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EFFECT OF FEED QUALITY RESTRICTION FOLLOWED BY REALIMENTATION ON GROWTH, NUTRIENT UTILIZATION, BIOCHEMICAL CHANGES AND HAEMATOLOGICAL PROFILES OF INDIAN MAJOR CARP, ROHU (*LABEO ROHITA* H.)

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ABSTRACT

To investigate the effect of protein restriction with subsequent realimentation on nutrient utilization, haematological and biochemical changes of Indian major carp, Rohu (*Labeo rohita* H.), 150 acclimatized Rohu fingerlings (average 20.74 ± 0.13 g) divided into five experimental groups (30 fingerlings in each groups with three replications with 10 fingerlings in each) for experimental trial of 90 days using completely randomized design. Control group (T_{CPR}) was fed with feed having 30% crude protein @ 3% of body weight for 90 days trial period. Other experimental groups T_{1PR} was alternatively 3 days fed with feed having 20% CP and 30% CP @ 3% of body weight, T_{2PR} was alternatively 7 days fed with feed having 20% CP and 30% CP @ 3% of body weight, T_{3PR} was alternatively 15 days fed with feed having 20% CP and 30% CP @ 3% of body weight and T_{4PR} was alternatively 25 days fed with feed having 20% CP and 30% CP @ 3% of body weight during 90 days trial period with daily ration in two equal halves at morning and afternoon. It was noticed that retention of different nutrients was almost similar among all treatment groups indicated improvement of digestibility of nutrients might not be the mechanisms for recovery growth in carps. Increased percent feed intake of body weight (hyperphagia) (4.14 ± 0.30 or 4.94 ± 0.46 and 3.33 ± 0.29), improved specific growth rate (1.86 ± 0.09 or 2.26 ± 0.05 and 1.43 ± 0.01), absolute growth rate (1.57 ± 0.08 or 1.84 ± 0.18 and 1.36 ± 0.12), protein efficiency ratio (1.19 ± 0.11 or1.16 ± 0.12 and 1.05 ± 0.09) were the important mechanism showing better performance index (21.60 ± 1.09 or 23.80 ± 0.21 and 19.45 ± 0.37) through which the experimental groups which were protein restricted and re-alimented at 3 or 7 days alternatively during 90 days trial period could able to compensate the growth retardation and to catch up the final body weight of control (128.68 ± 11.53 g/f) but other experimental groups failed to compensate during 90 days trial period. Result of the present study indicated that deprived fish i.e., fish received alternate 3 or 7 days protein restriction and re-alimentation showed recovery growth had still lower values of Hb (10.21 ± 0.02, and 9.88 ± 0.04 g/dl), haematocrit value (30.62 ± 0.05 and 26.64 ± 0.11%), total erythrocytic count (3.40 ± 0.01 and 3.29 ± 0.01 $X10^6$ mm^3), plasma glucose (126.93 ± 0.20 and 126.67 ± 0.05 mg/dl), total plasma lipid (1.04 ± 0.01 and 1.02 ± 0.01 g/dl) and liver glycogen (290.10 ± 0.80 and 288.99 ± 0.95 mg/kg) in comparison to control (10.56 ± 0.08 g/dl, 31.68 ± 0.24%, 3.52 ± 0.03 $X10^6$ mm^3, 128.23 ± 0.25 mg/dl, 1.07 ± 0.01g/dl and 292.00 ± 0.23 mg/kg) at the end of 90 days trial but total plasma protein in deprived group was compensated with advancement of trial period. All

haematological and biochemical parameters studied were proportionately lowered in the experimental group got higher degree of deprivation. These findings suggested that with the increase of trial length complete compensation of haematological and biochemical profiles of rohu might be achieved. The results indicated that the implementation of alternative 7 days low and high protein diet feeding during aquaculture of carps could make economize the operation through minimizing the feed input cost.

Key Words: protein restriction, growth, re-alimentation, nutrient utilization, haematological profiles, biochemical changes, Rohu (*Labeo rohita*).

