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Biochemical Composition of Few Commercially Important Food Fishes of River Sutlej in Punjab

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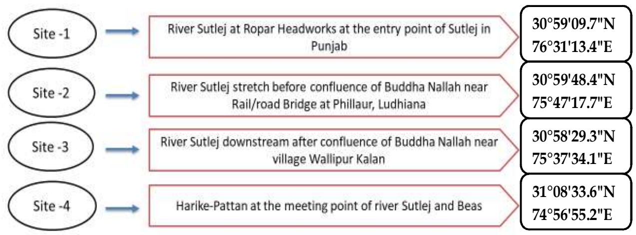
Abstract: River Sutlej is under pronounced pressure of anthropogenic activities and this study was devised to check whether the prevailing environmental conditions of the Sutlej have affected the biochemical composition of the few commercially important food fish species. The study was conducted from February 2018 to June 2019 to evaluate the biochemical composition of fish flesh (Protein, lipids, carbohydrates, ash, and moisture) of commercially important fish species *Labeo rohita, Cyprinus carpio, Sperata seenghala,* and *Wallago attu* owing to their high consumer preference. Fish samples were collected from four different designated sites i.e., Ropar Headworks, River Sutlej before confluence of Buddha Nallah at Phillaur, River Sutlej after the confluence of Buddha Nallah at Wallipur Kalan and Harike-Pattan where river Sutlej meets with Beas in plastic zipper bags (in triplicate) at two-monthly intervals . The percent moisture, lipid, protein, ash and carbohydrates ranged from 75.25-81.45, 1.13-2.50, 13.59-19.89, 1.20-1.59 and 1.12-1.15 at Ropar Headworks, River Sutlej before confluence of Buddha Nallah at Phillaur, River Sutlej after the confluence of Buddha Nallah at Wallipur Kalan and Harike-Pattan, respectively. However, protein, lipid, and carbohydrates were lower at River Sutlej after the confluence of Buddha Nallah at Wallipur Kalan as compared to other sites irrespective of fish species and seasons which might be due to the direct discharge of polluted water interfering with normal physiology of fish affecting the biochemical profile.

Keywords: Biochemical composition, Fishes, Punjab, Sutlej, Buddha Nallah

Fish is considered an important source of high-quality balanced and easily digestible protein profile, besides being a rich source of polyunsaturated fatty acids (Shamsan and Ansari 2010). The changes in proximate composition of fishes are often related to their habitat and thus affecting their nutritive value (Devi and Vijayaragahwan 2001). Protein and lipids are traditionally used as an indicator of the nutritional value as well as the physiological condition of the fish (Moghaddam et al 2007, Aberoumad and Pourshafi 2010). Proximate composition of fishes ranges between 65-90% water, 10-22% protein, 1-20% lipid and 0.5-05% minerals (Nair and Mathew 2000). It depends mostly on the season, size, age, sex, reproductive cycle, and breeding season (Singh et al 2016, Muchtadi et al 2016) as well as environmental factors such as temperature, habitat, availability, and source of food (Herawati et al 2018). The river Sutlej being a major source of capture fisheries in Northern India, possess a great diversity of fish species. But in recent times, due to natural and anthropogenic sources, it is under pronounced pressure of pollution which has deteriorated its water quality (Pandiarajan et al 2019) to the extent that it is unfit for any use. The deteriorating water quality of river Sutlej is a matter of concern (Kaur and Singh 2017) since it might be affecting the nutritional profile of fish species caught for human consumption by degrading their habitat as well as food sources. Habitat degradation due to pollution (Hussain et al 2018) as well as alterations in the ecology of a water body has a profound influence on changes in the proximate composition of fish muscles (Padmawati and Kumari 2006). The nutrient profile of fish flesh plays an important role in indicating their nutritional status as well as physiological health and is significantly affected by their food & feeding habits, habitat conditions and prevailing environmental factors. Since anthropogenic interferences are largely affecting the habitats of aquatic fauna, thus it becomes imperative to examine the biochemical composition of fishes collected from an ecologically sensitive aquatic environment to have a fair knowledge of any alteration in its biochemical profile. Therefore, keeping this in view, the present study was designed to evaluate the biochemical composition of few commercially imported fish species collected from river Sutlej which is a major freshwater source of capture fisheries in Punjab.

