



Effect of mixed feeding schedules with varying dietary protein levels on the growth performances of common carp (*Cyprinus carpio* Linn.)

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ABSTRACT

The applicability of mixed feeding schedule with varying protein levels in common carp was determined in the present study to reduce feed input cost. Acclimatized common carp, *Cyprinus carpio* Linn (12.06±0.04 g), were distributed in six experimental groups with 3 replicate each comprising ten fingerlings and reared for 8 weeks period in FRP tanks with recycling water system fitted with electrically operated aerators, using completely randomized design. Two kind diets comprising 20% crude protein considered as low protein (LP) diet and 30% crude protein considered as high protein (HP) diets were prepared. Fish of HP fed only HP diet, fish of LP fed only LP diet, fish of 1LP/1HP fed alternatively LP and HP diet at 1 day interval, fish of 3LP/3HP fed alternatively LP and HP diet at 3 days interval, fish of 7LP/7HP fed alternatively LP and HP diet at 7 days interval and fish of 14LP/14HP fed alternatively LP and HP diet at 14 days interval at twice daily for 8 weeks trial period. Results indicated that fish of 1LP/1HP and 3LP/3HP showed comparable growth, feed conversion ratio (FCR), specific growth rate (SGR) and protein efficiency ratio (PER) to the fish of HP but fish of 7LP/7HP, 14LP/14HP and LP were unable to show growth compensation during 8 weeks trial period. Muscle composition of fish indicated that the higher growth efficiency during realimentation was probably due to protein growth rather than fat deposition in gut. Thus, it is suggested that for profitable carp culture, farmers can use mixed feeding schedule with alternate feeding of low protein and high protein diets at 1 or 3 days interval as a means of minimizing the cost of production.

Key words: Mixed feeding schedule, Common carp (*Cyprinus carpio* Linn.), Dietary protein levels, Growth performances

The success of culturing fish depends heavily on maximizing cost effective approaches in the production process. An important approach to reducing feed costs in commercial aquaculture is to develop proper feed and feeding management and husbandry strategies (Lovell 1998), which promote growth, reduces feed input cost and at the same time reduce the quantity of waste products released in the water. The concept of a mixed feeding schedule as based on the observation that the digestibility of dry matter and protein varies from day to day, following an apparent cyclic pattern (Ali *et al.* 2005). The potential of mixed feeding schedules in reducing feed costs and improving nutrient utilization has been proved in *Channa striata*, *Catla catla*, *Labeo rohita*, *Oreochromis niloticus*, *Oreochromis mossambicus* × *O. niloticus*, *Pangasius hypophthalmus*, *Oncorhynchus mykiss*, *Marone chrysops* × *Marone saxatilis* and *Clarias gariepinus* (Hashim 1994, Nandeeshia *et al.* 1994, Sardar *et al.* 2008, Patel and Yakupitiyage 2003, Bolivar *et al.* 2006, El-Husseiny

et al. 2008, Fatan *et al.* 2005, Ali *et al.* 2005, Hossain *et al.* 2006, Sevgili *et al.* 2006, Turano *et al.* 2007 and Adewolu and Adoti 2010). Ali *et al.* (2005) suggested that feeding fish continuously with high protein diet is not economical. Therefore, the present study was planned to determine the effects of the use of mixed feeding schedules on growth, body composition and excretion of nitrogen and phosphorus of common carp (*Cyprinus carpio* Linn.) in culture conditions.

MATERIALS AND METHODS

Common carp (*Cyprinus carpio* L.) fingerlings were procured & acclimated to experimental conditions in laboratory in two flow-through fibre tanks for 2 weeks by feeding a commercial carp diet twice a day. After acclimation of fish, the experimental trial was conducted in the experimental facilities with 180 litre capacity (Water volume 150 litre) rectangular flow through fibre reinforced plastic (FRP) tanks (0.72×0.53×0.49 m³) with flow rate about 2 l/min for a period of 8 weeks. Two experimental diets (Table 1) consisting of low protein (20% protein, LP) and high protein (30% protein, HP) were prepared using locally

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Table 1. Formulation and proximate compositions of experimental diets for common carp*