INTRODUCTION

Effect of food restriction with subsequent realimentation on growth and carcass composition was investigated in many fishes (Russell and Wootton, 1992, Jobling *et al.*, 1993, Kim and Lovell, 1995, Hayward *et al.*, 1997). Usually food intake and conversion efficiency increases in fishes during their compensatory growth (Russell and Wootton, 1992, Jobling *et al.*, 1993, Hayward *et al.*, 1997) but nutrient utilization, haematological and biochemical changes in fishes during compensatory period were not documented. So the present study was conducted to investigate the effect of feed quality restriction followed by re-alimentation on growth, nutrient utilization, haematological and biochemical changes in Rohu (*Labeo rohita* H.).

MATERIALS AND METHODS

Effect of protein restriction with subsequent re-alimentation on nutrient utilization, biochemical and haematological changes of Indian major carp, Rohu (*Labeo rohita* H.) was tested during 90 days trial. 150 acclimatized Rohu fingerlings (average 20.74 ± 0.13g) were divided into five experimental groups (30 fingerlings in each groups with three replications with 10 fingerlings in each) for experimental trial of 90 days using completely randomized design. Proximate principles (DM%, CP%, CF%, EE%, TA%, OM% and NFE) of experimental Diet 1 (Table 1, NRC, 1993) and Diet 2 (Table 2) were analyzed as per the method described in AOAC (1995). Ca of feed was determined by AAS method (AOAC, 1995) and the P content of feed was estimated by spectrophotometric method (AOAC, 1975). Control group (T_{CPR}) was fed with feed having 30% crude protein @ 3% of body weight for 90 days trial period. Other experimental groups T_{1PR} was alternatively 3 days fed with feed having 20% CP and 30% CP @ 3% of body weight, T_{2PR} was alternatively 7 days fed with feed having 20% CP and 30% CP @ 3% of body weight, T_{3PR} was alternatively 15 days fed with feed having 20% CP and 30% CP @ 3% of body weight and T_{4PR} was alternatively 25 days fed with feed having 20% CP and 30% CP @ 3% of body weight during 90 days trial period with daily ration in two equal halves in morning and afternoon. In order to find out voluntary feed intake quantities of experimental diet offered and residue left, if any, were recorded daily by siphoning for fish (Rohu) of each group after 1 h of feeding and was subjected to dry matter estimation (AOAC, 1995) and pooled. Body weight of fish was recorded at the end of feed quality restriction and re-alimentation period and live weight change were also calculated. Feed conversion ratio (FCR), specific growth rate (SGR) and survival rate (SR%) in Rohu was calculated as per standard procedures and formula.

$$FCR = \frac{\text{Feed (DM) intake (g)}}{\text{Live wt. gain (g)}}$$

$$PER = \frac{\text{Live wt. gain (g)}}{\text{Protein intake (g)}}$$

$$SGR (\%) = \frac{\text{Log e } W_t - \text{Log e } W_0}{t} \times 100$$

Where,

W_t = Weight (g) attained after specific period of time 't' of experiment

Wo = Weight (g) at 'O' day of experiment

t = Specific period (hour or day or week or month or year) of experiment

$$SR (\%) = \frac{\text{Total live fish (No.)}}{\text{Total fish at '0' day (No.)}} \times 100$$

Ca, Cu, Fe, Mn and Zn of feed, residues and faecal matter were determined by AAS method (AOAC, 1995) and the P contents were estimated by spectrophotometric method (AOAC, 1975).

To assess the nutrients including minerals utilization in Rohu, metabolism trials of 10 days duration was conducted at the end of 80 days of experiment involving indirect method using 0.5% chromic oxide (Cr_2O_3, inert substance) as an indicator/marker in pelleted feed (Furukawa and Tsukahara, 1966) with collection of a small quantity of faeces within 5 h after every day's feeding of trial period by siphoning and was subjected to dry matter estimation (AOAC, 1995) and pooled. For nitrogen estimation another aliquots small quality representative sample from mixed faecal matter of different experimental groups were preserved with 0.1 ml dilute 25% sulphuric acid in wide mouth pre-weighed stoppered glass bottle. The aliquots of all 10 days for each group were preserved in the same bottle and mixed thoroughly, thereafter, aliquot were processed for nitrogen estimation. The metabolizable nutrients were calculated by estimating the concentration of Cr_2O_3 as per Furukawa and Tsukahara (1966) in feed and faeces and that of nutrients in feed and faeces (AOAC, 1995) by using standard formula as follows:

