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EFFECT OF SUPPLEMENTARY FEEDING OF AGRO-INDUSTRIAL BYPRODUCTS ON THE GROWTH PERFORMANCE OF NILE TILAPIA (*OREOCHROMIS NILOTICUS* L.) IN CONCRETE PONDS

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ABSTRACT: This study was conducted to evaluate the effect of supplementary feeding of wheat bran, noug cake and brewery waste on the growth of *Oreochromis niloticus* in concrete ponds. The feeding trial was conducted in eight concrete ponds of about 50 m^2 each. The control and experimental groups were run in duplicate with stocking density of 2 fish/m^2. The treatment groups were fed at 5% of their body weight with the respective test feeds and the control group was left to feed on endogenous phytoplankton diet. The results of the experiment showed that fish given supplemental diets grew much faster (ANOVA, $P<0.001$) than the control group. Although no significant growth differences were observed between the test feeds (ANOVA, $p=0.81$), fish raised in brewery waste (0.4 g/day) and noug cake (0.37 g/day) showed better growth rate than wheat bran (0.34 g/day). Differences in growth rates between the control and test feeds as well as among the test feeds can be attributed to both direct and indirect effects of supplementary feeds given to the fish. Direct intake of feeds by the fish provides more nutrients resulting in better growth and production. Moreover, addition of supplementary feeds can elevate the level of organic nutrients that favour the growth of flagellate phytoplankton which are good quality food for the fish. We therefore concluded that all supplementary feeds nearly doubled the growth of *O. niloticus* in ponds. In addition to feed ingredients, information on digestibility, palatability and levels of anti-nutritional substances should be determined under different agro-ecological conditions.

Key words/phrases: Agro-industrial byproducts, Growth, *Oreochromis niloticus*, Phytoplankton, Pond experiment, Production, Supplementary feeds.

INTRODUCTION

Aquaculture has been practiced for centuries in China and some Asian countries and served as primary source of cheap animal protein to many low-income communities (Popma and Michael, 1999). However, this farming practice was introduced to many African countries lately especially to sub-Saharan Africa and Ethiopia. Among the various culturing systems, semi-intensive aquaculture alone accounts for about 70% of finfish production in the world; the bulk of this production comes from a few

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numbers of fish species including carp, catfish and tilapia (Tacon and De Silva, 1997).

Over 20 species of Tilapia and Sarotherodon are known to be cultured either at subsistence or commercial scale. The Nile tilapia, *Oreochromis niloticus* is one of the most cultured fish accounting for over 60% of the total tilapia and cichlid finfish production world-wide (Hepher and Prugini, 1982; Tacon and De Silva, 1997). Among the tilapia, *O. niloticus* was found to be suitable for semi-intensive culture system because of its ability to utilize a variety of feed originating from plants, animals or mixed feeds (Liti *et al*., 2005). However, one of the major challenges facing the fish farming venture has been the problem of low-cost fish feeds which incur 30-60% of the total cost of production depending on the intensity of the production (De Silva and Anderson, 1995). One of the approaches to tackle this problem has been to experimentally test the use of agro-industrial byproducts to grow fish in ponds (Liti *et al*., 2005; 2006).

Under natural conditions adult tilapia are known to feed on a variety of foods of plant origin and detritus as documented from different lakes in Ethiopia (Getachew Teferra, 1987; 1989; Eyualem Abebe and Getachew Teferra, 1992; Getachew Teferra *et al*., 2002; Zenebe Tadesse, 1988; 1999). Biological information such as feeding, reproductive behaviour, age and growth of fish obtained from natural systems can be used to study the performance of the fish in controlled culture systems. Our understanding on the feeding and growth of *O. niloticus* in ponds is limited. So far, there are only few studies reported from Ethiopia (Kebede Alemu, 2003; Zenebe Tadesse *et al*., 2003).

