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Effects of shrimp waste in supplementary diet on growth performance of Indian major carps

F. H. Shikha, M. I. Hossain* and T. Chakma
Department of Fisheries Technology
Bangladesh Agricultural University, Mymensingh-2202, Bangladesh
*Corresponding author: E-mail: ihossain.ft@bau.edu.bd

Abstract

A comprehensive trial was undertaken to assess the effect of feed, formulated with shrimp waste product on the growth of Indian major carp (*Labeo rohita*, *Gibelion catla* and *Cirrhinus cirrhosus*) fingerlings. The experiment was conducted in a 60-day feeding trial in aquarium system from 1st April to 30th May, 2015. Three types of feed namely Diet-1 (feed with shrimp waste), Diet-2 (feed with plant protein source) and Diet-3 (Commercial feed) were applied in three different treatments. Protein percentage of three diets were 28.42%, 28.13% and 27.32%, respectively. The study showed highest weight gain with *Labeo rohita* (7.71 ± 0.72 g), *Gibelion catla* (9.95 ± 0.99g) and *Cirrhinus cirrhosus* (3.87 ± 0.10 g) in Treatment3 (T_3) for Diet-3 and comparable with the growth of *Labeo rohita* (7.6 ± 0.22 g), *Gibelion catla* (8.32 ± 0.48 g) and *Cirrhinus cirrhosus* (3.27 ± 0.08 g) in Treatment1 (T_1) for Diet-1. The apparently lower SGR value was obtained with *Labeo rohita* (0.92%/day), *Gibelion catla* (0.76%/day) and *Cirrhinus cirrhosus* (0.49%/day) in T_1 than that of T3; whereas T_2 showed minimum value. The best FCR value was found in T_3 (2.80) where T_1 (3.31) showed lower value than T_2 (4.01). Protein efficiency ratio (PER) in T_1 (1.06) was lower than T_3 (1.30) and T_2 (0.88) showed lowest value. Water quality parameters were in the acceptable level for carp culture. The highest survival rate (%) was recorded in T_3 with *Labeo rohita* (76.19%), *Gibelion catla* (61.90%) and *Cirrhinus cirrhosus* (80.95%) and the lowest in T_2 (61.90%, 42.86% and 66.67%). The per kilogram cost of Diet-1, Diet-2 and Diet-3 were 30.19 BDT, 37.79 BDT and 40.80 BDT, respectively. From the result of this study, it might be suggested that shrimp waste could be used as a replacement of finfish diets which would be cost effective.

Key Words: Shrimp industry waste, supplementary feed, Indian major carp, aquaria, growth performance.

Introduction

Shrimp is a high value aquaculture product and is processed for the meat, leaving the carapace and head as waste products (Omum, 1992 and Knorr, 1991). The amount of shrimp waste (40–48%) contains head and body carapace (Sachindra *et al*., 2005). The shrimp waste composed mainly of protein (40%), minerals (35%) and chitin (14-30%) (Synowiecki and Al-Khateeb 2000) and is very rich in carotenoid pigments mainly astaxanthin (Britton, 1997 and Gimeno *et al*., 2007). The shrimp wastes mostly discarded in the municipal dumping yard in coastal regions. Shrimp waste meal has higher mineral, protein and calcium content than fish meal, as well as some amino acids such as aspartic acid, glutamic acid, leucine, lysine and argentine (Ariyani, 1989). Shrimp waste could be processed in drying, fermentation, for recycle use such as shrimp meal, fish meal, poultry meal, a natural source of carotenoids and human foods. Usually, shrimp waste is dried on the beaches which encourage environmental problems (Mathew and Nair, 2006). Among commonly used feed ingredients, fish meal is considered to be the best ingredients, due to its compatibility with the protein requirement of fish (Alam *et al*., 1996). Replacement of fish meal with cheaper ingredients in fish feed is necessary because of rising cost and uncertain availability of fish meal (Higgs *et al*., 1995). Excessive shrimp waste which discarded from processing industry could be easily used as feed ingredients due to its high protein content. However, the use of shrimp waste in the formulation of fish feed is not recommended due to its high fiber and ash contents, which results in the formation of weak pellets (Meyers, 1986) with poor stability in water. Therefore, an economically viable and socially feasible simple technology is essential for the people involved with waste utilization and mitigation of environmental problems as well.

