A semi intensive approach on growth and profit margin of Indian major carps (*Catla catla*, *Labeo rohita* and *Cirrhinus cirrhosus*) with cost effective standard feed formulation

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Abstract. In the present experiment, the viability of formulated feed with locally available feed ingredients was evaluated over traditionally prepared hand-made feed and commercial pellet feed for pond culture of carp species. Three commonly cultured carp species namely *Catla catla*, *Labeo rohita* and *Cirrhinus cirrhosus* with the average initial weight of 25.21±2.22 g, 24.97±1.25 g and 25.20±2.77 g respectively were stocked at a stocking density of 1976 (*C. catla*), 4940 (*L. rohita*) and 2964 (*C. cirrhosus*) individuals ha^{-1} and allowed to grow for five months. Water quality parameters were ideal for carp culture in the pond. The fishes grew to an average final weight of 216.67±4.04, 319.25±5.41 and 310.33±4.98 g for *C. catla*; 207.78±8.59, 314.19±12.50 and 301.31±9.69 for *L. rohita*; and 232.97±11.30, 311.65±3.13 and 308.90±5.61 for *C. cirrhosus* fed with handmade ball (HMB), semi-auto feed mill pellet (SAFM-Pellet) and commercial-pellet feed, respectively. The ponds also yielded an overall average biomass of 1627.08±66.77, 2555.59±100.06 and 2409.19±53.39 kg ha^{-1} for the fishes fed with HMB, SAFM-Pellet and commercial-pellet feed. Among the feed types, SAFM-pellet feed was found to give better feed conversion ratio (FCR) (2.81±0.36) and benefit-cost ratio (BCR) (0.64) followed by commercial-pellet feed (FCR 3.44±0.09, BCR 0.30). The present experiment concludes that SAFM-pellet would increase the yield of carp species from ponds and would be economically sustainable.
Key Words: low cost feed, economic analysis, carp fishes, earthen pond.

Introduction. Successful management of fish culture in earthen pond requires a comprehensive understanding of feeding strategy. For any kinds of fish culture system, supplementary feeding is most essential. Supplementary feeding offers the means of optimal fish production within a short time period in ponds. Therefore, the importance of supplementary feeding in fish culture is increasing day-by-day (Shahzadi et al 2006). Carrying capacity of culture ponds is known to be influenced significantly by supplementation of feeds which enhance the fish production by many folds (Samocha et al 2004). With the developing of different culture system, the fish feed has also been changed. Traditional fish feed was used in the extensive culture technique. But now in the intensive culture system, different types of artificial feed are used. In carp polyculture of Bangladesh, farmers often use a mixture of rice bran and wheat bran and make this into a wet non pelleted ball (dough) before dispensing to the pond. Although commercial feeds are recognized as nutritious for fish species, they are unaffordable for most of the local fish farmers in Bangladesh. Fish feed known to responsible for at least 40-60% of the total cost of fish production in aquaculture system (Craig & Helfrich 2002; Jamu & Ayinla 2003). Therefore, the increase in cost and demand for feed protein from commercial sources make the farmers of our country think about incorporating cheap and locally available ingredients in fish feeds. Several artificial feedstuffs of plant and animal origin (by-products) are available in Bangladesh which is useful to formulate nutritional feed for proper growth and development of carp species. However, formulated feed that is produced from locally available indigenous raw materials become cheaper and easily affordable by farmers. Development of quality fish feed depends on proper formulation and manufacturing technology that may ensure an optimal level of proteins, lipids, minerals, vitamins, growth promoting substances and energy in feed. The most important barrier towards fish feed development in Bangladesh is the lack of simple technology to formulate feed from locally available ingredients. Increasing feed cost and quality feed now a major problem in the aquaculture industry of Bangladesh. So, the present study was designed to evaluate a formula to produce low-cost quality fish feeds from locally available ingredients and to determine their effects on growth, production and economics of Indian major carps in earthen fish culture ponds.

Material and Method

Experimental design. The experiment was conducted in 9 earthen ponds (size ranged between 17 to 20 decimal) for a period of 150 days (July 2015 to November 2015) in selected farmer's ponds in Tungipara of Gopalgonj district, Bangladesh (Figure 1). Three treatments each with three replications were assigned to evaluate the nutritional potential of the formulated diets compared with local and commercially available diets.

