

Evaluation of nutritive value, fatty acid composition and lipid quality indices of freshwater catfishes and murrels

Abstract

The study was conducted to determine the nutritive value in terms of proximate composition, fatty acid (FA) profile and lipid quality indices of four catfish species (*Wallago attu*, *Ompok pabda*, *Clarias gariepinus*, *Pangasidon hypophthalmus*) and two murrel species (*Channa striatus*, *Channa punctatus*) from Odisha, India. Among the species investigated the maximum fillet protein (22.35%) and lipid (13.45%) was recorded in *C. striatus* and *C. gariepinus*, respectively. All the fish species showed a FA profile of saturated fatty acid (SFA) > mono unsaturated fatty acid (MUFA) > poly unsaturated fatty acid (PUFA). The n-3 PUFA distribution in the experimental species was observed as docosahexaenoic acid (DHA, 22:6 n-3) > alpha linolenic acid (ALA, 18:3 n-3) > eicosapentaenoic acid (EPA, 20:5 n-3) except *C. gariepinus*. The fillet EPA and DHA content of two murrel species and *W. attu* were similar and significantly higher ($P < 0.05$) among the species. Similarly these three species viz., *W. attu*, *C. striatus* and *C. punctatus* showed maximum DHA quantity in their fillet. The n-6/n-3 ratios in five species except *C. gariepinus* were below 4.0. The atherogenic index (IA) and thrombogenic index (IT) were <1 and cholesterolomic index (h/H) for all species were >1, suitable for human health. Overall, considering nutritive value, fillet protein and very essential fatty acids, the experimental species can be arranged in the following order *C. striatus* > *C. punctatus* = *W. attu* > *P. hypophthalmus* > *O. pabda* > *C. gariepinus*.

Keywords: catfishes, murrels, fatty acid profile, lipid quality indices

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Introduction

Aquatic food products have been an integral part of the human diet since mankind started fishing the oceans and producing food through aquaculture.¹ Fish is a rich source of high quality and easily digestible proteins and unsaturated fats, particularly long chain omega-3 fatty acids which play important roles in human health. Dietary fatty acids are increasingly getting high attention for their role as biological regulators. Importantly, the two series of fatty acids i.e., n-3 and n-6 polyunsaturated fatty acids (PUFA) gets utmost consideration. The most biologically active fatty acids are 20 and 22 hydrocarbon chains which are known as arachidonic acid (20:4 n-6), eicosapentaenoic acid (20:5 n-3, EPA) and docosahexaenoic acids (22:6 n-3, DHA). These fatty acids have important roles in human health relating to decreasing the risk of coronary heart disease, delaying the onset of neurological degeneration of ageing, decreases inflammation, tumour cell growth, optimizes visual signalling, improves insulin sensitivity

and maintenance of bone mass.²

Fish is relatively a much better source of n-3 PUFA than other foods.³ The consumption rate of fish has manifold in recent years, an average per capita consumption of 9.9kg in the 1960s to above 20kg in 2014.⁴⁻⁶ A lot of emphases have also led on the enhancement of aquaculture production in recent years. Since catfishes and murrels fetch good market price and wide acceptability for their delicacy these have been suggested as a component of aquaculture by researchers in India.⁷

In the present study, we have investigated the proximate composition, fatty acid profile and lipid quality indices of four catfishes and two murrel species few of them are even endangered and threatened according to the IUCN red list status (Table 1). The nutrition status of the species will definitely motivate for conservation and propagation of their culture.

Table 1 Introduction to the cat fishes and murrels studied in the present experiment

Species	Classification	Environment	Biology	Food habit	IUCN Red List Status
¹² WA	Siluriformes, Siluridae	¹ FW, ² BW, ³ D, ⁴ PD, ⁵ T.	A large, voracious and predatory catfish, a pre-monsoon summer breeder	Juveniles feed mainly on insects; adults feed on smaller fish, crustaceans, and mollusks	⁸ NT
¹³ OP	Siluriformes, Siluridae	¹ FW, ³ D, ⁴ PD, ⁵ T.	Adults inhabit clear as well as muddy rivers, streams, ponds and lakes	Omnivore, feeds on algae, roots of some higher plants, protozoa, small fishes and shrimps	NT
¹⁴ CG	Siluriformes, Clariidae	¹ FW, ⁷ BP, ⁴ PD, ⁶ ST.	Prefer shallow and swampy areas. Widely tolerant of extreme environmental conditions	Feeds on insects, plankton, invertebrates, fish, young birds, rotting flesh and plants preferably at night	⁹ NE

Table Continued..