Materials and Methods

Feed ingredients collection, formulation and preparation

Different types of feed ingredients such as rice bran, maize, soyabean, wheat bran, molasses, minerals and vitamins premix were purchased from local market of Mymensingh (Table-1). The main ingredient, the shrimp waste (shrimp head and shell) was collected from different shrimp processing plants situated in Chittagong. For performing this experiment, two types of diets (Diet-1: feed with shrimp waste and Diet-2: feed with plant ingredients) were formulated for T_1 and T_2 (Table-1). The third one (Diet–3: commercial feed) was purchased from the market. The selected ingredients were milled and mixed thoroughly. Mixing of ingredients were performed by hand before adding water with stirring to form dough which finally, made into pellets using a pellet machine. The pellets were sundried in solar tent drier. The pellets were packed in air-tight water impermeable bags and stored in dry and cool place. The flow diagram of the Diets preparation procedure is shown in Fig. 1. Diet-3 which was used in T_3 was purchased from the distributor of Spectra Hexa Feeds Limited (it is particularly known as Mega feed Limited).

Table 1: Formulation of Diet-1 and Diet-2 for T_1 and T_2

Diet-1 (with shrimp waste) for T_1		**Diet-2 (without shrimp waste) for T_2**	
Feed ingredients	**Amount of ingredients (%)**	**Feed ingredients**	**Amount of ingredients (%)**
Shrimp waste	40.00		
Soya bean meal	24.00	Soya bean	48.00
Wheat bran	10.00	Wheat bran	12.00
Maize	13.00	Maize	25.00
Rice bran	10.00	Rice bran	12.00
Molasses	2.00	Molasses	2.00
Vitamin & mineral mix	0.50	Vitamin and mineral	0.50
Salt	0.50	Salt	0.50
Total	**100.00**	**Total**	**100.00**

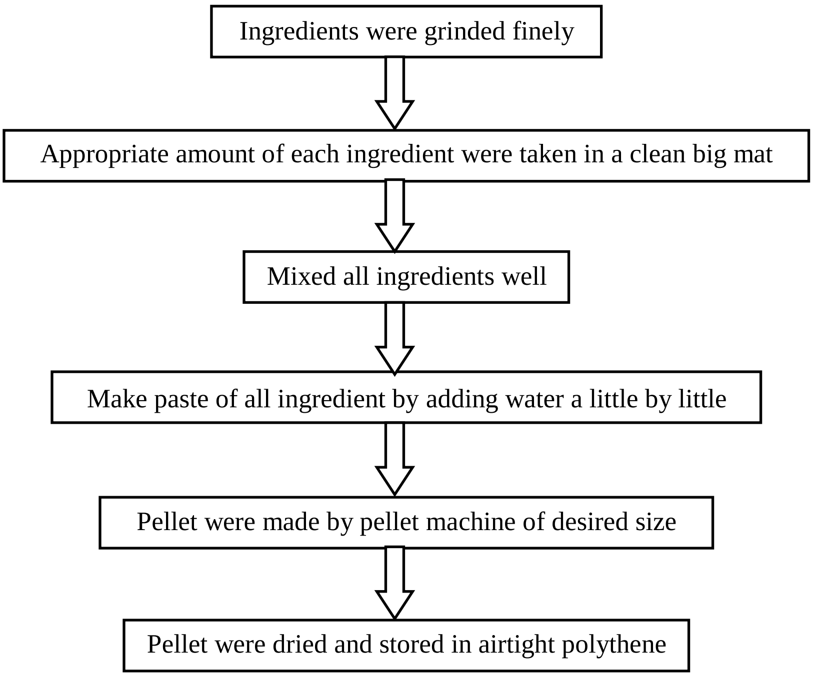

Fig. 1: Protocol for preparation of diets

Analytical methods

Proximate composition of all individual feed ingredients and prepared feeds from those ingredients were analyzed in the Fish Processing Laboratory of the Department of Fisheries Technology, Bangladesh Agricultural University, Mymensingh, Bangladesh following the methods of the Association of Official Analytical Chemists (1990) with slight modification.

