

Dietary supplementation of formulated fish specific mineral mixture improved growth and health status of Indian major carps

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ABSTRACT

The present study was undertaken to standardize the dose and efficacy of formulated fish specific mineral mixture on survival, growth and health status of Indian major carps (IMC) catla (*Labeo catla*), rohu (*Labeo rohita*) and mrigal (*Cirrhinus mrigala*). The feeding trial (120 days) consists of five treatments (T1-T5, in triplicate), basal diet consisted of rice bran (49-50%), mustard de-oiled cake (48.5-49%), mineral mixture (0-2%) and salt (0.5%), positive control with commercially available mineral mixture (T1) and negative control without any mineral mixture (T2) and three (T3-T5) treatments supplemented with formulated mineral mixture (as per ICAR 2013 recommendations) at three inclusion levels 1%, 1.5% and 2%, respectively. All the water quality parameters were within the acceptable limits. Supplementation of formulated mineral mix in fish feed significantly improved growth performance, feed utilization, haematological parameters and blood metabolic profile whereas, the flesh quality of catla, rohu and mrigal also improved (non-significantly) and recorded best in T4 (formulated mineral mixture at 1.5% of total fish feed) in comparison to positive (T1) and negative (T2) control. The data obtained in the present study will be helpful in increasing the fish production and productivity in sustainable way and in terms enhancing fish farmer's income and also helping in nutritional security of the nation.

Keywords: Biochemical study, Growth, Health, Indian major carps, Mineral mixture

Fish growth, development, health, and a variety of other life activities are significantly impacted by minerals, which are necessary inorganic elements (Lall and Kaushik 2021). Fish species' dietary mineral requirements are contingent upon the element's concentration in the medium (Ogino and Takeda 1976). Furthermore, the temperature of the rearing system, salinity, and mineral concentration all have an impact on the amount of minerals and trace elements that fish consume. Carps need major minerals like iron (Fe), calcium (Ca), magnesium (Mg), and phosphorous (P), and they also need minor elements like cobalt (Co), iodine (I), zinc (Zn), copper (Cu), fluorine (F), manganese (Mg), molybdenum (Mo), and sulphur (S) (Lall 2002). With increasing commercialization of carp farming and greater market focus, demand of the commercially viable and nutritionally balanced pelleted feeds is increasing. Information on dietary phosphorus and calcium requirements of fry *Labeo rohita* (Paul *et al.* 2006), and magnesium, phosphorus, potassium, iron, zinc and copper (Musharraf and Khan 2022) requirements of fingerling *L. rohita* are available. One technique that is frequently used to assess the physiological status and health of fish

is haematological evaluation (Fazio 2019). Behera *et al.* (2022) worked on the diversity study of three Indian major carps from four riverine ecosystems. Haematological research is one way to improve the performance of ichthyopathological diagnosis. In addition to being a useful predictor of fish welfare and general health, haematological research also offers a veiled window into the state of the environment. The goal of the current study is to standardize the dosage and effectiveness of a low-cost, fish-specific mineral mixture on the on survival, growth and health status of Indian major carps in a semi-intensive system. The mixture was created by scientists at Guru Angad Dev Veterinary and Animal Sciences University in accordance with recommendations (ICAR 2013) as per the mineral requirements of carp.

MATERIALS AND METHODS

Experimental design: The study was carried out in 20 m² cemented tanks at the Instructional cum Research Farm, of College of Fisheries, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana. The experiment consisted of 5 treatments (T1 to T5) with 3 replicates each.

Water quality parameters: Water samples were collected fortnightly in the morning hours for the analyses of physico-chemical parameters according to standard methods of APHA (2012).

Growth parameters: Growth parameters of fish for each

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treatment were calculated (Halver 1957).

Stocking of fingerlings: After 15 days of fertilization all the 15 tanks were stocked with fingerlings of *L. catla* (7.5-9 cm and 8-11 gm), *L. rohita* (6-8 cm and 8-9 gm) and *C. mrigala* (9-10 cm and 14.0±1.3 gm) after exposing the fish to a dip treatment with 5 ppm of KMnO₄ solution. Fish were stocked in the ratio of 3:4:3 i.e. catla, rohu and mrigal respectively in 12:16:12 number (total 40 fingerlings/nursery pond of 20 m² size).