Ingredients (%)	Diet	
	Low protein diet (LP), 20% crude protein	High protein diet (HP), 30% crude protein
Maize	25.35	16.05
Broken rice	20.00	7.00
Deoiled rice bran	13.50	6.00
Soybean meal	13.50	25.30
Groundnut cake	14.50	32.50
Fish meal	5.00	5.00
Soyabean oil	3.00	3.00
Guar gum	2.00	2.00
DCP (dicalcium phosphate)	1.00	1.00
LSP (lime stone powder)	0.50	0.50
Iodized salt	1.00	1.00
Trace minerals premix ¹	0.02	0.02
Vitamin premix ²	0.45	0.45
Methionine	0.10	0.10
Lysine	0.05	0.05
BHA (butylated hydroxyl anisole)	0.03	0.03
<i>Proximate compositions (as fed basis, n = 3 samples)</i>		
Moisture (%)	8.97	9.14
Crude protein (%)	20.00	30.09
Crude fat (%)	7.52	7.57
Crude fibre (%)	6.74	7.85
Total ash (%)	5.18	3.42
Nitrogen free extract (%) ³	51.59	41.93
Gross energy (kcal/g) ⁴	4.25	4.47
Inorganic phosphorus (%)	0.57	1.29
Available phosphorus (%) (calculated)	0.34	0.77
Phytate phosphorus (%)	0.23	0.52
P/E ratio (mg/kcal, calculated) ⁵	46.85	67.36
Price of diet (₹/kg)	13.60	16.40

*Proximate composition of ingredients (%)—Maize—moisture, 10.40; crude protein, 4.60; crude fat, 7.80; crude fibre, 2.90; total ash, 1.00; nitrogen free extract, 72.70; Broken rice—moisture, 10.00; crude protein, 12.00; crude fat, 40.20; crude fibre, 5.30; total ash, 3.10; nitrogen free extract, 65.40; Deoiled rice bran—moisture, 7.20; crude protein, 12.10; crude fat, 1.30; crude fibre, 15.20; total ash, 23.80; nitrogen free extract, 40.40; Soybean meal—moisture, 10.00; crude protein, 46.00; crude fat, 0.90; crude fibre, 7.30; total ash, 0.60; nitrogen free extract, 35.20; Groundnut cake—moisture, 10.00; crude protein, 42.00; crude fat, 7.30; crude fibre, 13.00; total ash, 2.50; nitrogen free extract, 25.20; Fish meal—moisture, 9.00; crude protein, 50.00; crude fat, 7.00; crude fibre, 0.50; total ash, 13.00; nitrogen free extract, 20.00.

Trace minerals (mg/kg diet) Cu (CuSO₄ · 5H₂O, 250 g kg⁻¹ Cu), 2.70 mg; Fe (FeSO₄ · 7H₂O, 200.9 g kg⁻¹ Fe) 27.03 mg; Mn (MnSO₄ · H₂O, 360.1 g kg⁻¹ Mn), 11.71 mg; Zn (ZnSO₄, 401.7 g kg⁻¹ Zn), 27.03 mg; I (KI, 760.1 g kg⁻¹ I), 5 mg; Se (Na₂SeO₃, 530.2 g kg⁻¹ Se), 0.27 mg. vitamins (IU or mg/kg diet)²: vitamin A, 20,000 IU, vitamin D₃, 3,000 IU; vitamin E, 16 mg; vitamin K, 2 mg; vitamin B₁, 1.6 mg; vitamin B₂, 10 mg; vitamin B₆, 3.2 mg; vitamin B₁₂, 0.041 mg; niacin, 24 mg, Ca pantothenate, 16 mg; folic acid, 1.6 mg; biotin, 1 mg; ascorbic acid, 100 mg; choline, 1,500 mg. nitrogen free extract³ = 100 – (% protein + % lipid + % ash + % fibre). kcal⁴ = 4.184 kJal. P/E⁵ = protein and energy ratio.