Experimental species and system

The experiment was carried out in nine glass aquaria for a period of two months; from 1st April to 30th May, 2015. The experiment was carried out in the Laboratory of Fish Handling and Harvesting Laboratory at the Department of Fisheries Technology, BAU, Mymensingh, Bangladesh. Three species combination of Indian major carps fingerlings were selected for this experiment viz. *Labeo rohita*, *Gibelion catla* and *Cirrhinus cirrhosus*. Fingerlings were collected from the local fish traders and hatcheries. All the stocking and rearing activities were conducted in one experimental system, aquarium. Well aerated nine glass aquaria were used for this purpose.

All the aquaria were placed and kept on 1.0 m high cemented table for better observation and accessibility. For preparing aquaria, first any leakage of each aquarium were checked up and blocked by the glass glue. The aquaria were then cleaned with detergent and sponged thoroughly. These were washed with water and scooped out from the aquaria. The aquaria were rewashed and filled with water almost up to the top level and kept for a day. The aquaria were again washed with sodium chloride (NaCl) to destroy the harmful microorganisms. Again the aquaria were sponged and filled with tap water. On the following day, water was scooped out and then dried. For convenience the aquaria were numbered as 1, 2, 3 up to 9.There were three experimental groups, each with three replicates, in nine (09) uniform glass aquaria (30 L capacity) which followed a completely randomized design. To observe the growth performance of *Labeo rohita*, *Gibelion catla* and *Cirrhinus cirrhosus* and to measure water quality parameters, three experimental diets (Diet-1, Diet-2 and Diet-3) were assigned to three different experimental treatments. T_1, T_2 and T_3 respectively.

The fingerlings were kept in the aquaria in the laboratory for two weeks to acclimatize with the new environment. The fingerlings were fed with Diet-1, Diet-2 (formulated feed with plant ingredients) and Diet-3. Seven individuals of rui (*Labeo rohita*), catla (*Gibelion catla*) and mrigal (*Cirrhinus cirrhosus*) were stocked in each aquarium. Before releasing, initial weight of fingerlings were measured.

Artificial aeration system with the help of aerator (Aquarium air pump, Model no: SB 348A) were introduced to facilitate an adequate level of dissolved oxygen in each aquarium during the experimental period. The leftover feed and fecal matters in tanks were cleaned everyday by siphoning from tanks and the tanks were cleaned manually. Removed water was replaced by fresh deep tube well water.

The feed was supplied daily at the rate of 5% of their body weight for the first month and then the feeding rate gradually reduced to 4.5% in the next two weeks and 4% in last two weeks. Feeding rates were adjusted on the basis of fish weight gain at 10 days interval. The daily ration was divided into two parts. About half of the ration applied in the morning between 8.30 to 9.30 am and another half in the afternoon between 4:30 to 5:30 pm.

Sampling of fish and water quality parameters

Sampling of fish was done during ten days interval to observe the growth of fish and to adjust the feeding rate. Weight of fish was measured by using a digital electronic balance. Some important water quality parameters such as dissolved oxygen (mg/l), water temperature (ºC) and pH were measured during every sampling day. The sample collection was done between 8.30 to 9.30 am.

Weight gain (g)

Weight gain was calculated as:
Weight gain = Mean final fish weight —Mean initial fish weight

Percent weight gain

Percent weight gain was calculated as:
% weight gain=(Mean final weight-Mean initial weight)/(Mean initial weight)×100

Specific growth rate (SGR %/day)

Specific growth rate (SGR) was estimated as:

$$\text{SGR (\% per day)} = \frac{(\text{Loge } W_2 - \text{Loge } W_1)}{T_2 - T_1} \times \frac{100}{1}$$

Where:
W_2 = Weight of fish at time T_2 (final)
W_1 = Weight of fish at time T_1 (initial)

Feed conversion ratio (FCR)

The feed conversion ratio was expressed by the amount of food consumed to gain per kilogram weight by using following formula
FCR = (Amount of feed (kg) fed/(Live weight gain (kg)

Protein efficiency ratio (PER)

Protein efficiency ratio (PER) was measured by following formula
PER = (Live weight gain (kg))/(Amount of protein (kg) fed

Survival rate (%)

Survival rate (%) = (Total number of fish harvested)/(Total number of fish stocked)

Data Analysis

Data obtained from the present experiment were analyzed statistically to measure growth performances of different fish species in different treatments. Data were entered into the MS Excel to done simple statistics and XLSTAT for analysis of variances (ANOVA). The mean values were compared by Duncan Multiple Range Test at 5% level of significance.