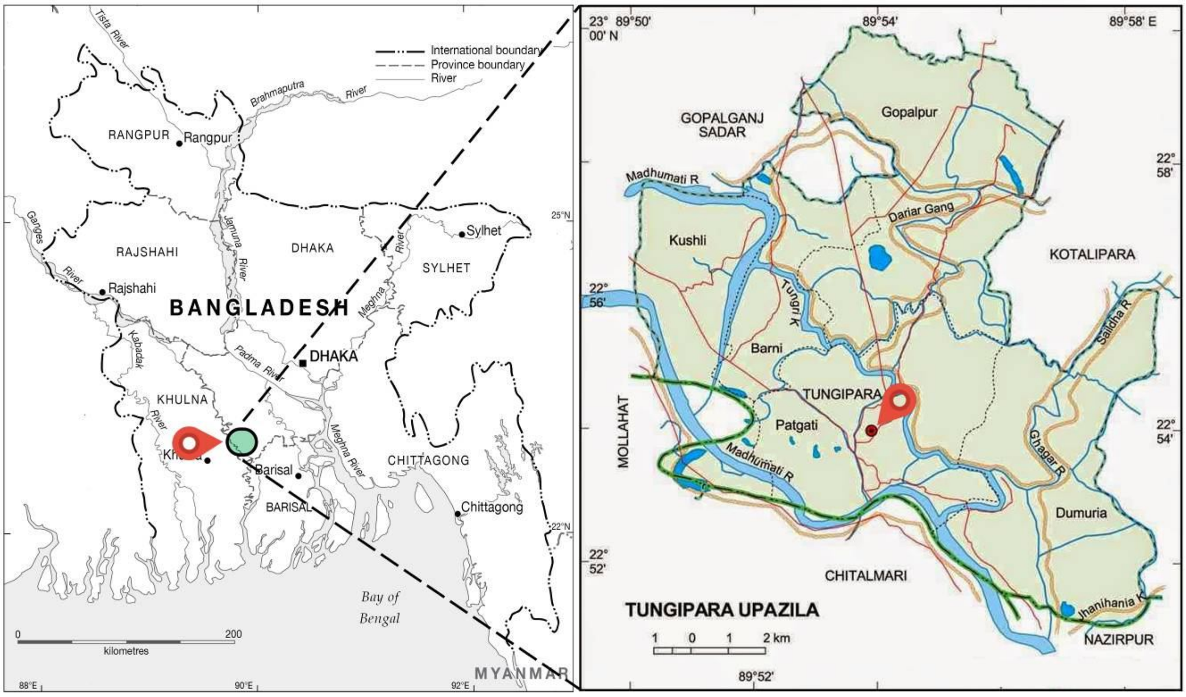

Figure. 1 Geographical position of experimental ponds.

Preparation and stocking of experimental ponds. Rectangular ponds were used for this experiment which was fully exposed to prevailing sunlight. Before starting the experiment, the aquatic weeds of the ponds were completely removed by manual effort. Firstly, poisoning of pond water with rotenone (2.5 g m^{-3}) and after that repeated netting was used to remove unwanted fish species from the ponds. After one week of rotenone application, the ponds were limed at the rate of 247 kg ha^{-1}. After seven days of liming tube well water was used to fill the ponds. Fertilization of ponds was done using Urea and TSP at the rate of 38 and 20 kg ha^{-1}, respectively. After pond preparation the fishes with an initial weight of 25.21±2.22g of *Catla catla*, 24.97±1.25g of *Labeo rohita* and 25.20±2.77g of *Cirrhinus cirrhosis* were stocked at a stocking density of 1976 (*C. catla*), 4940 (*L. rohita*) and 2964 (*C. cirrhosus*) individuals ha^{-1}.

Preparation of experimental diets and feeding. The experimental fishes were fed with the handmade ball (HMB), semi-auto feed mill pellet (SAFM-pellet) and a commercial-pellet at the rate of 5% of body weight for first two months and 3% per body weight for rest of the three months. HMB and SAFM-pellet were prepared using locally available feed ingredients. The required amount of different ingredients was mixed with a blender to prepare the experimental diets. The different ingredients with their amounts used to prepare experimental diets are shown in Table 1. The commercial-pellet feed was collected from local markets.

