Evaluation of Rice Bran and Wheat Bran as Supplemental Feed Compared to a Commercial Feed for Monoculture of GIFT Strain of Tilapia (*Oreochromis niloticus*) in Bangladesh

HOSSAIN Md. Sakhawat[1], HOSSAIN Md. Arshad[2*], MAMUN Md. Abdullah-Al[1], ALI Md. Zulfikar[3], BULBUL Mahbuba[4], KOSHIO Shunsuke[4] and KADER Md. Abdul[4**]

1: Faculty of Fisheries, Sylhet Agricultural University, Sylhet, Bangladesh
2: Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh- 2202, Bangladesh.
3: Bangladesh Fisheries Research Institute, Mymensingh-2201, Bangladesh.
4: Lab of Aquatic Animal Nutrition, Faculty of Fisheries, Kagoshima University, Shimoarata 4-50-20, Kagoshima 890-0056, Japan.
**Present address: Mariculture and Fisheries Department, Kuwait Institute for Scientific Research, PO Box# 1638, Salmiya 22017, Kuwait*
***Corresponding author: k3212335@kadai.jp; abdulkader_fc@yahoo.com*

Abstract

A feeding trial was conducted to evaluate the effect of rice bran and wheat bran as supplementary feed in comparison to a commercial feed for monoculture of GIFT strain of tilapia (*Oreochromis niloticus*). Four experimental diets such as commercial tilapia diet, rice bran, wheat bran, and a mixture of rice bran and wheat bran (50:50) were assigned to four treatments designated as T_1, T_2, T_3 and T_4 respectively. Triplicate groups of fish (initial mean weight 2.80 g) were delivered the test diets in 12 experimental ponds for four months. Result of the study showed that fish fed commercial diet (T_1) had highest ($P < 0.05$) weight gain (147.8g) followed by T_2 (124.0g), T_4 (119.5g) and T_3 (118.5g). Feed conversion ratio followed the similar trend as with weight gain and ranged between 1.84 and 2.23. Protein efficiency ratio and apparent net protein utilization were ranged between 2.11 and 3.34, and 11.48 and 18.32% respectively. Survival of fish was not affected by the dietary treatments and ranged between 78.67 and 83.33%. The highest fish production (kg ha^{-1}) was found in treatment T_1 (4173), followed by T_2 (3435), T_4 (3301) and T_3 (3180). A simple economic analysis showed that treatment T_2 generated the highest net profit of USD 2083.5 (Tk.145,848) ha^{-1} 4 $months^{-1}$ followed by treatments T_4, T_1 and T_3. It is concluded that the use of rice bran as supplementary feed is more economical and beneficial than wheat bran and even commercial tilapia feed for monoculture of GIFT strain in ponds.
Key words: commercial feed, GIFT tilapia, growth, rice bran, supplemental feed, wheat bran

Received: 27 March, 2011
Accepted: 28 May, 2011

Introduction

Tilapia (*Oreochromis niloticus*) is widely recognized as one of the most important species for farming in a wide range of aquaculture systems (PULLIN 1985). The most significant landmark in aquaculture development was the development of a new and improved tilapia strain called GIFT (Genetically Improved Farmed Tilapia) with the assistance of UNDP and ADB, Worldfish Center (formerly known as ICLARM) developed this strain through the selective breeding of Nile tilapia. In collaboration with Bangladesh Fisheries Research Institute (BFRI), DEGITA Bangladesh project first introduced GIFT in Bangladesh in 1994.

In on-farm trails, the GIFT fish grew on average 60% better in growth and 50% better in survival than normal farmed tilapia breeds (SULTANA *et al.* 1997). In Bangladesh, culture of GIFT strain (*O. niloticus*) in fresh water pond is getting popular due to its higher market price and desirable features for aquaculture practice such as faster growth rate compared to any other short cycle fish species, higher yield, survival and culture feasibility in both perennial and seasonal ponds. Tilapia has good resistance to poor water quality and disease, tolerance to a wide range of environmental conditions, ability to convert efficiently the organic and domestic waste into high quality protein, rapid growth rate and tasty flavour (BALARIN and HALLER 1982).

Feed cost generally constitutes the highest single operating cost in semi-intensive and intensive farming operation (SHANG and COSTA-PIERCE 1983). It is therefore, very important for low income or rural poor farmers to utilize their investment in feeding management as optimal as possible. At present, a number of feed manufacturers produce commercial fish feed in Bangladesh. The commonly available fish feeds are graded as Starter-1, Starter-2, Starter-3, Grower-1 and Grower-2 based on life cycle or age of fish (KADER *et al.* 2005). Commercial fish farmers are using these formulated feed for their culture operation. However, poorer marginal farmers cannot afford these high cost formulated feeds (KADER *et al.* 2011).

Since Bangladesh is an agro-based developing country a large variety of agricultural by-products such as rice brans, wheat brans, pulse brans, oilcakes and molasses are being used as fish feeds (HOSSAIN and PAUL 2007, KADER *et al.* 2011). Wheat bran and rice bran are comparatively cheaper and easily available feed ingredients for the rural poor farmers and can play an important role in tilapia culture by the low income or marginal fish farmers. However, there is no information on the efficacy of rice bran or wheat bran used as supplemental feed as compared to a commercial diet on the growth of GIFT strain of tilapia in monoculture.