Results

Proximate Composition of Experimental Diets

During experimental period, proximate composition of different experimental diets including the control (commercial feed) were analyzed which is shown in Table 2. Diet-1 contained the highest protein content (28.42%). The lipid content varied between 5.45% to 6.53% while the highest lipid value (6.53%) found for Diet-1in T_1.The highest ash content (12.35%) also was found in T_1 for Diet-1. The moisture content varied from 10.42% to 11.13%. In this experiment, the mean crude protein content of in Treatments for Diet-1, Diet-2 and Diet-3 was found 28.42%, 28.13% and 27.32% respectively whereas the mean crude lipid content for Diet-1, Diet-2 and Diet-3 found 6.53%, 5.84% and 5.45%, respectively.

Table 2: Proximate composition of the experimental Diets for different treatments

Content (%)	Diets		
	Diet 1 (T_1)	**Diet 2 (T_2)**	**Diet 3 (T_3)**
Moisture	10.74	10.42	11.13
Protein	28.42	28.13	27.32
Lipid	6.53	5.84	5.45
Ash	12.35	11.63	9.87

Water quality parameters

The water quality parameter such as dissolved oxygen, pH and temperature of the experimental ponds water in all the treatments were monitored in every 10 days interval during the experimental period. Monthly variation in the ranges and the mean value of different parameters of different treatment are shown in Table 3.

Table 3: Monthly variation in the ranges and mean values of water temperature, dissolved oxygen (DO) and pH in different treatments

Parameter	Months	Treatments		
		T_1 (Mean ± SD)	**T_2 (Mean ± SD)**	**T_3 (Mean ± SD)**
Temperature (ºC)	April	24.7- 25.9 (25.2 ± 0.35)	24.7-25.8 (25.2 ± 0.38)	24.6-25.8 (25.2 ± 0.37)
	May	25.5-26.2 (25.8 ± 0.26)	25.6-26.3 (25.9 ± 0.37)	25.5-26.3 (25.8 ± 0.31)
Dissolved Oxygen (mg/l)	April	6.26-6.88 (6.47 ± 0.17)	6.23-6.88 (6.50 ± 0.19)	6.19-6.89 (6.49 ± 0.20)
	May	5.97-6.41 (6.26 ± 0.15)	5.83-6.44 (6.16 ± 0.23)	5.81-6.49 (6.15 ± 0.25)
pH	April	7.74-8.23 (7.92 ± 0.13)	7.73-8.17 (7.91 ± 0.13)	7.76-8.21 (7.91 ± 0.14)
	May	7.75-8.19 (7.89 ± 0.13)	7.76-7.98 (7.87 ± 0.08)	7.72-8.21 (7.89 ± 0.15)

The mean value of the temperature measured in different treatments ranged from 24.6ºC to 26.3ºC (Table 3) during the experimental period. The minimum temperature (24.6ºC) and the maximum temperature (26.3ºC) was recorded in April and May in T_3 and T_2 respectively.

The mean value of the dissolved oxygen (DO, mg/l) of the sub-surface water in the different treatments ranged from 5.81 mg/l to 6.89 mg/l (Table 3). The highest DO concentration (6.89 mg/l) and the lowest DO concentration (5.81 mg/l) were observed in T_3 on April and May, respectively.

The mean value of the hydrogen ion concentration of the sub-surface water in the different experimental treatments during the study periods varied from 7.72 - 8.23 (Table 3). The highest pH value 8.23 was recorded in T_1 on April and the lowest value 7.72 was observed in T_3 on May.

Growth performance of experimental fishes (*Labeo rohita, Gibelion catla* and *Cirrhinus cirrhonus*)

The mean weight gain of *Labeo rohita*, *Gibelion catla* and *Cirrhinus cirrhonus* in different treatments between 2.73g to 9.85g. The highest weight gain of *Labeo rohita* (7.71g), *Gibelion catla* (9.85g) and *Cirrhinus cirrhonus* (3.87g) was found for Diet-3 in T_3. The lowest weight gain of these three treatments was found for Diet-2 in T_2. Significant variation was observed in case of *Gibelion catla* and *Cirrhinus cirrhonus* for Diet-3 and Diet-2, respectively. The mean weight gain is shown in Table 4.