Table 1

Ingredients used for preparation of experimental diets with their prices

Name of feed Ingredients (%)	*Handmade ball*	*SAFM - pellet*	*Commercial-pellet**
Rice bran (Gr-A)	40	42	
Mustard oil cake	45	20	
Soybean oil cake	-	10.8	
Wheat flour	-	10	
Dry fish	-	15	
Wheat bran	15	-	
Vitamin & minerals	-	0.2	
Salt	-	0.5	
Binder	-	0.5	
Limestone (powder)	-	1	
Total	100	100	
Feed cost (BDT kg^{-1})	20	23	28

***** As the commercial-pellet feed was collected directly from market, the ingredients used to formulate the feed are unknown.

Monitoring of water quality parameters. Water samples were collected fortnightly (twice in a month) between 10:00 to 11:00 am for analysis of various physico-chemical parameters using dark bottles. Water temperature and transparency were measured using a Celsius thermometer and a black and white standard colour coded Secchi disc of 30 cm diameter. Water pH was measured using an electronic pH meter (Jenwary, 3020) and dissolved oxygen (DO) was measured directly with a DO meter (Lutron, DO-5509). Total dissolved solids (TDS) was measured by a TDS meter (Adwa AD31 water prove EC/TDS tester) and ammonia, total alkalinity using a HACH water analysis kit (Model FF-2, USA).

Fish sampling, growth parameters and yield analysis. Fish sampling was carried out in the morning between 7:00 to 9:00 am using a scoop net. Around 10% of fishes were sampled monthly to note the weight of fishes and to check any abnormalities in the fish body due to disease. At the final harvest, all fishes were weighed, measured and the survival rate and mean weight were determined. Growth response of experimental fishes was calculated by the following: Rana (1997); Islam et al (2017); Paul et al (2018):

Mean weight gain (g) = Mean final weight (g) – Mean initial weight (g)

$$\text{Average daily weight gain (ADG)} = \frac{\text{Final weight} - \text{Initial weight}}{\text{Culture period}}$$

$$\text{SGR } (\% \, bwd^{-1}) = \frac{\ln[\text{Final weight} - \ln[\text{Initial weight}]}{\text{Culture period}} \times 100$$

$$\text{Survival rate } (\%) = \frac{\text{No. of fish harvested}}{\text{No. of fish stock}} \times 100$$

$$\text{Food conversion ratio} = \frac{\text{Weight of feed fed}}{\text{Fish weight gain}}$$

Fish yield (kg/ha/150 days) = Fish biomass at harvest - fish biomass at stock

Proximate composition analysis. Proximate composition of the experimental diet was analyzed by the standard methods of the Association of Official Analytical Chemists (AOAC 1995). Moisture content was determined by drying the diets at 135°C for 2 hrs. Crude lipid content was determined by the soxhlet apparatus using Soxtec system 1046 (Foss, Hoganas, Sweden) and crude protein content by Kjeldahl method (N × 6.25) after acid digestion, distillation and titration of samples. Ash content was determined by using a muffle furnace (600°C for 4 hrs). Carbohydrate was analyzed by acid method (Miller 1972). Analysis of the samples was done in the Fish Nutrition Lab, Department of Aquaculture, Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh, Bangladesh.

Economic analysis. Economic analysis of the experiment was done by following the formula given by Asaduzzaman et al (2010) as follows:

$$R = I - (FC+VC+Ii)$$

Where: R = net return;
I = income from fish sale;
FC = fixed/common costs;
VC = variable costs;
Ii = interest on inputs.

The benefit-cost ratio was determined as:

Benefit-cost ratio (BCR) = Total net return/Total input cost

Statistical analysis. Water quality, fish growth and production parameters, proximate composition and economic analysis were performed by one-way ANOVA followed by Duncan New Multiple Range Test (Duncan 1955) at 5% level of significance (Gomez & Gomez 1984). Analysis of percentages and ratio data were done after transforming (arcsine) the data. All analyses were performed using SPSS (Statistical Package for Social Science) version 20.0 (IBM Corporation, Armonk, NY, USA).