Preparation of experimental diet: Diets were prepared using rice bran (49-50%), mustard de-oiled cake (48.5-49%), mineral mixture (0-2%) and salt (0.5%) respectively. Five treatments (T1-T5 in triplicate), positive control with commercially available mineral mixture (T1) and negative control without any mineral mixture (T2) and three (T3-T5) treatments supplemented with formulated mineral mixture (as per ICAR 2013 recommendations and contain elements Ca, P, Mg, Cu, Fe, Zn, Mn, I) at three inclusion levels 1%, 1.5% and 2% respectively. All ingredients were mixed thoroughly and sinking pellets were made by using a mechanical pelletizer. The pellets were dried in the hot air oven at 40°C for overnight and were stored in an airtight container in cool dry place till further use. Fish were fed @ 5-3% of body weight for 120 days (November 2022-March 2023). Proximate analysis of the test diets and flesh quality were analysed, according to standard procedures (AOAC 2012).

Haematological and biochemical parameters: The blood (heparinised 150 IU mL⁻¹) collected from each group was analysed for haemoglobin (Hb), total erythrocyte count (TEC), total leukocyte count (TLC) and Haematocrit (Ht). Haemoglobin (Hb) concentration was estimated by acid haematin method (Sahli 1962). MCV, MCH and MCHC were calculated using the formulae (Haney *et al.* 1992) as

given below.

$$\text{MCV } (\mu\text{m}^3) = \text{Ht} / \text{RBC} \times 10, \text{MCH } (\text{g}\%) = \text{Hb} / \text{RBC} \times 10, \\ \text{MCHC } (\text{g}\%) = \text{Hb} / \text{Ht} \times 100$$

For serum biochemical parameters, Erba Kits, Erba Mannheim (Germany) was used to estimate total proteins (TP) and albumin (Alb) in blood serum by following the principle of Biuret reaction (Gornall *et al.* 1949) and Globulin (Glb) and Alb/Glb ratio was calculated as

$$\text{Glb } (\text{gdL}^{-1}) = \text{Total protein } (\text{gdL}^{-1}) - \text{Alb. } (\text{gdL}^{-1}), \\ \text{Alb/Glb ratio} = \text{Alb/Glb}$$

Statistical analysis: Statistical assessment of the results was carried out using SPSS software, version 16. The differences between parameters were analysed by one-way analysis of variance (ANOVA), followed by Duncan's multiple comparisons to determine significant difference. Results were presented as mean±SEM and the level of significance was set as $p < 0.05$.

RESULTS AND DISCUSSION

Physico-chemical parameters: Water quality parameters such as temperature, pH, DO, total alkalinity, total hardness and ammonia in different treatment shows no significant difference throughout the culture period. These were within the range as suggested by Bhatnagar and Devi (2013) for general aquaculture in pond.

Survival of fish: Survival (%) observed at the end of the experiment in which average survival (%) of fish does not show any significant difference ($p < 0.05$) among the treatment and species (Table 1).

Net weight gain (NWG): At the end of culture period, significantly ($p < 0.05$) high weight gain was observed in T4 group. Among the species, maximum weight was recorded in rohu followed by mrigal and catla respectively (Table 1).

Table 1. FCR and PER of Indian major carps at the end of the experiment*

Parameter	Treatment				
	T1	T2	T3	T4	T5
<i>Catla</i>					
Survival (%)	98.33 ± 0.33	98 ± 0.001	98.33 ± 0.33	98.33 ± 0.33	98 ± 0.58
NWG (g)	29.67 ^b ±0.43	23.41 ^d ±0.15	27.77 ^c ±0.12	33.29 ^a ±0.11	29.48 ^b ±0.17
SGR (%)	1.32 ^b ±0.02	1.18 ^c ±0.02	1.32 ^b ±0.01	1.42 ^a ±0.01	1.35 ^b ±0.01
<i>Rohu</i>					
Survival (%)	98.33 ± 0.33	98 ± 0.58	97.67 ± 0.33	97.67 ± 0.33	98 ± 0.58
NWG (g)	56.13 ^b ±0.98	45.60 ^d ±0.45	49.67 ^c ±0.34	58.07 ^a ±0.32	50.07 ^c ±0.32
SGR (%)	1.68 ^a ±0.02	1.50 ^c ±0.02	1.57 ^b ±0.02	1.65 ^a ±0.01	1.54 ^{bc} ±0.01
<i>Mrigal</i>					
Survival (%)	98.33 ± 0.33	98 ± 0.001	98.33 ± 0.33	98.33 ± 0.33	98 ± 0.58
NWG (g)	35.29 ^b ±0.39	18.93 ^d ±0.44	25.15 ^d ±0.37	40.47 ^a ±0.32	32.43 ^c ±0.27
SGR (%)	1.43 ^b ±0.01	1.03 ^c ±0.02	1.19 ^d ±0.01	1.52 ^a ±0.01	1.36 ^c ±0.01
<i>Catla, Rohu and Mrigal</i>					
FCR	1.25 ^d ±0.17	2.15 ^a ±0.48	1.65 ^b ±0.29	1.06 ^c ±0.16	1.48 ^c ±0.23
PER	3.72 ^d ±0.54	2.25 ^b ±0.61	2.60 ^a ±0.72	4.33 ^a ±0.73	3.14 ^c ±0.56