Table 4: Mean weight gain (g) of *Labeo rohita*, *Gibelion catla* and *Cirrhinus cirrhonus* in different treatments

Species	**Treatments**		
	Diet 1 (T_1)	**Diet 2 (T_2)**	**Diet 3 (T_3)**
Labeo rohita	7.6±0.22[a]	6.99±0.42[a]	7.71±0.72[a]
Gibelion catla	8.32±0.48[b]	7.65±0.25[b]	9.85±0.99[a]
Cirrhinus cirrhonus	3.28±0.08[ab]	2.73±0.62[b]	3.87±0.11[a]

The highest weight increment was found for Diet-3 in T_1 and the lowest increment was found for Diet-2 in T_2. The weight increment every 10 days interval during experiment period of *Labeo rohita*, *Gibelion catla* and *Cirrhinus cirrhonus* in aquara is shown in the Table 5.

Table 5: Weight increment of *Labeo rohita*, *Gibelion catla* and *Cirrhinus cirrhonus* in different treatments during the experimental period

Weight increment of *Labeo rohita*						
Treatments	Time (Days)					
	10 days	20 days	30 days	40 days	50 days	60 days
Diet 1 (T_1)	0.95	1.06	1.27	1.26	1.44	1.5
Diet 2 (T_2)	0.89	0.94	1.12	1.24	1.37	1.43
Diet 3 (T_3)	1.03	1.16	1.36	1.43	1.47	1.57
Weight increment of *Gibelion catla*						
Treatments	Time (Days)					
	10 days	20 days	30 days	40 days	50 days	60 days
Diet 1 (T_1)	1.18	1.25	1.36	1.48	1.57	1.79
Diet 2 (T_2)	0.97	1.08	1.21	1.34	1.43	1.61
Diet 3 (T_3)	1.32	1.43	1.50	1.60	1.67	1.93
Weight increment of *Cirrhinus cirrhonus*						
Treatments	Time (Days)					
	10 days	20 days	30 days	40 days	50 days	60 days
Diet 1 (T_1)	0.29	0.38	0.52	0.62	0.69	0.79
Diet 2 (T_2)	0.23	0.29	0.44	0.52	0.56	0.68
Diet 3 (T_3)	0.47	0.51	0.61	0.67	0.74	0.83

The percent weight gain of *Labeo rohita*, *Gibelion catla* and *Cirrhinus cirrhonus* in different treatments ranged from 49.37- 142.43%. The higher percent weight gain was found in *Labeo rohita* (130.57%), *Gibelion catla* (100.74%) and *Cirrhinus cirrhonus* (56.78%) for Diet-1 than Diet-2. The highest percent weight gain was found in *Labeo rohita* (136.37%), *Gibelion catla* (142.43%) and *Cirrhinus cirrhonus* (67.61%) for Diet-3 in T_3 (Table 6). Significant difference was found only with *Gibelion catla* among three treatments.

The specific growth rate (SGR, %/day) of *Labeo rohita*, *Gibelion catla* and *Cirrhinus cirrhonus* in different treatments ranged from 0.44%/day to 0.97%/ day (Table 6). The higher SGR value was obtained in *Labeo rohita* (0.92%/day), *Gibelion catla* (0.76%/day) and *Cirrhinus cirrhonus* (0.49%/day) for Diet-1 in T_1. The highest SGR value was obtained for Diet-3 (controlled diet) in T_3.

Table 6: Percent weight gain and Specific growth rate (SGR %/day) of *Labeo rohita*, *Gibelion catla*, and *Cirrhinus cirrhonus* in different treatments during experimental period

Species of Fish	**Percent weight gain**		
	Treatments		
	Diet 1 (T_1)	**Diet 2 (T_2)**	**Diet 3 (T_3)**
Labeo rohita	130.57 ± 3.02^a	121.21 ± 14.54^a	136.37 ± 30.70^a
Gibelion catla	100.74 ± 9.37^b	95.77 ± 7.95^b	142.43 ± 33.61^a
Cirrhinus cirrhonus	56.78 ± 2.99^a	49.37 ± 17.91^a	67.61 ± 2.83^a
Species of Fish	**Specific growth rate (SGR %/day)**		
	Treatments		
Labeo rohita	0.92 ± 0.01^a	0.87 ± 0.07^a	0.94 ± 0.14^a
Gibelion catla	0.76 ± 0.05^b	0.74 ± 0.04^b	0.97 ± 0.16^a
Cirrhinus cirrhonus	0.49 ± 0.02^a	0.44 ± 0.13^a	0.57 ± 0.02^a