MATERIAL AND METHODS

Study area: The River Sutlej is one of the major sources of capture fisheries in Northern India. It originates southwest of the Tibetan lakes of Rakasthal and Mansarover, enters the plains of Punjab at Ropar, flowing via the industrial city of Ludhiana, and finally meets with river Beas at Harike-Pattan. For the present study, the whole stretch of river was divided into four sites as given below:



Sample collection: Samples were collected from the above-designated sites in triplicate at two-monthly intervals from February 2018 to June 2019. *Labeo rohita, Cyprinus carpio, Sperata seenghala* and *Wallago attu* were selected for the study, being commercially important, preference by consumers, and their greater contribution towards the faunal diversity of river Sutlej. Fish samples were collected in plastic zippers and brought to the laboratory in insulated boxes under iced condition sand were immediately analyzed at the College of Fisheries, Guru Angad Dev Veterinary & Animal Sciences University (GADVASU), Ludhiana for biochemical composition as per standard protocols.

Biochemical composition analysis: The biochemical composition of the species under study was analyzed for moisture, ash, total protein, lipid, carbohydrate following standard methodology (AOAC 2000). The protocol being followed is tabulated as below:

Parameter	Protocol
Moisture	Moisture was estimated by heating samples in an oven at 100 ± 5^{0}C to a constant weight and loss of weight considered as moisture.
Ash	Ash was determined by the ignition of a known weight of sample at about 550 ^{0}C in a muffle furnace till all carbon has been removed.
Total protein	Sample digestion was done with protein digestion system- KEL PLUS (model no-KES 12L), distillation with KEL PLUS-Classic DX Model (Pelican, make) and titrated with standard acid (0.1 N sulphuric acid). The amount of N obtained was multiplied by a factor of 6.25 to calculate the Total Protein content of sample
Lipid	The ether extract was estimated by Soxhlet extraction apparatus SOCS PLUS, (Model-SCS 6)
Carbohydrate	Carbohydrates (%) = 100 – (% Lipid + % TP + % Ash + % Moisture)

Table 1. Biochemical composition (%) of flesh of *L. rohita* during the study period

Month	Site	Moisture	Lipid	Protein	Ash	Carbohydrate
February 2018	S-1	77.85^{a}	2.40^{a}	17.15^{a}	1.48^{a}	1.12^{a}
	S-2	77.58^{a}	2.23^{b}	17.55^{a}	1.46^{a}	1.18^{a}
	S-4	78.08^{a}	2.52^{a}	16.72^{b}	1.56^{a}	1.12^{a}
April 2018	S-1	78.29^{a}	2.24^{b}	16.98^{a}	1.38^{b}	1.11^{a}
	S-2	78.43^{a}	2.16^{b}	16.83^{a}	1.40^{b}	1.18^{a}
	S-4	78.88^{a}	2.56^{a}	15.83^{b}	1.58^{a}	1.15^{a}
June 2018	S-1	76.82^{a}	2.92^{a}	17.83^{a}	1.25^{b}	1.18^{a}
	S-2	77.63^{a}	2.62^{b}	17.25^{b}	1.38^{b}	1.13^{a}
	S-4	77.93^{a}	2.48^{c}	16.98^{c}	1.49^{a}	1.12^{a}
December 2018	S-1	76.89^{a}	2.87^{a}	17.80^{a}	1.28^{b}	1.16^{a}
	S-2	77.07^{a}	2.58^{b}	17.85^{a}	1.32^{b}	1.18^{a}
	S-4	77.32^{a}	2.38^{c}	17.70^{a}	1.45^{a}	1.15^{a}
February 2019	S-1	76.43^{a}	2.99^{a}	18.25^{a}	1.21^{c}	1.12^{a}
	S-2	76.70^{a}	2.82^{b}	17.98^{b}	1.32^{b}	1.18^{a}
	S-4	76.30^{a}	2.48^{c}	17.85^{b}	1.41^{a}	1.16^{a}
April 2019	S-1	77.97^{a}	2.42^{b}	17.12^{a}	1.37^{a}	1.12^{a}
	S-2	78.05^{a}	2.31^{c}	16.98^{b}	1.48^{a}	1.18^{a}
	S-4	78.09^{a}	2.60^{a}	16.72^{b}	1.40^{a}	1.19^{a}
June 2019	S-1	77.20^{a}	2.78^{a}	17.58^{a}	1.32^{b}	1.12^{a}
	S-2	77.72^{a}	2.61^{b}	17.12^{a}	1.37^{b}	1.18^{a}
	S-4	78.12^{a}	2.48^{c}	16.82^{b}	1.43^{a}	1.15^{a}