Pacific island countries also recognize that aquaculture provides one of the few long-term, sustainable, ways of deriving benefits from inshore fisheries resources (WILLIAMS 1996). Small scale tilapia aquaculture has entered 30 - 40 years back as the subsistence economy in some areas of the Pacific islands including Fiji, Guam, Solomon islands, Northern Marianas, Tuvalu, Vanuatu and Tonga etc (ADAMS *et al.* 2001). However, with the problems in world aquaculture industry, the tilapia production cost rising very fast which ultimately reduces the profit from aquaculture venture. If the agricultural by-products such as wheat bran and rice bran could be effectively utilized in tilapia feed, it would be possible to minimize the production cost. Thus, the present study was undertaken to evaluate the growth performance and economic feasibility of *O. niloticus* (GIFT strain) culture using rice bran and wheat bran as supplemental feed and compared to a commercial feed.

Materials and Methods

Experimental system

The feeding trial was conducted for 4 months in 12 earthen experimental ponds at the Faculty of Fisheries, Bangladesh Agricultural University (BAU), Mymensingh, Bangladesh. The size of each experimental pond was 30 m^2. The water depth was maintained to a maximum of 1.2 m using fine meshed PVC over-flow pipe on the bank fixed at 1.2 m above the pond bottom. There is well organized inflow and outflow system to maintain the water level. The ponds were equal in size and similar in shape, depth, basin configuration and pattern type including water supply facilities. All the ponds were drained out and lime was applied at the rate of 1 kg $decimal^{-1}$. No fertilization was applied. The ponds were arbitrarily numbered as 1 to 12 for the convenience of experimental work.

Experimental fish

The fingerlings of Genetically Improved Farmed Tilapia (GIFT *O. niloticus*) with mean initial weight of 2.8 $\pm$ 0.03 g were obtained from Freshwater Station, Bangladesh Fisheries Research Institute, Mymensingh.

Table 1. Proximate composition (% dry matter basis) and cost (USD kg^{-1})[1] of the supplemental feeds used in different treatments of the experiment.

Parameters	Treatment					
	T_1 (Commercial feed)[2]			T_2 (rice bran)[3]	T_3 (wheat bran)[3]	T_4 (rice bran + wheat bran)
	Starter-II	Starter-III	Grower			
Dry matter	88.4	85.6	88.4	83.4	85.6	85.1
Protein	30.3	28.2	21.3	14.1	14.4	14.3
Lipid	7.32	6.87	7.47	18.2	6.35	11.3
Ash	18.0	18.9	20.3	8.3	4.7	6.8
Crude fiber	14.2	15.0	18.4	9.4	11.0	10.1
NFE[4]	30.23	31.1	32.5	50.0	63.5	57.5
Gross energy (kcal g^{-1})[5]	3.57	3.17	3.35	5.75	5.02	5.74
Cost	0.257	0.257	0.229	0.121	0.171	0.146

[1] USD ($) 1.00 = Taka (Tk.) 70.0.
[2] Saudi Bangla Fish feed Ltd, Mymensingh, Bangladesh.
[3] Commercially available in local market.
[4] Nitrogen free extract = 100 - % (protein + lipid + ash + crude fiber).
[5] Calculated according to JAUNCEY and ROSS (1982).

Supplemental feed

Different types of supplemental feed used in this study namely rice bran (auto), wheat bran and commercial tilapia feed (Saudi Bangla Starter-II, Starter- III and Grower) were collected from Mymensingh local market. The proximate composition of these supplemental feeds was analyzed and the results are presented in Table 1.

Experimental diet and feeding rate

The experiment was conducted in completely randomized design. A commercial tilapia feed (Saudi-Bangla Fish Feed Ltd., Mymenshing, Bangladesh) was assigned to treatment T_1. Three supplemental feeds rice bran, wheat bran, and rice bran + wheat bran (50:50) were assigned to three different treatments viz. T_2, T_3 and T_4 respectively. Each treatment had three replicates. Fish with mean initial weight of 2.8 $\pm$ 0.03 g were stocked at the rate of 100 fish per pond (33,333 ha^{-1}). Fish were fed at the rate of 10% of body weight at the beginning. The feeding rate was gradually reduced to 5, 4 and 3% of the body weight for the last three months respectively. The total amount of feed was divided into two equal feedings at 9.00 and 17.00 h. Rice bran and wheat bran were mixed with small amount of water, made into dough or balls and thrown over the pond water. Saudi Bangla commercial tilapia feeds were also dispersed by hand broadcasting over the water. About 20% of the total fish were sampled fortnightly by a cast net to monitor the fish growth and to adjust feeding rates. The weight of fish during sampling was measured by using a digital electronic balance (OHAUS, Model CT 1200-S, New Jersey, USA). The amount of supplied feeds was recorded throughout the experimental period.

