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Comparative Study of Body Composition and Mineral Profile of Selected Herbivorous and Carnivorous Fish Species in River Chenab and Hatchery, Punjab

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Key words
Body composition, Aquaculture, Herbivorous fish, Carnivorous fish, Mineral profile, Hatchery

ABSTRACT

The purpose of this study is to investigate the body composition and mineral status of herbivorous fish species (*Labeo rohita, Catla catla* and *Cirrhinus mrigala*) and carnivorous fish species (*Sperata seenghala, Channa marulius* and *Wallago attu*). In this research, the selected fish species were collected from River Chenab, Chiniot and Fish Seed Hatchery, Faisalabad. A total of 18 fish samples were analyzed for moisture, protein, fat, ash and mineral estimation for 60 days. The results of body composition in herbivorous fish (*C. catla*) of River Chenab had best carcass (moisture: 76.02%, crude protein: 18.45%, crude fat: 3.26%, and ash: 2.27%) than herbivorous fish of hatchery. Similarly, carnivorous fish (*C. marulius*) of River Chenab had high quality carcass (moisture: 67.97%, crude protein: 24.49%, crude fat: 4.47%, ash: 3.07%) than carnivorous fish of hatchery. Furthermore, it was observed that carnivorous fish species in both the river and hatchery had higher body composition than herbivorous fish species. On the other hand, mineral status of carnivorous fish (*C. marulius*) in River Chenab gave best results (Na: 0.66%, K: 1.36%, Mg: 0.48%, Ca: 1.66%, and P: 1.02%) than hatchery. Likewise, herbivorous fish (*C. catla*) in river showed maximum minerals (Na: 0.78%, K: 1.27%, Mg: 1.37%, Ca: 2.45%, and P: 1.60%) than in hatchery. Moreover, it was shown that better minerals were observed in carnivorous fish species of both rivers and hatcheries. Conclusively, carnivorous fish had better body composition and mineral status of River Chenab and fish are preferred over herbivorous fish but herbivorous fish have their own benefits.

INTRODUCTION

Hunger is the world's leading risk factor, causing the mortality of a large number of people (World Food Program, 2012). Therefore, the fundamental challenge for the global development agenda is ensuring a greater accessibility of food. For this purpose, they considered fish to be a nutritious source of peptides, proteins, and other essential amino acids (EAAs) in contrast to terrestrial animals (Tacon and Metian, 2013; Grafton *et al*., 2015). Aquatic animals particularly, fish are more efficient in converting feed into protein than terrestrial livestock. For example, chicken and pigs convert around 18-30% of the food ingested, although fish converts about thirty percent of the food consumed (Huntington and Hasan, 2019). Aside from protein, fish also contains long-chain polyunsaturated fatty acids (LC-PUFAs) and readily available fundamental micro-nutrients such as vitamins D, and B, as well as minerals, which are required for human consumption (HLPE, 2014). It also absorbs nutrients from

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their diet and the surrounding waterways (Tacon *et al*., 2022).

Unfortunately, worldwide fish populations are declining rapidly. Aquaculture is the most suitable approach for the production of sufficient seafood for the world (Shah *et al*., 2018). Moreover, in the current century, the growth of the aquaculture sector has increased because of its significant relationship with global food security (Njinkoue *et al*., 2016). It has expanded by approximately twelve times in the last thirty years and currently accounts for more than forty percent of world fish consumption, allowing aquaculture to fulfill the rising demand (Kumar, 2014).

Knowing the nutritional composition of any eatable organism is crucial for evaluating its nutritional quality (Soundarapandian *et al*., 2013). Body composition is considered significant in fisheries research because it helps in estimating their nutrient contents (Daniel, 2015). Most fish have protein synthesis of up to thirty percent of their body weight, lipid content of up to twenty-five percent, and a moisture content of approximately fifty to eighty percent (Hasan *et al*., 2015; Hossain *et al*., 2015; Chakma *et al*., 2020). On the other hand, minerals play a crucial role in maintaining the body's acid-base and water balance, tooth and bone formation, and metabolic response acceleration (Zhang *et al*., 2020). Among the vertebrates, fishes are extraordinary in their capacity to retain minerals from their diets (Lall, 2022).

Out of seventy-five percent, 2.5 percent of water is present in the form of freshwater. Punjab has five rivers that pass through it. The Chenab River is considered a significant waterway of both India and Pakistan. It runs in the District of Himachal Pardesh of India and flows through the Jammu region into the fields of the Punjab, Pakistan (Hussain *et al*., 2017).