Species	Classification	Environment	Biology	Food habit	IUCN Red List Status
¹⁵ PH	Siluriformes, Pangasiidae	¹ FW, ⁷ BP, ⁴ PD, ⁵ T.	Inhabits large rivers. A migratory species	Omnivorous feeding on fish and crustaceans as well as on vegetable debris	¹⁰ EN
¹⁶ CS	Perciformes, Channidae	¹ FW, ² BW, ⁷ BP, ⁴ PD, ⁵ T.	Prefers stagnant and muddy water of plains. Survive dry season by burrowing in bottom mud of lakes, canals and swamps	Feed on fish, frogs, snakes, insects, earthworms, tadpoles and crustaceans	¹¹ LC
¹⁷ CP	Perciformes, Channidae	¹ FW, ² BW, ⁷ BP, ⁴ PD, ⁵ T.	Adults prefer stagnant waters in muddy streams. Year round breeder	Feed on worms, insects and small fish	¹¹ LC

¹FW, Freshwater; ²BW, Brackishwater; ³D, demersal; ⁴PD, Potamodromous; ⁵T, Tropical; ⁶ST, Subtropical; ⁷BP, Benthopelagic; ⁸NT, Near Threatened; ⁹NE, Not evaluated; ¹⁰EN, Endangered; ¹¹LC, Least concern; ¹²WA, *Wallago attu*; ¹³OP, *Ompok pabda*; ¹⁴CG, *Clarias gariepinus*; ¹⁵PH, *Pangasidon hypophthalmus*; ¹⁶CS, *Channa striatus*; ¹⁷CP, *Channa punctatus*

Materials and methods

Sampling

Twenty numbers of four different catfish species viz., *Wallago attu* (WA), *Ompok pabda* (OP), *Clarias gariepinus* (CG) and *Pangasidon hypophthalmus* (PH) and two different murel species viz., *Channa striatus* (CS) and *Channa punctatus* (CP), were collected over five times from the local fish market of Bhubaneswar, Odisha India. These fish were caught from different water bodies such as rivers, canals, pools and ponds during the premonsoon season. The fresh fishes were kept inside the insulated box and brought to the laboratory. The weight and length of the individual fish were measured. The fish were immediately beheaded and gutted. Fins and scales, if any were removed and filleted. All the fillets for individual fish species were pooled for further processing.

Proximate analysis

Fish fillet moisture was determined by oven drying to constant weight at 105°C for 24h. Crude protein content was determined by Kjeldahl analysis (nitrogen×6.25; Kjeltac Autoanalyser, Vapodest-50, Gerhardt, Germany). Lipid was determined by chloroform: methanol (2:1) extraction. The ash content was determined by combustion of fillet samples in a crucible at 550°C for 4hrs in a muffle furnace. The gross energy content of fish fillet was determined using an adiabatic bomb calorimeter (IKA C5003, Staufen, Germany) and expressed as Kcal/g. All analyses were performed in accordance with the methods described by AOAC.⁸ All the samples were analyzed in triplicate to minimize the error.

