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MOBILIZATION OF TAURINE FOR RESTORATIVE GROWTH, CARCASS COMPOSITION AND HEMATOLOGY IN *CYPRINUS CARPIO* FINGERLINGS FED ON LINSEED MEAL BASED DIET

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ABSTRACT

In intensive culture fish cannot digest the plant-based diets properly and negatively affects their overall performance. Addition of organic acids in plant-based diets and their salts improves the performance of *C. carpio*. Current research was conducted to estimate the influences of dietary Tau addition in linseed meal-based diet on growth, hematological indices and carcass composition of common carp fingerlings. *C. carpio* fingerlings were fed (@4% of live wet body weight) on linseed meal-based diet supplemented with graded levels (0, 2, 4, 6, 8 and 10 gkg^{-1}) of dietary taurine for 60 days. The linseed meal-based diets were given to triplicate groups of fish fingerlings (6.22 g average initial body weight) twice a day. Fish fed with linseed meal supplemented with Tau at $4gkg^{-1}$ indicated maximum retention of CHO, CP as well as gross energy as compared to fish in control treatment. Growth performance of fish was significantly improved ($p<0.05$) by dietary Tau up to optimal level of $4gkg^{-1}$, after which a noticeable decline in fish growth was observed due to poor retention of various essential nutrients and minerals while, EE absorption was maximum at $6gkg^{-1}$ diet. Maximum weight gain (18.31) and survival (97.78) were found maximum at $4gkg^{-1}$ level based diet. Similarly, best values of various hematological indices i.e., RBCs, Hb, PCV, MCHC, MCH were also found at $4gkg^{-1}$ diet. These results indicate that the taurine supplementation at $4gkg^{-1}$ level is most suitable for highest fish performance as well as its ability to combat various pathogens.

Keywords: *Cyprinus carpio*, Linseed meal, Taurine, growth performance, whole body composition, hematology

Abbreviations: DM= Dry matter, FM= Fish meal, CP= Crude protein, CF= Crude fibre, EE= Ether extract, CHO= Carbohydrates, GE= Gross energy, IW=Initial weight, FW=Final weight, WG=Weight gain, FI=Feed intake, RBCs= Red blood cells, Hb= Hemoglobin, PLT= Platelets, Ht= Hematocrit, WBCs= White blood cells, PCV= Packed cell volume, MCHC= Mean corpuscle hemoglobin concentration, MCH= Mean corpuscular hemoglobin, MCV= Mean corpuscular volume, Tau= Taurine.

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INTRODUCTION

Aquaculture trends are changing from low cost semi-intensive system to more costly intensive systems where processed feed is crucial component. Undoubtedly such transmutation makes the role of nutrition immensely important and development of low cost diets is inevitable through nutritional research and exploration (Akhtar *et al.* 2009). Previously FM has been given priority as excellent and palatable protein supplement used in a number of aquaculture diets, but being exorbitant and certain environmental concerns may limit its subsequent use (Naylor *et al.* 2000). Access to reliable, available and low price feed adjuvants is becoming one of the most formidable challenge for the fish farming production. The principal confrontations for the fish production are to subdue feed price and substantial footmarks of environment without bringing down product premium quality and value. The insistence for premium products at cheap costs facetiously impels manufacturers to lessen costs of feed by utilizing low- priced ingredients and lesser feed specifications (Halteren *et al.* 2009).

One of the best methods to narrow feed cost and ameliorate the growth of fish is through the use of plant based supplements (Dada and Sonibare 2015). A number of plant based protein supplements have been previously utilized in fish feeds including by product remaining after cotton is ginned, barleycorn, peanut, soybean, corn gluten by product and sunflower seed husk etc. (Shahzad *et al.* 2017). Linseed meal (LSM) is suitable replacer of soybean because of its higher protein value and excellent amino acid contour. Fishes have low degrees of acidic secretions in the gut as compared to warm blooded creatures. Incorporation of natural acids in their feed decreases pH in the gut and improves the phytate hydrolysis, diminishes the pace of gastric exhausting and improves mineralization and supplement ingestion (Shah *et al.* 2015). Plant-derived ingredients are in destitute of certain components, such as Tau (El-Sayed, 2014). Taurine (2-aminoethanesulfonic acid, CAS 107-35-7) is an organic acid which was first narrated from ox bile Tiedemann and Gmelin (1827). Tau has been found to have vital role in physiological functions in detoxification, calcium transport, myocardial contractility, retina and brain development and osmotic regulation (Huxtable, 1992). Literature review indicates that supplementation of dietary Tau significantly affected the whole-body composition and WG rate (WGR) of grouper and several other fish species (Shen *et al.* 2019).