In light of the preceding information, the current study aimed to compare the body composition and mineral status of herbivorous (*Labeo rohita, Catla catla, Cirrhinus mrigala*) and carnivorous (*Sperata seenghala, Wallago attu, Channa marulius*) fish species from River Chenab and hatchery. However, few studies have been conducted on nutritional values of both herbivorous and carnivorous fishes (Ravichandran *et al*., 2012).

MATERIALS AND METHODS

Site selection and fish sampling

The study was carried out at Chiniot, the administrative headquarters of Chiniot District in the province of Punjab, Pakistan, along the Chenab River. The 18 fish samples (3 replicates of each herbivorous fish species named; *L. rohita, C. catla* and *C. mrigala* as well as 3 replicates of each carnivorous fish species named; *C. marulius, S. seenghala* and *W. attu*) were collected from River Chenab at Chiniot Bridge in Chiniot and 18 samples from Hatchery, Faisalabad. These fish species were chosen due to their diverse feeding patterns, such as herbivorous and carnivorous, as well as their flavor and price. Samples were collected with the help of a local fisherman. All fish specimens were immediately transferred in an ice slurry and transported to Fish Nutrition lab, Department of Zoology, Government College University, Faisalabad. This study was carried out for 60 days.

Fish dissection and preservation

All fish species were gutted, eviscerated using a clean stainless-steel knife, and thoroughly washed in flowing tap water. After removing the central vertebra, skin was removed, and the eatable portion comprised of flesh, was cut into small pieces. The samples were oven dried at 105℃ till they were completely dried. The dried samples were pulverized with a glass mortar and pestle, sieved through 1 mm mesh and kept in airtight jars within the desiccator. A homogenized mixture was prepared and kept at 4℃ until the analysis was done.

Body composition analysis

Body composition of muscles of freshwater fish i.e *L. rohita, C. mrigla, C. catla, S. seenghala, W. attu,* and *C. marulis*, was analyzed by following Hussain *et al*. (2024).

Determination of moisture content

To determine the moisture contents of fish samples, two grams of body flesh were placed in pre-weighed petri dishes and weight (W_1) was noted. The samples were than dried in an oven at 105℃ for 24 h. After drying, they were placed in the desiccator for the purpose of cooling for at least thirty minutes and weighed (W_2). The moisture content of fish muscles was estimated using the following formula:

$$\text{Moisture (\%)} = \frac{W_1 - W_2}{\text{weight of sample}} \times 100$$

Determination of ash content

For ash analysis, a muffle furnace was used. The furnace temperature was fixed at 550℃. 1 g of homogenized dried fish flesh samples were placed in the porcelain crucibles and weighed (W_1). Then, they were put in the muffle furnace. After drying, they were put in the desiccator for the purpose of cooling for at least thirty minutes and weighed (W_2). The ash content was determined using the following formula:

$$\text{Ash (\%)} = \frac{W_1 - W_2}{\text{weight of sample}} \times 100$$

Determination of crude protein content

The crude protein was determined by using micro Kjeldhal apparatus. A digestion mixture was prepared by adding potassium sulfate, copper sulfate, and iron sulfate in a ratio of 90:7:3. 1 g of each homogenized sample were added in Kjeldhal flask along with 5 g of digestion mixture and 30 mL of H_2SO_4. The flask was heated on a hotplate till the solution became green and transparent. Then, they were allowed it to cool down. Once they were cooled, distilled water was added to dilute it. In cleaned Kjeldhal's apparatus, 10 mL of 40% of sodium hydroxide was mixed with 10 mL of diluted solution. It is then steam distilled. We collected the ammonia when the solution's color change from pink to yellowish-golden. Following that, boric acid solution was titrated against 0.1 mL of ammonium sulfate. Methyl red indicator was used. The percentage of nitrogen and crude protein were calculated by using following formulae:

$$\text{Nitrogen } (N_2)\ \% = \frac{\text{Volume of } H_2SO_4 \times \text{ Normality of } H_2SO_4 \times 0.014 \times 250}{\text{Weight of sample } \times 10} \times 100$$

$$\text{Crude Protein} = N_2\,\% \times 6.25$$

Determination of crude fat content

Weight of the thimble was calculated by using weighing scale, after which 1g of dried homogenized sample was added and then it was covered with cotton. It was put into the Soxhlet's extractor and fitted to the flask containing 300 mL of petroleum ether, which was then dried in an oven before use. Extractor and flask were placed into the heating mantle and condenser. Switch on the apparatus, flask was heated till the solvent in it boiled. After completing the cycles, the fat was collected on the surface of solvent. Extraction cup containing fat was removed, placed in desiccant and weighed again.

$$\text{Fat } (\%) = \frac{\text{weight of residue left in beaker}}{\text{Original wet body weight of sample taken}} \times 100$$

Mineral estimation

The fish carcass samples of fish were digested in boiling nitric acid and perchloric acid mixture (2:1) according to AOAC (2005). After appropriate dilution, mineral contents were estimated by using Atomic Absorption Spectrophotometer at the absorbance of 370 nm.