*Values (Mean±SEM) with different alphabetical superscripts in a row differ significantly ($p \leq 0.05$). Survival (%): Number of fishes harvested at the end of the experiment x 100/ Number of fishes stocked at the start of experiment, Net weight gain: Average final body weight (g) – average initial body weight (g), Specific growth rate (SGR): 100 x (ln final body weight–ln initial body weight)/days, Feed conversion ratio (FCR): dry feed fed (g)/weight gain (g); Protein efficiency ratio (PER): Live weight gain (g)/protein intake (g)

Specific growth rate (SGR): Significantly ($p<0.05$) high specific growth was observed in T4 followed by T1 and the lowest in T2. Among species, rohu shows the highest SGR followed by mrigal and catla respectively (Table 1).

Feed conversion ratio (FCR): At the end of the experiment, FCR observed best in T4 followed by T1 and the lowest observed in T2. The FCR calculated for different treatment are 1.25, 2.15, 1.65, 1.06 and 1.48 in T1, T2, T3, T4 and T5 respectively (Table 1).

Protein efficiency ratio (PER): At the end of the experiment, PER was observed best in T4 followed by T1 and the lowest in T2. PER value calculated for each treatment are 3.72, 2.25, 2.60, 4.33 and 3.14 in T1, T2, T3, T4 and T5 respectively (Table 1).

Fish fed a 2% salt diet had higher values for parameters such specific growth rate (SGR), weight gain (%), and fish biomass productivity (Gangadhar *et al.* 2014). Higher growth rate observed in grass carp and common carp fed with Agrimin compared to Fishmin, may be due to presence of higher mineral content and presence of methionine and L-lysine in its composition (Sudhakar *et al.* 2015). The present investigation is in agreement with the earlier studies (Datta and Kaviraj 2003) reported that in the preparation of formulated feed for the carps, minerals are generally mixed at 1-2% of the feed. In similar studies, Musharraf and Khan

(2022) worked on the mineral requirement of Indian major carp. Whereas, Storebakken *et al.* (2000) reported Animal and plant feed stuff used in the artificial feed formulation provide a significant quantity of minerals, which are often in excess of the estimated requirement.

Haematological parameters: At the end of the experiment, haematological parameters were recorded (Table 2). Significant increase in the value of Hb, TLC and TEC with the increase in the concentration of minerals was observed. Among all the treatment groups T4 shows the highest result than other groups. MCHC also shows an increase while MCV and MCH values were decreasing with the increase in mineral concentration. Within species, catla shows better result compare to rohu and mrigal.

Blood metabolic profile: At the termination of the experiment, the metabolic profile of fish was analyzed, which included glucose, total serum protein, albumin, globulin, albumin/globulin (Alb/Glb) ratio, triglycerides, cholesterol and HDL (Table 3). Significant ($p<0.05$) improvements were seen in terms of glucose, total serum protein, albumin, triglyceride, cholesterol and HDL in T4 in all the Indian major carps in comparison to positive (conventional mineral mix) and negative (no mineral mix) control. Among the species catla shows better result than rohu and mrigal.