Investigations on the development of alternative low-cost feeds suitable for small-scale farmers has become a priority in many developing countries, including sub-Saharan Africa. Agro-industrial byproducts are known to be important sources of carbohydrate, lipids and protein for somatic growth of fish in semi-intensive cultures (Liti *et al*., 2005; 2006; Ashagrie Gibtan *et al*., 2008). In spite of the presence of diversified agro-ecologies and enormous water resources in the country, aquaculture is relatively new to Ethiopia and has been limited to stocking of water bodies with fingerlings. On the other hand, the limited production of fish from the capture fishery cannot fulfill the rapidly growing demand of the population. Hence, aquaculture is believed to be the best way out to alleviating the current shortage of fish supply in Ethiopia.

This study was therefore, conducted to evaluate the effect of supplementary feeding of three agro-industrial byproducts, namely, wheat bran, noug cake and brewery waste, on the growth performance of *O. niloticus* in concrete experimental ponds.

MATERIALS AND METHODS

The pond experiment was conducted at Sebeta National Fisheries and Aquatic Life Research Centre (NFALRC), which is located about 23 km south-west of the capital city, Addis Ababa. The center is situated at 2200 m above sea level, and the mean annual temperature of the area is about 20°C. A total of 8 concrete ponds each with an area of 50 m^2 were used to carry out the experiment. The experiment was conducted for a period of six months between March and September 2005. It was conducted on a randomized design with duplicates per treatment. Before the start of the actual experiment, each pond was dried and limed by adding calcium carbonate (15 kg/ha) to prevent growth of pests and frogs that may affect the experiment. All ponds were then filled to an average depth of 0.8 m using spring water and about one-third of the pond water was changed bi-weekly. Before the stocking of the ponds with the experimental fingerlings, all ponds were left for two weeks to allow the natural growth of algae.

O. niloticus fingerlings stocked for the experiment were collected from Lake Hora using beach seine and then transported to Sebeta. The collected fingerlings were then acclimatized in ponds for about two weeks before the start of the feeding experiment. The feeding trial consisted of three treatment groups, fed with (i) noug cake (NC), (ii) wheat bran (WB) and (iii) brewery waste (BW). The control group was deprived of any feed supplementation. Fish having similar sizes (7- 8 cm TL) were selected and stocked randomly into ponds. A total of 100 fish (2 fish/m^2) were stocked in each pond. Total length (TL) and total weight (TW) of 50 fish were measured from each pond every month throughout the study period. Fish were fed with supplementary diets at 5% of their total body weight for six days a week, except Sundays. The daily ration was given twice a day by hand casting, in the morning (10:00 am) and in the afternoon (3:00 pm). The daily ration was calculated and adjusted regularly according to the weight gain of the fish every month. About 50% of the stocked fish were sampled monthly to monitor the growth of fish to the nearest 0.1 cm in total length and 0.1 g total weight. Mortality of fish was monitored and recorded continuously throughout the experiment. At the end of the experiment, the volume of the water was reduced and all fish were harvested using beach seine.

Water temperature of each pond was measured twice a day, in the morning and afternoon, with a thermometer. Secchi depth of each pond was measured monthly using a black and white disc measuring 25 cm in diameter. Plankton samples were collected from each pond using plankton net of 25 µm stretched mesh size. All samples collected were preserved in iodine solution and stored in plastic Whirlpak bags in the laboratory. Phytoplankton were identified to the genus level using standard references (Prescott, 1970; Komarek, 1989). Relative numerical abundance of major taxa was visually rated under the compound microscope.

Growth performances of fish were determined in terms of final individual weight (g). Rates of survival (%), daily growth rates (DGR) and Fulton's condition factor (FCF) were computed in the experiment. Growth parameters were calculated following standard equations given below (Adebayo *et al*., 2004).

- DGR (g/day) = Final weight (g) – Initial weight (g)/culture period
- Weight gain (g) = Final weight (g) – Initial weight (g)
- Survival rate (%) = (Number of fish harvested/Number of fish stocked) x100
- FCF = TW/TL3*100, where TW is total body weight in g, TL total length in cm

Nutrient content of supplementary feeds was chemically determined following standard methods (AOAC, 1990). Moisture content was estimated by heating samples in an oven at 100°C for 24 hours, and weight loss of samples was computed and expressed in percentage. Total organic matter (TOM) was determined by igniting a known weight of sample at 550°C for 6 hours in a furnace. Loss in weight between the initial and final weight was taken as TOM. Crude protein was estimated based on the nitrogen value multiplied by a factor of 6.25 (Gnaiger and Bitterlich, 1984). Lipid was determined gravimetrically using chloroform-methanol solvent (Barnes and Black, 1973). Total carbohydrate was estimated colorimetrically using standard technique (AOAC, 1990).