*Values with different alphabetical superscripts (a, b, c..) differ significantly between the sites within a month (in a column) ($P < 0.05$)
Fish samples were not available at Site-3

Statistical analysis: Duncan Multiple Range Test (DMRT) was applied to find out the significant differences in biochemical composition parameters with SPSS-16 software package.

RESULTS AND DISCUSSION

The *L. rohita* percent moisture, lipid, protein, ash and carbohydrate varied from 76.30-78.88, from 2.16-2.99, 15.83-18.25, 1.21-1.58 and 1.11-1.19, respectively (Table 1) whereas in *C. carpio*, it ranged from 76.92-82.67, 1.20-2.82, 12.20-18.23, 1.22-1.98 and 1.12-3.15, respectively (Table 2). Similarly, for *S. seenghala*, the percent moisture, lipid, protein, ash and carbohydrate varied from 74.63-81.40, 1.37-2.78, 13.02-20.44, 1.15-1.89 and 1.01-3.08, respectively (Table 3) while as for *W. attu*, varied from 74.59-81.69, 1.32-2.81, 13.10-20.82, 1.11-1.35 and 1.02-2.18, respectively (Table 4). Comparatively, the highest moisture (80.87 %) was recorded in *W. attu* at S-3, lipid (2.72 %) in *S. seenghala* at S-3, protein (19.89 %) in *W. attu* at S-1, ash (1.59 %) in *C. carpio* at S-4 and carbohydrates (1.18 %) in *C. carpio* at S-1 (Table 5). The variation in the moisture may depend upon the size and maturity stage of the fish while as higher protein content is mainly found during the pre-spawning periods since more protein assimilation is required for the process of vitellogenesis and to cope up the energy requirement of fast body metabolic rate. (Bakhtiyar and Langer 2018).

Bakhtiyar and Langer (2018) observed that in *L. rohita* protein content may vary with age but doesn't differ significantly during the different month and lipids also varied with the maturity stage of fish while as moisture content may decrease or increase as per the size of the fish rather than

Table 2. Biochemical composition (%) of flesh of *C. carpio* during the study period