Table 2. Haematological parameters of Indian major carps at the end of the experiment*

Parameter	Treatment				
	T1	T2	T3	T4	T5
<i>Catla</i>					
Hb (g%)	5.39 ^a ± 0.007	4.60 ^d ± 0.019	4.78 ^c ± 0.017	5.43 ^a ± 0.014	5.16 ^b ± 0.055
TEC (×10 ⁶ mm ³ -1)	1.30 ^b ± 0.012	0.96 ^c ± 0.008	1.16 ^d ± 0.009	1.36 ^a ± 0.005	1.25 ^c ± 0.003
TLC (×10 ³ mm ³ -1)	1.88 ^b ± 0.005	1.63 ^c ± 0.006	1.78 ^d ± 0.007	1.99 ^a ± 0.008	1.83 ^c ± 0.008
PCV/Hct (%)	21.14 ^b ± 0.017	20.32 ^c ± 0.015	20.62 ^d ± 0.011	21.41 ^a ± 0.015	20.89 ^c ± 0.018
MCV (µm ³)	167.43 ^c ± 0.58	211.86 ^a ± 1.93	177.5 ^b ± 1.43	163.55 ^d ± 1.19	157.18 ^e ± 0.67
MCH (g%)	41.20 ^b ± 0.403	48.04 ^a ± 0.519	41.2 ^b ± 0.368	39.93 ^c ± 0.153	41.43 ^b ± 0.52
MCHC (g%)	25.49 ^a ± 0.038	22.67 ^d ± 0.089	23.21 ^c ± 0.079	25.41 ^a ± 0.076	24.74 ^b ± 0.262
<i>Rohu</i>					
Hb (g%)	5.26 ^b ± 0.019	4.66 ^c ± 0.020	5.02 ^b ± 0.142	5.42 ^{ab} ± 0.013	5.47 ^a ± 0.008
TEC (×10 ⁶ mm ³ -1)	1.27 ^c ± 0.005	1.16 ^c ± 0.004	1.24 ^d ± 0.007	1.33 ^b ± 0.005	1.37 ^a ± 0.008
TLC (×10 ³ mm ³ -1)	1.91 ^b ± 0.007	1.66 ^c ± 0.011	1.81 ^d ± 0.008	2.01 ^a ± 0.008	1.88 ^c ± 0.006
PCV/Hct (%)	24.71 ^c ± 0.011	24.13 ^c ± 0.016	24.44 ^d ± 0.015	24.99 ^b ± 0.035	25.25 ^a ± 0.017
MCV (µm ³)	193.62 ^c ± 0.87	206.69 ^b ± 0.81	197.21 ^a ± 1.16	187.94 ^d ± 0.81	188.65 ^c ± 1.05
MCH (g%)	41.20 ^{ab} ± 0.26	39.94 ^b ± 0.16	42.27 ^a ± 1.07	40.76 ^{ab} ± 0.19	39.79 ^b ± 0.21
MCHC (g%)	21.28 ^a ± 0.072	19.32 ^b ± 0.085	21.44 ^a ± 0.58	21.69 ^a ± 0.064	21.67 ^a ± 0.041
<i>Mrigal</i>					
Hb (g%)	4.96 ^b ± 0.037	4.56 ^d ± 0.024	4.75 ^c ± 0.019	5.34 ^a ± 0.015	5.36 ^a ± 0.009
TEC (×10 ⁶ mm ³ -1)	1.17 ^c ± 0.04	0.90 ^c ± 0.005	1.08 ^d ± 0.005	1.27 ^b ± 0.003	1.32 ^a ± 0.005
TLC (×10 ³ mm ³ -1)	1.84 ^b ± 0.007	1.51 ^c ± 0.09	1.61 ^d ± 0.008	1.91 ^a ± 0.007	1.80 ^c ± 0.006
PCV/Hct (%)	23.04 ^c ± 0.026	22.45 ^c ± 0.023	22.74 ^d ± 0.017	23.33 ^b ± 0.014	23.64 ^a ± 0.016
MCV (µm ³)	196.79 ^c ± 0.82	247.71 ^a ± 1.61	210.46 ^b ± 1.04	183.42 ^d ± 0.53	178.11 ^e ± 0.77
MCH (g%)	42.42 ^c ± 0.28	50.31 ^a ± 0.42	43.99 ^b ± 0.36	41.99 ^d ± 0.19	40.42 ^c ± 0.17
MCHC (g%)	21.56 ^b ± 0.16	20.31 ^d ± 0.10	20.89 ^c ± 0.09	22.89 ^a ± 0.06	22.69 ^a ± 0.04

*Values (Mean±SEM) with different alphabetical superscripts in a row differ significantly ($p\leq 0.05$). Haemoglobin (Hb), Haematocrit (Ht) or Packed Cell Volume (PCV), Total Erythrocyte Count (TEC), Total Leucocyte Count (TLC), Mean Corpuscular Volume (MCV), Mean Corpuscular Haemoglobin (MCH) and Mean Cell Haemoglobin Concentration (MCHC).