Mean feed conversion ratio (FCR) and protein efficiency ratio (PER) in different treatments ranged from 2.80 to 4.01 and 0.88 to 1.30, respectively (Table 7). The best FCR value was found for Diet-3 (2.80) in T_3. There was significant variation in FCR value among the treatments. In the case of protein efficiency ratio the highest value was found for Diet-3 in T_3 whereas in T_1 the value found lowest for Diet-1 (0.88). Here also significant variations were observed among the treatments.

Table 7: Mean FCR (Food conversion ratio) and PER (Protein efficiency ration) of diets in different treatments during the experimental period

Growth parameters	Treatments		
	Diet 1 (T_1)	**Diet 2 (T_2)**	**Diet 3 (T_3)**
FCR	3.31 ± 0.80b	4.01 ± 0.75a	2.80 ± 0.94c
PCR	1.06 ± 0.26b	0.88 ± 0.18c	1.30 ± 0.24a

Survival rate (%)

The survival rate (%) of fish in different treatments was estimated after total harvest by draining out of the aquaria. The survival rate (%) of three species of carp ranged from 42.86% to 80.95%. The highest survival rate (%) was recorded for diet 3 in T_3 and the lowest for Diet-2 in T_2. A comparison of survival rate (%) of *Labeo rohita*, *Gibelion catla* and *Cirrhinus cirrhonus* is shown in Table 8.

Table 8: Comparison of survival rate (%) of *Labeo rohita*, *Gibelion catla* and *Cirrhinus cirrhonus* in different treatments during the experimental period

Species	Treatments		
	(T_1)	**(T_2)**	**(T_3)**
Labeo rohita	66.67 ± 8.24	61.90 ± 16.49	76.19 ± 8.18
Gibelion catla	47.62 ± 8.24	42.86 ± 14.28	61.90 ± 14.87
Cirrhinus cirrhonus	80.95 ± 6.68	66.67 ± 8.24	80.95 ± 6.68

Cost analysis of formulated diets

Shrimp waste is a good source of protein, lipid, crude fiber and minerals. Shrimp waste along with other ingredients in fin fish diet bears a great significance to make a feed cost effective. Price of feed ingredients per unit value used in Diet-1 and Diet-2 is shown in the Table 9. Diet-3 (control diet) the commercial feed which is used widely in Bangladesh for finfish polyculture. This feed was brought direct from the market whole seller (Spectra hexa feed limited). The cost of feed sack (25kg) was 970 BDT. The calculated price including carrying cost was 40.80 BDT/kg.

Table 9: Cost estimation of experimental Diet-1(shrimp shell along with other ingredients) and Diet-2 (ingredients from plant source)

Feed ingredients	**Unit price (BDT/Kg)**		**Amount of ingredient (g)**		**Cost (BDT)**	
	Diet 1	**Diet 2**	**Diet 1**	**Diet 2**	**Diet 1**	**Diet 2**
Shrimp shell	16.66	-	400		6.32	
Soya bean meal	42	42	240	480	10.08	20.16
Wheat bran	30	30	100	120	3.00	3.60
Maize	23	23	130	250	2.99	5.75
Rice bran	24	24	100	120	2.04	2.88
Molasses	60	60	20	20	0.80	0.80
Vitamin premix	500	500	5	5	2.50	2.50
Salt	25	25	5	5	0.10	0.10
Other charge					2.00	2.00
Total					**30.19**	**37.79**