$$\text{Metabolizable nutrient (\%)} = 100 - \left(100 \times \frac{\%Cr_2O_3 \text{ (in feed)}}{\%Cr_2O_3 \text{ (in faeces)}} \times \frac{\% \text{ nutrient (in faeces)}}{\% \text{ nutrient (in feed)}}\right)$$

At the end of 45 and 90 days of trial, blood samples were collected aseptically directly from the heart in vials containing heparin as anticoagulant and processed for haematological and biochemical studies. Plasma biochemical parameters like total proteins (as per the method described by Keller, 1991 by using MERCK autoanalyzer kit), Glucose (using MERCK autoanalyzer kit as described by Mayne, 1994) and total lipids (as described by Chabrol, 1961, using LABKIT diagnostic kit) were estimated. Freshly collected heparinized whole blood samples were used for estimation of haematological parameters like haemoglobin (by Cyanomethaemoglobin method as described by Van Kampen and Zijlstra, 1961 using Crest Biosystem diagnostic kit, Hemocor-D), Packed cell volume (PCV) or Haematocrit (Hct) value, total erythrocytic count (TEC) and total leucocytic count (TLC) as per the standard method of Schalm et al. (1975). Freshly liver samples were collected from Rohu after 45 and 90 days of trial period and were kept in 5% saline solution for liver glycogen estimation. The liver glycogen was estimated according to the method as stated by Montgomery (1957). The data were analyzed statistically as per the methods described by Snedecor and Cochran (1994) using Compare Means (SPSS, 1997).

RESULTS AND DISCUSSION

Feeding fish everyday with same level of protein is not economical (De Silva, 1985). Based on this hypothesis, the experiment was conducted to test nutrient utilization, haematological and biochemical changes in rohu (*Labeo rohita*) advanced fingerlings during mixed feeding schedules.

The final body weight (gm/f) and Specific growth rate (%/d/f) (Table 3) of fish at the end of 90 days trial period indicated that no significant difference of final body weight between control and the experimental groups restricted and re-alimented to proteins for alternative 3 or 7 days interval but fish of other experimental groups showed significantly lower final body weight. The experimental groups showed growth compensation with control might be due to increased percent live weight gain with the advancement of experiment which was also confirmed in the present experiment (Table 3). These observations indicated that during feed quality deprivation growth retardation occurred and gradually these fishes tried to compensate reduced growth showing increased rate of growth during realimentation period, might be owing to increased percent feed intake in relation to body weight, increased protein efficiency ratio as confirmed in the present experiment (Table 3).

Table 1. Ingredients and nutrient composition of experimental diet D_1 for Rohu

Ingredient composition and amount	
Ingredient composition	**Amount (Kg/100Kg)**
Maize	27.5
Rice bran	5
Soybean meal	50
Fish meal	10
Wheat gluten meal	2
Wheat flour	2
Vegetable oil	1
DCP	0.5
Chromic oxide	0.5
Iodized salt	0.924
Trace mineral premix [a]	0.028
Vitamin premix [b]	0.423
Lysine	0.025
Butylated hydroxyl anisole (BHA)	0.05
Methionine	0.05
Total	**100.00**

Nutrient composition	
Moisture (%, estimated)	13.37
CP (%, estimated)	30.75
EE (%, estimated)	4.50
TA (%, estimated)	2.51
CF (%, estimated)	5.78
NFE (%, estimated)	43.09
ME (KCal/kg, calculated)	2562.70
Ca (%, estimated)	0.28
Inorganic P (%, estimated)	1.29
Available P (%, calculated)	0.77
Lysine (%, calculated)	1.56
Methionine (%, calculated)	0.83
P/E ratio (mg/KCal, calculated)	119.99

