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Cyclic feeding of low and high protein diets reduces production cost of *Labeo rohita* (Hamilton, 1822)

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ABSTRACT

Eighty four days feeding trial (3 feeding cycle ; each cycle of 28 days comprising 21 days with low protein and 7 days with normal or high protein diets) was conducted with *Labeo rohita* fingerlings to investigate the growth performance. Four diets; D_1 (10% CP); D_2 (30% CP); D_3 (35% CP) and D_4 (40% CP) were prepared. A total of 225 fingerlings were distributed randomly into five treatments in triplicates. T_1 and T_2 groups were fed with D_1 and D_2 diets respectively throughout the experimental period. The feeding cycle of 28 days consisted of 21 days feeding with D_1 and 7 days with D_2 (T_3); D_3 (T_4) or D_4 (T_5). Higher growth rate in terms of specific growth rate, feed conversion ratio and apparent net protein utilisation were found in T_2 and T_3 group compared to T_4 and T_5. However, protein efficiency ratio of T_3 group was significantly higher than the T_2 group ($p<0.05$). Highest and lowest content of protein and lipid was observed in T_2 group, whereas, the ash content was highest in T_1 group. Feeding cost was considerably reduced with T_3 group of low protein intake (43.63%) registering 20.17% saving in production cost. The results indicate that fish fed with cyclic feeding schedule of 21 days with D_1 (10% CP) followed by 7 days with a normal diet, D_2 (30% CP) could reduce the production cost with considerable savings in feed cost.

Keywords: Cyclic feeding schedule, Dietary protein level, Feed cost, *Labeo rohita,* Production cost, Protein utilisation

Introduction

Feed is the major input in terms of cost in fish culture, that invites the attention of nutritionists to reduce the cost by optimising the most expensive nutrient protein (Wee and Wang, 1987) either through proper formulation or adopting economic feeding strategies. The cost of feed is largely influenced by protein in terms of its level of inclusion and its source. The reduction of feed cost by the substitution of fishmeal by cheaper protein sources is the possible alternate approach (Tacon and Jackson, 1985; Kaushik, 1989). Use of locally available ingredients through proper processing methods in order to improve the nutritional quality for feed preparation is recommended even by FAO (Anon., 1993). The efficacy of various plant protein sources for partial or complete replacement of fishmeal in aqua-feeds has been investigated by a number of workers (Atack and Matty, 1979; Viola *et al*., 1982; Tacon, 1993; Ray and Das, 1995).

Another approach to reduce feed cost is the management in feeding (Singh and Srivatava, 1984, 1985). Published reports state that feeding of fish with same level of protein every day is not economical (De Silva, 1985) and strategy of cyclic/mixed feeding schedule resulted in better nutrient utilisation. Application of mixed feeding schedules in feed cost reduction and nutrient utilisation improvement is reported in different fish species like Indian major carps, *Catla catla* and *Labeo rohita* (Nandeesha *et al.,* 1993, 1994); common carp, *Cyprinus carpio* (Srikanth *et al*., 1989; Nandeesha *et al*., 1995, 2002); Nile tilapia, *Oreochromis niloticus* (Patel and Yakupitiyage, 2003); Sutchi catfish, *Pangasius hypophthalmus*; and silver carp, *Hypophthalmichthys molitrix* (Ali *et al*., 2005).

Labeo rohita is the most preferred species constituting about 35% of the total Indian major carps production (FAO, 2000). *L. rohita* is a herbivorous species and primarily prefers to feed on plant materials (Talwar and Jhingran, 1991). Feeding of 30% crude protein (CP) may not be required for rohu fingerlings on day to day basis as reported for other species. Hence, cyclic feeding of low protein diet followed by a normal or high protein diet may be an ideal strategy to reduce the production cost. There is scanty information on this aspect and therefore, the present experiment was conducted with the objective to select an ideal feeding strategy for economic production of *L. rohita* fingerlings