Common carp (*Cyprinus carpio*) is one of the most significant aquaculture species of cyprinid with an annual global production of 3.4 million tons, accounting for almost 14% of the freshwater aquaculture production in the world (Ji *et al.* 2012)and its annual global production has been increased up to 4.1 million tons in 2017 FAO (2019). At present, farming of freshwater carps is present all over Pakistan particularly in the provinces of Punjab and Sindh (Khan *et al.* 2016).

Information regarding hematological parameters has provided valuable knowledge for fish experts in development of fish health and in monitoring fish stress responses (Hrubec *et al.* 2000). In past, most of research was carried out to determine influences of Tau on growth performance, digestive enzymes function and anti-oxidant capacity in a number of marine fishes but limited data is available on effects of Tau on whole body composition and hematological parameters of freshwater fishes. So there is a need to find optimal level of Tau in fish feed to enhance nutrient utilization in fish. Current study was designed to determine the role of Tau addition in LSM based diet on growth performance, carrion constitution & hematologic parameters of Common carp fish and to estimate optimal inclusion of Tau in plant based diet.

MATERIALS AND METHODS

Current study was done to determine the effect of Tau addition on growth rate, hematological indices & carcass of *C. carpio* fingerlings catered on LSM diet. Experimental work has been carried out in Fisheries Nutrition Laboratory, Division of Zoological science, University of Education, Lahore, Pakistan.

Experimental settings. *C. carpio* fingerlings were purchased from Sindhwa Fish farm, Head balloki, Kasur. Fingerlings were acclimatized to lab conditions in specially designed V- shaped tanks having 70 L water capacity for fifteen days. Fingerlings were treated with saline mixture for 5-10 minutes to kill all pathogens if present (Rowland and Ingram, 1991). Meanwhile fish was given feed twice a day on basal diet (Allan and Rowland, 1992).Water quality parameters have been maintained, and oxygen supply was aided by air pump using capillary system throughout the experimental period.

Experimental design. Linseed oil seed husk has been utilized as test ingredient to devise experimental diet. TD was acidified with graded levels of Tau (0, 2,4,6,8 and 10 gkg^{-1}) to derive one control ($0gkg^{-1}$) and five TDs. For this purpose, triplicate tanks were used & in every single tank fifteen fingerlings were stockpiled. The experiment continued for 60 days. Each linseed meal based diet supplemented with Tau was compared with other diets and control diet to determine growth performance, hematological parameters and carcass composition by using Completely Randomized Design (CRD).

Processing of linseed oil seed and TD formulation. Linseed oil seeds were purchased from native market place of Lahore. Seeds were air-dried and de-fatted by press method (Salem and Makkar, 2009). Defatted flax seeds were pulverized to make fine powder.

Feed pellets formation. Component parts of the feed which has been purchased from native marketplace in Lahore, were ground to fine powder to permeate through 0.3mm sieve size and examined for organic chemical composition by ensuing conventional model AOAC (1995) methods before the preparation of speculative trial diets (Table 1). The whole sum of ingredients were carefully blended in a food processor and fish oil was gradually added. Appropriate amount of distilled water was added to make suitable dough. In order to make floating pellets this dough was processed through experimental extruder. All the TDs were dried and stored at 4°C until used.

Feeding procedure. *C. carpio* fingerlings were given prescribed diet at the rate of 4% of live wet weight twice daily. After the feeding duration of two hours, the surplus diet was sluice out from each tank by opening the valves of the tanks. The tanks were cleansed entirely to whip out the feed particles and freshened with tap water.

Analysis of Growth performance. Fingerlings (15) of mean wt. (4.77g $fish^{-1}$) were abound in each replicate. The fish were bulk weighed in each tank after fifteen days during the whole experimental duration to estimate the growth performance. Growth variables such as WG (g), FCR, WG (%) and SGR of fingerlings have been computed by using standard formulae NRC (1993). Recorded values of Growth parameters of *C. carpio* fed Tau supplemented diets for 8 weeks has been shown in table 2.

WG % = (FW – IW)/IW × 100

FCR = Total dry FI (g) / Wet WG (g)

SGR% = (ln. FW of fish – ln. IW of fish) / Trial days × 100

Table 1. Ingredients and chemical composition (%) of feed ingredients and diets (Dry based).

Ingredients	TDs	DM (%)	CP (%)	CF (%)	Ash (%)	EE (%)	CHO	GE (kcal/g)
Linseed meal	33	89.91	32.64	12.93	11.74	3.73	38.96	3.99
FM	16.5	91.54	49.31	1.29	24.66	6.99	17.75	2.23
Corn gluten (60%)	13.5	90.37	59.34	1.41	1.63	4.79	32.83	4.38
Wheat flour	17.5	92.73	9.43	2.88	2.06	2.41	83.22	3.09
Rice polish	8.5	91.86	13.02	13.06	11.17	12.76	49.99	3.03
Fish oil	7							
Vitamin premix	1							
Mineral premix	1							
Ascorbic acid	1							
Chromic oxide	1							
Tau level (gkg^{-1})*	0.0-10 gkg^{-1}							

*Wheat flour was replaced with the cost of Taurine.