A one-way ANOVA was used to test the effect of supplementary feeds on the growth performance of experimental fish. Duncan’s multiple range test was applied to compare between means of different parameters considered. Differences were considered significant at $p < 0.05$. All data were analyzed using the SPSS software program of statistical analysis (Mead *et al*., 1993).

RESULTS

Data on the growth performance of *O. niloticus* are presented in Table 1. Generally, fish fed with supplementary diets grew significantly higher than the control group (ANOVA, $P<0.001$). Although the growth of fish varied less significantly ($p=0.81$) among the dietary supplements, fish fed with brewery waste (BW) and noug cake (NC) had the highest mean weight followed by wheat bran (WB). However, the control group showed the lowest mean weight compared with the treatment groups.

Table 1. Physical features, growth rate, and mortality rate of *O. niloticus* recorded in experimental ponds (N= 800).

Parameters	Control	NC	WB	BW
Initial weight (g)	5.73	6.17	6.72	6.26
Final weight (g)	36.04	72.68	67.73	75.76
Initial length (cm)	8.3	8.0	7.9	8.3
Final length (cm)	12.1	14.9	14.2	15.4
Weight gain (g)	30.31	66.51	61.01	69.5
Daily growth rate (g/day)	0.17	0.37	0.34	0.40
Mortality rate (%)	5	14	10	20
Water temperature (°C)	19-26	19-26	19-26	19-26
Secchi depth (cm)	46	32	34	29

NC- noug cake, WB- wheat bran, BW- brewery waste

Growth trends of *O. niloticus* supplied with different supplemental diets are shown in Fig.1. The rate of growth of fish appears to vary between months. Fish grew faster between April and June and slower in the remaining months of the experiment.

The levels of major chemical nutrients found in the supplemental diets are shown in Table 2. NC (31%) and BW (27%) contained more protein compared with WB (14%). However, the levels of total organic matter in all test feeds were generally high and exceeded 90% of the total dry matter. Similarly the amount of ash was found to be low and ranged between 5.2 and 9.8%.

Table 2. Nutrient composition (% dry weight) of supplementary feeds.

Nutrient content % DM	NC	WB	BW
Crude protein	31.2	13.7	27
Total lipid	6.7	3.6	2.7
Organic matter	90	92.2	94.8
Ash	10.2	7.8	5.2
Dissolved matter	91.8	89.7	90.5