available feed ingredients. Twenty fish (an average body weight 12.06±0.04 g) were randomly stocked into triplicate tanks for each of six treatments such as feeding of fish continuously with high protein diet (30% protein, HP), continuously with low protein (20% protein, LP), one day low protein diet followed by one day high protein diet (1LP/1HP), three days low protein diet followed by three days high protein diet (3LP/3HP), 7 days low protein diet followed by 7 days high protein diet (7LP/7HP), and 14 days low protein diet followed by 14 days high protein diet (14LP/14HP) throughout the experimental period. All the experimental fish were again acclimated to the HP diet for 1 week before the actual feeding of the respective experimental diets. The fish were fed daily at the rate of 3% of their body weight which were divided in two equal amounts and offered at 09:00 and 17:00 hours daily. Any uneaten feed was collected 1 hour after every feeding and the dry matter content was determined for both supplied and uneaten diet (AOAC 1995) and the data used for feed consumption calculation. Fish were weighed every fortnight and the daily rations adjusted accordingly. Daily water temperatures were recorded at morning and evening and water samples were collected fortnightly for water quality analysis. Initially carps fingerlings were subjected for estimation of initial whole carcass composition on wet weight basis. At the end of the experiment fish were collected for estimation of final muscle composition on wet weight basis. Feed conversion ratio (FCR), Protein efficiency ratio (PER) specific growth rate (SGR), and percent survival in fish were calculated according to Castell and Tiews (1980). Feed costs per unit average weight gain (AWG) were calculated by multiplying diet prices in Indian Rupees (₹/kg) of each treatment with their respective average FCR values. In the estimation of cost saving of the schedules, feed cost of treatment HP was assumed as 100%. Proximate compositions (dry matter DM%, crude protein CP%, ether extract EE%, crude fiber CF% and total ash TA%) were performed for feed ingredients (dry matter basis), experimental diet (dry matter basis) and carcass of fish (wet weight basis) (AOAC 1995). Experimental diets and fish samples were analyzed for P contents according to AOAC (1990). Phytate-phosphorus was determined according to the method of Latta and Eskin (1980). Gross energy of feed was estimated by combustion in a microbomb calorimeter. Water quality parameters were determined following APHA (1998) methods. The growth performance, feed utilization, survival and muscle composition data were analysed using one-way ANOVA (Snedecor and Cochran 1994) and Duncan's Multiple Range Tests (Duncan 1955) were to analyze the significance of the difference among the means of treatments (P<0.05) by using Compare Means (SPSS 1997) on PC.

RESULTS AND DISCUSSION

Except ammonia nitrogen (NH₃-N) and phosphate

phosphorus ($\text{PO}_4\text{-P}$), all other water quality parameters like temperature, pH, dissolved oxygen (DO), free carbon dioxide (CO_2) and total alkalinity did not vary significantly between any of the treatments (Table 2) and were within the optimal range of fish production (Banerjee 1967, Jhingran 1991). This finding corroborated the observation of our earlier study in Indian major carp, rohu *Labeo rohita* (Sardar *et al.* 2008). $\text{NH}_3\text{-N}$ concentrations in water were significantly ($P<0.05$) highest (0.033 mg/l) in treatment HP followed by 7LP/7HP (0.013 mg/l) and 14LP/14HP (0.012 mg/l) but it did not vary between LP, 1LP/1HP and 3LP/3HP those showed the significantly ($P<0.05$) equal lowest value of 0.004 mg/l. $\text{PO}_4\text{-P}$ concentrations in water of different treatments showed exactly the similar trend of $\text{NH}_3\text{-N}$ content. Therefore it is obvious that statistically significant increases ($P<0.05$) in $\text{NH}_3\text{-N}$ production and $\text{PO}_4\text{-P}$ concentration were in the treatment where fish fed high protein diet continuously might be due to more excretion of nitrogenous metabolites or due

to releasing of more amount of phytate bound protein and phosphorus of soybean meal and thus might result eutrophication in the fresh water environment. Similar observations were also reported by NRC (1993), Brunty *et al.* (1997), Yang *et al.* (2002), Cheng *et al.* (2003) and Sardar *et al.* (2007).