Materials and methods

The experiment was conducted for 84 days using fingerlings of *L. rohita* (5.45±0.03 g). The fingerlings were brought from fish seed farm at Kosamba in Gujarat and acclimated to the experimental condition for one month. Fifteen fishes were stocked in each tub (100 l capacity) with continuous aeration. Feed was formulated and prepared by weighing all ingredients and mixing in a big bowl to get homogenous mixture. Dough was made with the addition of sufficient water and oil was added to the dough for uniform distribution. Steaming of the dough was done for 10 min in a pressure cooker and vitamin-mineral premix (EmixTM plus, India) along with vitamin C was added after cooling. Uniform sized pellets were made with hand pelletiser and pellets were dried in oven at 50°C after air drying for 4 h. The completely dried pellets were packed in airtight labeled polythene bags and stored at 4°C until use. Fingerlings were fed to apparent satiation twice a day at 09 00 hrs in the morning and 18 00 hrs in the evening. Cleaning of the experimental tubs were done every day by siphoning out the water along with faecal matter and left over feed and same volume of water was replaced with fresh bore well water free of chlorine.

Feeds and feeding schedules

Experimental diet formulation and its proximate composition are given in Table 1. Four diets were prepared *viz.,* D_1 (10% CP); D_2 (30% CP); D_3 (35% CP) and D_4 (40% CP). The feeding trial was conducted with five treatments (T_1 to T_5) in triplicate. The feeding schedules followed included a cycle of 28 days, which consisted of 21 days of feeding with D_1 and 7 days with D_2, D_3 or D_4. The treatments were T_1 (D_1 fed group); T_2 (D_2 fed group) and three cyclic feeding schedules *viz.* T_3 (21 days feeding with D_1 and 7 days feeding with D_2), T_4 (21 days feeding with D_1 and 7 days feeding with D_3) or T_5 (21 days feeding with D_1 and 7 days feeding with D_4). The fish were fed for 84 days.

Growth study

Growth was assessed at each cycle (21st and 28th day) by bulk weighing of fingerlings in each tub and performance was evaluated in terms of WG (weight gain %), SGR (specific growth rate) and feed utilisation parameters like FCR (feed conversion ratio), FCE (feed conversion efficiency), PER (protein efficiency ratio) and ANPU (apparent net protein utilisation) calculated using the following standard formulae:

WG (Weight gain) % = (Final weight-Initial weight)/Initial weight x 100

SGR = 100 (ln average final weight - ln average initial weight)/No. of culture days

Table 1. Experimental diet formulation and its proximate composition

Ingredients (%)	Experimental diets			
	D_1 (10% CP)	D_2 (30% CP)	D_3 (35%CP)	D_4 (40% CP)
Fish meal	-	15.00	20.00	25.00
Soybean	2.00	36.00	41.00	48.00
Rice bran	40.00	12.00	9.00	5.00
Wheat bran	36.00	15.00	9.00	5.00
Wheat flour	15.00	15.00	14.00	10.00
Cod liver oil: Sunflower oil (1:2)	5.00	5.00	5.00	5.00
CMC*	0.50	0.50	0.50	0.50
Vitamin-mineral mix**	1.40	1.40	1.40	1.40
Vitamin C	0.10	0.10	0.10	0.10
Total	100.0	100.0	100.0	100.0
Proximate composition of the diets (% DM)				
Organic matter	90.78	90.80	90.61	90.54
Protein	12.79	30.86	35.96	41.22
Lipid	5.66	5.29	5.26	5.55
Ash	15.14	9.82	9.46	9.23
Crude fiber	16.32	11.45	10.53	10.23
Nitrogen free Extract	50.49	42.58	38.79	33.77
Gross energy (kcal 100 g^{-1})	369.34	387.17	388.46	390.83