TDs: Test diets, DM: Dry Matter, CP: Crude Protein, CF: Crude fibre: EE: Ether Extract, CHO: Carbohydrate, GE: Gross Energy

Table. 2. Recorded values of Growth parameters of *C. carpio* fed Tau supplemented diets for 8 weeks.

Growth Parameters	Tau level gkg^{-1}					
	0	2	4	06	08	10
	TD - I	TD – II	TD - III	TD - IV	TD – V	TD - VI
IW(g)	6.21 ± 0.19^{a}	6.23 ± 0.17^{a}	6.23 ± 0.12^{a}	6.22 ± 0.15^{a}	6.22 ± 0.10^{a}	6.21 ± 0.14^{a}
FW(g)	19.16 ± 0.28^{c}	22.30 ± 0.47^{b}	24.54 ± 0.57^{a}	23.19 ± 0.64^{ab}	22.02 ± 0.76^{b}	18.34 ± 0.74^{c}
WG(g)	12.95 ± 0.11^{c}	16.07 ± 0.30^{b}	18.31 ± 0.64^{a}	16.97 ± 0.50^{ab}	15.80 ± 0.85^{b}	12.13 ± 0.69^{c}
WG %	208.74 ± 4.85^{c}	257.85 ± 2.34^{b}	294.26 ± 14.51^{a}	272.96 ± 3.03^{ab}	254.25 ± 17.65^{b}	195.35 ± 10.75^{c}
WG (fish^{-1} day^{-1})g	0.19 ± 0.00^{c}	0.23 ± 0.00^{b}	0.26 ± 0.01^{a}	0.24 ± 0.01^{ab}	0.23 ± 0.01^{b}	0.17 ± 0.01^{c}
FI(fish^{-1} day^{-1})g	0.27 ± 0.01^{b}	0.32 ± 0.01^{a}	0.32 ± 0.01^{a}	0.32 ± 0.02^{a}	0.34 ± 0.02^{a}	0.31 ± 0.02^{ab}
FCR	1.48 ± 0.07^{b}	1.39 ± 0.02^{bc}	1.24 ± 0.04^{d}	1.32 ± 0.04^{cd}	1.50 ± 0.05^{b}	1.76 ± 0.08^{a}
SGR	1.25 ± 0.02^{c}	1.42 ± 0.01^{b}	1.52 ± 0.04^{a}	1.46 ± 0.01^{ab}	1.40 ± 0.05^{b}	1.20 ± 0.04^{c}
Survival rate	91.11 ± 3.85^{ab}	95.56 ± 3.85^{a}	97.78 ± 3.85^{a}	93.33 ± 0.00^{ab}	88.89 ± 3.85^{ab}	84.44 ± 3.85^{b}

Means in rows possessing dissimilar superscripts are statistically dissimilar at $P < 0.05$

Data in each is mean of triplicates

Blood samples and hematological analysis. After completion of trial, fingerlings from each diet group were taken and their blood sample was collected from caudal vein using heparinized syringe. Blood samples were brought to science laboratory for hematologic scrutiny. Micro-hematocrit technique was exploited to estimate hematocrit with the help of capillary tubes. RBCs and WBCs counts were measured with a haemo-cytometer with approved Neubauer counting chamber. Hb concentration calculations have been gauged as delineated by Wedemeyer and Yastuke (1977). The below mentioned parameters have been estimated: MCHC, MCH and MCV by using the following formulae.

$$M = \frac{H}{P} \times 100$$

$$M = \frac{P}{R} \times 10$$

$$\mathrm{MCH} = \frac{\mathrm{Hb}}{\mathrm{RBC}} \times 10$$

Chemical analysis of fish body composition. For analysis of body composition, sacrificed fish were dried at room temperature. The dried fish samples from each treatment have been cohered separately using mortar & pestle to analyze using conventional techniques (AOAC, 1995). To determine hydric content in fish body, oven drying method was utilized at 105°C for 12 hours. Micro Kjeldahl's apparatus was used to examine CP of whole-body sample. Gross fat was evaluated by petroleum ether extraction using Soxhlet system. Gross fiber constituents were measured as loss on ignition of dried lipid-free residues after digestion with 1.25% sodium hydroxide and1.25% H_2SO_4 whereas, ash by burning in electric-powered boiler (Naberthern B170) at 650°C for 12 hours to constant weight. Total CHO (N-free extract) were calculated by difference, i.e.