The effect of mixed feeding on growth and feed utilization is shown in Table 3. Significantly ($P<0.05$) highest percent survival (100%) of fish was observed in HP, 1LP/1HP and 3LP/3HP followed by 7LP/7HP and 14LP/14HP (more than 95%), whereas significantly ($P<0.05$) lowest percent survival (90%) was found in fish of LP (Figure 1). Initial body weight did not vary significantly ($P>0.05$) between any of the dietary treatments. Significantly ($P>0.05$) higher weight gain and specific growth rate (SGR) were observed in common carp of treatment 1LP/1HP and 3LP/3HP fed the low protein and high protein diet on every alternate day and alternately at 3 days interval respectively in comparison to fish fed high

Table 2. Average (mean $\pm$ SE) water quality parameters observed in different treatments*

Parameters	Treatment					
	HP	LP	1LP/1HP	3LP/3HP	7LP/7HP	14LP/14HP
Temperature ($^{\circ}\text{C}$)	28.3 $\pm$ 2.9	27.9 $\pm$ 2.7	27.7 $\pm$ 3.0	27.7 $\pm$ 2.5	27.8 $\pm$ 2.5	28.1 $\pm$ 2.1
pH	6.5 $\pm$ 0.4	6.7 $\pm$ 0.4	6.2 $\pm$ 0.4	6.4 $\pm$ 0.3	6.4 $\pm$ 0.3	6.3 $\pm$ 0.3
Dissolved oxygen (mg/l)	7.3 $\pm$ 0.1	7.1 $\pm$ 0.2	7.2 $\pm$ 0.3	7.0 $\pm$ 0.3	7.4 $\pm$ 0.2	7.3 $\pm$ 0.3
Free carbon dioxide (mg/l)	4.6 $\pm$ 0.3	4.8 $\pm$ 0.2	4.9 $\pm$ 0.1	4.7 $\pm$ 0.3	4.7 $\pm$ 0.2	4.6 $\pm$ 0.2
Total alkalinity (mg/l)	135.5 $\pm$ 20.1	146.5 $\pm$ 25.1	126.5 $\pm$ 15.1	141.7 $\pm$ 20.1	130.5 $\pm$ 18.1	138.3 $\pm$ 23.5
Ammonia nitrogen (mg/l)	0.033 ^a $\pm$ 0.001	0.004 ^c $\pm$ 0.004	0.004 ^c $\pm$ 0.003	0.004 ^c $\pm$ 0.002	0.013 ^b $\pm$ 0.003	0.012 ^b $\pm$ 0.01
Phosphate phosphorus (mg/l)	2.8 ^a $\pm$ 0.01	0.4 ^c $\pm$ 0.03	0.4 ^c $\pm$ 0.02	0.4 ^c $\pm$ 0.04	0.9 ^b $\pm$ 0.04	1.0 ^b $\pm$ 0.02

*Values are mean $\pm$ SE of triplicate groups (n = 16); Means carrying different superscript showed significant difference ($P<0.05$).

Table 3. Growth and feed utilization of common carp (*Cyprinus carpio* Linn) maintained on mixed feeding schedules