Fatty acid analysis

Total lipids were extracted from 30g of individual fresh fish samples. The flesh was homogenized by a mechanical stirrer with 15 volumes of chloroform-methanol (2:1v/v) mixture containing 0.01% butylated hydroxyl toluene (BHT).⁹ The weight of lipid was determined gravimetrically after evaporation of the solvent and fatty acid methyl esters (FAME) were prepared as described by Christie.¹⁰ Fatty acid methyl esters were analyzed by a gas chromatograph equipped with a flame-ionization detector (Shimadzu GC-2010, Kyoto, Japan) on a DB-25 capillary column (20m×0.10mm I.D., 0.10µm J&W Scientific, Santa Clara, CA, USA). The detailed separation method was followed as per Pradhan et al.¹¹ The chromatographic peaks in the samples were identified by comparing the relative retention times to the standard FAME peaks (Supelco 37 component FAME mix standard). Relative amount of each fatty acid methyl ester was expressed as a percentage of the total amount of fatty acids in the analyzed sample.

Calculations

The condition factor (CF) of the species were calculated by

$$CF = \text{weight/length}^3 \times 100.$$

Lipid quality indices, i.e., atherogenic index (AI) and thrombogenicity index (TI), were calculated according to Ulbricht and Southgate.¹²

$$AI = [12:0 + (4 \times 14:0) + 16:0] / [(PUFA_{n-6} + n-3) + 18:1 + \text{other MUFA}]$$

$$TI = [14:0 + 16:0 + 18:0] / [0.5 \times 18:1 + 0.5 \times \text{other MUFA} + 0.5 \times n-6 \text{ PUFA} + 3 \times n-3 \text{ PUFA} + (n-3 \text{ PUFA} / n-6 \text{ PUFA})]$$

Cholesterol index (h/H) was calculated as per Santos-Silva et al.¹³

$$(h/H) = [C18:1n-9 + C18:2n-6 + C18:3n-3 + C18:3n-6 + C20:2n-6 + C20:3n-6 + C20:4n-6 + C20:5n-3 + C22:6n-3] / [C12:0 + C14:0 + C16:0]$$

Statistical analysis

Data were analyzed through one way analysis of variance using the SPSS (SPSS 16.0). The significant differences were considered significant at P<0.05 among the species and Duncan multiple range (DMR) was applied to know the significance level.

Results

The average weight of *W. attu*, *O. pabda*, *C. gariepinus*, *P. hypophthalmus*, *C. striatus* and *C. punctatus* were 559.00±18.57g, 40.34±3.37g, 335.00±32.86g, 1740.00±86.49g, 421.67±18.28g and

50.33±3.83g, respectively. The condition factors (CF) of all the species were evaluated. In the present study, CF of *C. punctatus* (1.15±0.03) was significantly higher (P<0.05), whereas *W. Attu* exhibited significantly lower condition factor (0.49±0.01) among the fishes (Table 2).

The proximate composition of the experimental fish is shown in Table 3. Among the six experimental species, the fillet of *C. gariepinus* had the significantly lower (P<0.05) moisture content (65.38±1.37%). The rest catfish and murel species irrespective of their different size and weight exhibited similar fillet moisture content of around 74%.

Among catfishes, the fillet protein content of *W. attu* and *P. sucthi* were similar, around 20%. However, significantly higher ($P<0.05$) fillet protein (22.35%) was recorded in the murel species, *C. striatus*. The lipid (13.45±1.20%) and energy (6.40±0.05 Kcal/g) content of *C. gariepinus* was significantly higher ($P<0.05$) among the fish species. Murels exhibited relatively lower fillet lipid content in comparison to catfishes. The fillet ash content of *C. Punctatus* (3.32%) was significantly higher ($P<0.05$) among the experimental species.

In Table 4, the fatty acid (FA) profile of catfishes and murels are reported. FA profiles showed the following distribution:

SFA>MUFA>PUFA. The total fillet saturated fatty acid (SFA) percentage of *C. gariepinus* was significantly lower ($P<0.05$) among the experimental fish species. The highest SFA (54.03%) was obtained from the fillets of *C. punctatus*. The palmitic acid (C16:0, 19.49-29.52%) was the most predominant fatty acid followed by stearic acid (C18:0, 5.61–8.63%) and myristic acid (C14:0, 1.41-6.12%), presented the following distribution: C16:0>C18:0>C14:0. However, in murels the distribution pattern of predominant saturated fatty acids was C16:0 > C14:0 > C18:0.