Statistical analysis

Data was subjected to three-way analysis of variance (ANOVA). The differences among means were compared by Tukey's Honesty Significant Difference Test and was considered significant at $p<0.05$ (Snedecor and Cochran, 1991). The Co-Stat Computer Software (Version 6.303, PMB 320, Monterey, CA, 93940 USA) was used for statistical analysis.

RESULTS

Body composition of fish species

The results of body composition of selected herbivorous and carnivorous fish species collected from the Chenab River are significantly different ($p<0.05$) from that of the hatchery. The results of body composition of chosen herbivorous and carnivorous fish species collected from Chenab River, are shown in Table I. The results of body composition of selected herbivorous fish species, i.e., *L. rohita, C. catla* and *C. mrigala,* were as follows:

Table I. Body composition (%) of selected herbivorous and carnivorous fish species of River Chenab and hatchery.

Habitat	Fish species	Feeding habitat	Moisture	Protein	Fat	Ash
River	*L. rohita*	Herbivorous	75.03±0.65^a	17.82±0.86^h	4.28±0.53^c	2.87±0.50^b
	Catla catla		76.02±0.63^b	18.45±0.80^g	3.26±0.34^f	2.27±0.69^d
	C. mrigala		74.45±0.27^c	17.74±0.43^i	4.25±0.54^c	3.56±0.81^a
	S. seenghala	Carnivorous	69.17±0.69^g	23.98±0.63^b	3.77± 0.93^d	3.08±0.69^{ab}
	C. marulius		67.97±1.21^i	24.49±1.17^a	4.47±0.72^b	3.07±0.78^{ab}
	W. attu		71.46±1.23^e	22.39±0.55^d	3.56±0.33^e	2.58±0.50^b
Hatchery	*L. rohita*	Herbivorous	77.40±0.65^a	16.82±0.62^j	4.05±0.11^c	1.73±0.13^e
	C. catla		77.56±0.57^a	17.26±0.85^i	3.94±0.81b^d	1.30±0.43^f
	C. mrigala		75.88±0.35^b	16.55±0.16^j	5.07±0.43^a	2.50±0.34^c
	S. seenghala	Carnivorous	71.91±1.02^d	21.47±0.77^f	4.02±0.68^d	2.60±0.63^c
	C. marulius		68.82±0.81^h	22.97±0.63^c	4.94±0.62^a	3.27±0.47^a
	W. attu		71.02±1.20^f	22.09±0.82^e	3.95±0.92^d	2.94±0.51^b

Means within columns having different superscripts are significantly differed at ($p>0.05$). Data are mean of three replicates.

Table II. Minerals profile of selected herbivorous and carnivorous fish species of River Chenab and hatchery.

Habitat	Fish species	Feeding habitat	Na (%)	K (%)	Mg (%)	Ca (%)	P (%)
River	*L. rohita*	Herbivorous	0.42±0.30^{d}	1.17±0.76^{b}	0.35±0.18^{f}	1.47±0.11^{c}	1.18±0.28^{lc}
	C. catla		0.66±0.14^{a}	1.36±0.64^{a}	0.48±0.30^{e}	1.66±0.10^{c}	1.02±0.35^{d}
	C. mrigala		0.34±0.19^{d}	1.09±0.82^{c}	0.27±0.13^{f}	1.19±0.14^{e}	0.79±0.15^{e}
	S. seenghala	Carnivorous	0.58±0.32^{b}	1.19±0.90^{b}	0.69±0.55^{d}	1.90±0.28^{b}	0.85±0.61^{d}
	C. marulius		0.78±0.35^{a}	1.27±0.27^{a}	1.37±0.35^{a}	2.45±0.17^{a}	1.60±0.39^{a}
	W. attu		0.67±0.06^{a}	1.30±0.45^{a}	1.15±0.65^{b}	2.29±0.60^{a}	1.35±0.31^{b}
Hatchery	*L. rohita*	Herbivorous	0.32±0.14^{e}	1.19±0.92^{b}	0.33±0.14^{f}	1.21±0.29^{d}	0.95±0.11^{d}
	C. catla		0.53±0.36^{d}	1.27±0.84^{a}	0.41±0.26^{e}	1.53±0.20^{c}	1.11±0.35^{c}
	C. mrigala		0.29±0.23^{e}	1.06±0.12^{c}	0.17±0.08^{f}	0.99±0.14^{e}	0.65±0.29^{e}
	S. seenghala	Carnivorous	0.60±0.17^{b}	1.11±0.47^{c}	0.49±0.16^{e}	1.66±0.55^{c}	1.05±0.23^{d}
	C. marulius		0.65±0.18^{a}	1.21±0.37^{b}	1.06±0.36^{b}	2.31±0.81^{a}	1.73±0.28^{a}
	W. attu		0.46±0.09^{d}	0.81±0.24^{d}	0.80±0.54^{c}	1.60±0.18^{c}	1.32±0.31^{b}