Water quality parameter

The water quality parameter such as temperature, dissolved oxygen (DO) and pH were recorded fortnightly throughout the experimental period. The temperature and dissolved oxygen of the ponds were measured by DO meter (YSI, model 58, USA). The water pH was measured by pH meter (Jenway, model 3020, UK).

Quantitative and qualitative assessment of plankton

For the quantitative and qualitative study of phytoplankton and zooplankton of water, an integrated 10 liters of water samples was randomly collected from different sites of each pond and was passed through plankton net (mesh size 50 μm) and finally concentrated to 50 ml. Then the concentrated samples were preserved in small plastic bottles with 5% formalin and studied subsequently. Plankton number was estimated using a Sedgewick-Rafter counting cell (S - R cell) under a compound microscope (Olympus, model BH-2). One ml sub-sample of each stored sample was placed on the counting chamber of the S - R cell and then the plankton (phytoplankton & zooplankton) on 10 randomly selected fields of the chamber was counted (RAHMAN 1992). Plankton was expressed as cells or units per liter of water of each ponds.

Carcass composition

At the beginning of the experiment thirty fish from the stock was randomly sacrificed for proximate analysis and was considered as initial carcass composition of fish. At the end of the experiment three fish from each replicates (nine fish from each treatment) were sacrificed and used for final carcass proximate composition analysis.

Analytical methods

The proximate composition of fish samples, feed ingredients, and experimental diets was analyzed in triplicate according to standard procedures given by ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS (1990).

Statistical analysis

MSTATC package program and one way analysis of variance (ANOVA) were used to determine the effect of different methods of feeding on the performance of fish. Percentage survival data were arcsin-square-root transformed before statistical analysis. Levels of significance between individual treatments ($P < 0.05$) were evaluated by Duncun's Multiple Range test.

Economic analysis

A simple economic analysis was performed to estimate the net profit in different dietary treatments. The production cost was based on the Mymensingh whole sale market price (2006) for the inputs used. The cost of lime was USD 0.143 (Tk.10) kg^{-1} and each fingerling was USD 0.007 (Tk.0.50). The cost (USD kg^{-1}) of supplemental feed and commercial tilapia feed were: rice bran 0.121, wheat bran 0.171, Starter- II & III 0.257 and Grower 0.229. The selling price for tilapia was considered as USD 1.00 (Tk.70.0) kg^{-1}. The cost of leasing of pond was not included. An additional 7.5% on total cost was included as operational cost (AQUACULTURE DEVELOPMENT AND CO-ORDINATION PROGRAMME 1983).

Results

Water quality parameters

The water quality results are summarized in Table 2. Although there were variations among different water quality parameters, no significant difference ($P > 0.05$) was found among the treatments.

Plankton population

The mean abundance of different plankton groups are shown in Table 3. Cyanophyceae was found to be the most dominant phytoplankton throughout the study period and its mean abundance varied between $(43.71 \pm 4.74) \times 10^4$ to $(71.62 \pm 6.12) \times 10^4$ cells l^{-1}. Bacillariophyceae was the least abundant plankton and its mean abundance varied between $(14.25 \pm 2.35) \times 10^4$ and $(23.20 \pm 3.18) \times 10^4$ cells l^{-1}. The highest abundance of all

Table 2. Ranges and mean values (± S.D.) of water quality parameters observed in different treatments during the experimental period.

Parameters	Treatment			
	T_1	T_2	T_3	T_4
Temperature (°C)	26.7 − 32.1	27.0 − 32.2	26.0 − 32.5	26.9 − 32.8
	(29.7 ± 0.46)	(29.6 ± 0.58)	(28.4 ± 0.59)	(29.7 ± 0.39)
Dissolved oxygen (mg l^{-1})	4.87 − 8.02	5.23 − 8.58	5.27 − 8.60	4.15 − 8.32
	(6.39 ± 0.25)	(6.35 ± 0.37)	(6.53 ± 0.35)	(6.20 ± 0.30)
pH	6.5 − 7.7	6.7 − 7.5	6.6 − 7.9	6.9 − 7.7
	(7.0 ± 0.3)	(7.0 ± 0.2)	(7.2 ± 0.2)	(7.2 ± 0.2)

Table 3. Plankton population (mean values$\times 10^4 \pm$S.D.) in pond water (1 L) in different treatments.