Table 2 Biometry of the experimental catfishes and murels¹

Attributes	¹ WA	² OP	³ CG	⁴ PH	⁵ CS	⁶ CP
Avgwt (g)	559.00±18.57	40.34±3.37	335.00±32.86	1740.00±86.49	421.67±18.28	50.33±3.83
Avg length (cm)	48.50±0.69	18.74±0.60	37.10±2.31	56.60±1.19	37.10±1.23	16.20±0.45
Condition Factor	0.49±0.01 ^a	0.60±0.03 ^{ab}	0.67±0.06 ^{ab}	0.96±0.02 ^b	0.84±0.05 ^{ab}	1.15±0.03 ^{bc}

¹Data are expressed as mean±SE of triplicate group of 20 fish of individual species. Values on the same row and different superscripts are significantly different ($P<0.05$). The difference in weight and length of the fish species being from different families were not analyzed statistically. ¹WA, *Wallago attu*; ²OP, *Ompak pabda*; ³CG, *Clarias gariepinus*; ⁴PH, *Pangasidon hypophthalmus*; ⁵CS, *Channa striatus*; ⁶CP, *Channa punctatus*

Table 3 Fillet proximate compositions (% on wet weight basis) of experimental catfishes and murels¹

Attributes	¹ WA	² OP	³ CG	⁴ PH	⁵ CS	⁶ CP
Moisture	74.72±0.42 ^b	73.92±0.27 ^b	65.38±1.37 ^a	74.92±0.50 ^b	74.57±0.48 ^b	74.31±0.25 ^b
Crude Protein	20.19±0.30 ^c	17.56±0.18 ^a	18.93±0.30 ^b	20.66±0.37 ^c	22.35±0.37 ^d	20.62±0.16 ^c
Total Lipid	3.53±0.36 ^c	6.76±0.17 ^d	13.45±1.20 ^e	3.35±0.90 ^{bc}	1.16±0.16 ^a	1.69±0.12 ^{ab}
Ash	1.62±0.06 ^c	1.83±0.06 ^d	1.40±0.02 ^b	1.10±0.05 ^a	1.56±0.06 ^{bc}	3.32±0.06 ^e
Energy (Kcal/g)	5.40±0.06 ^b	5.89±0.03 ^c	6.40±0.05 ^d	5.26±0.11 ^b	5.00±0.01 ^a	4.91±0.04 ^a

¹Data are expressed as mean±SE of triplicate group of 20 fish of individual species. Values on the same row and different superscripts are significantly different ($P<0.05$). ¹WA, *Wallago attu*; ²OP, *Ompak pabda*; ³CG, *Clarias gariepinus*; ⁴PH, *Pangasidon hypophthalmus*; ⁵CS, *Channa striatus*; ⁶CP, *Channa punctatus*