Parameters	Treatment					
	HP	LP	1LP/1HP	3LP/3HP	7LP/7HP	14LP/14HP
Initial weight (g)	12.06 $\pm$ 0.04	12.06 $\pm$ 0.04	12.06 $\pm$ 0.04	12.06 $\pm$ 0.04	12.06 $\pm$ 0.04	12.06 $\pm$ 0.04
Final weight (g)	65.50 ^b $\pm$ 8.89	34.63 ^d $\pm$ 3.23	84.12 ^a $\pm$ 5.67	83.77 ^a $\pm$ 6.52	54.96 ^c $\pm$ 7.21	50.03 ^c $\pm$ 2.25
Weight gain (g)	53.44 ^b $\pm$ 4.36	22.57 ^d $\pm$ 2.21	72.06 ^a $\pm$ 6.23	71.71 ^a $\pm$ 5.89	42.90 ^c $\pm$ 6.12	37.97 ^c $\pm$ 5.65
Weight gain (%)	443.11 ^b $\pm$ 10.26	187.15 ^c $\pm$ 6.98	597.51 ^a $\pm$ 12.44	594.61 ^a $\pm$ 10.88	355.72 ^c $\pm$ 9.89	314.84 ^d $\pm$ 8.49
Feed intake (g)	120.24 ^b $\pm$ 14.23	70.42 ^c $\pm$ 12.89	146.28 ^a $\pm$ 16.25	146.28 ^a $\pm$ 15.78	116.69 ^b $\pm$ 12.99	111.40 ^b $\pm$ 11.69
FCR ¹	2.25 ^c $\pm$ 0.05	3.12 ^a $\pm$ 0.13	2.03 ^d $\pm$ 0.06	2.04 ^d $\pm$ 0.07	2.72 ^b $\pm$ 0.11	2.93 ^b $\pm$ 0.12
PER ²	1.48 ^c $\pm$ 0.06	1.60 ^b $\pm$ 0.07	1.97 ^a $\pm$ 0.05	1.96 ^a $\pm$ 0.06	1.47 ^c $\pm$ 0.04	1.36 ^d $\pm$ 0.05
SGR ³ (%/d)	2.81 ^b $\pm$ 0.04	1.83 ^c $\pm$ 0.02	3.23 ^a $\pm$ 0.05	3.23 ^a $\pm$ 0.06	2.53 ^c $\pm$ 0.05	2.36 ^d $\pm$ 0.03
Survival (%)	100.00 ^a $\pm$ 0.00	90.00 ^c $\pm$ 1.20	100.00 ^a $\pm$ 0.00	100.00 ^a $\pm$ 0.00	96.67 ^b $\pm$ 3.33	96.67 ^b $\pm$ 3.33
Feed cost (Rs./kg fish)	36.90	42.43	30.45	30.60	40.80	43.95
Cost saving (%) ⁴	-	(-)14.99	(+)17.48	(+)17.07	(-)10.57	(-)19.11

*Values are mean $\pm$ SE of triplicate groups (n = 5); Means in each row carrying different superscript showed significant difference ($P<0.05$).

¹FCR, Feed (DM) intake (g) / Live weight gain (G).

²PER, Live weight gain (g) / Protein intake (g).

³SGR, $\text{Log } e W_t - \text{Log } e W_0 / \text{Time (t) X 100}$; where W_t = weight (g) attained after specific period of time 't' of experiment; W_0 , weight (g) at '0' day of experiment; t, Specific period (hour or day or week or month or year) of experiment.

⁴ (-) and (+) indicate % more cost and % less cost respectively in comparison to HP.

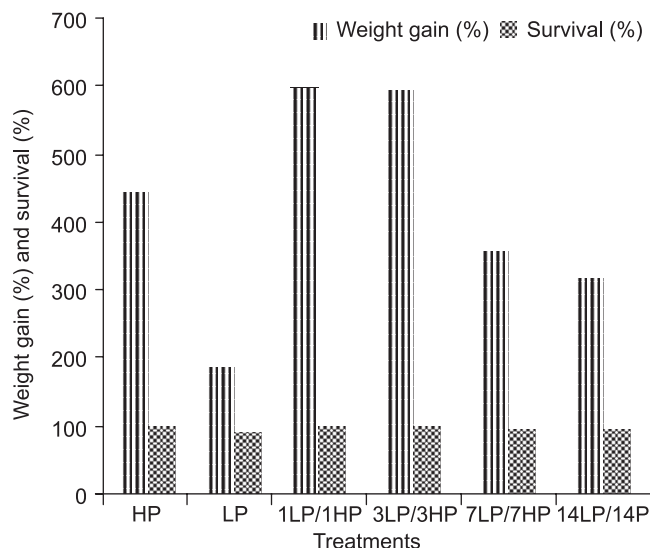


Fig 1. Weight gain (%) and survival (%) of common carp (*Cyprinus carpio* Linn.).