Table 3. Blood metabolic profile of Indian major carps at the end of the experiment*

Parameter	T1	T2	T3	T4	T5
<i>Catla</i>					
Glucose (gdL ⁻¹)	83.11 ^d ± 0.103	89.21 ^a ± 0.09	87.33 ^b ± 0.10	80.11 ^c ± 0.013	84.84 ^c ± 0.119
Total protein (gdL ⁻¹)	3.19 ^b ± 0.004	2.88 ^c ± 0.012	2.92 ^d ± 0.022	3.28 ^a ± 0.006	3.09 ^c ± 0.005
Albumin (gdL ⁻¹)	1.54 ^b ± 0.008	1.25 ^c ± 0.007	1.33 ^d ± 0.006	1.69 ^a ± 0.007	1.45 ^c ± 0.007
Globulin (gdL ⁻¹)	1.65 ^a ± 0.008	1.62 ^{ab} ± 0.018	1.59 ^b ± 0.022	1.59 ^b ± 0.012	1.63 ^a ± 0.09
A/G ratio (gdL ⁻¹)	0.94 ^b ± 0.009	0.77 ^c ± 0.013	0.84 ^d ± 0.014	1.07 ^a ± 0.012	0.89 ^c ± 0.009
Triglyceride (mgdL ⁻¹)	108.17 ^d ± 0.12	114.2 ^a ± 0.11	112.17 ^b ± 0.10	106.33 ^c ± 0.61	110.27 ^c ± 0.14
Cholesterol (mgdL ⁻¹)	98.33 ^d ± 0.110	104.34 ^a ± 0.10	102.43 ^b ± 0.132	96.31 ^c ± 0.127	100.29 ^c ± 0.06
HDL (mgdL ⁻¹)	68.66 ^d ± 0.255	83.73 ^a ± 0.266	78.73 ^b ± 0.277	63.63 ^c ± 0.370	73.73 ^c ± 0.275
<i>Rohu</i>					
Glucose (gdL ⁻¹)	88.29 ^d ± 0.115	94.38 ^a ± 0.145	93.04 ^b ± 0.735	86.17 ^c ± 0.103	90.11 ^c ± 0.129
Total protein (gdL ⁻¹)	3.14 ^{ab} ± 0.004	3.12 ^b ± 0.016	3.12 ^{ab} ± 0.007	3.15 ^a ± 0.004	3.14 ^{ab} ± 0.004
Albumin (gdL ⁻¹)	1.70 ^b ± 0.07	1.43 ^c ± 0.01	1.53 ^d ± 0.01	1.77 ^a ± 0.006	1.62 ^c ± 0.007
Globulin (gdL ⁻¹)	1.44 ^d ± 0.010	1.69 ^a ± 0.018	1.59 ^b ± 0.015	1.38 ^c ± 0.009	1.51 ^c ± 0.006
A/G ratio (gdL ⁻¹)	1.19 ^b ± 0.013	0.85 ^c ± 0.013	0.97 ^d ± 0.016	1.29 ^a ± 0.013	1.08 ^c ± 0.009
Triglyceride (mgdL ⁻¹)	113.13 ^d ± 0.094	119.17 ^a ± 0.097	117.2 ^b ± 0.11	112.04 ^c ± 0.35	114.99 ^c ± 0.17
Cholesterol (mgdL ⁻¹)	103.34 ^d ± 0.11	109.34 ^a ± 0.11	107.37 ^b ± 0.11	101.35 ^c ± 0.12	105.31 ^c ± 0.12
HDL (mgdL ⁻¹)	78.70 ^d ± 0.276	93.46 ^a ± 0.41	88.70 ^b ± 0.31	73.63 ^c ± 0.38	83.73 ^c ± 0.25
<i>Mrigal</i>					
Glucose (gdL ⁻¹)	78.28 ^d ± 0.099	84.35 ^a ± 0.12	82.33 ^b ± 0.11	76.42 ^c ± 0.128	80.34 ^c ± 0.128
Total protein (gdL ⁻¹)	2.96 ^a ± 0.004	2.80 ^b ± 0.111	2.92 ^{ab} ± 0.004	3.06 ^a ± 0.016	2.95 ^{ab} ± 0.005
Albumin (gdL ⁻¹)	1.36 ^b ± 0.006	1.05 ^c ± 0.008	1.16 ^d ± 0.005	1.47 ^a ± 0.004	1.25 ^c ± 0.006
Globulin (gdL ⁻¹)	1.60 ^b ± 0.01	1.75 ^{ab} ± 0.11	1.76 ^a ± 0.01	1.59 ^b ± 0.02	1.69 ^{ab} ± 0.01
A/G ratio (gdL ⁻¹)	0.86 ^a ± 0.01	0.63 ^c ± 0.06	0.66 ^{bc} ± 0.005	0.93 ^a ± 0.013	0.74 ^b ± 0.01
Triglyceride (mgdL ⁻¹)	103.23 ^d ± 0.11	109.17 ^a ± 0.10	107.17 ^b ± 0.10	101.43 ^c ± 0.14	104.93 ^c ± 0.18
Cholesterol (mgdL ⁻¹)	93.44 ^d ± 0.13	99.47 ^a ± 0.13	97.12 ^b ± 0.33	91.47 ^c ± 0.13	95.43 ^c ± 0.12