DM-dry matter, NC- noug cake, WB- wheat bran, BW- brewery waste

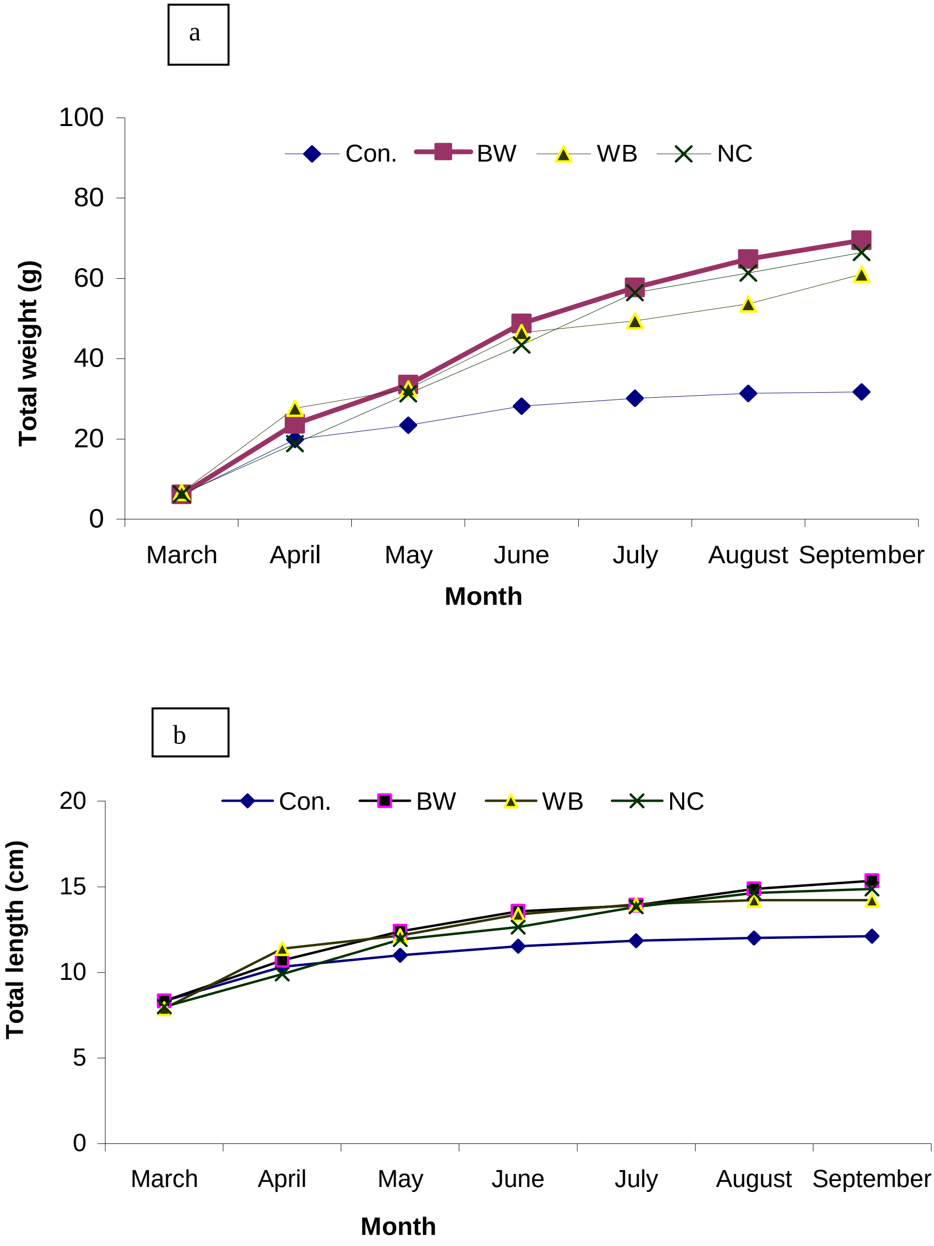

Fig. 1. Growth in (a) total weight and (b) total length of *O. niloticus* fed with different agro-industrial feeds in ponds. (Con - control, BW- brewery waste, WB- wheat bran, NC- noug cake)

During the experiment, the pond water of the treatment ponds turned greenish while the control group remained transparent indicating higher growth of phytoplankton in the treatment ponds and less algal biomass in the control pond (Table 3). This was also confirmed by the higher secchi depth in the control pond (46 cm) than the treatment group (29-34 cm). Microscopic examination of net samples collected from pond waters showed the presence of different species of algae in all ponds (Table 3). Several taxa of phytoplankton such as blue greens, green algae, diatoms and flagellates were identified. However, the relative abundance of the various algal species varied between the treatment and control ponds. In the treatment ponds the phytoplankton biomass was dominated by flagellates unlike the control. The greenish colour of the water in the treatment pond was mainly due to the dominance of flagellates, especially, *Phacus* sp.

Table 3. Relative abundance of major phytoplankton taxa identified from ponds.

Phytoplankton taxa	Control	NC	WB	BW
Blue greens				
Aphanizomenon sp.	R	C	C	C
Anabaenopsis sp.	R	C	C	C
Anabaena sp.	R	C	C	C
Nostoc sp.	R	R	R	R
Green algae				
Pediastrum biwae	C	R	R	R
Scenedesmus quadricauda	C	C	C	C
S. accumunatus	C	C	C	C
S. dimorphus	C	C	C	C
Coelatrum sp.	R	R	R	R
Cosmarium sp.	C	C	C	C
Cyclotella sp.	R	R	R	R
Diatoms				
Navicula sp.	C	C	C	C
Nitzschia sp.	R	R	R	R
Flagellates				
Phacus sp.	R	A**	A**	A**
Peridinium sp.	R	R	R	R

R= rare; C= common; A= abundant; **= dominant taxa accounting for over 80% of the total algal biomass
NC- noug cake, WB- wheat bran, BW- brewery waste

The Fulton's condition factor of the fish in the treatment and control groups showed variations as shown in Fig. 2. Fish given supplementary diets were found to be in better condition than the control which agrees with the superior growth rate of the treatment groups.