Table 4 Fatty acid profile (% of total FA) of experimental catfishes and murels¹

Fatty acids	¹ WA	² OP	³ CG	⁴ PH	⁵ CS	⁶ CP
C10	0.27±0.08a	ND	ND	ND	0.33±0.07a	ND
C11	0.72±0.07 ^c	0.17±0.03 ^a	ND	ND	ND	0.54±0.05 ^b
C12	0.25±0.06b	ND	ND	ND	0.16±0.05a	0.22±0.02b
C13:0	2.72±0.43 ^{bc}	1.88±0.34 ^{bc}	0.58±0.02 ^a	2.67±0.31 ^{bc}	1.68±0.23 ^b	2.87±0.18 ^c
C14:0	6.12±0.90 ^{ab}	2.47±1.14 ^a	1.41±0.36 ^a	5.29±0.23 ^{ab}	10.22±2.47 ^c	9.73±0.12 ^{bc}
C15:0	1.40±0.26 ^b	0.81±0.17 ^{ab}	0.17±0.00 ^a	0.31±0.01 ^a	1.18±0.18 ^b	2.42±0.21 ^c
C16:0	24.44±0.61 ^{bc}	25.78±1.33 ^c	24.50±0.51 ^{bc}	29.52±0.82 ^d	19.49±1.35 ^a	22.58±0.61 ^b
C17:0	0.75±0.28	0.31±0.04	ND	ND	0.38±0.07	0.73±0.20
C18:0	7.87±0.20 ^b	7.89±0.47 ^b	5.61±0.07 ^a	7.99±0.36 ^b	8.63±0.32 ^b	8.57±0.84 ^b
C20:0	1.19±0.28	0.90±0.26	1.03±0.49	1.10±0.48	2.73±1.06	0.65±0.01
C21:0	2.56±0.46	2.10±0.27	0.99±0.33	0.19±0.01	2.41±0.62	3.32±0.15
C22:0	0.36±0.07b	0.19±0.02a	0.45±0.03c		0.22±0.06a	0.20±0.01a
C23:0	1.66±0.19 ^b	1.43±0.56 ^b	0.24±0.05 ^a	1.47±0.10 ^b	1.61±0.41 ^b	2.23±0.19 ^b
C24:0	ND	0.63±0.32	ND	ND	ND	0.15±0.02
ΣSFA	48.31±1.81 ^{bc}	42.87±4.93 ^b	34.41±1.04 ^a	48.36±1.33 ^{bc}	47.19±2.55 ^b	54.03±0.48 ^c
C14:1	0.59±0.10d	0.51±0.06d	0.12±0.00a	ND	0.33±0.07b	0.46±0.04c
C15:1	0.66±0.10c	0.44±0.00a	ND	ND	0.58±0.12b	ND

Table Continued..

Fatty acids	¹ WA	² OP	³ CG	⁴ PH	⁵ CS	⁶ CP
C16:1	5.73±0.61 ^b	5.63±0.38 ^b	5.31±0.28 ^b	2.25±0.31 ^a	3.96±0.70 ^{ab}	5.86±0.23 ^b
C17:1	0.92±0.11 ^d	0.71±0.18 ^{cc}	0.20±0.04 ^a	0.48±0.02 ^b	0.60±0.12 ^c	1.00±0.14 ^d
C18:1	17.98±1.20 ^a	27.98±1.48 ^c	37.73±0.96 ^d	30.63±1.23 ^c	18.09±0.96 ^a	23.43±0.98 ^b
C20:1	2.12±0.63 ^a	1.06±0.28 ^a	2.49±0.90 ^a	2.54±1.60 ^a	11.62±2.00 ^b	0.96±0.11 ^a
Σ MUFA	27.77±0.88 ^a	35.62±1.16 ^b	45.70±1.35 ^c	35.90±0.28 ^b	34.32±2.31 ^b	31.23±0.52 ^{ab}
C18:2n6	6.98±0.80 ^a	11.12±1.32 ^b	14.52±0.63 ^c	7.94±0.48 ^{ab}	6.45±0.66 ^a	6.35±0.13 ^a
C18:3n6	0.36±0.02 ^a	0.48±0.10 ^b	1.41±0.16	0.67±0.02 ^c	0.36±0.04 ^a	0.47±0.06 ^b
C20:2n6	1.10±0.31 ^d	0.77±0.11	0.29±0.08 ^a	0.66±0.02 ^c	1.08±0.22 ^d	0.39±0.01 ^b
C20:3n6	1.69±0.61 ^{ab}	1.05±0.34 ^{ab}	1.42±0.15 ^{ab}	1.48±0.68 ^{ab}	3.03±1.04 ^b	0.48±0.04 ^a
C20:4n6	0.66±0.21 ^b	0.35±0.06 ^a	0.41±0.16 ^a	0.90±0.02 ^c	0.96±0.36 ^c	0.51±0.04 ^{bc}
Σ n-6 PUFA	10.56±1.40 ^{ab}	13.09±1.26 ^b	17.91±0.33 ^c	11.65±1.08 ^{ab}	9.97±1.23 ^{ab}	7.40±0.36 ^a
C18:3n3	4.90±0.62 ^b	3.60±0.28 ^{ab}	1.83±0.23 ^a	1.95±0.51 ^a	3.98±0.65 ^b	3.90±0.06 ^b
C20:3n3	0.56±0.12 ^c	0.29±0.04 ^a	ND	ND	0.38±0.11 ^b	0.29±0.01 ^a
C20:5n3	0.97±0.17 ^{bc}	0.78±0.02 ^b	0.27±0.07 ^a	0.44±0.05 ^{ab}	1.19±0.19 ^c	1.12±0.11 ^c
C22:6n3	5.53±0.24 ^c	2.97±0.40 ^b	1.09±0.20 ^a	2.23±0.38 ^{ab}	6.27±0.60 ^c	5.20±0.09 ^c
Σ n-3 PUFA	11.84±0.81 ^c	7.49±0.68 ^b	3.20±0.50 ^a	4.62±0.20 ^a	9.97±1.23 ^c	10.41±0.17 ^c
n-6:n-3	0.89±0.03 ^a	1.75±0.05 ^{ab}	5.60±0.18 ^c	2.52±0.05 ^b	1.10±0.07 ^{ab}	0.71±0.04 ^a