Month	Site	Moisture	Lipid	Protein	Ash	Carbohydrate
February 2018	S-1	77.26^{b}	2.12^{a}	17.90^{a}	1.59^{b}	1.13^{b}
	S-2	77.56^{b}	1.80^{b}	17.85^{a}	1.64^{a}	1.15^{b}
	S-3	82.30^{a}	1.66^{c}	12.23^{c}	1.43^{b}	2.18^{a}
	S-4	78.2^{b}	1.98^{a}	16.98^{b}	1.72^{a}	1.12^{b}
April 2018	S-1	77.09^{b}	2.17^{a}	17.89^{a}	1.60^{b}	1.15^{b}
	S-2	78.28^{b}	1.89^{b}	16.88^{c}	1.78^{a}	1.17^{b}
	S-3	82.01^{a}	1.29^{c}	13.20^{d}	1.35^{c}	2.12^{a}
	S-4	78.03^{b}	2.02^{a}	17.25^{b}	1.42^{c}	1.18^{b}
June 2018	S-1	77.46^{b}	2.13^{a}	17.68^{a}	1.58	1.15^{b}
	S-2	77.69^{b}	1.78^{c}	18.10^{a}	1.26^{b}	1.17^{b}
	S-3	81.70^{a}	1.20^{d}	13.22^{b}	1.26^{b}	2.12^{a}
	S-4	77.36^{c}	1.95^{b}	17.92^{a}	1.52^{a}	1.15^{b}
December 2018	S-1	76.92^{b}	2.18^{a}	18.08^{a}	1.57^{b}	1.25^{a}
	S-2	77.08^{b}	2.13^{a}	17.91^{a}	1.68^{a}	1.20^{a}
	S-3	80.13^{a}	1.90^{b}	12.20^{b}	1.49^{c}	1.18^{a}
	S-4	77.48^{b}	1.87^{b}	17.98^{a}	1.52^{b}	1.15^{a}
February 2019	S-1	77.25^{b}	2.24^{a}	18.10^{a}	1.22^{b}	1.19^{b}
	S-2	77.31^{b}	2.08^{b}	18.23^{a}	1.24^{b}	1.14^{b}
	S-3	82.67^{a}	1.46^{c}	12.31^{c}	1.28^{b}	2.18^{a}
	S-4	77.35^{b}	2.12^{b}	17.82^{b}	1.59^{a}	1.12^{b}
April 2019	S-1	76.97^{b}	2.39^{a}	17.96^{a}	1.48^{a}	1.20^{b}
	S-2	77.76^{b}	2.25^{b}	17.28^{a}	1.52^{a}	1.19^{b}
	S-3	81.09^{a}	1.42^{c}	13.77^{b}	1.37^{b}	3.15^{a}
	S-4	77.93^{b}	2.18^{b}	17.23^{a}	1.48^{a}	1.18^{b}
June 2019	S-1	78.09^{b}	2.02^{b}	16.83^{a}	1.87^{b}	1.19^{b}
	S-2	78.64^{b}	1.95^{b}	16.25^{a}	1.98^{a}	1.18^{b}
	S-3	81.29^{a}	2.82^{a}	13.85^{b}	1.62^{c}	2.12^{a}
	S-4	78.95^{b}	1.88^{c}	16.12^{a}	1.89^{b}	1.16^{b}

*Values with different alphabetical superscripts (a, b, c..) differ significantly between the sites within a month (in a column) ($P < 0.05$)

any seasonal impact. Protein is one of the major constituents of fish which can vary depending on the time of year, environmental condition, stage of maturity of the gonads, state of nutrition, and age. The highest values of protein in February and June may be ascribed to the more accumulation of the protein for facilitating enhanced metabolic rate and process of vitellogenesis besides the abundance of natural food, desirable temperature, and other suitable environmental parameters during these months. The decline of muscle protein during the spawning and post-spawning phase may be attributed to its channelization towards ovaries to meet the energy requirement of fish for the process of vitellogenesis in conformity with the findings of Dabhade et al (2009). Relatively higher values of protein were recorded in *S. seenghala* and *W. attu* as compared to *L. rohita* and *C. carpio.* Relatively lower values of protein and lipid along with slightly higher values of moisture were observed at S-3 during the present study reflecting an inverse relationship between them. Ozyurt and Polat (2006) and Memon et al (2010) also reported similar results in the Indus river fishes and sea bass, respectively. The lipid content was <5 (%) which indicated that fishes were lean which is in corroboration with findings of Bennion and Scheule (2000). Total lipid composition in fish varies more than any other nutrient component (Thakur et al 2003) which was observed in present study also. Lower values of carbohydrates were recorded at S-3 as compared to other sites under study which may be attributed to chemical stress owing to higher pollution load which might have led to the depletion of stored carbohydrates. Similar findings have