Parameters	Treatment			
	T_1	T_2	T_3	T_4
A. Phytoplankton				
Bacillariophyceae	14.25 ± 2.35	23.20 ± 3.18	19.60 ± 2.79	22.69 ± 3.70
Chlorophyceae	40.73 ± 4.32	65.18 ± 4.88	56.24 ± 4.57	60.03 ± 4.90
Cyanophyceae	43.71 ± 4.74	71.62 ± 6.12	54.80 ± 5.31	64.01 ± 6.80
Euglenophyceae	16.77 ± 2.56	25.80 ± 4.10	21.08 ± 3.54	24.20 ± 4.03
B. Zooplankton				
Crustacea	10.81 ± 0.68	20.09 ± 1.22	23.50 ± 1.82	18.67 ± 0.84
Rotifera	19.21 ± 0.88	18.35 ± 1.24	9.76 ± 0.50	15.98 ± 1.07

groups of phytoplankton was observed in treatment T_2. Among the abundant groups, the most dominant was Cyanophyceae followed by Chlorophyceae ($40.73 \pm 4.32 \times 10^4$ to $65.18 \pm 4.88 \times 10^4$ cells l^{-1}), Euglenophyceae ($16.77 \pm 2.56 \times 10^4$ to $25.80 \pm 4.10 \times 10^4$ cells l^{-1}) and Bacillariophyceae ($14.25 \pm 2.35 \times 10^4$ to $23.20 \pm 3.18 \times 10^4$ cells l^{-1}). The zooplankton population consisted of Crustacea and Rotifera. The highest mean zooplankton population was recorded in treatment T_2 while the lowest was observed in T_1. The mean abundance of Crustacea varied from $10.81 \pm 0.68 \times 10^4$ to $23.50 \pm 1.82 \times 10^4$ individuals l^{-1} while mean abundance for Rotifera varied from $9.76 \pm 0.50 \times 10^4$ to $19.21 \pm 0.88 \times 10^4$ individuals l^{-1}.

Growth performance of fish

The growth performance of fish in terms of initial weight (g), final weight (g), weight gain (g), specific growth rate (SGR, % day^{-1}), feed conversion ratio (FCR), protein efficiency ratio (PER), survival (%) , apparent net protein utilization (ANPU %) and production (kg ha^{-1}) are shown in Table 4. Among the treatments the weight gain of fish was significantly ($P < 0.05$) highest in treatment T_1 receiving commercial tilapia diet, while it was lowest in T_3 receiving wheat bran. The SGR in different treatments ranged between 3.14 and 3.32 with significantly highest in treatment T_1. However, there was no significant difference ($P > 0.05$) among the SGR values in treatments T_2, T_3 and T_4. Survival of fish was not significantly different among the treatments and ranged between 78.7 and 83.3%.

Table 4. Growth, feed utilization and production of GIFT strain (*O. niloticus*) in different treatments.

Parameters	Treatment			
	T_1	T_2	T_3	T_4
Mean initial weight (g)	2.80 ± 0.05	2.80 ± 0.02	2.80 ± 0.03	2.80 ± 0.03
Mean final weight (g)	150.6 ± 7.5[b]	126.8 ± 2.8[a]	121.3 ± 3.7[a]	122.4 ± 1.8[a]
Mean weight gain (g)	147.8 ± 7.5[b]	124.0 ± 2.8[a]	118.5 ± 3.7[a]	119.5 ± 1.8[a]
Weight gain (%)	5279 ± 267[b]	4428 ± 101[a]	4234 ± 132[a]	4269 ± 66[a]
SGR (% day^{-1})[1]	3.32 ± 0.05[b]	3.18 ± 0.02[a]	3.14 ± 0.03[a]	3.15 ± 0.02[a]
FCR[2]	1.84 ± 0.04[a]	2.07 ± 0.04[b]	2.23 ± 0.07[c]	2.09 ± 0.04[b]
PER[3]	2.11 ± 0.03[a]	3.34 ± 0.06[c]	3.03 ± 0.09[b]	3.29 ± 0.10[c]
Survival (%)	83.3 ± 6.5	81.3 ± 3.2	78.7 ± 3.1	81.0 ± 3.0
ANPU (%)[4]	11.48 ± 0.29[a]	18.32 ± 0.26[c]	16.58 ± 0.14[b]	17.89 ± 0.11[c]
Production (kg pond^{-1})	12.52 ± 0.42[b]	10.31 ± 0.30[a]	9.54 ± 0.35[a]	9.90 ± 0.22[a]
Production (kg ha^{-1})	4173 ± 139[b]	3435 ± 101[a]	3180 ± 117[a]	3301 ± 72[a]

Values are means of triplicate groups ± S.D. Within a row, means with the same letters are not significantly different ($P > 0.05$).

[1] Specific growth rate (SGR % day^{-1}), {ln (final weight) - ln (initial weight)/120 days} × 100.

[2] Feed conversion ratio (FCR), total dry feed intake (g)/total live weight gain (g).

[3] Protein efficiency ratio (PER), live weight gain (g)/dry protein intake (g).

[4] Apparent net protein utilization (ANPU %), ((final carcass nitrogen - initial carcass nitrogen) × 100) / nitrogen intake

Table 5. Economic analysis of the cost of production after 4 months feeding trial.

Investment (USD Treatment^{-1})[1]	Treatment			
	T_1	T_2	T_3	T_4
Pond preparation	0.321	0.321	0.321	0.321
Cost of fingerlings[2]	2.14	2.14	2.14	2.14
Feed cost[3]	18.3	8.86	12.8	10.6
Operational cost[4]	1.56	0.85	1.14	0.98
Total production cost	22.3	12.2	16.4	14.0
Gross income from sale[5]	37.6	30.9	28.6	29.7
Net profit[6]	15.3	18.8	12.2	15.7
Net profit (USD ha^{-1} 4 months^{-1})	1695	2084	1358	1740

[1] USD ($) 1.00 = Taka (Tk). 70.00.