Total CHO % = 100 – (EE %+ CP % + Ash % + CF % + Moisture %)

Statistical analysis. Data of fish hematologic indices and carrion constitution was subjected to one way ANOVA using CoStat Computer Package. For comparison of values, Tukey's Honesty Significant Difference Test was applied and considered significant at *P*<0.05 Snedecor and Cochran (1991).

RESULTS

The maximum WG % (294), SGR value (1.52), highest survival rate (98%) and minimum FCR (1.24) was observed in group III, fed on 4gkg^{-1} level of Tau supplemented linseed meal based diet, implying better feed utilization efficiency. The minimum WG (12g), WG% (195), SGR (1.20) and highest FCR (1.76) were observed in group VI fed on 10gkg^{-1}. Following results clearly demonstrate that Tau augmentation up to a certain level of 4 gkg^{-1} played a major role in ameliorating feed utilization and growth performance of *C. carpio* fingerlings (Table 2).

Addition of Tau take the lead in enhancing nutrient retention in fish when given Tau supplemented LSM based diet as compared to fish fed on control diet (Table 3). Highest values of CPs (18.23), GE (2.13) and CHO (2.84) were found in fingerlings of group III fed on 4gkg^{-1} level of Tau supplemented LSM based diet and was found significantly (*P*>0.05) different from recorded value in control treatment as well as other Tau supplemented TDs. It was noticed that there is subsequent increase in GE and CP retention starting from 2gkg^{-1} level of Tau but with further addition of Tau (6 and 8gkg^{-1}), an acute downfall in value was recorded. The least value for CPs (11.37%) and CHO (2.54%) was observed in group VI. On the other hand, highest amount of EE (7.86) was recorded in group IV followed by (7.81%) in group III. Crude fiber (1.34%) and ash (6.29%) were found maximum in control group which was fed on control diet. Lowest values for crude fiber (1.24%) and ash (6.10%) were recorded in group VI. In case of moisture, highest value (70%) was recorded in group VI and (62%) least value was recorded in group III as shown in Figure1.

According to results (Table 4), highest values of RBCs (3.08×10^{6}mm^{-3}) Hb g/100ml (8.53), MCHC% (35.84), PCV% (26.43) and MCH (53.05 **pg**) were recorded in fish of group III, fed on 4gkg^{-1}of Tau supplemented LSM based diet. Maximum numbers of WBCs (7.10×10^{3}mm^{-3}) were noted in group VI which was fed on 10gkg^{-1} taurine, followed by (6.84×10^{3}mm^{-3}) in group IV. Highest PLT (64.59) and Lymphocytes % (26.48) were observed in group II, fed on 2gkg^{-1} Tau supplemented LSM based diet. Maximum value of MCV (fl); 175.70 and Ht % (35.23) was noted in group IV, fed on 6gkg^{-1} Tau supplemented LSM based diet. Lowest values of RBCs, Hb, MCHC, PLT, Lymphocytes %, PCV%, MCH (pg), MCV (fl) and Ht% were found in group VI which was fed on 10gkg^{-1}. There was a significant difference (*P*>0.05) in values from control treatment and other Tau supplemented TDs (Figure 3). The least numbers for WBCs were noted in control treatment. Highest percentages of Eosinophile, Neutrophile and Monocytes were recorded in group VI, which was fed on 10gkg^{-1} Tau supplemented LSM based diet. The hematology results indicate that 4gkg^{-1} is optimum level of Tau supplemented LSM based diet.

Table 3. Body composition (gross energy, carbohydrates, proteins and fiber content) of *C. carpio* fed on LSM based diet.

Diets	TD – I	TD - II	TD – III	TD - IV	TD – V	TD - VI
Tau levels gkg^{-1}	0	2	4	6	8	10
CHO	2.58±0.42^{a}	2.85±0.24^{a}	2.84±0.45^{a}	2.72±0.20^{a}	2.60±0.39^{a}	2.54±0.41^{a}
Proteins	14.13±0.77^{cd}	16.03±0.66^{b}	18.23±0.75^{a}	15.69±0.41^{bc}	12.98±0.38^{de}	11.37±0.61^{e}
Fat	7.11±0.37^{a}	7.61±0.61^{a}	7.81±0.26^{a}	7.86±0.22^{a}	7.69±0.45^{a}	7.57±0.38^{a}
GE	1.27±0.26^{b}	1.74±0.27^{ab}	2.13±0.25^{a}	1.82±0.43^{ab}	1.61±0.24^{ab}	1.44±0.27^{ab}
Ash	6.29±0.39^{a}	5.17±0.43^{a}	5.32±0.45^{a}	5.30±0.32^{a}	5.92±0.84^{a}	6.10±0.63^{a}
Crude fiber	1.34±0.20^{a}	1.21±0.18^{a}	1.26±0.20^{a}	1.29±0.19^{a}	1.30±0.21^{a}	1.24±0.13^{a}
Moisture	67.27±0.92^{ab}	65.40±0.96^{b}	62.40±0.89^{c}	65.31±0.76^{b}	67.90±0.92^{a}	69.75±0.98^{a}

Means in rows possessing dissimilar superscripts are statistically dissimilar at P < 0.05
Data in each is mean of triplicates

Table 4. Statistical results evaluated for Hematological indices of *C. carpio* fish feeding on Tau substituted LSM feed. Mean without similar superscript is different significantly (P< 0.05).