Results

Water quality parameters. Mean values (mean±SD) and ranges (parentheses) of water quality parameters measured in the experimental ponds during the study period are shown in Table 2. There were no significant differences ($p < 0.05$) in all water quality parameters among the treatments. During the study period, water temperature ranged from 24.10 to 32.00ºC, water transparency ranged between 17.80 to 33.00 cm, pH ranged between 6.50 to 7.90, DO varied between 3.50 to 6.80 mg L^{-1}, TDS ranged from 113.00 to 259.00 mg L^{-1}, un-ionized ammonia (NH_3) varied from 0.00 to 0.07 mg L^{-1} and total alkalinity ranged between 61.55 to 69.23 mg L^{-1} in all the experimental ponds.

Table 2

Water quality parameters during the study period (values in parentheses indicate range)

Parameters	*Treatments*		
	HMB	*SAFM - pellet*	*Commercial-pellet*
Temperature (ºC)	$27.67±2.47^a$ (24.10-31.10)	$27.22±2.77^a$ (23.20-32.00)	$27.86±2.87^a$ (23.40-31.00)
Transparency (cm)	$26.71±5.05^a$ (17.80-33.00)	$27.26±3.57^a$ (20.20-32.40)	$27.61±4.21^a$ (18.50-32.00)
pH	$6.91±0.23^a$ (6.50-7.50)	$6.96±0.34^a$ (6.60-7.80)	$6.99±0.37^a$ (6.50-7.90)
DO (mg L^{-1})	$4.37±0.71^a$ (3.50-6.10)	$4.44±0.76^a$ (3.40-5.70)	$4.23±0.61^a$ (3.70-6.80)
TDS (mg L^{-1})	$160.73±35.48^a$ (113.00-234.00)	$166.33±40.81^a$ (110.00-259.00)	$152.20±28.46^a$ (113.00-195.00)
NH_3 (mg L^{-1})	$0.014±0.014^a$ (0.00-0.05)	$0.012±0.009^a$ (0.00-0.07)	$0.021±0.021^a$ (0.00-0.03)
Total alkalinity (mg L^{-1})	$65.87±2.36^a$ (62.36-68.25)	$66.03±1.72^a$ (61.55-69.23)	$66.02±2.24^a$ (62.36-68.65)

Values in the same raw having the same superscripts are not significantly different according to ANOVA, HSD, $p < 0.05$.

Growth and yield parameters. Details of growth parameters, survival and production of fish species are presented in Table 3. During the present study, the highest final average weight was attained by *C. catla* fed with SAFM-pellet. *C. catla* reached an average final weight of 216.67±4.04, 319.25±5.41 and 310.33±4.98 g feeding with HMB, SAFM-Pellet and commercial-pellet feed, respectively. The average final weight attained by *L. rohita* was 207.78±8.59, 314.19±12.50 and 301.31±9.69 g for the fishes feeding with HMB, SAFM-pellet and commercial-pellet feed, respectively. For the same feed types, the average final weight noted was 232.97±11.30, 311.65±3.13 and 308.90±5.61 g for *C. cirrhosus.* Significant differences ($p < 0.05$) were also observed in mean weight gain, % weight gain, average daily gain (ADG) and specific growth rate (% day^{-1}) of fishes fed with different types of experimental diets. Comparison of percentage weight gaining of different types of feed is shown in Figure 2. However, SAFM-pellet feed fed fishes were found to give the best growth performance compared to the other two types of feed. Total yield (combined of three species) and food conversion ratio (FCR) of different feed groups are shown in Table 4. Along with the better performance of FCR (2.81±0.36) the total yield (2555.59±100.06 kg ha^{-1}) of fishes fed with SAFM-pellet was also the highest. Final yield percentages of Indian major carps from different treatments are shown in Figure 3.

Proximate composition of experimental diets. The proximate compositions of the used three feed types (HMB, SAFM-pellet and commercial-pellet) are shown in Table 5. The percentage of crude lipid, crude protein and crude ash were significantly different ($p < 0.05$) and higher in commercial-pellet (7.76±0.60, 24.88±0.02 and 12.29±0.01%, respectively) than SAFM-pellet (6.66±0.03, 24.68±0.03 and 11.53±0.02%, respectively) and HMB (6.48±0.08, 22.60±0.10 and 6.35±0.01%, respectively). Inverse to the above mentioned parameters the percentage (%) of moisture, crude fibre and carbohydrate content were also significantly different ($p < 0.05$) and higher in HMB (15.67±0.02, 6.96±0.01 and 41.95±0.01%, respectively) than SAFM-pellet (12.16±0.01, 6.77±0.03 and 38.20±0.04%, respectively) and commercial-pellet (11.95±0.01, 5.89±0.01 and 37.23±0.02%, respectively).