protein diet continuously. Weight gain (Fig. 1), protein efficiency ratio (PER) and SGR were significantly lower in fish of 7LP/7HP and 14LP/14HP than that of fish of HP. Although fish of LP showed significantly lower weight gain and SGR, protein efficiency ratio (PER) was significantly higher in comparison to fish of HP. Feed intake was increased when fish were subjected to mixed feeding schedule of 1LP/1HP and 3LP/3HP but again decreased at feeding schedule of 7LP/7HP and 14LP/14HP. Significantly lowest feed intake was observed in fish of LP. Significantly lower feed conversion ratio (FCR) was exhibited by the fish subjected to the mixed feeding schedules of 1LP/1HP and 3LP/3HP whereas it was higher in fish of 7LP/7HP and 14LP/14HP in comparison to fish of HP. Fish of LP exhibited significantly highest FCR. Overall, when fish fed the low protein diet continuously common carp exhibited poorest growth and feed utilization. The most economical feed cost per kilogram fish production was obtained in the group of fish reared on both 1LP/1HP and 3LP/3HP where feed cost was about 17% less than that of HP.

Our results of feeding trial demonstrated that the mixed feeding schedule of a low protein alternated with a high protein at one (1LP/1HP) and three (3LP/3HP) days interval resulted in the best growth and feed utilization in fish for showing compensatory growth in comparison to common carp fed a high protein diet continuously (HP) might be due to stress of fish with high ammonia content in the later group and better protein digestibility in the fish of former group (Ali *et al.* 2005). In agreement with the present finding, Nandeesh *et al.* (2002), Patel and Yakupitiyage (2003), Bolivar *et al.* (2006) and Sardar *et al.* (2008) observed higher growth and feed utilization using mixed feeding schedule in fishes. Therefore, mixed feeding schedule might be considered as a possible way of feeding management for

reducing feed cost. In corroboration with the present findings Wang *et al.* (2000), Jiang *et al.* (2002), Li and Qin (2003), Ali *et al.* (2005), Sardar *et al.* (2008) observed that specific growth rate in deprived groups of tilapia, red drum, *Lates calcarifer*, sutchi catfish and silver carp and rohu respectively was greater to achieve compensatory growth. Hyperphagia may be the one of the important mechanism of compensatory growth as confirmed in the present study was also in agreement with the findings of Cho *et al.* (2006), Turano *et al.* (2007), Sardar *et al.* (2008), Hakim *et al.* (2009). Feeding daily at a recommended protein level and a constant feeding rate is the most prevalent practice in fish farming. However, De Silva and Perera (1984) observed a rhythmic variation in the protein digestibility of Nile tilapia under laboratory conditions. Based on this observation, it was hypothesized that continuously high protein feeding may be wasteful as on a day when the digestibility efficiency of the fish is high, relatively lower protein intake would be sufficient to fulfill the requirement and vice versa. Subsequently, De Silva (1985) demonstrated that mixed feeding schedules, whereas a high protein diet was alternated with a low protein diet, were more efficient in term of growth and nutrient utilization compared with feeding Nile tilapia with a high protein diet continuously. The results of the present trial compared well with earlier investigations on *Channa striata* (Hashim 1994), Indian major carps, *catla catla* (Nandeesh *et al.* 1994), *Labeo rohita* (Sardar *et al.* 2008), *Oreochromis niloticus* (Patel and Yakupitiyage 2003, Bolivar *et al.* 2006, El-Husseiny *et al.* 2008), *Oreochromis mossambicus* × *O. niloticus* (Fatan *et al.* 2005), *Pangasius hypophthalmus* with *Hypophthalmichthys molitrix* (Ali *et al.* 2005, Hossain *et al.* 2006), *Oncorhynchus mykiss* (Sevgili *et al.* 2006), *Marone chrysops* × *Marone saxatilis* (Turano *et al.* 2007), *Clarias gariepinus* (Adewolu and Adoti 2010).

The poor growth exhibited by common carp fed with a low protein diet regularly is probably a consequence of an insufficient intake of protein and energy in the diet (Ali *et al.* 2005). Because of significant improvement in feed utilization and higher growth performance of common carp, the mixed feeding schedule of 1LP/1HP and 3LP/3HP proved to be more efficient in economic terms might be due to better feed utilization in terms of FCR and PER. It is reasonable to assume that the results reflect the effectiveness of the mixed feeding schedules as a husbandry practice in carp. PER in common carp was lower with regular feeding with HP in comparison to continuous feeding with a LP. Similar trends were also noticed in earlier studies with sutchi catfish (Ali *et al.* 2005). Protein efficiency ratio did not reflect the growth trend; instead, it varied inversely with the amount of crude protein in the diet. The higher PER recorded in the LP suggests the efficient utilization of the small quantity of protein provided for growth.