Discussion

Proximate composition of experimental diets

Protein is the major growth promoting factor in feed. The protein requirement of fish is influenced by various factors such as water temperature, feeding rate, availability and quality of natural foods. Nandeesha (1993) reported that the proximate composition of factory made feeds is reported to be 20-30 percent protein, 2-4 percent lipid, 10-15 percent fiber, 30-40 percent carbohydrate and 8-10 percent ash and often are claimed to have been enriched with lysine, methionine, vitamins and minerals. Ahmad *et al*., (2012) reported that diet containing 40% protein, 9.31% lipid and 10.08% carbohydrate is the best one for a more profitable and successful culture of Common carp. Those former studies agreed with the present study. Singh *et al*., (2006) reported that in terms of growth, food conversion ratio, protein efficiency ratio, survival and ratios of protein and lipid deposition in muscle, diet containing 30% protein level revealed a significantly ($p<0.01$) better performance for the *Labeo rohita* in comparison with other diets containing lower or higher protein levels. Nandeesha *et al*., (1994) improved the growth performance of Rohu and Catla by alternating the feeding schedules between high and low protein diets. Rahman *et al*., (2006) and Tareque *et al*., (2009) reported 30% incorporated protein in diet resulted better results with respect of growth and SGR for *Cyprinus carpio* var. *Nudus* and *Puntius gonionotus*, respectively which is similar with present study.

The protein content of three different diets matched with Wilson (2002) suggestion. They suggested that herbivorous and omnivorous fish require a diet with 25-35% crude protein. Mookerjee and Mazumdar (1946) reported that growth and production in fish culture are generally dependent on the daily feed consumption, qualities of feed and feeding frequency. According to Chakraborty *et al*., (1999) the growth of carp (*Cyprinus carpio*) increases with protein levels, and there was an approximately linear increase of growth with feeding level for any given diet.

Water quality parameters

Temperature plays a major important role in fish physiology. Water temperature affects the different factors related to growth of fish directly. Cho and Slinger (1980) observed that food intake increases with the increase in temperature up to optimum levels as the energy requirement for maintenance increases. Ideal temperature range for different cold water and warm water species are 14 to18ºC and 24 to 30ºC respectively. Jhingranand Pullin (1985) reported that Indian major carps can tolerate temperature ranging from 10 to 37.8ºC. Present experimental data was with in the tolerance level of Indian major carps as found in other studies.

In culture systems dissolved oxygen (DO) is the most important growth increasing factor which influencing the condition of fish. Oxygen consumption varies with different factor such as species, size, activity, season and temperature. According to Banerjee (1967), cyprinids require 6-7 mg/l oxygen for good growth, but the tolerance levels as low as 3 mg/l for concise periods. Cheng *et al.,* (2003) stated that DO values higher than 5 mg/l have often been recommended for intensive culture practices. Banerjee (1967) also reported that oxygen concentration above 5 mg/l is indicative of productivity. DO value of present experiment ranged from 5.81-6.89 mg/l in different treatments was in the acceptable limit.

The pH of water is a measure of hydrogen ion concentration and indicator of the water quality is either acidic or basic. Das *et al*. (1995) reported that the water having a pH range of 6.5-9.0 is more suitable for fish culture and values above 9.5 are unsuitable. Das *et al*. (1995) also suggested that a pH range of 6.12-8.6 is most suitable for survival of the Indian major carp fry. The pH in the present study ranged between 7.72 and 8.23, which is in the desirable limits for the optimum growth of three species of Indian major carps (*Labeo rohita*, *Gibelion catla* and *Cirrhinus cirrhonus*).

Growth performance of experimental fishes (*Labeo rohita*, *Gibelion catla* and *Cirrhinus cirrhonus*)

Abid and Ahmed (2009) conducted an experiment to determine the efficacy of varying dietary protein regimes on growth of *Labeo rohita* fingerlings under intensive rearing for a period of six months where the mean body weight gain ranged from 5.99-21.97 g in seven different treatments. The result of the present study showed that the mean body weight gain of Indian major carps *Labeo rohita*, *Gibelion catla* and *Cirrhinus cirrhonus* ranged from 6.99-7.11g, 7.66-9.95g, 2.73-8.87g respectively which is slightly lower than those of previous record. Sinha and Ramachandran (1985) reported that under crowded condition and higher stocking density fish suffer stress due to aggressive feeding interaction, eat less and grow slowly. Indian major carps are sensitive to environmental conditions and do not attain maximum growth in a confined environment compared with other hardy species such as tilapia and common carp (Benkappa and Verghese, 2003). Due to the static and controlled experimental condition, growth of Indian major carp in different treatments was less because of the unavailability of plankton and other growth promoting factors compared to that of pond system. Saha *et al*., (1997) found that the daily weight gain of Catla, Rui and Mrigal were 0.53g to 0.70g, 0.38g to 0.57g and 0.39g 0.93g which is not agreed with the present study due to location, time and culture system. In the present study, weight gain (%) is similar with Patnaik *et al*. (2005) who reported that the weight gain (%) of Indian major carp (*Gibelion catla*) fry in five different treatments varied from 82.67%-220.43% in 70 days experiment in fiberglass tank (2.5 x 1 x 1 m). Weight gain (%) is higher in *Gibelion catla* in different treatment which is similar with Abid and Ahmad (2009).