Economic analysis. Comparison of economic return incurred by the fishes fed with different feed types is shown in Table 6. The mean total inputs including 10% annual interest per ha pond were significantly ($p < 0.05$) higher in the commercial-pellet fed pond (285449.08 BDT; referred as Bangladeshi currency) followed by SAFM-pellet fed pond (239935.72 BDT) and HMB feed fed pond (205541.60 BDT). There were significant differences ($p < 0.05$) in the mean values of total net return among the feed types and the highest value was obtained from SAFM-pellet (390993.68 and 151057.96 BDT) followed by commercial-pellet (370401.47 and 84952.39 BDT) and HMB (253688.09 and 48146.50 BDT). The benefit-cost ratio (BCR) was also significantly different ($p < 0.05$) among the treatments and it was higher in SAFM-pellet (0.64) followed by commercial-pellet (0.30) and HMB (0.24) feed (Table 6).

Table 3

Growth performance, survival and yield of fishes in the experimental ponds

Parameters	*Catla catla*			*Labeo rohita*			*Cirrhinus cirrhosus*		
	HMB	*SAFM - pellet*	*Commercial-pellet*	*HMB*	*SAFM - pellet*	*Commercial-pellet*	*HMB*	*SAFM - pellet*	*Commercial-pellet*
Initial weight (g)	25.03±0.23[a]	25.21±0.54[a]	25.02±0.13[a]	24.93±0.48[a]	24.97±0.34[a]	25.01±0.03[a]	25.02±0.06[a]	25.20±0.75[a]	24.99±0.47[a]
Final weight (g)	216.67±4.04[c]	319.25±5.41[a]	310.33±4.98[b]	207.78±8.59[c]	314.19±12.50[a]	301.31±9.69[a]	232.97±11.30[b]	311.65±3.13[a]	308.90±5.61[a]
Weight gain (g)	191.65±4.02[c]	294.03±5.70[a]	285.32±4.86[b]	182.85±8.79[c]	289.23±12.56[a]	276.30±9.69[a]	207.94±11.26[b]	286.47±2.82[a]	283.91±6.02[a]
% weight gain	765.91±17.33[b]	1166.73±41.73[a]	1140.47±13.76[a]	733.74±43.72[c]	1158.33±55.39[a]	1104.90±38.45[a]	830.94±43.57[b]	1137.30±33.16[a]	1136.47±33.16[a]
ADG (g)	1.28±0.03[b]	1.93±0.06[a]	1.90±0.03[a]	1.22±0.06[c]	1.93±0.12[a]	1.84±0.07[a]	1.39±0.08[b]	1.90±0.00[a]	1.89±0.04[a]
SGR (% day^{-1})	1.44±0.01[b]	3.61±0.03[a]	3.59±0.01[a]	1.41±0.04[c]	3.60±0.04[a]	3.56±0.03[a]	1.49±0.03[b]	3.59±0.02[a]	3.59±0.03[a]
Survival rate (%)	88.00±2.00[a]	90.33±1.53[a]	88.33±1.53[a]	87.33±2.31[a]	90.33±1.53[a]	88.33±2.08[a]	87.00±2.00[a]	90.00±2.65[a]	87.33±2.52[a]
Net yield (kg ha^{-1})	327.21±1.72[c]	520.14±19.91[a]	492.34±17.73[b]	773.42±48.18[b]	1278.85±66.98[a]	1191.55±62.02[a]	526.44±28.39[b]	756.60±24.08[a]	725.30±13.36[a]

Values in the same raw having the same superscripts for *C. catla, L. rohita* and *C.cirrhosus* are not significantly different according to ANOVA, HSD, $p < 0.05$.