The effect of mixed feeding schedule with alternate feeding of low and high protein diet on whole body

Table 4. Initial and final whole body composition (wet weight basis) of common carp *Cyprinus carpio* Linn maintained on mixed feeding schedules in laboratory condition for 8 weeks*

Parameters	Treatment						
	Initial	HP	LP	1LP/1HP	3LP/3HP	7LP/7HP	14LP/14HP
Moisture (%)	79.724±0.03	76.01±0.08	75.64±0.06	74.64±0.08	76.21±0.07	75.62±0.05	76.12±0.07
Crude protein (%)	12.75±0.01	15.44 ^a ±0.07	13.44 ^b ±0.03	15.42 ^a ±0.08	15.43 ^a ±0.06	13.48 ^b ±0.06	13.46 ^b ±0.05
Crude lipid (%)	2.57±0.01	2.93 ^a ±0.06	2.63 ^b ±0.04	2.91 ^a ±0.05	2.89 ^a ±0.07	2.66 ^b ±0.07	2.65 ^b ±0.05
Total ash (%)	3.45±0.02	3.48 ^a ±0.03	3.16 ^b ±0.04	3.49 ^a ±0.06	3.47 ^a ±0.05	3.19 ^b ±0.08	3.20 ^b ±0.06
Phosphorus (%)	0.45±0.05	1.09 ^b ±0.09	0.99 ^c ±0.08	1.20 ^a ±0.04	1.18 ^a ±0.03	1.11 ^b ±0.02	1.13 ^b ±0.03

*Values are mean±SE of triplicate groups (n = 5); Means in each row carrying different superscript showed significant difference (P<0.05).

compositions of common carp (*Cyprinus carpio* L.) is presented in Table 4. Whole body moisture contents of fish were decreased and crude protein, crude lipid and total ash in fish were increased to initial values. Whole body moisture content of common carp did not differ among the different dietary groups whereas significantly (P<0.05) higher protein, lipid and ash content were found in fish fed high protein diet continuously, one day low protein diet followed by one day high protein diet (1LP/1HP) and three days low protein diet followed by three days high protein diet (3LP/3HP) in comparison to fish of LP, 7LP/7HP and 14LP/14HP. Though significantly lowest and highest phosphorus (P) content was observed in fish of LP and 1LP/1HP 3LP/3HP respectively, it did not vary between fish of HP, 7LP/7HP and 14LP/14HP. Generally, there was low fat accumulation in fish receiving LP throughout. A similar trend of findings was also reported with *Oreochromis niloticus* (De Silva 1985), sutchi catfish and silver carp (Ali *et al.* 2005), *Labeo rohita* (Sardar *et al.* 2008), *Oncorhynchus mykiss* (Sevgili *et al.* 2006).

The possible physiological mechanisms that could be operating in regard to daily changes in digestibility and thereby the response of fish to a mixed feeding schedule have been discussed by De Silva (1985). In aquaculture, the ultimate aim is not to achieve the highest mean weight (De Silva *et al.* 1989) but especially, in the current context of practices, the emphasis is also on a low environmentally burden and the cost effectiveness. The overall results of the present trial provided evidence of the potential applicability of mixed feeding schedules in reducing the feed cost and environmental pollution in terms of P and N content in water under laboratory conditions of carp culture. Furthermore, this investigation also supports the hypothesis that it is economically beneficial and biologically more productive to provide the fish with LP and HPs alternately both at one and three day interval, instead of feeding only the HP (De Silva 1985). Among the mixed feeding schedule, the highest saving in protein and cost may be achieved with feeding of fish by alternate low and high protein diet at both one and three days interval during culture period. Thus, this study indicated that for profitable carp culture, farmers can use a

mixed feeding schedule using alternate feeding of LP and HPs at one or three days interval (1LP/1HP or 3LP/3HP) as a means of reducing feed cost.

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