Parameters	TD – I	TD – II	TD - III	TD - IV	TD – V	TD - VI
Tau level(gkg^{-1})	0	2	4	6	8	10
RBCs (106mm^{-3})	2.24±0.28^{b}	2.71±0.26^{a}	3.08±0.24^{a}	2.82±0.13^{a}	2.05±0.18^{b}	1.12±0.10^{c}
WBCs(10^{3}mm^{-3})	6.43±0.18^{b}	6.46±0.14^{b}	6.46±0.33^{b}	6.84±0.25^{ab}	6.68±0.15^{ab}	7.10±0.20^{a}
PLT	62.52±0.78^{a}	64.59±0.69^{a}	63.34±0.76^{a}	59.50±0.80^{b}	57.48±1.29^{bc}	55.98±0.75^{c}
Hb(g/100ml)	6.63±0.35^{bc}	7.47±0.71a^{b}	8.53±0.31^{a}	7.09±0.52^{b}	5.48±0.23c^{d}	4.99±0.18^{d}
PCV (%)	24.80±0.84^{ab}	26.25±0.94^{a}	26.43±0.68^{a}	23.16±0.85^{bc}	22.71±0.82^{bc}	21.70±0.88^{c}

MCHC (%)	32.35±0.81^{b}	32.31±0.93^{b}	35.84±0.94^{a}	35.56±0.88^{a}	31.37±0.85^{b}	28.66±0.81^{c}
MCH (pg)	46.58±0.91^{b}	51.93±0.37^{a}	53.05±0.84^{a}	48.39±0.77^{b}	40.53±0.94^{c}	33.46±0.68^{d}
MCV (fl)	120.43±0.87^{b}	174.66±0.92^{a}	175.28±0.81^{a}	175.70±0.81^{a}	118.23±0.90^{b}	90.66±0.73^{c}
Ht %	31.43±0.85^{bc}	33.50±0.86^{ab}	34.81±0.87^{a}	35.23±0.65^{a}	30.61±0.91^{c}	25.63±0.98^{d}
Lymphocyte %	20.67±0.88^{bc}	26.48±0.71^{a}	25.65±0.72^{a}	22.30±0.94^{b}	19.46±0.81^{cd}	17.28±0.92^{d}
Eosinophile %	1.41±0.26^{ab}	1.27±0.11^{ab}	1.21±0.09^{b}	1.34±0.11^{ab}	1.48±0.15^{ab}	1.66±0.14^{a}
Monocyte %	2.23±0.23^{ab}	2.32±0.42^{ab}	3.17±0.78^{a}	1.71±0.21^{b}	2.55±0.22^{ab}	3.23±0.28^{a}
Neutrophile %	75.70±1.24^{b}	69.92±0.27^{c}	69.97±0.02^{c}	74.66±0.77^{b}	76.51±0.81^{ab}	77.83±0.74^{a}

Means in rows possessing dissimilar superscripts are statistically dissimilar to be same at $P < 0.05$
Data in each is mean of triplicates