[2] Cost of fingerling = USD 0.007 fry^{-1}.

[3] Prices on July 2006.

[4] Operational cost is considered as 7.5% of the total cost AQUACULTURE DEVELOPMENT AND CO-ORDINATION PROGRAMME (1983).

[5] Sale price of fish = 1 USD kg^{-1}.

[6] Net profit = gross income from sale (USD Treatment^{-1}) - total production cost (USD Treatment^{-1}).

The mean FCR values in different treatments varied between 1.84 and 2.23 with significantly (P < 0.05) lowest in T_1. There was no significant difference in FCR values between T_2 and T_4 and these values were significantly higher compared to those of T_1. The PER values ranged between 2.11 and 3.34 with T_1 having significantly the lowest PER value. The ANPU values ranged between 11.48 and 18.32% with treatment T_2 and T_4 showing higher ANPU (%) values.

The production of tilapia in terms of kg ha^{-1} 4 $months^{-1}$ was higher (4173 kg) in treatment T_1, followed by treatments T_2 (3435 kg), T_4 (3301 kg) and T_3 (3180 kg) respectively. A simple economic analysis showed that treatment T_2 receiving rice bran generated the maximum net profit of USD 2083.5 (Tk.145,848) ha^{-1} 4 $months^{-1}$ followed by treatments T_4, T_1 and T_3 (Table 5).

Whole body proximate composition

The whole body proximate composition (% fresh matter basis) of tilapia at the start and end of the experiment is presented in Table 6. The final carcass moisture content ranged between 68.6 and 66.1 % with higher moisture contents in treatment T_1 and T_3. There was no significant difference in whole body protein contents of fish among different treatments which ranged between 16.2 and 16.4%. Fish in treatments T_2 and T_4 had significantly higher lipid content than those in T_1 and T_3. The whole body lipid content varied between 9.87 and 13.16%. Fish in treatment T_1 had significantly lowest lipid content. The ash content varied from 4.08 to 5.24% with treatments T_1 and T_3 showing the higher values compared to T_2 and T_4.

Table 6. Whole body proximate composition (% wet basis) of tilapia at the start and end of the experiment.

Parameters	Initial[1]	Treatment			
		T_1	T_2	T_3	T_4
Moisture	81.1	68.6 ± 0.3^b	66.1 ± 0.2^a	68.5 ± 0.2^b	66.4 ± 0.4^a
Crude protein	12.8	16.3 ± 0.1	16.4 ± 0.1	16.3 ± 0.1	16.2 ± 0.2
Crude lipid	1.58	9.87 ± 0.3^a	13.1 ± 0.1^b	10.1 ± 0.2^a	13.2 ± 0.2^b
Ash	4.44	5.24 ± 0.1^b	4.37 ± 0.2^a	5.03 ± 0.2^b	4.08 ± 0.2^a

Values are means of triplicate groups ± S.D. Within a row, means with the same letters are not significantly different (P > 0.05).

[1] Values are not included in statistical analysis.

Discussion

Environmental parameters exert an immense influence on the maintenance of a healthy aquatic environment and production of food organisms. The water quality parameters measured in different treatments in the present study were found to be more or less similar and all of them were within the acceptable range for fish culture (JHINGRAN 1991, RAHMAN 1992, KADER *et al.* 2011).

The water temperature as recorded in the experimental ponds ranged from 26.0 - 32.8 °C. The ranges of water temperature were suitable for fish culture in freshwater ponds (AMINUL 1996, HOSSAIN *et al.* 2004, KADER *et al.* 2011). The overall mean dissolved oxygen (DO) contents in the present study ranged from 4.15 to 8.60 mg l^{-1}. DO content in the present study was slightly lower than expected. This might be due to the measurement of DO was performed at morning (10.00 am). ALIKUNHI (1957) and BANERJEE (1967) considered 5.0 - 7.0 ppm DO content in water to be fair or good in respect of productivity. The average DO values in our study were above 6.0 ppm which can be considered favorable for fish growth. Moreover, the values for DO level might not have any negative effect in the performance of tilapia since this fish has wide range of tolerance for DO levels (HOSSAIN *et al.* 2004). MICHAEL (1969) reported that the suitable pH range for fish production is 7.3 to 8.4 respectively. During the culture period, pH values ranged between 6.98 and 7.23 which were suitable for GIFT tilapia culture (HOSSAIN *et al.* 2004).