Means within columns having different superscripts are significantly differed at (p>0.05). Data are mean of three replicates

the percentage of moisture contents (75.03±0.65%, 76.02±0.63% and 74.45±0.27%), protein contents (17.82±0.86%, 18.45±0.80% and 17.74±0.43%), fat contents (4.28±0.53%, 3.26±0.34% and 4.25±0.54%) and ash contents (2.87±0.50%, 2.27±0.69% and 3.56±0.81%), respectively. In case of carnivorous fish species (*S. seenghala, C. marulius* and *W. attu*), moisture contents range from 67.97±1.21% to 71.46±1.23%, protein contents from 22.39±0.55% to 24.49±1.17%, fat contents range between 3.56±0.33% and 4.47±0.72% and ash contents range from 2.58±0.50% to 3.08±0.69%.

The body composition for selected herbivorous fish species showed that percentage of moisture contents ranged from 72.69±1.73 to 75.03±0.65%, protein contents 17.82±0.86 to 18.07±0.33%, fat contents 3.26±0.34 to 4.28±0.53% and ash content varied from 2.87±0.50 to 5.93±1.25%. The body composition of selected carnivorous fish species ranged from 75.59±0.72% to 74.791.10% moisture, 19.73±0.94% to 21.050.67% protein, 1.41±0.37% to 2.211.13% fat and 1.93.027% to 3.27±2.38% ash. However, it was observed that carnivorous fish species in both the river and hatchery had a higher protein content than herbivorous fish species (Table II).

Minerals profile of fish species

The results of mineral composition of selected herbivorous and carnivorous fish species collected from the Chenab River are significantly different (p<0.05) from that of the hatchery. In current study, minerals profile of selected herbivorous and carnivorous fish species living under same environmental conditions (River Chenab) was examined and minerals such as sodium (Na), potassium (K), magnesium (Mg), phosphorous (P) and calcium (Ca) were observed in them as shown in Table II. Mineral concentration in *L. rohita, C. catla* and *C. mrigala* ranged from 0.34±0.19% to 0.66±0.14% for Na, 0.79±0.15% to 1.18±0.28% for P, 1.17±0.76% to 1.09±0.82% for K, 0.27±0.13% to 0.48±0.30% for Mg and 1.19±0.14% to 1.66±0.10% for Ca. In case of selected carnivorous species of fish, the percentage of Na, P, K, Mg and Ca goes from 0.58±0.32 to 0.78±0.35%, 0.85±0.61 to 1.60±0.40%, 1.28±0.27 to 1.19±0.91, 0.69±0.55 to 1.16±0.65 and 2.46±0.17 to 1.90±0.28%, respectively.

The minerals analysis of selected herbivorous and carnivorous fish species of hatchery was carried out and their concentration in selected herbivorous fish species was found to be between 0.53±0.36 and 0.29±0.23% for Na, 1.11±0.35 and 0.65±0.29 for P, 1.27±0.84 and 1.06±0.12 for K, 0.41±0.26 and 0.17±0.08% for Mg and 1.53±0.20 and 0.99±0.15 for Ca, respectively. While the sequence of concentration of minerals in S. *seenghala*, *C. marulius* and *W. attu* was as follows; 0.60±0.17%, 0.65±0.18% and 0.46±0.09% for Na, 1.05±0.23%, 1.73±0.28% and 1.32±0.31% for P, 1.11±0.47%, 1.21±0.37% and 0.81±0.24% for K, 0.60±0.17%, 1.06±0.36% and 0.80±0.54% for Mg and 1.66±0.55%, 2.31±0.81% and 1.60 ± 0.18% for Ca, respectively. Moreover, it was shown that better minerals were observed in carnivorous fish species of both rivers and hatcheries as shown in Table II.