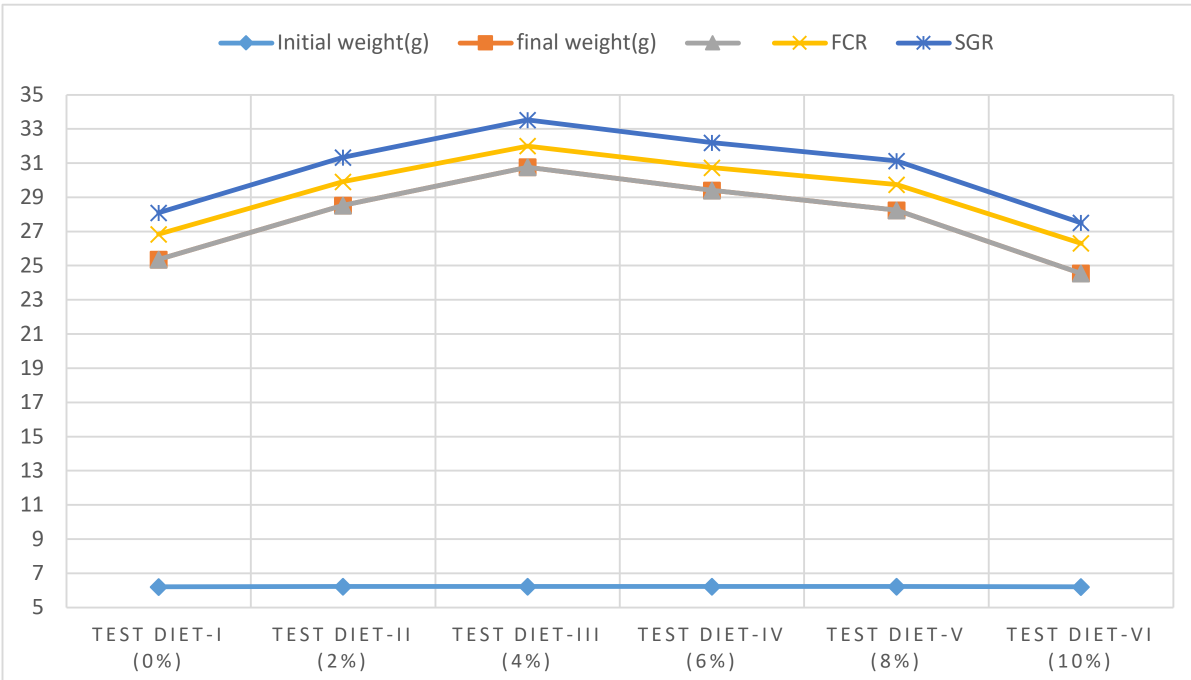

Figure 1: Graphical Presentation of Growth Performance in *C. carpio's* Fingerlings

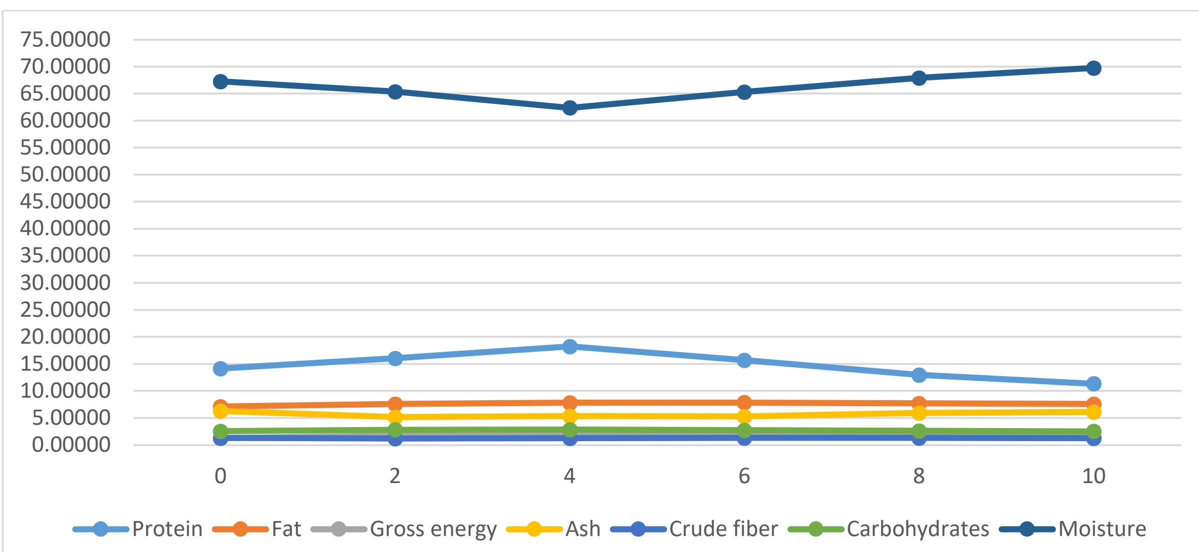

Figure 2: Graphical presentation of *C. carpio's* proximate carcass composition fed on LSM based diet