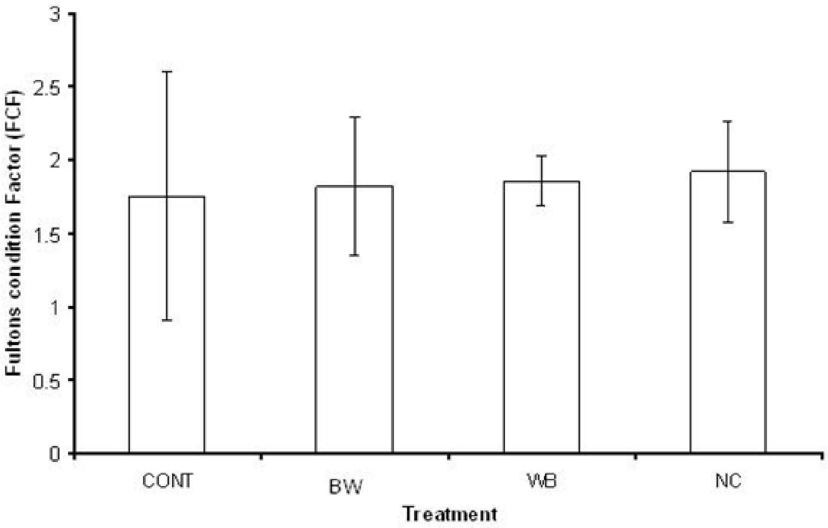

Fig. 2. Fulton's condition factor (FCF ± s.d.) of *O. niloticus* fed with different agro-industrial byproducts. (Cont - control, BW- brewery waste, WB- wheat bran, NC- noug cake)

DISCUSSION

Supplementation of brewery waste, noug cake and wheat bran to *O. niloticus* fingerlings showed remarkable variations on the growth performance of fish between the test groups and the control (Fig. 1 and Table 2). Fish supplied with supplementary feed grew significantly better than the control group, which were left to feed only on natural plankton (ANOVA, $P<0.001$). Among the experimental groups, fish fed with brewery waste and noug cake grew better than fish fed with wheat bran. However, the difference in growth rate between the treatment group was not significant (ANOVA, $p=0.81$; Table 4).

Table 4. One-way ANOVA results on the variations in total weight and total length of fishes fed with different supplemental diets.

Statistical parameters	df	F critical value	Tabulated F value	P-value
I) Variation in fish total weight (TW)				
a) All groups (Controls; BW;WB;NC)	3	2.63	29.86	<0.001
b) Between treatments (BW;WB;NC)	2	3.03	0.48	0.62
II) Variations in fish total length (TL)				
a) All groups (Controls; BW;WB;NC)	3	2.63	28.96	<0.001
b) Between treatments (BW;WB;NC)	2	3.03	0.22	0.81

BW- brewery waste, WB- wheat bran, NC- noug cake

Various factors, including food quantity and quality, water temperature as well as the genetic make-up and sex of fish have been reported as important factors attributing to differences in fish growth. The quality of supplemental diets in terms of nutrient composition is another key factor for the growth performance of fish. The relatively better growth of fish grown in NC (31% crude protein) and BW (27% crude protein) might be attributed to the high crude protein content of the test diets as compared to WB with 14% crude protein. The correct level of protein required for optimum growth of fish is controversial. However, a study by De Silva and Radampola (1990) on tilapia (*Oreochromis niloticus*) showed that the optimal protein level required for the growth of both males and females was 30%. This indicates that the amount of protein obtained from the test feeds mainly from NC and BW appear to be sufficient enough for optimal growth of the fish as shown in this study. However, the fish still grew well in WB which indicates that the natural phytoplankton available in the ponds might have served as alternate source of protein for deficiency observed in the WB-supplemented pond.