DISCUSSION

Fish plays a crucial role in food security and poverty mitigation in Pakistan's agricultural and urban areas (Jabeen and Chaudhry, 2016). Each of selected fishes were analyzed not only for their different dietary categories such as herbivorous (*L. rohita*, *C. mrigala* and *C. catla*) and carnivorous (*C. marulius, S. seenghala* and *W. attu*) but also for their affordable price and consumer's dietary preferences.

In our study, the body composition of herbivorous fish species viz., *C. catla, L. rohita,* and *C. mrigala,* showed lower protein content than protein content in carnivorous fish species (*W. attu, S. seenghala* and *C. marulius*) in both river and hatchery. Our findings showed similarity with the results of FAO (2013) for freshwater fish species. Our results are in contrast with Hadyait *et al*. (2018) who concluded that crude protein was maximum in meat of farmed fish species as compared to wild fish species.

The moisture content in the current experiment showed that farmed fishes have high moisture content which coincides with the results of Naz *et al*. (2020) and Tsegay *et al*. (2016). In contradiction to our findings, Naz *et al*. (2020) stated that protein contents in farmed fishes are highest than in wild fishes because it is due to the control of food quality and every physicochemical parameter in farming rather than in rivers where all types of food are present and water quality is poor due to water pollution. Whereas our findings showed that protein content in river fish is higher than hatchery fish due to variety of foods present in riverine systems (Asghar *et al*., 2023).

In terms of fat content, fish were categorized in the following order: Lean fat (less than 2%), low fat (from 2 to 4%), medium fat (from 4 to 8%) and high fat (greater than 8%) (Guimaraes *et al*., 2016). According to the above classification, selected carnivorous fish species of our research are considered as low-fat fish species and selected herbivorous fish species are low to medium fat fish. The average percentage of fat was significantly higher in hatchery fishes (5.07%) than river fishes (3.77%) because pelleted fish food has a much higher fat content than the natural diet (Blouin *et al*., 2021). The results do not coincide to results given by Hadyait *et al*. (2018) which showed that maximum fat content was seen in wild as compared to farmed fish. However, the findings of Chakraborty *et al*. (2016) and Naz *et al*. (2020) showed the same outcomes as our study. Fat contents in *O. mykiss* were observed 10-36.99% by Naeem *et al*. (2016) and 1-25% by Naeem *et al*. (2013). These values were higher as compared to our results. The results of research by Adebayo *et al*. (2016) are consistent with those of our study, which found that catfish have slightly more protein than tilapia.

The percentage of ash content in selected fish species were ranged from 1.30-3.56%, as in the studies of Sary *et al*. (2012) and Chrisolite *et al*. (2015). The findings of Ahmed *et al*. (2020) did not coincide with our findings as they reported that herbivorous fish showed minimum values while carnivorous fish showed maximum amount of ash.

Minerals are essential for regulating the body's acid-base and water balance, bone production, and metabolic response acceleration (Zhang *et al*., 2020). In the present research, concentrations of K, Mg, Na, P and Ca were examined in selected herbivorous and carnivorous species. The value of Ca and Mg contents of our study coincide with findings of Ullah *et al*. (2022). The lower Na and greater K concentrations in selected fish species make them an excellent meal for public health, particularly in the prevention of cardiovascular disease which coincides with the outcomes of Bu *et al*. (2012) and Perez and Cheng (2014). However, such variations in mineral concentrations in different fish samples could be due to the difference of species, seasons, catching areas and many other physical and environmental conditions of the area.

CONCLUSION

There was limited comparative information on the body composition and mineral profile of the Chenab River's herbivorous and carnivorous fish species. As a result, this study examined the nutritional properties of both herbivorous and carnivorous fish species. The findings revealed that the examined species of fish serve as effective sources of essential nutrients and minerals. Moreover, the findings of this study showed that carnivorous fish species can be used as an excellent source of nutrients because they contain a high amount of protein but low amount of fat, their mineral content is higher than that of herbivorous fish species. The experimental data also suggests that nutritionally freshwater fish is better than the hatchery ones for human consumption and body comparison varies from species to species as well as from habitat to habitat with the predetermined set of principles. Further research is required to confirm the results given by recent studies.

DECLARATIONS

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Ethical statement

This study was conducted in accordance with the ethical guidelines set forth by Government College University Faisalabad, ensuring that all procedures and methods employed adhered to the highest standards of ethics and integrity.

Statement of conflict of interest

The authors have declared no conflict of interest.

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