Abid and Ahmad (2009) reported that the SGR (%/day) value of *Labeo rohita* fingerlings ranged 3.11-12.21%/day in different treatments. Patnaik *et al*. (2005) observed the SGR (%/day) of Indian major carps (*Gibelion catla*) reared in fiberglass tank varied from 0.86-1.67%/day. Mustafa *et al*. (2010) conducted an experiment (60 days) on culture of climbing perch (*Anabas testudineus*) in cement tanks (12×6×1.5feet) using different protein level diets where SGR (%/day) value ranged from 0.9-1.26%/day in four different treatments. Present study showed that, the SGR (%/day) values of Indian major carps (*Labeo rohita*, *Gibelion catla*, and *Cirrhinus cirrhonus*) in different treatments ranged from 0.44%/day to 0.97%/day which are similar to the findings of Patnaik *et al*., (2005). Pillay (1992) reported that, prolonged exposure of dissolved oxygen bellow optimum level in water and too much excretory products of the fish suppress its own growth rate. In static water condition (aquarium) the growth rate also might be suppressed due to small surface area.

Savita *et al*., (2010) conducted an experiment on the growth performance of Indian major carp (*Catla catla*, Ham.) over a period of six months through formulated feeds consisting of three seaweeds, namely *Chlorodesmis fastigiata*, *Padinatetra stomatica* and *Stoechospermumm arginatum* where the average food conversion ratio (FCR) ranged from 0.67-2.54 in three treatment. Abid and Ahmed (2009) monitored the FCR value of *Labeo rohita* ranged from 0.99-1.79 in 7 different diet treatments. The present study showed that the FCR value ranged from 2.80 to 4.01 in three different treatments which were higher than the authors mentioned above.

Tiamiyu *et al*., (2014) conducted an experiment where *Cyprinus carpio* were treated with various levels of raw watermelon seed meal found PER value ranged from 1.09-1.43. Present study showed that the PER value ranged from 0.88 to 1.30. The PER value found in different treatments was similar with the findings of Patnaik *et al*., (2005) who observed the PER value of Indian major carps (*Gibelion catla*) reared in fiberglass tank and the values varied from 0.88 to 1.66.

Tiamiyu *et al*., (2014) and Rahman *et al*., (2012) found that the survival rate (%) of *Cyprinus carpio* fingerlings varied from 93.30 to 100% and from 70 to 93.33%, respectively in different treatments. In present study the survival rate (%) ranged from 42.86 to 80.95%. The survival rate of *Gibelion catla* was reported lowest (42.86% to 61.90%) whereas the survival rate (%) of *Gibelion catla* in 70 days experiment ranged from 83.33 to 100% reported by Patnaik *et al*., (2005).

Cost analysis of formulated diets

The high protein content in the naturally available feeds provides an inexpensive feed supplement during the initial grow-out period suggested by Edwards (2009) agreed with the present result. Dorsa *et al*., (1982), Ofojekwu and Ejike (1984) reported that feeds from plant origin have been reported to be effective and less expensive ingredients to fish diets. In Diet-1 (T_1) and Diet-2 (T_2), shrimp waste and plant based protein especially soybean meal was used as protein supplement respectively. Patnaik and Das (1979) observed that in the recent years, feeds from plant origin have been accepted for Indian major carps as the growth in fishes has been reported to be as good as the traditional feed.

Conclusions

The result showed that the highest weight gain as well the best growth performance of the fingerlings of Indian major carps obtained in T_3 with Diet-3 (commercial feed) and lowest T_2 with Diet-2 (feed without shrimp waste). The weight increment of the fingerlings with Diet-1 (with shrimp waste) was quite near to the values obtained in T_3 for Diet-3. The cost analysis for feed preparation indicated that, the addition of shrimp waste along with other available feed ingredients in finfish diet not only provides better protein percentage in the diet, it also minimized the feed production cost in a significant margin.

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