Table 4

Total net production and FCR under different treatments

Parameters	*Treatments*		
	HMB	*SAFM-pellet*	*Commercial-pellet*
FCR	4.07 ± 0.34^{b}	2.81 ± 0.36^{a}	3.11 ± 0.09^{a}
Total yield (kg ha^{-1})	1627.08 ± 66.77^{c}	2555.59 ± 100.06^{a}	2409.19 ± 53.39^{a}

Values in each same raw having different superscripts are significantly different according to ANOVA, HSD, $p < 0.05$.

Table 5

Proximate composition of different experimental diets

Proximate (%)	*HMB*	*SAFM-Pellet*	*Commercial-pellet*
Moisture	15.67 ± 0.02^{a}	12.16 ± 0.01^{b}	11.95 ± 0.01^{c}
Crude lipid	6.48 ± 0.08^{c}	6.66 ± 0.03^{b}	7.76 ± 0.60^{a}
Crude protein	22.60 ± 0.10^{b}	24.68 ± 0.03^{a}	24.80 ± 0.02^{a}
Crude ash	6.35 ± 0.01^{c}	11.53 ± 0.02^{b}	12.29 ± 0.01^{a}
Crude fiber	6.96 ± 0.01^{a}	6.77 ± 0.03^{b}	5.89 ± 0.01^{c}
Carbohydrate	41.95 ± 0.01^{a}	38.20 ± 0.04^{b}	37.23 ± 0.02^{c}

Values in the same raw having different superscripts are significantly different according to ANOVA, HSD, $p < 0.05$.

Table 6

Economic analysis among three treatments for 1 ha pond and 150 days of culture period

Variables	*Price rate (BDT)*	*Treatments*		
		HMB	*SAFM-pellet*	*Commercial-pellet*
Fixed cost				
Land used cost		12350.00	12350.00	12350.00
Variable cost				
Pond preparation and management cost (Rotenone, lime, Urea, TSP)		22665.04	22662.46	22663.20
Fish fingerling		19760.00	19760.00	19760.00
Feed cost	HMB = 20 BDT kg^{-1}; SAFM-Pellet = 23 BDT kg^{-1}; Commercial-pellet = 28 BDT kg^{-1}	132489.79^{b}	165432.50^{b}	209658.82^{a}
Labour cost		4940.00	4940.00	4940.00
Fish harvesting and marketing cost		5115.10	5193.33	4659.10
Sub total		184969.93^{b}	217988.29^{b}	261681.12^{a}
Total (fixed + variable cost)		197319.93^{b}	230338.29^{b}	274031.12^{a}
Interest on inputs (5 months)	10% annually	8221.66	9597.43	11417.96
Total inputs		205541.60^{b}	239935.72^{b}	285449.08^{a}
Financial return				
Fish sale as total return	*C. catla* = 127.50±3.35 BDT kg^{-1}; *L. rohita*=141.50±2.12 BDT kg^{-1}; *C. cirrhosis* = 137.50±3.54 BDT kg^{-1}	253688.09^{b}	390993.68^{a}	370401.47^{a}
Total net return		48146.50^{c}	151057.96^{a}	84952.39^{b}
BCR		0.24^{b}	0.64^{a}	0.30^{b}

Values in the same raw having different superscripts are significantly different according to ANOVA, HSD, $p < 0.05$.