Table 2. Ingredients and nutrient composition of experimental diet D_2 for Rohu

Ingredient composition and amount	
Ingredient composition	**Amount (Kg/100 Kg)**
Maize	48
Rice bran	8
Soyabean meal	35
Wheat gluten meal	2
Wheat flour	3.5
Vegetable oil	1
DCP	1
Chromic oxide	0.5
Iodized salt	0.424
Trace mineral premix [a]	0.028
Vitamin premix [b]	0.423
Lysine	0.025
Butylated hydroxy anisole (BHA)	0.05
Methionine	0.05
Total	**100.00**

Nutrient composition	
Moisture (%, estimated)	14.76
CP (%, estimated)	20.34
EE (%, estimated)	5.36
TA (%, estimated)	0.84
CF (%, estimated)	5.92
NFE (%, estimated)	52.78
ME (KCal/kg, calculated)	2531.50
Ca (%, estimated)	0.36
Inorganic P (%, estimated)	0.57
Available P (%, calculated)	0.34
Lysine (%, calculated)	1.15
Methionine (%, calculated)	0.17
P/E ratio (mg/KCal, calculated)	80.35

[a] Trace mineral premix supplied the following per Kg of diet:Cu ($CuSO_4$, $5H_2O$, 25% Cu), 2.70 mg; Fe ($FeSO_4$, $7H_2O$, 20.09% Fe) 27.03 mg; Mn ($MnSO_4$, H_2O, 36.01% Mn), 11.71 mg; Zn ($ZnSO_4$, 40.17 % Zn), 27.03 mg; I (KI, 76.01% I), 5 mg; Se (Na_2SeO_3, 53.02 % Se), 0.27 mg. [b]Vitamin premix supplied the following per Kg of diet:Vitamin A, 20,000 IU, Vitamin D3, 3,000 IU; Vitamin E, 16 mg; Vitamin K, 2 mg; Vitamin B_1, 1.6 mg; Vitamin B_2, 10mg; Vitamin B_6, 3.2 mg; Vitamin B_{12}, 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.

Table 3. Performance parameters of rohu fingerlings reared on different feeding schedules.

Treatments Parameters		T_{CPR}	T_{1PR}	T_{2PR}	T_{3PR}	T_{4PR}	P
Initial b. wt (g/f)		20.63 ± 0.09	20.75 ± 0.07	20.66 ± 0.11	20.78 ± 0.14	20.82 ± 0.04	> 0.05
Initial b. length (cm/f)		12.38 ± 0.05	12.45 ± 0.04	12.39 ± 0.06	12.47 ± 0.08	12.49 ± 0.03	> 0.05
Final b. wt (g/f)	**0-45 d**	67.39[a] ± 5.77	54.76[ab] ± 6.87	47.57[bc] ± 6.31	41.78[bc] ± 5.25	32.82[c] ± 3.35	< 0.05
	45-90 d	128.68[a] ± 11.53	125.55[a] ± 10.90	130.59[a] ± 14.38	85.50[b] ± 11.52	65.79[b] ± 8.76	< 0.05
Average wt gain (g/f)	**0-45 d**	46.76[a] ± 5.68	34.01[ab] ± 6.82	26.91[bc] ± 6.40	21.00[bc] ± 5.38	11.99[c] ± 3.31	< 0.05
	45-90 d	61.29[bc] ± 5.76	70.79[ab] ± 4.01	83.02[a] ± 8.06	43.71[cd] ± 6.27	32.97[d] ± 5.41	< 0.05
	0-90 d	108.05[a] ± 11.44	104.80[a] ± 10.84	109.93[a] ± 14.47	64.71[b] ± 11.64	44.96[b] ± 9.72	< 0.05