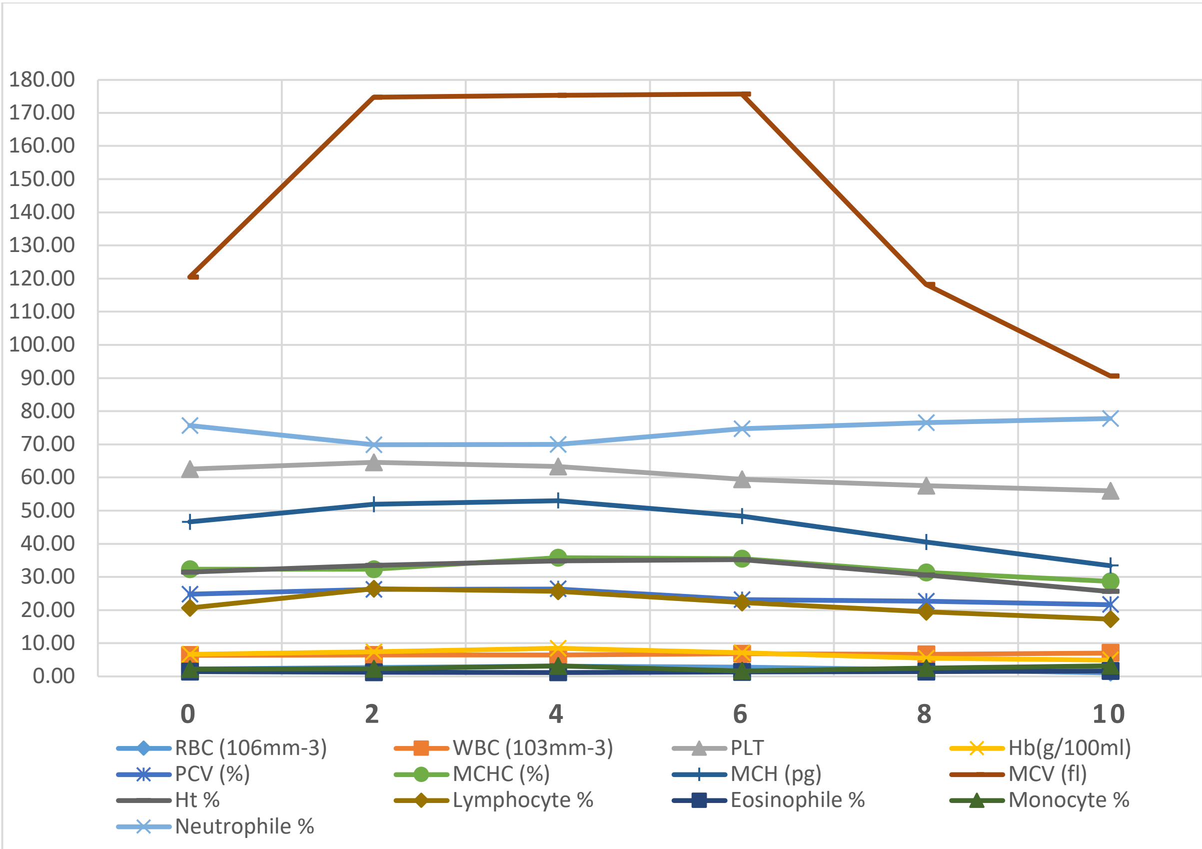

Figure 3: Graphical presentation of hematological indices of *c. carpio* fingerlings fed on Tau supplemented LSM based diet.

DISCUSSION

Replacement of FM with plant proteins alters the amino acid composition of fish diets. Thus, individual essential amino acids are often added to diets to make the amino acid composition of the plant diets equivalent to those of fish-meal diets or to meet the estimated requirements of the species being reared. Present study has clearly indicated that 4gkg^{-1}level of Tau was enough to hydrolyze phytic acid and to release the bound minerals and nutrients of plant based diet (Linseed meal). Such effects might be due to the increased exudation of digestive enzymes resulting in better feed digestion and consumption, & eventually better growth. In similar studies with carps, Liu *et al.* (2006) and Luo *et al.* (2006) pinpointed that Tau addition strengthen growth rates, feed digestibility and feed efficacy. When reviewed in literature, the results of the current study were analogous to those recorded in other fish, such as Nile tilapia at 10 gkg^{-1} diet (Al-Feky *et al.* 2016), white sea bass i.e. at 9.9 gkg^{-1} diet (Jirsa *et al*. 2014), yellow catfish at 10.9 gkg^{-1} diet (Li *et al.* 2016), for Japanese flounder at 16.6 gkg^{-1} diet (Kim *et al.* 2005), turbot at 11.5 gkg^{-1} diet, (Qi *et al.* 2012), *Rachycentron canadum* (cobia) at 5.0 gkg^{-1} diet (Lunger *et al.* 2007), for rainbow trout at 8.5 gkg^{-1} diet (Gaylord *et al*. 2007), common dentex (*Dentexdentex*) at 2.0 gkg^{-1} diet (Chatzifotis *et al.* 2008). The dietary Tau prerequisites of fish have a wide range (from 2 to 16.6 gkg^{-1} diet), which is probably influenced by dietary origins of protein and levels, experimental conditions, assimilation rate, fish sizes & species (El-Sayed, 2014; Salze and Davis, 2015). Conversely the found results, Kim *et al.* (2008) mentioned that dietary Tau is not involved in improvement of growth of common carp juveniles. Supplementation of Tau at 0.3–3% has no considerable impact on growth rate of common carp fingerlings. In present research work, the most suitable FCR (1.24), SGR (1.52) values and survival rate (98%) were recorded at 4gkg^{-1}over those of fingerlings fed on control diet (without taurine) and other Tau supplemented diets. Similar to our results, improved FCR (1.31) and SGR (3.88) in common carp fed on soybean meal (SBM) based diet was recorded at 10 gkg^{-1}and 15gkg^{-1} respectively, while life expectancy (98%) at 5gkg^{-1} and 15gkg^{-1}level of Tau (Abdel-Tawwab and Monier, 2018).