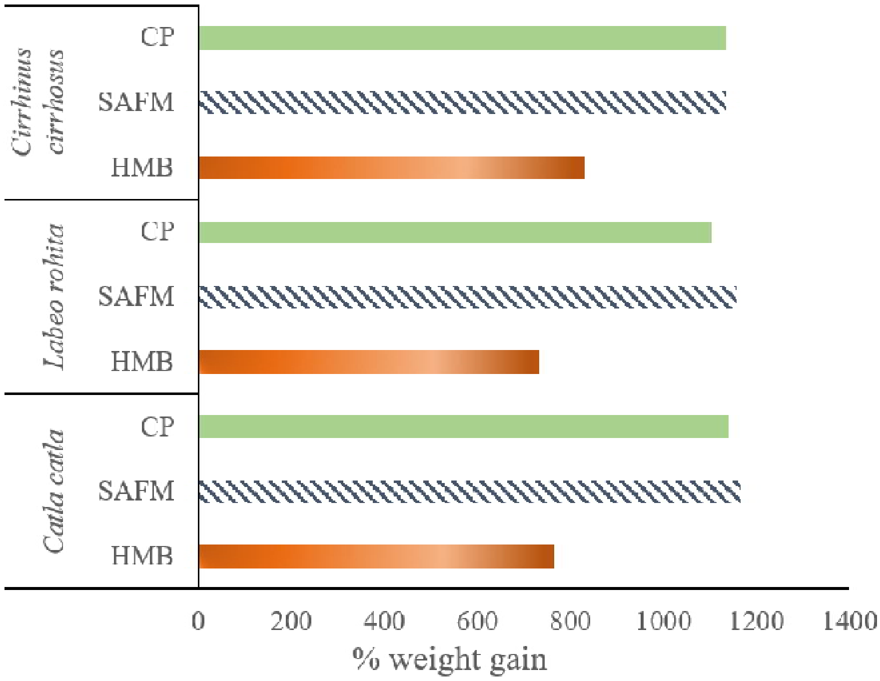

Figure. 2 Comparative weights gaining among major carps in different treatments.

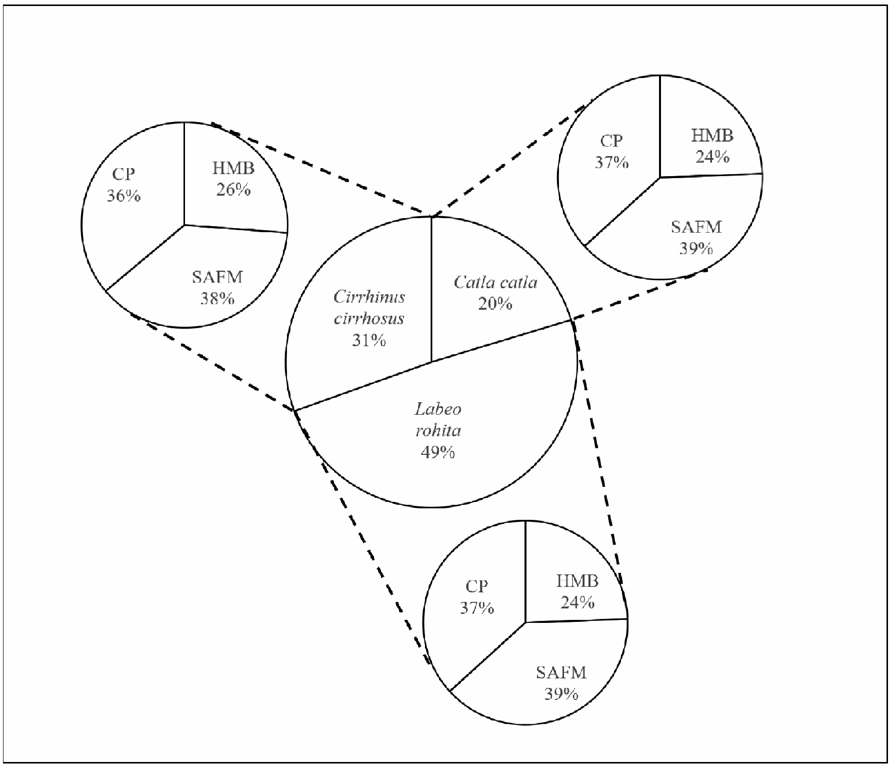

Figure 3. Final yield percentages of Indian major carps from different treatments.