Average % wt gain	0-45 d	226.45 [a] ± 26.61	163.74 [ab] ± 32.34	130.56 [bc] ± 31.48	101.40 [bc] ± 26.57	57.55 [c] ± 15.78	< 0.05
	45-90 d	90.81 [c] ± 0.78	131.61 [b] ± 9.41	176.29 [a] ± 6.81	104.09 [c] ± 2.31	99.14 [c] ± 6.42	< 0.05
	0-90 d	523.30 [a] ± 53.27	504.79 [a] ± 50.73	532.82 [a] ± 72.13	312.10 [b] ± 58.07	215.76 [b] ± 41.45	< 0.05
Final b. length (cm/f)	0-45 d	19.26 [a] ± 1.65	15.65 [ab] ± 1.96	13.59 [bc] ± 1.80	11.94 [bc] ± 1.50	9.38 [c] ± 0.96	< 0.05
	45-90 d	21.45 [a] ± 1.92	20.93 [a] ± 1.82	21.77 [a] ± 2.40	14.25 [b] ± 1.92	10.96 [b] ± 1.46	< 0.05
DMI (% of b. wt)	0-45 d	3.18 [c] ± 0.27	3.85 [bc] ± 0.32	4.58 [ab] ± 0.49	4.99 [ab] ± 0.39	5.28 [a] ± 0.37	< 0.05
	45-90 d	3.33 [c] ± 0.29	4.14 [bc] ± 0.30	4.94 [ab] ± 0.46	5.46 [a] ± 0.38	5.59 [a] ± 0.35	< 0.05
FCR	0-45 d	2.07 [d] ± 0.10	2.85 [cd] ± 0.06	3.77 [bc] ± 0.10	4.73 [b] ± 0.41	7.13 [a] ± 1.06	< 0.05

	45-90 d	3.15^{b} ± 0.26	3.31^{b} ± 0.33	3.49^{b} ± 0.37	4.81^{a} ± 0.30	5.06^{a} ± 0.18	< 0.05
	0-90 d	2.68^{d} ± 0.19	3.14^{cd} ± 0.22	3.54^{c} ± 0.28	4.75^{b} ± 0.17	5.53^{a} ± 0.20	< 0.05
SGR (%/d/f)	0-45 d	2.62^{a} ± 0.18	2.12^{ab} ± 0.28	1.81^{abc} ± 0.31	1.52^{bc} ± 0.29	0.99^{c} ± 0.23	< 0.05
	45-90 d	1.43^{c} ± 0.01	1.86^{b} ± 0.09	2.26^{a} ± 0.05	1.58^{c} ± 0.02	1.53^{c} ± 0.07	< 0.05
	0-90 d	2.02^{a} ± 0.09	1.99^{a} ± 0.09	2.03^{a} ± 0.13	1.55^{b} ± 0.16	1.26^{b} ± 0.15	< 0.05
PER	0-45 d	1.58^{a} ± 0.07	1.40^{a} ± 0.03	1.05^{b} ± 0.03	0.90^{b} ± 0.07	0.58^{c} ± 0.07	< 0.05
	45-90 d	1.05^{ab} ± 0.09	1.19^{a} ± 0.11	1.16^{a} ± 0.12	0.77^{b} ± 0.04	0.79^{b} ± 0.03	< 0.05
	0-90 d	1.23^{a}	1.25^{a}	1.14^{a}	0.81^{b}	0.73^{b}	< 0.05

		± 0.08	*± 0.08*	*± 0.08*	*± 0.03*	*± 0.03*	
SR (%)	0-45 d	*96.67 ± 3.33*	*100.00 ± 0.00*	*93.33 ± 3.33*	*93.33 ± 3.33*	*90.00 ± 5.77*	*> 0.05*
	45-90 d	*100.00* ± 0.00	*100.00* ± 0.00	*96.67* ± 3.33	*96.67* ± 3.33	*96.67* ± 3.33	*> 0.05*

Means bearing different superscripts along rows differed significantl (P<0.05), whereas with same superscript did not differ significantly (P>0.05). DMI = Dry matter intake; FCR = Feed conversion ratio; SGR = Specific growth rate; PER = Protein efficiency ratio; SR = Survival rate.

Table 4. Nutrient utilization in rohu fingerlings during different feeding schedules for 90 days trial period.