Table 3. Biochemical composition (%) of flesh of *S. seenghala* during the study period

Month	Site	Moisture	Lipid	Protein	Ash	Carbohydrate
February 2018	S-1	75.28^{b}	2.34^{a}	20.03^{a}	1.20^{b}	1.15^{b}
	S-2	76.27^{b}	2.22^{a}	18.98^{a}	1.34^{a}	1.19^{b}
	S-3	81.40^{a}	1.37^{c}	13.22^{c}	1.34^{a}	2.10^{a}
	S-4	77.31^{b}	1.98^{b}	18.25^{b}	1.38^{a}	1.08^{c}
April 2018	S-1	75.66^{b}	2.56^{b}	19.36^{a}	1.24^{b}	1.18^{b}
	S-2	75.95^{b}	2.42^{c}	19.23^{a}	1.22^{b}	1.18^{b}
	S-3	80.87^{a}	2.78^{a}	13.02^{c}	1.18^{b}	2.10^{a}
	S-4	76.65^{b}	2.12^{d}	18.72^{b}	1.40^{a}	1.11^{b}
June 2018	S-1	74.63^{b}	2.62^{a}	20.44^{a}	1.15^{c}	1.16^{b}
	S-2	75.45^{b}	2.43^{b}	19.66^{b}	1.32^{b}	1.14^{b}
	S-3	79.96^{a}	2.50^{b}	13.87^{c}	1.59^{a}	2.08^{a}
	S-4	75.47^{b}	2.24^{c}	19.98^{b}	1.29^{b}	1.08^{c}
December 2018	S-1	74.88^{c}	2.68^{a}	20.24^{a}	1.19^{b}	1.01^{c}
	S-2	75.11^{b}	2.61^{a}	19.84^{a}	1.29^{a}	1.15^{b}
	S-3	80.24^{a}	2.72^{a}	13.96^{b}	1.20^{b}	3.08^{a}
	S-4	76.24^{b}	2.21^{b}	19.12^{a}	1.25^{a}	1.18^{b}
February 2019	S-1	75.86^{b}	2.51^{a}	19.23^{a}	1.38^{b}	1.02^{c}
	S-2	75.16^{b}	2.38^{b}	19.99^{a}	1.29^{c}	1.18^{b}
	S-3	79.94^{a}	2.11^{c}	13.95^{b}	1.89^{a}	2.11^{a}
	S-4	76.31^{b}	2.18^{c}	19.11^{a}	1.28^{c}	1.12^{b}
April 2019	S-1	75.05^{b}	2.46^{a}	20.12^{a}	1.18^{c}	1.19^{b}
	S-2	75.27^{b}	2.28^{b}	19.96^{b}	1.31^{a}	1.18^{b}
	S-3	80.94^{a}	1.58^{c}	13.92^{c}	1.25^{b}	2.31^{a}
	S-4	76.06^{b}	2.12^{b}	19.38^{b}	1.28^{b}	1.16^{b}
June 2019	S-1	75.43^{b}	2.23^{a}	19.88^{a}	1.27^{c}	1.19^{b}
	S-2	76.39^{b}	2.12^{a}	18.92^{b}	1.41^{b}	1.16^{b}
	S-3	80.95^{a}	1.38^{b}	13.94^{c}	1.61^{a}	2.12^{a}
	S-4	77.16^{b}	2.02^{a}	18.29^{a}	1.39^{b}	1.14^{b}

*Values with different alphabetical superscripts (a, b, c..) differ significantly between the sites within a month (in a column) (P< 0.05)

Table 4. Biochemical composition (%) of flesh of *W. attu* during the study period