In the present study, phytoplankton population was composed of four groups *viz.* Bacillariophceae, Chlorophyceae, Cyanophyceae and Euglenophyceae; and zooplankton belongs to Rotifera and Crustacea. Both the plankton groups reflected the common plankton composition in tropical fish ponds (DEWAN *et al.* 1991, WAHAB *et al.* 1995). The highest abundance of plankton was observed in treatment T_2 receiving rice bran as supplementary feed. The higher density of phytoplankton might be attributed to the uneaten rice bran left over in the pond bottom which was decomposed and acted as fertilizer to increase the primary productivity. It was also observed that the plankton concentration gradually increased in course of time in treatment T_2. The continuous stirring of bottom deposits by tilapia helped to mineralize the accumulated organic material and the fertility being recycled which encouraged plankton growth. Zooplankton concentration was also higher in treatment T_2 receiving rice bran. MIMS *et al.* (1995) also found that use of rice bran increased the zooplankton concentration in case of larval paddle fish rearing. However, the plankton abundance in different treatments recorded in the present study was much lower than those reported by DEWAN *et al.* (1991) and WAHAB *et al.* (1995). This will be due to the fact that fertilizer, either organic or inorganic was not applied to the ponds in the present study.

In the present study, mean weight gains of tilapia varied between 118.45 and 147.81 g. The highest weight gain of tilapia was observed in treatment T_1 receiving the commercial diet. Supplemental feeding with formulated commercial diet resulted in highest growth of *O. niloticus* than did supplemental feeding with single ingredient. CAO *et al.* (1998) also found similar results in case of *O. niloticus* fed formulated diet. In the present study, tilapia fed rice bran (T_2) and wheat bran (T_3) as single ingredients attained weight gain of 124.0 and 118.54 g respectively. HUSSAIN *et al.* (2000) reported a weight gain of about 128 g for GIFT strain in on-farm ponds for a culture period of 6 months fed rice bran at 5 - 6% of their body weight. Considering the 4 month culture period in the present study compared to 6 month period by HUSSAIN *et al.* (2000), tilapia in the present study performed better. These differences in growth might be related to the season or water temperature. HUSSAIN *et al.* (2000) conducted the experiment from January to May when water temperature was comparatively lower than those applied in the present study.

Although, the particle size of rice bran was smaller than that of wheat bran, fish fed rice bran showed better growth than those with wheat bran. This is possibly due to increasing natural productivity from the uneaten rice bran rather than direct ingestion of rice bran which is reflected by the higher plankton production in T_2. The higher growth of fish in T_2 might also be related to the higher lipid content (18%) in rice bran which provided higher gross energy. However, growth of fish fed rice bran + wheat bran (50:50) was intermediate between treatment T_2 and T_4.

In the present study, SGR varied from 3.14 to 3.32 % day^{-1}. This result agrees with the previous findings, indicating SGR values between 3 - 4 % day^{-1} in tilapia fed on-farm supplemental feed (DE SILVA and DAVY 1992, DIANA *et al.* 1996). On the other hand, GREEN (1992) and HOSSAIN *et al.* (2004) reported a lower SGR value of 2.03 and 2.30 in Nile tilapia and GIFT tilapia respectively fed formulated diet. The difference in SGR values might be due to the water temperature and natural productivity of the ponds. The initial size of fish will be another factor for lower performance of fish. For example, the initial mean weight of tilapia used by GREEN (1992) was 18.6g whereas in the present study it is 2.8g only.

The FCR of supplemental feed was approximate. This is because fish received the nutrition from supplemental feed as well as from natural food in the pond. SUMAGAYSAY *et al.* (1991) reported that feed conversion ratios decreased as dietary protein increased with a significantly higher value (3.9) for rice bran than for 22 % and 27.4% protein diets (2.5 and 2.2 respectively) for milkfish. In the present study, FCR values varied between 1.84 and 2.23 with the lowest value in treatment T_1 receiving commercial tilapia diet (26.6% protein). HOSSAIN *et al.* (2004) found FCR value for GIFT tilapia fed on formulated diet (30.9 % protein) was 1.71 to 1.77. The FCR values in other treatments were higher than that of T_1, which could be due to the fact that rice bran and wheat bran usually contain higher crude fiber are not easily digestible.

The mean survival rate of fish in the different treatments, which varied between 78.7 and 83.3%, are relatively lower than the survival recorded by HOSSAIN *et al.* (2004). The low survival of fish in the present study might be related to the smaller size of fingerlings (2.8g) stocked.

The highest production (4173 kg ha^{-1} 4 $month^{-1}$) was obtained with fish in treatment T_1 receiving commercial feed. However, no significant differences ($P > 0.05$) in total production were found among the treatment T_2, T_3 and T_4. The highest total production in treatment T_1 is due to the significantly higher weight gain of individual fish in treatment

T_1, since survival (%) was not significantly different. Formulated diets contribute more to the growth of fish than do single ingredients (CAO *et al.* 1998). In the present study, supplemental feeding with formulated feeds i.e. commercial tilapia diet resulted in higher growth of *O. niloticus* than supplemental feeding with a single ingredient such as rice bran and wheat bran. The fish production obtained in the present study is more or similar to the values obtained in previous studies with Nile tilapia (VEVERICA *et al.*1998, HOSSAIN *et al.* 2004).