Discussion

Water quality parameters. During the present study, there were no significant differences found ($p > 0.05$) in all the water quality parameters among the different feed types. The range of water temperature recorded during the study period (24.10-32°C) was quite suitable according to Santhosh & Singh (2007) and Thirupathaiah et al (2012) as they recorded a temperature of 24 to 30°C and 24.75 to 28.5°C and mention that this temperature is suitable for carp culture in pond. Hasan et al (2010) recorded transparency of water was 17-29 cm in fish culture pond which was more or less similar to the present findings. The pH values recorded during the study period were also identical to the findings of Shrivastava & Kanungo (2013). The values of dissolved oxygen were favourable for normal growth of fishes which was within the range of 3.85-7.2 mg L^{-1} obtained by Samad et al (2014) in their study. During the study period, the values of TDS ranged between 113.00 to 259.00 mg L^{-1} and it was below the maximum allowable limit reported by WHO (2004) (500 mg L^{-1}) and DoE (1997) standard of Bangladesh (1000 mg L^{-1}). The concentrations of un-ionized ammonia (NH_3) noted during the present study were within the acceptable limits and it was not harmful to the experimental fishes as because in all the feeding groups the level of ammonia was below the recommended range of Bhatnagar & Singh (2010) who recommended that less than 0.2 mg L^{-1} ammonia is suitable for pond fish culture. Total alkalinity was also found within the range reported by Boyd & Lichtkoppler (1979), who reported the total alkalinity ranged between 20 to 150 mg L^{-1} in their study. Therefore, the overall growth performance of experimental fishes was absolutely free from the influence of water quality parameters.

Growth parameters and yield of fishes. Growths of *C. catla, L. rohita* and *C. cirrhosis* obtained from the present study indicated that variations may be due to the different protein content of experimental diets. In fish feeding dietary protein bears the primary importance (Jauncey & Ross 1982), thus in order to ensure the rapid growth of cultured species sufficient supply of dietary protein is needed (Lovell 1989). In the present study, growth parameters like weight gain, % weight gain, average daily gain (ADG), specific growth rate (% day^{-1}) and total yield (combined of three species) were significantly ($p < 0.05$) higher in the fishes fed with SAFM-pellet (24.68% crude protein) followed by commercial-pellet (24.88% crude protein) and lowest in fishes fed with HMB (22.60% crude protein). The possible cause of better growth performance of fish in SAFM-pellet might be due to the quality of protein or the amino acid balance in that feed. Mazid et al (1997) also observed the effect of different protein content on various growth performance of *L. rohita* and found the best performance in the formulated feed. However, the mode of preparation of diet somehow also influenced the growth rate of fish during the present study. A similar observation was also made by Ajani et al (2011) where they mentioned that feed forms sometimes can affect the growth performance of fish species. Significantly ($p < 0.05$) highest SGR was recorded in fishes fed with SAFM-pellet feed, might be due to the better feed utilization of this feed type. These results were in accordance with the findings of Dars et al (2010) and Nekoubin & Sudagar (2013), where they also found highest SGR in formulated feed than commercial feed for *C. catla* and *Ctenopharyngodon idella*. During the study period, survival rate (%) of fishes in different treatments was fairly high ranging from 87.00 ± 2.00 (HMB fed fish group) to 90.33 ± 1.53% (SAFM-pellet fed fish group) which was in accordance with the range (85.0 to 90.0%) recorded by Abou et al (2013). Therefore, feed types were not found to have any significant effect on the survival of fishes. The growth and FCR are good tools to compute the acceptability of feed in fish feeding experiments (Inayat & Salim 2005). A low FCR value is an indicator of better food utilization efficiency of formulated feed. In the present study, significantly lower FCR value (2.81) was obtained in fish fed with SAFM-pellet feed indicated good performance of this feed type compared to the other two types of feed. Commercial feed and HMB feed types were lower in nutrient quality and might contain different pollutants which might ultimately be responsible for higher FCR in commercial feed and HMB feed type.

Economics. The production of fish species fed with different feed types obtained in the present study was varied significantly ($p < 0.05$). The higher production that obtained in SAFM-pellet feed fed fishes were much higher than the findings of Ahmed et al (1996) who reported production of 339.39 kg ha^{-1} for *Pangasius pangasius* fed with commercial fish feed. The possible reason for better production performance of SAFM-pellet feed fed fishes might be the higher protein content. The optimal utilization of this feed was also responsible for the better performance of fishes. The highest BCR was also obtained in

SAFM-pellet feed fed fishes might be due to the low feed formulation cost. SAFM-pellet was prepared from locally available feed ingredients and it was cheaper than the commercial feed produced with more expensive animal origin feed ingredients.

Conclusions. During the study period, all the growth parameters (mean final weight, weight gain, ADG, SGR, FCR, survival rate) and total production of fishes were relatively higher in SAFM-pellet feed fed fishes compared to other two feed types. Based on the present study, SAFM-pellet feed could be a better option for the successful pond culture of carp fishes in Bangladesh.

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