CMC* = Carboxy methyl cellulose,

Vitamin-mineral mix** = Composition of vitamin mineral mix (EMIX PLUS) (quantity/2.5 kg): Vitamin A 55,00,000 IU; Vitamin D_3 1,100,000 IU; Vitamin B_2 2,000 mg; Vitamin E 750 mg; Vitamin K 1,000 mg; Vitamin B_6 1,000 mg; Vitamin B_{12} 6 mcg; Calcium Pantothenate 2,500 mg; Nicotinamide 10 g; Choline chloride 150 g; Mn 27,000 mg; I 1,000 mg; Fe 7,500 mg; Zn 5,000 mg; Cu 2,000 mg; Co 450 mg; Ca 500 g; P 300 g; L-lysine 10 g; DL-methionine 10 g; Selenium 50 ppm; Selenium 50 ppm; Satwari 250 ppm.

PER	=	Total wet weight gain (g)/Crude protein fed (g)
ANPU	=	(Final tissue protein-Initial tissue protein)/ Protein fed x100
Survival %	=	(Final no. of fish harvested/Initial no. of fish stocked) x100

Diet and tissue analysis

Proximate composition of the diets and whole fish were analysed following the standard methods of AOAC (1995) at the beginning and end of the feeding trial. Moisture content was determined by drying the samples at 105°C to a constant weight. Nitrogen content was analysed by Kjeltec (2200 Kjeltec auto distillation, Foss Tecator, Sweden) and crude protein (CP) content was estimated by multiplying nitrogen percentage by 6.25. Ether extract (EE) was analysed by Soxtec (1045, Soxtec extraction unit, Tecator, Sweden) using diethyl ether (boiling point, 40-60°C) as a solvent and ash content was estimated by incinerating the samples in a muffle furnace at 600°C for 6 h. Total carbohydrate was calculated using the following formula:

Total carbohydrate (%) = 100 - (CP % + EE % + Ash %).

The digestible energy (DE) value was calculated as per Halver (1976).

Economics and statistical analysis

The cost of each feed was computed from the prevailing market prices of ingredients without taking any other expenditure into account. The total feed and feeding cost for each treatment was determined and calculated for the savings in terms of protein intake and production cost (Table 4). For calculation of economics, the cost incurred in case of T_2 group was compared with other groups.

The software SPSS version 14.0 was used for the statistical analysis of the data. The treatment effects were compared with ANOVA and comparison among the means was made using Duncan's multiple range tests (1955)

Results and discussion

Growth performance

Growth rate of fingerlings (Table 2) during experimental period of 56 days (Fig. 1 and 2) was similar in all treatment groups and T_5 fed group exhibited the lowest growth rate among the entire schedule. Similar pattern was also recorded for SGR. Highest weight gain (WG %) was recorded in group fed with T_3, which was not different from T_2 group (p>0.05).

In the present experiment, 21 days feeding of fingerlings with low protein diet continued by 7 days feeding with normal protein diet (T_3) was found to be equally effective and comparable to fingerlings fed continuously with 30% CP (T_2). It appears that feeding 30% protein daily in the diet or cyclic feeding of 10% CP for 21 days followed by 30% CP for 7 days were equally effective for growth in *L. rohita* fingerlings. This reveals that normal protein diet is not necessary for daily feeding as the protein requirement of a species is an average figure of an extended period. Hence adopting cyclic feeding schedule of variable protein levels for short duration may satisfy the requirement. Beneficial

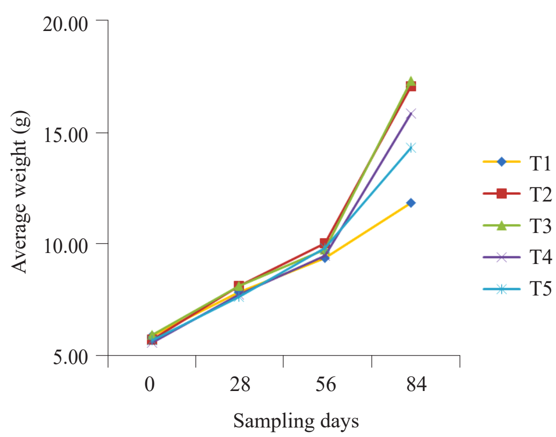

Fig. 1. The average growth of *L. rohita* fingerlings at the end of each cyclic feeding schedule