Addition of supplemental diets to the pond water favoured the growth of organotrophic algae which are nutritionally better than the blue greens, green algae and diatoms. This has been confirmed by the microscopic examination of water samples taken from ponds which revealed the dominance of flagellated algae in all ponds supplemented with feeds (Table 3). These ponds turned deep green and showed less transparency compared with the control. Since tilapias are indiscriminate filter feeders, they take in the flagellated algae along with the feed supplemented. Flagellated algae are known to be nutritionally superior to either the blue green or green algae which predominate in the control ponds (Ahlgren *et al*., 1992).

The growth rate of fish varied between months in all groups. Fish showed relatively better growth rate between March and June and declined after June. This difference may be attributed to change in season. The air temperature is relatively warmer during the dry season between February and June and declines in the wet season mainly in July and August. The difference in temperature will affect the feeding rate of fish and hence the growth rate. This has been reported in a study conducted under controlled system in aquaria (Zenebe Tadesse *et al*., 2003). Similarly, lower growth rate of *O. niloticus* fingerlings were observed during cold months in natural lakes in the Ethiopian Rift Valley (Demeke Admassu and Ahlgren, 2000).

Fish kept in the control group showed lower growth rate indicating that the natural diet is insufficient to support high fish growth. The relative poor growth of the control group may be attributed to the lower biomass of phytoplankton available in the control ponds. This was confirmed by the higher secchi depth and higher transparency of the control pond indicating the low algal biomass of phytoplankton (Table 2). Comparably poor growth of the control fish has been reported in a similar experiment conducted earlier by Kebede Alemu (2003).

The optimal performance of cultured fish do not depend only on the provision of a suitable diet. The culture environment also influences the feeding response and the performance of *O. niloticus*. Low water temperature and oxygen level below the tolerance limit influence feed intake. Even when compared to the growth of fish in natural lakes of the same fish species from the Ethiopian Rift Valley lakes, the control groups showed lower growth rate than the wild fish which may be due to the low water temperature and poor algal biomass of the pond which in turn affected the feeding rate of the fish.

The mortality of fish was found to be much higher in the treatment ponds (Table 2). On one occasion, many fish were found dead in NC and BW ponds. This fish kill might be due to the poor quality of the water which turned deep green resulting from the addition of organic matter from the supplemental diets. Therefore, deterioration of water quality might be the cause of the high mortality of fish in the treatment groups as compared with the control. This problem can be reduced by monitoring the water quality regularly and changing the water more frequently. Presence of anti-nutritional factors in the diet might also be another possible cause for the death of fish in the treatment ponds. Plant-derived materials such as legume seeds, oil seed cakes, leaf meals are known to contain a variety of anti-nutritional substances that could inhibit growth and subsequently lead to death of fish (Francis *et al*., 2001).

In culture systems, social hierarchy observed among individual fish could suppress appetite and feeding rate of subordinates. Such variation in body size of fish was observed as the experiment progressed in the present study (Table 2). This variation was more pronounced in fish given supplementary diets. Hence, dominance and size hierarchies of fish could finally result in a large range of sizes at harvesting, which will in turn affect the market price. Sex-based differences on the growth of fish might also be another factor contributing to the size disparity of fish observed. Male tilapias are known to grow much faster than females. This has been experimentally tested in a pond experiment conducted in the National Fisheries and Aquatic Life Research Centre (NFALRC) where mono-sex male tilapia grew almost twice the size of fish grown in mixed sexes (Adamneh Dagne *et al*., 2007). Since both sexes were randomly taken for this experiment, sex-difference based dominance of fish might also be another reason for the big variations in size of fish observed in the same ponds. This seems to be a serious problem in the aquaculture industry and can be partly tackled by sorting fish into similar size and sex groups before stocking.

In conclusion, the present study showed that supplementation of agro-industrial byproducts such as brewery waste, noug cake and wheat bran resulted in better growth performance of *O. niloticus* in ponds. However, the growth rate of the fish was generally lower than similar studies reported earlier in Ethiopia. The poor growth of fish might be attributed to a combination of factors including poor water quality, low water temperature and social behaviour of the fish. Hence, more detailed studies should be conducted to investigate these aspects under different agro-ecologies and pond management in the future.

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