Parameters / Treatments	T_{CPR}	T_{1PR}	T_{2PR}	T_{3PR}	T_{4PR}	P
DMR	81.08 ± 2.77	79.38 ± 2.65	77.17 ± 2.71	77.78 ± 2.64	75.44 ± 3.12	>0.05
NR	62.28 ± 3.22	60.67 ± 3.20	60.16 ± 3.34	59.6 ± 3.09	58.92 ± 3.15	>0.05
TAR	35.23 ± 1.64	35.05 ± 2.45	33.69 ± 2.87	32.65 ± 2.31	32.13 ± 2.10	>0.05

CaR	44.86 ± 2.88	44.19 ± 2.16	43.43 ± 2.34	44.21 ± 1.83	41.74 ± 2.86	>0.05
PR	43.46 ± 1.71	43.58 ± 2.72	42.05 ± 1.91	42.44 ± 3.00	42.24 ± 2.72	>0.05
CuR	64.71 ± 2.51	64.35 ± 2.34	64.07 ± 2.65	63.35 ± 2.53	62.73 ± 2.50	>0.05
FeR	54.73 ± 2.52	54.45 ± 2.63	54.02 ± 3.03	53.65 ± 3.15	53.19 ± 3.22	>0.05
MnR	15.42 ± 1.66	15.04 ± 1.85	14.24 ± 2.20	14.20 ± 2.18	13.84 ± 1.93	>0.05
ZnR	36.46 ± 3.13	35.72 ± 2.86	35.43 ± 2.48	35.06 ± 2.67	34.58 ± 3.03	>0.05

Table 5. Haematological and biochemical profiles in rohu fingerlings reared on different feeding schedules.

Treatments / Parameters		T_{CPR}	T_{1PR}	T_{2PR}	T_{3PR}	T_{4PR}	P
Hb (g/dl)	0-45 d	10.38[a] ± 0.08	10.03[b] ± 0.01	9.70[c] ± 0.04	9.32[d] ± 0.01	8.98[e] ± 0.04	< 0.05
	45-90 d	10.49[a] ± 0.08	10.14[b] ± 0.02	9.81[c] ± 0.04	9.43[d] ± 0.02	9.09[e] ± 0.04	< 0.05
PCV or Hct (%)	0-45 d	31.14[a] ± 0.24	30.08[b] ± 0.05	29.10[c] ± 0.11	27.96[d] ± 0.05	26.95[e] ± 0.11	< 0.05
	45-90 d	31.83[a] ± 0.24	30.77[b] ± 0.05	29.79[c] ± 0.11	28.65[d] ± 0.05	27.64[e] ± 0.11	< 0.05
TEC ($X10^6 mm^3$)	0-45 d	3.46[a] ± 0.03	3.34[b] ± 0.01	3.23[c] ± 0.01	3.11[d] ± 0.01	2.99[e] ± 0.02	< 0.05
	45-90 d	3.37[a] ± 0.03	3.26[b] ± 0.01	3.15[c] ± 0.01	3.03[d] ± 0.01	2.92[e] ± 0.01	< 0.05

TLC ($X10^4 mm^3$)	**0-45 d**	2.98 ± 0.01	2.96 ± 0.01	2.98 ± 0.02	2.97 ± 0.03	2.95 ± 0.03	> 0.05
	45-90 d	3.48 ± 0.01	3.46 ± 0.01	3.48 ± 0.01	3.47 ± 0.02	3.45 ± 0.03	> 0.05
Total plasma protein (g/dl)	**0-45 d**	2.52^a ± 0.02	2.37^b ± 0.02	2.21^c ± 0.03	2.15^c ± 0.02	2.07^d ± 0.02	< 0.05
	45-90 d	2.77 ± 0.02	2.70 ± 0.02	2.76 ± 0.03	2.76 ± 0.02	2.74 ± 0.02	>0.05
Plasma glucose (mg/dl)	**0-45 d**	128.15^a ± 0.25	126.85^b ± 0.20	126.59^{bc} ± 0.05	126.17^c ± 0.04	126.11^c ± 0.05	< 0.05
	45-90 d	128.20^a ± 0.25	126.90^b ± 0.20	126.64^{bc} ± 0.05	126.22^c ± 0.04	126.16^c ± 0.05	< 0.05
Plasma total lipid (g/dl)	**0-45 d**	1.08^a ± 0.01	1.05^b ± 0.01	1.03^b ± 0.01	1.00^c ± 0.01	0.98^c ± 0.01	< 0.05
	45-90 d	1.03^a ± 0.01	1.00^b ± 0.01	0.98^b ± 0.01	0.95^c ± 0.01	0.93^c ± 0.01	< 0.05