Month	Site	Moisture	Lipid	Protein	Ash	Carbohydrate
February 2018	S-1	76.18^{b}	2.28^{a}	19.26^{a}	1.20^{a}	1.08^{c}
	S-2	76.66^{b}	2.14^{a}	18.95^{a}	1.12^{a}	1.03^{c}
	S-3	81.59^{a}	1.33^{b}	13.50^{b}	1.23^{a}	2.01^{a}
	S-4	77.32^{b}	2.23^{a}	18.15^{a}	1.18^{a}	1.12^{b}
April 2018	S-1	75.28^{b}	2.21^{a}	20.21^{a}	1.12^{b}	1.18^{b}
	S-2	75.40^{b}	2.19^{a}	19.98^{a}	1.28^{a}	1.15^{b}
	S-3	81.69^{a}	1.32^{b}	13.55^{c}	1.18^{b}	2.16^{a}
	S-4	76.98^{b}	2.10^{a}	18.51^{b}	1.23^{a}	1.18^{b}
June 2018	S-1	75.91^{b}	2.40^{a}	19.33^{b}	1.21^{a}	1.15^{b}
	S-2	75.17^{b}	2.25^{a}	20.29^{a}	1.15^{b}	1.14^{b}
	S-3	81.56^{a}	1.58^{c}	13.50^{d}	1.18^{b}	2.18^{a}
	S-4	77.12^{b}	2.02^{b}	18.55^{c}	1.16^{b}	1.15^{b}
December 2018	S-1	75.81^{b}	2.38^{a}	19.34^{a}	1.26^{b}	1.21^{a}
	S-2	76.16^{b}	2.12^{a}	19.20^{a}	1.32^{a}	1.20^{a}
	S-3	81.51^{a}	2.18^{a}	13.10^{b}	1.32^{a}	1.11^{b}
	S-4	76.24^{b}	2.25^{a}	18.98^{a}	1.35^{a}	1.18^{b}
February 2019	S-1	74.62^{b}	2.68^{a}	20.33^{a}	1.18^{b}	1.19^{b}
	S-2	75.22^{b}	2.38^{b}	20.23^{a}	1.15^{b}	1.02^{c}
	S-3	80.13^{a}	2.21^{b}	13.72^{c}	1.11^{b}	2.15^{a}
	S-4	75.05^{b}	2.56^{a}	19.91^{b}	1.30^{a}	1.18^{b}
April 2019	S-1	74.77^{b}	2.81^{a}	19.98^{a}	1.32^{a}	1.12^{b}
	S-2	75.06^{b}	2.58^{b}	20.06^{a}	1.19^{b}	1.11^{b}
	S-3	80.82^{a}	2.02^{d}	13.81^{c}	1.19^{b}	2.16^{a}
	S-4	76.58^{b}	2.30^{c}	18.61^{b}	1.33^{a}	1.18^{b}
June 2019	S-1	74.59^{c}	2.25^{a}	20.82^{a}	1.15^{c}	1.19^{b}
	S-2	75.50^{c}	2.18^{a}	19.92^{a}	1.22^{b}	1.18^{b}
	S-3	80.49^{a}	2.12^{a}	13.66^{c}	1.25^{b}	2.08^{a}
	S-4	77.17^{b}	2.13^{a}	18.26^{b}	1.32^{a}	1.12^{b}

*Values with different alphabetical superscripts (a, b, c..) differ significantly between the sites within a month (in a column) ($P < 0.05$)

been reported by Vijayavel and Balasubramanian (2006). Higher pollution load at S-3 could also be a reason for the lower nutritional profile of fish flesh since stressful conditions might have interfered with the normal physiology of fish thereby inhibiting the conversion of food material into energy. Kaur (2016) also reports similar trend. Variations reported in biochemical composition could also be attributed to the amount of food intake, season, size, and habitat of fish species (Deka et al 2012, Begum et al 2012). Exposure to environmental stressors may have an adverse effect on physiological health and nutritional value of fish (Kafilat et al 2013). The biochemical composition of fishes collected from different designated sites does not differ significantly except at S-3 where relatively lower values were recorded. This might be attributed to environmental stressors, altered physicochemical parameters of water, lesser availability of food, and interfered fish physiology due to higher pollutant load which eventually diminished the nutritional value of fish flesh that could have a pronounced effect on the human health benefits of fish flesh.