Table 2. The growth performance of fingerlings maintained on cyclic feeding schedule for 84 days

Parameters	Feeding schedules				
	T_1	T_2	T_3	T_4	T_5
Initial body weight (g)	5.65±0.01	5.65±0.04	5.65±0.03	5.46±0.03	5.57±0.04
Final body weight (g)	11.79^a±0.06	17.06^d±0.01	17.31^d±0.07	15.83^c±0.03	14.31^b±0.05
WG (%)	109.56^a±1.42	206.02^d±2.30	209.11^d±2.54	189.85^c±2.62	156.69^b±1.47
SGR (% day)	2.45^a±0.01	2.82^d±0.01	2.83^d±0.01	2.74^c±0.01	2.64^b±0.01
FCR	3.77^d±0.05	2.09^a±0.02	2.00^a±0.04	2.23^b±0.01	2.69^c±0.04
PER	1.62^a±0.02	1.87^b±0.03	2.64^d±0.08	2.23^c±0.01	1.71^a±0.02
ANPU (%)	15.12^a±0.24	34.67^d±0.77	34.52^d±0.77	30.20^c±0.09	21.62^b±0.47
Survival rate (%)	100	100	100	100	100

Mean values bearing different superscripts in a row are significantly different (p<0.05)

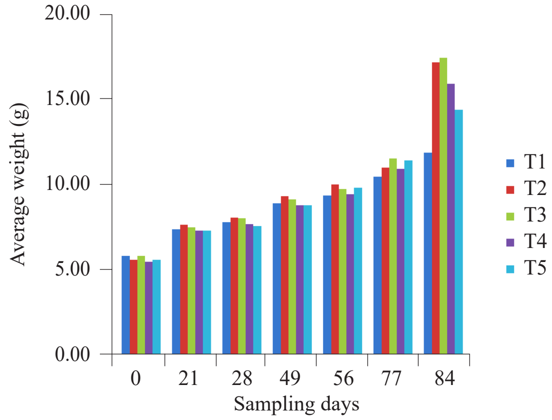

Fig. 2. Average weight of *L. rohita* fingerlings at each sampling days over 84 days

effect of mixed/cyclic feeding schedule as suitable strategy has been reported in common carp (Srikanth *et al.*, 1989; Nandeesha *et al*., 1993).

FCR and PER were also significantly influenced by the different feeding schedules. Lowest FCR was observed in T_3, which was not different from T_2, whereas highest FCR was recorded in T_1 group. The highest PER was recorded in T_3 and lowest in T_5, which was not different ($p>0.05$) from T_1 group. However, the highest ANPU was recorded in T_3, which was not different from T_2 ($p>0.05$). The ANPU value gradually decreased with higher protein feed fed in T_4 and T_5. Lowest ANPU value was found in T_1 group.

The present study showed that the SGR, FCR and ANPU in *L. rohita* fingerlings were influenced by the different feeding schedules. T_3 fed fingerlings performed maximum growth, which was comparable to fingerlings fed with diet of 30% CP (T_2). Similar ANPU values in both the treatment groups suggests that the nutrient utilisation was similar in both groups. T_3 fed group recorded more PER value than T_2 group, due to less protein fed to the T_3 group. As protein content increased in the T_4 and T_5 fed groups, PER and ANPU values decreased which proved that at higher inclusion level, the protein utilisation would be less. Similar studies have been reported in common carp (Nandeesha *et al.*, 1995, 2002).

Muscle tissue composition

Proximate composition of muscle tissue of rohu fingerlings maintained on different feeding schedules is presented in Table 3. Among the different feeding schedules, highest ($p<0.05$) moisture content was observed in T_1 and lowest in T_2 group. Lowest protein and lipid content were recorded in T_1 group, whereas highest protein and lipid content was observed in T_2 group. There was no significant difference in values of lipid content in the muscle of fingerlings fed under various feeding schedules. Highest ash content was recorded in T_1 group and there was no significant difference among the rest of the groups.