*Values (Mean±SEM) with different alphabetical superscripts in a row differ significantly ($p \leq 0.05$).

Ca, P and Mg are major elements for the hard structure of the organism, such as scales and bones; Na and K as the major intracellular and extracellular cations play a role in ionic balance (Lall 2002). Zinc in water up to 0.10 mg/L resulted in increased growth of fish in FRP tanks, beyond this it has detrimental effect on growth of carp fingerling (Mohanty *et al.* 2009). Exposure to sub-lethal concentration of copper sulphate results in decrease in haemoglobin, red blood cells, packed cell volume, and increase in white blood cells, erythrocyte sedimentation rate, clotting rate and mean corpuscular volume (MCV) (Singh *et al.* 2008).

Flesh quality of the fish: At the termination of the experiment, flesh quality (wet weight basis) were analysed from each treatment groups. Among the treatment groups, maximum protein was recorded in T4 (13.04, 13.23 and 13.49) and minimum from T2 (12.84, 13.08 and 13.13) in catla, rohu and mrigal respectively but no significant changes was observed except in mrigal. While significant change was observed in ash, as ash content in fish flesh increases with increasing mineral content in feeds.

Minerals are necessary for the regular functioning, involving in several structural and metabolic processes required for all animals including fishes (Watanabe *et al.*

1997). Minerals interconnect with other nutrients due to their volatile and chemical reaction tendency. The extra vitamins in the diet may not actually be necessary for IMC in pond ecosystems, particularly in semi-intensive polyculture practises where formulated diets are used and ponds are fertilised with the right amounts of organic and inorganic fertilisers to produce a sufficient amount of fish food organisms (De Silva and Anderson 1995), while dietary minerals affect many fish species' growth and survival. Pandey and Satoh (2013) worked on common carp and concluded that 2% of monocalcium phosphorous satisfies phosphorous requirements of the fish. Whereas, maximum weight gain was obtained at 0.7% phosphorous level regardless of dietary calcium level in case of carp (Ogino and Takeda 1976). Zooplankton considered as major source of cobalt and selective preference of zooplankton shows better growth in common carp compared to *Heteropneustes fossilis* fed with 2% mineral diet (Mukherjee and Kaviraj 2009). Fish feed with 30% protein, 7.9% lipid, 2% mineral- vitamin mixture made by rice bran, mustard oil cake, madua flour, soya cake and vitamin and mineral mixture are seen effective for growth of Chinese carp in mid-hilly regions of Uttarakhand (Mehta *et al.* 2020). Anti-

nutritional factors (ANFs) such as phytic acid, gossypol, oxalates, glucosinolates, saponin, lectin, tanin and even non-starch polysaccharides can affect mineral absorption and utilisation in fish (Francis *et al.* 2001).

It can be concluded that supplementation of formulated mineral mix in fish feed significantly ($p < 0.05$) improved feed conversion ratio, specific growth rate, protein efficiency ratio and hematological parameters, blood metabolic profile and flesh quality in Indian major carps catla (*Labeo catla*), rohu (*Labeo rohita*) and mrigal (*Cirrhinus mrigala*) and recorded best in T4 (formulated mineral mixture at 1.5% of total fish feed). The data obtained in the present study will be helpful in increasing the fish production and productivity in sustainable way and in terms enhancing fish farmer's income and also helping in nutritional security of the nation.

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