In contrast to our results improved WG (47g) and FCR (56) in juvenile channel catfish was reported by Peterson and Li, (2018) when juveniles were fed on 2gkg^{-1} Tau supplemented SBM based diet. Similarly, Lim *et al.* (2013) reported that juvenile parrot fish showed better growth and feed utilization when fed on SBM based diets supplemented with dietary Tau at 8gkg^{-1} level.

In intensive farming, body analysis is very helpful for quality assessment of complete body contents in response to dietary restriction of an essential nutrient. Fat and protein contents in whole body are generally known as criterion constituents for determining the quality of fish flesh and the hepatosomatic indices (Caulton and Bursell, 1977). This is the first study assessing the effects of nutritional supplemental Tau on proximate body composition and hematological indices of Chinese carp i.e. common carp. We observed that it was possible to substitute the diets with Tau supplemented LSM based diet since increasing values of CHO, CPs, crude fibers, GE and fat were recorded in *C. carpio*. Usually 2 to 15gkg^{-1} of Tau supplementation in plant by products are considered as optimum level for nutrient retention in different freshwater fishes. Variability in nutrient retention depends on ingredients composition, feed formulation, presence or absence of stomach, feed processing technology and fish species as well. Our results indicated that highest contents of CPs (18.23) along with GE (2.13) were found in fish that was fed on 4gkg^{-1} level Tau supplemented LSM based diet and was found statistically dissimilar from recorded value in control treatment as well as other Tau supplemented TDs. It was noticed that there is subsequent increase in GE and CP retention starting from 2gkg^{-1} level of Tau but with further addition of Tau (6 and 8gkg^{-1}) an acute downfall in value was recorded. Highest amount of CHO (2.85) were observed in group II which was fed on 2gkg^{-1} followed by (2.84) in group IV. On the other hand, highest amount of EE (7.86) was recorded in group IV and least value for EE was recorded in control group. Different from our results, improved body composition was observed in *Lutjanus colorado* Juvenile when fed on optimal level of Tau (16.3gkg^{-1}) in soybean meal based diet (Hernandez *et al.* 2018). Contrary to our results, Persian sturgeon, fed with Tau supplemented diet showed lowest whole body lipid content. Present outcomes are quite similar to those as were obtained in case of *Salmo salar* (Espe *et al.* 2012) and *S. maximus* (Yun *et al.* 2012) fed on diets supplemented with graded levels of taurine. Whereas Tau addition augmented whole body fat content in *S. maximus* (Qi *et al.* 2012), but had no significant effects on *Anoplopoma fimbria* (Johnson *et al. 2*015) and *P. olivaceus* (Han *et al.* 2014). In our results, crude fiber (1.34) and ash (6.29) were found maximum in control group (with 0gkg^{-1} Tau level). Lowest values for crude fiber (1.24%) and ash (6.10%) were recorded in group VI. Moisture content was highest in group VI. Unlike our results Tau supplementation at 2gkg^{-1} seems to have no effects on whole body constitution of large-mouth Bass (Frederick *et al.* 2016).

Our results related to hematology, have shown that 4gkg^{-1} is optimum level based diet conferring better fish growth whereas better immune responses were recorded at 10gkg^{-1} Tau supplemented LSM based diet. Highest percentages of Eosinophile (1.66%), Neutrophile (77.83%) and Monocytes (3.23%) were recorded in fish group which was fed on 10gkg^{-1} Tau supplemented LSM based diet. The nutritional importance of Tau has been previously estimated in saline water species and data regarding freshwater species is largely limited. There is no previous record on this topic, but it is suggested that increased numbers of Monocytes, Neutrophile and Eosinophile confer better immune functions in common carp and their number can be improved by Tau supplementation in diet. There is a need for determination of underlying mechanisms for Tau induced better growth and immunological functions in freshwater fish species.

Conclusion: On the basis of this study it was concluded that common carp fed on LSM based diet requires supplementation of Tau because plant by- products contain trace amount of taurine. Supplementation of Tau at the rate of 4gkg^{-1} in diet is essential which is either partially or wholly supplemented in plant proteins, to improve the growth performance, carcass composition and hematological indices.

Contribution: M. M. Shahzad and S. M. Hussain, designed experiment, assisted in idea conception, Supervised, revision of manuscript critically for important intellectual content.

F. Khalid, conducted trial for research, collected samples and prepared manuscript

M. Hussain, M. Y. Zahoor, supervised throughout study trial and helped in critical review of manuscript preparing

Z. Hussain, contributed in analysis and interpretation of data

R. A. Rehman, helped in manuscript preparation reviewing and proof reading

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