Liver glycol-gen (mg/kg	0-45 d	289.85^{a} ± 1.99	282.31^{ab} ± 4.30	272.77^{b} ± 4.46	216.41^{c} ± 8.93	203.33^{c} ± 3.42	< 0.05
	45-90 d	289.88^{a} ± 0.23	287.98^{ab} ± 0.80	286.87^{b} ± 0.99	286.61^{b} ± 0.38	286.96^{b} ± 0.61	< 0.05

Means bearing different superscripts (^{abcde}) along rows differed significantly (P<0.05), whereas with same superscript did not differ significantly (P>0.05). Hb = Haemoglobin; PCV = Packed cell volume; TEC = Total erythrocytic count; TLC = Total leucocytic count.

Final length of experimental fish got changed at the similar fashion of final body weight change indicated compensatory growth happened due to protein growth rather than due to fat deposition in the gut. From these observations it might be said that increased feed intake (hyperphagia), improved specific growth rate, protein efficiency ratio and superior feed conversion ratio were the important mechanism through which the experimental groups which were restricted and re-alimented to protein at 3 or 7 days alternatively during 90 days trial period could able to compensate the growth retardation to catch up the final body weight of control but the experimental groups which were restricted and re-alimented at 15 or 25 days interval were unable to compensate the growth retardation during 90 days trial period.

Similar to present observation, Li and Qin (2003) and Wang *et al.* (2000) found that specific growth rate in deprived groups of *Lates calcarifer* and *Tilapia* respectively was greater to achieve compensatory growth. Present finding was also in corroboration with the observation of Jiang *et al.* (2002) who reported that as the starvation prolonged, feed conversion efficiency increased feed, that was superior in deprived groups than control.

Gaylord *et al.* (2001) observed in channel catfish that fish on the restricted feeding regime had improved cumulative feed efficiency compared to fish fed daily to apparent satiation. Improved growth and feed efficiency had also been reported for some other fishes showing compensatory growth. Hyperphagia might be one of the important mechanisms for compensatory growth as conformed in the present findings that was also corroborated with the observation of Schwarz *et al.* (1985), Wang *et al.* (2000) and Nikki *et al.* (2004).

At the end of the experiment of the present study, it was noticed that retention of different nutrients (Table 4) were almost similar among all treatment groups indicated hyperphagia, better protein efficiency ratio and improved growth efficiency (Table 3) that might be mechanisms for compensatory growth rather than improvement of digestibility of nutrients. The present findings were also in corroboration with the observation of Wang *et al.* (2000) in *tilapia* and *Qian et al.* (2000) in gibel carp but in contrary with the observations of *Li* and *Qin* (2003) in *barramundi, Jiang et al.* (2002) in *red drum* and *Schwarz et al.* (1985) in common carp.

Result of the present study indicated that deprived fish showed recovery growth (data not shown) had still lower values of Hb, haematocrit value, total erythrocytic count, plasma glucose, total plasma lipid and liver glycogen in comparison to control at the end of 90 days trial but total leucocytic count could not be changed between any groups and total plama protein in deprived group that was compensated with advancement of the experiment (Table 5). All haematological and biochemical parameters studied were proportionately lowered in the experiment group which got higher degree of deprivation. Lower glycogen content indicated that deprived group tried to maintain normal glucose level in blood but there was no surplus glucose for storage as glycogen in liver. This finding suggested that though growth compensation achieved, with the increase of trial length complete compensation of haematological and biochemical profiles of rohu might be achieved. Hyperphagia might be related to metabolic adaptation acquired during restricted feeding i.e., glucose sparing action (Pethick *et al.*, 1983). Literature support in relation to compensatory growth and haematological and biochemical change is still lacking.

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