Proximate composition of muscle tissue of *L. rohita* fingerlings, maintained on cyclic feeding schedule for 84 days varied considerably among the treatments. Highest content of protein and fat in fish muscle was recorded in T_2 group. The protein and fat deposition in fish muscle was found to clearly correlate with the growth pattern of the group. Fingerlings fed with lowest protein level (T_1) exhibited lowest fat accumulation and this finding was similar to the experiment with common carp (Srikanth *et al.*, 1989; Nandeesha *et al.*, 2002).

Economics

Economics of various feeding schedules for *L. rohita* fingerlings is presented in Table 4. It is evident from various parameters that, the feeding cost for T_3 was minimum when compared to the other feeding schedules. The feed cost for T_1 was the least. The cost of production *i.e.* feeding cost for the production of unit weight of fish was also minimum for T_3. Thus, the T_3 group showed production at less feed cost and minimum protein intake with saving of production cost to the extent of 20.17%. Production cost increased up to 35.38% when fed with T_5. The protein intake of T_3 also significantly reduced to 43.63% compared to T_2.

Overall the results indicated that cyclic feeding of 28 days comprising 21 days feeding of low protein (10%) followed by a normal protein diet (30%) for 7 days led to growth rate similar to the normal protein fed group (30%) continuously. Adopting this feeding strategy helps to save protein to the extent of 43.63%, which translates into an economic saving of production cost to the extent of 20.17%. With the adoption

Table 3. Proximate composition of muscle tissue (% wet weight) of *L. rohita* fingerlings at the end of the experiment

Proximate composition	Treatments				
	T_1	T_2	T_3	T_4	T_5
Moisture	$76.21^{d}\pm0.13$	$73.90^{a}\pm0.20$	$74.74^{b}\pm0.13$	$75.46^{c}\pm0.12$	$75.52^{c}\pm0.08$
Protein	$12.72^{a}\pm0.08$	$16.46^{e}\pm0.13$	$15.86^{d}\pm0.04$	$14.49^{b}\pm0.10$	$14.86^{c}\pm0.06$
Lipid	$2.41^{a}\pm0.013$	$3.32^{c}\pm0.023$	$2.60^{b}\pm0.013$	$2.61^{b}\pm0.013$	$2.62^{b}\pm0.01$
Ash	$3.77^{b}\pm0.081$	$3.06^{a}\pm0.104$	$3.04^{a}\pm0.026$	$3.02^{a}\pm0.012$	$3.07^{a}\pm0.012$

Mean values bearing different superscripts in a row are significantly ($p<0.05$) different

Table 4. Economics of cyclic feeding schedule for *L. rohita* fingerlings maintained for 84 days

Parameters	T_1	T_2	T_3	T_4	T_5
Feed intake (g)	23.35	24.19	24.17	23.12	23.67
Feeding cost (₹ g^{-1})	0.14	0.19	0.16	0.17	0.19
Weight gain (g)	6.14	11.41	11.66	10.37	8.74
Cost of production (₹ kg^{-1})	22.82	16.96	13.47	16.72	22.34
Protein intake (g)	2.99	7.47	4.55	4.74	5.27

Feed cost: 10% CP- ₹ 6.00; 30% CP- ₹ 8.00; 35% CP - ₹12.00; 40% CP- ₹15.00.
Feeding cost (₹) = Feed intake (g) x cost of feed (₹)
Cost of production = (Feeding cost (₹)/ Weight gain (g)) x 1000
Protein intake = Feed intake (g) x CP% of the feed
Cost saving = [(Feeding cost of Control B - Feeding cost of respective schedule)/ Feeding cost of control B] x 100

of this feeding strategy, survival and proximate composition also was not affected much, which proved that feeding a low protein diet followed by normal diet may be an ideal strategy for reducing the production cost in finfish culture. However, long term studies need to be undertaken further as there are few reports on this aspect.

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