Endogenous factors such as fish size or sex as well as exogenous factors such as diet composition and culture environment influence the proximate composition of fish (SHEARER 1994). In this experiment carcass composition was influenced by different supplementary feeds. There was a marked increased in lipid content of fish fed supplementary feed of rice bran, and rice bran + wheat bran compared to the initial lipid content of fish (Table 6). The carcass lipid content was directly influenced by the dietary lipid content. An inverse relationship between carcass moisture and lipid content in fish was reported in earlier studies (GARLING and WILSON 1976, JAUNCEY 1982). However, there was no significant variation in carcass protein content of fish due to different supplemental feeding.

A simple economic analysis of the growth performance of fish showed the highest net profit (USD 2083.5 or Tk.145,848 ha^{-1} 4 $months^{-1}$) in treatment T_2 which was due to the fact that rice bran is almost two times cheaper than commercial tilapia feed. On the other hand, fish fed rice bran + wheat bran (50:50) (T_4) also showed higher profit than those fed commercial tilapia diet (T_1) and wheat bran (T_3).

Although growth performance, feed utilization, survival and fish production was highest in treatment T_1 receiving commercial tilapia feed, the net profit was highest in T_2 receiving rice bran because of the lower price of rice bran. Therefore, it is recommended to utilize rice bran as an economical and beneficial supplementary feed which increases the profitability (compared to wheat bran and even commercial tilapia feed) of GIFT tilapia monoculture in semi-intensive farming conditions in Bangladesh as well as the other parts of the world including South Pacific Islands.

Acknowledgement

The authors would like to thank Director General, Bangladesh Fisheries Research Institute, Mymensingh, Bangladesh, for supplying the fingerlings of GIFT tilapia.

References

ADAMS, T., BELL, J. and LABROSSE, P. 2001. Current Status of Aquaculture in the Pacific Islands. In: Aquaculture in the Third Millennium. Technical Proceedings of the Conference on Aquaculture in the Third Millennium, Bangkok, Thailand, 20-25 February 2000 (Eds. SUBASINGHE, R. P., BUENO, P., PHILLIPS, M. J., HOUGH, C., MCGLADDERY, S. E. and ARTHUR, J. R.), 295-305, NACA, Bangkok and FAO, Rome.

ALIKUNHI, K. H. 1957. Fish Culture in India. Farm Bulletin Indian Council of Agricultural Research, 20: 1-150.

AMINUL, I. M. 1996. Qualities of Water and Soil in Aquaculture, 87 pp., DOF Publication, Dhaka, Bangladesh.

AQUACULTURE DEVELOPMENT AND CO-ORDINATION PROGRAMME 1983. Fish Feeds and Feeding in Developing Countries. Aquaculture Development and Co-ordination Programme, 97 pp., ADCP/ REP/ 83/ 18. FAO, Rome, Italy.

ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS 1990. Official Methods of Analysis. 15th Edtion, 1298 pp., Association of Official Analytical Chemists, Inc., Arlington, Virginia, USA.

BALARIN, J. D. and HALLER, R. D. 1982. The Intensive Culture of Tilapia in Tanks, Raceways and Cages. In: Recent Advances in Aquaculture (Eds. MUIR, J. F. and ROBERTS, J. J.), 265-365, Westview Press, Boulder, Colorado, USA.

BANERJEE, S. M. 1967. Water Quality and Soil Condition of Fish Ponds in Some States of India in Relation to Fish Production. Indian Journal of Fisheries, 14: 115-144.

CAO, T. B., LIN C. K. and DEMAINE, H. 1998. Evaluation of Low Cost Supplemental Diets for Culture of *Oreochromis niloticus* (L.) in Northern Vietnam. In: Fifteenth Annual Technical Report. Pond Dynamics/Aquaculture CRSP (Eds. BURKE, D., BAKER, J., GOETZE, B., CLAIR, D. and EGNA, H.), 167-175, Oregon State University, Corvallis, Oregon, USA.

DE SILVA, S. S. and DAVY, F. B. 1992. Fish Nutrition Research for Semi-Intensive Culture System in Asia. Asian Fisheries Science, 5: 129-144.

DEWAN, S., WAHAB, M. A., BEVERIDGE, M. C. M., RAHMAN, M. H. and SARKER, B. K. 1991. Food Selection, Electivity and Dietary Overlap among Planktivorous Chinese and Indian Major Carp Fry and Fingerlings Grown in Extensively Managed, Rain-Fed Ponds in Bangladesh. Aquaculture and Fisheries Management, 22: 277-294.

DIANA, J. S., LIN, C. K. and YI, Y. 1996. Timing of Supplemental Feeding for Tilapia Production. Journal of the World Aquaculture Society, 27: 410-419.

GARLING, D. L. JR. and WILLSON, R. P. 1976. Optimum Dietary Protein to Energy Ratio for Channel Catfish Fingerlings, *Ictalurus punctatus*. Journal of Nutrition, 106: 1368 -1375.

GREEN, B. W. 1992. Substitution of Organic Manure for Pelleted Feed in Tilapia Production. Aquaculture, 101: 213-222.