CONCLUSION

The biochemical composition of all the fishes under study was within the range as reported by several researchers however, at Site-3 where Buddha Nallah meets river Sutlej and carries along it the industrial effluents, the bio-chemical profile of fish species was altered as evident from the lower values of protein, lipid, and carbohydrates. This might be due to severity of pollution affecting the normal fish physiology and hampering the efficient conversion of food into body

Table 5. Comparative biochemical composition (%) of flesh of selected fish species during the study period

Site	Fish	Moisture	Lipid	Protein	Ash	Carbohydrate
S -1	*L. rohita*	$77.95^{a,2}$	$2.06^{c,5}$	$17.53^{b,3}$	$1.33^{b,3}$	$1.13^{a,1}$
	C. carpio	$77.29^{a,2}$	$2.17^{b,4}$	$17.77^{b,3}$	$1.55^{a,1}$	$1.18^{a,1}$
	S. seenghala	$75.25^{b,2}$	$2.48^{a,2}$	$19.68^{a,1}$	$1.23^{c,4}$	$1.12^{a,1}$
	W. attu	$75.30^{b,2}$	$2.43^{a,2}$	$19.89^{a,1}$	$1.20^{c,4}$	$1.16^{a,1}$
S -2	*L. rohita*	$77.59^{a,2}$	$2.47^{a,2}$	$17.36^{b,3}$	$1.39^{b,3}$	$1.17^{a,1}$
	C. carpio	$77.76^{a,2}$	$1.98^{c,5}$	$17.85^{b,3}$	$1.58^{a,1}$	$1.17^{a,1}$
	S. seenghala	$75.65^{b,2}$	$2.35^{a,3}$	$19.51^{a,1}$	$1.31^{b,3}$	$1.16^{a,1}$
	W. attu	$75.59^{b,2}$	$2.26^{b,3}$	$19.80^{a,1}$	$1.20^{c,4}$	$1.11^{a,1}$
S -3	*C. carpio*	$81.45^{a,1}$	$1.63^{c,6}$	$13.79^{a,5}$	$1.45^{a,2}$	$1.05^{a,2}$
	S. seenghala	$80.10^{a,1}$	$2.72^{a,1}$	$13.59^{b,5}$	$1.48^{a,2}$	$1.02^{a,2}$
	W. attu	$80.87^{a,1}$	$1.73^{b,5}$	$13.74^{a,5}$	$1.21^{b,4}$	$1.02^{a,2}$
S -4	*L. rohita*	$77.81^{a,2}$	$2.50^{a,2}$	$16.94^{c,4}$	$1.47^{b,2}$	$1.14^{a,1}$
	C. carpio	$77.90^{a,2}$	$2.10^{c,4}$	$17.32^{b,3}$	$1.59^{a,1}$	$1.15^{a,1}$
	S. seenghala	$76.45^{b,2}$	$2.12^{c,4}$	$18.97^{a,2}$	$1.32^{c,3}$	$1.12^{a,1}$
	W. attu	$76.63^{b,2}$	$2.22^{b,3}$	$18.71^{a,2}$	$1.26^{c,4}$	$1.15^{a,1}$

*Values with different alphabetical superscripts (a, b, c) differ significantly between the fish species within the site and with different numerical superscripts (1, 2, 3) differ significantly between the sites ($P < 0.05$)

nutrients besides non-availability of natural food a key precursor for accumulation of body nutrients. This waterbody being a major source of capture fisheries in Punjab, further studies are warranted to find the impact of pollution on the biochemical profile of fish species.

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