, indicating that MOLM is better than LLLM as protein source in tilapia diets; and 3) The results of the present study show that producing fish using diets with higher levels of leaf meals is more economical than using diets with higher levels of Soya bean meal.

ANTICIPATED BENEFITS

The study provided fish farmers some knowledge of *Moringa oleifera* and *Leucaena leucocephala* as possible protein sources for fish feed. Farmers acquiring this knowledge can prepare home-made fish feed using locally available feed resources. As more farmers use *Moringa oleifera* and *Leucaena leucocephala* in home-made fish diets, the cost of fish production will decline and profitability of small-scale fish farming in rural areas will improve. It is expected that profitability can increase by more than 100%, which would help increase household income and food security. In addition, as the technology is adopted nation-wide, *Moringa oleifera* and *Leucaena leucocephala* could be utilized on a commercial scale to produce commercial fish diets at lower cost. This will have a positive impact on fish nutrition, aquaculture productivity, and profitability of fish farming in Tanzania.

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