HOSSAIN, M. A. and PAUL, L. 2007. Low-Cost Diet for Monoculture of Giant Freshwater

Prawn (*Macrobrachium rosenbergii* de Man) in Bangladesh. Aquaculture Research, 38: 232-238.

HOSSAIN, M. A., ROY, R., RAHMATULLAH, S. M. and KOHINOOR, A. H. M. 2004. Effect of Stocking Density on the Growth and Survival of GIFT Tilapia, (*Oreochromis niloticus*) Fed on Formulated Diet. Journal of Agricultural and Rural Development, 2: 127-133.

HUSSAIN, M. G., KOHINOOR, A. H. M., ISLAM, M. S., MAHATA, S. C., ALI, M. Z., TANU, M. B., HOSSAIN, M. A. and MAZID, M. A. 2000. Genetic Evaluation of GIFT and Existing Strains of Nile tilapia, *Oreochromis niloticus* L., under on Station and on Farm Conditions in Bangladesh. Asian Fisheries Science, 13: 117-126.

JAUNCEY, K. 1982. The Effect of Varying Dietary Protein Level on the Growth, Food Conversion, Protein Utilization and Body Composition of Juvenile Tilapia (*Sarotherodon mossambicus*). Aquaculture, 27: 43-54.

JAUNCEY, K. and ROSS, B. 1982. A Guide to Tilapia Feeds and Feeding, 111 pp., Institute of Aquaculture, University of Stirling, Scotland, UK.

JHINGRAN, V. G. 1991. Fish and Fisheries of India, 3rd edition, 727 pp., Hindustan Publishing Corporation, Delhi, India.

KADER, M. A., BULBUL, M., YOKOYAMA, S., ISHIKAWA, M., KOSHIO, S., HOSSAIN, M. S., AHMED, G. U. and HOSSAIN, M. A. 2011. Evaluation of Meat and Bone Meal as Replacement for Protein Concentrate in the Practical Diet for Sutchi Catfish, *Pangasius hypophthalmus* (Sauvage 1878) Reared Under Pond Condition. Journal of the World Aquaculture Society, 42: 287-296.

KADER, M. A., HOSSAIN, M. A. and HASAN, M. R. 2005. A Survey of the Nutrient Composition of Some Commercial Fish Feeds Available in Bangladesh. Asian Fisheries Science, 18: 59-69.

MICHAEL, R. G. 1969. Seasonal Trends in Physico-Chemical Factors and Plankton of a Fresh Water Fish Pond and Their Role in Fish Culture. Hydrobiologia, 33: 144-160.

MIMS, S. D., CLARK, J. A., WILLIAMS, J. C. and LOVSHIN, L. L. 1995. Food Selection of Larval Paddlefish *Polyodon spathula* Supplied With Rice Bran to Promote Production of Live Foods, with Prepared Diets, or with Their Combination in Earthen Ponds. Journal of the World Aquaculture Society, 26: 438-446.

PULLIN, R. S. V. 1985. Tilapias: 'Every Man's Fish'. The Biologist, 32: 84-88.

RAHMAN, M. S. 1992. Water Quality Management in Aquaculture, 75 pp., BRAC Prokahsana, Dhaka, Bangladesh.

SHANG, Y. C. and COSTA-PIERCE, B. A. 1983. Integrated Agriculture-Aquaculture Farming System - Some Economic Aspects. Journal of the World Mariculture Society, 14: 523-530.

SHEARER, K. D. 1994. Factors Affecting the Proximate Composition of Cultured Fishes with Emphasis on Salmonids. Aquaculture, 119: 63-88.

SULTANA, R., KOHINOOR, A. H. M., ISLAM, M. S., MAZID, M. A. and HUSSAIN, M. G. 1997. Comparative Studies on Growth of Fry of GIFT and Existing Strain of Nile Tilapia (*Oreochromis niloticus*). Bangladesh Journal of Fisheries Research, 1: 25-30.

SUMAGAYSAY, N. S., MARQUEZ, F. E. and CHIU-CHERN, Y. N. 1991. Evaluation of

Different Supplementary Feeds for Milkfish (*Chanos chanos*) Reared in Brackish Water Ponds. Aquaculture, 93: 177-189.

VEVERICA, K. L., GICHURI, W. and BOWMAN, J. 1998. Relative Contribution of Supplemental Feed and Inorganic Fertilizers in Semi-Intensive Tilapia Production. In: Sixteenth Annual Technical Report, Pond Dynamics in Aquaculture CRSP (Eds. MCELWEE, K., BURKE, D. and EGNA, H.), 43-45, Oregon State University, Corvallis, Oregon, USA.

WAHAB, M. A., ISLAM, M. T., AHMED, Z. F., HOQ, M. S., HAQUE, M. A. and BISWAS, B. K. 1995. Effect of Frequency of Fertilization on the Pond Ecology and Growth of Fishes. Bangladesh Agricultural University Research Progress, 9: 410-419.

WILLIAMS, M. 1996. The Transition in the Contribution of Living Aquatic Resources to Food Security. Food Agriculture Environmental Discipline Paper 13, 41 pp., International Food Policy Research Institute, Washington, DC, USA.