MUFA, monounsaturated fatty acid; ND, not detected (zero values were excluded from the table); PUFA, polyunsaturated fatty acids; SFA, saturated fatty acid.¹The data are expressed as percentage of total fatty acids and average of three lots analyzed. Values reported are mean±SE (n=3). Values of each feeding level with different superscript letters in the same row are significantly different (P<0.05). ¹WA, *Wallago attu*; ²OP, *Ompak pabda*; ³CG, *Clarias gariepinus*; ⁴PH, *Pangasidon hypophthalmus*; ⁵CS, *Channa striatus*; ⁶CP, *Channa punctatus*

The total mono unsaturated fatty acids (MUFA) content ranged between 27.77 to 45.70%. The lowest MUFA content was found in the muscle of *W. attu* and the highest in *C. gariepinus*. Oleic acid was the most prevalent MUFA.

In the n-6 PUFA, linoleic acid (C18:2n-6) was the major fatty acid with levels of 6.35 to 14.52% in the fillets of experimental species. Both the murel species exhibited similar level of fillet n-6 PUFA. The parent omega-3 fatty acid, α-linolenic acid (C18:3n-3, ALA) ranged between 1.83 to 4.90% in the studied species.

The ALA percentage of *C. gariepinus* and *P. Hypophthalmus* was alike and significantly lower (P<0.05) than that of other species studied. There was no variation (P>0.05) in fillet EPA and DHA percent between the murel species. Among the fishes significantly

lower (P<0.05) percentage of fillet EPA and DHA was recorded in *C. gariepinus*. The three species viz., *W. attu*, *C. striatus* and *C. punctatus* showed similar quantity (P>0.05) of total n-3 PUFA in their fillet where DHA was the predominant n-3 PUFA. The n-3 PUFA distribution in the experimental species was observed as DHA>ALA>EPA except *C. gariepinus*. The n-6/n3 ratio was recorded from 0.71 to 5.60 in the studied species.

The lipid quality indices viz., thrombogenic index (IT), atherogenic index (IA) and cholesterol index (h/H) was calculated for catfishes and murels (Table 5). The IA and IT for the all the catfishes (except *P. hypophthalmus*) and murels in the present experiment were below 1 and h/H levels for all species were above 1. *C. gariepinus* exhibited significantly higher (P<0.05) cholesterol index (h/H) (2.28±0.04) in comparison to other fish species.

Table 5 Lipid quality indices of experimental catfishes and murels¹

Lipid quality	¹ WA	² OP	³ CG	⁴ PH	⁵ CS	⁶ CP
Thrombogenic Index (IT)	0.69±0.03 ^{ab}	0.75±0.03 ^b	0.71±0.05 ^b	1.06±0.04 ^c	0.59±0.07 ^a	0.66±0.02 ^{ab}
Atherogenic Index (IA)	0.71±0.05 ^b	0.59±0.03 ^{ab}	0.40±0.01 ^a	0.77±0.04 ^b	0.67±0.11 ^b	0.70±0.03 ^b
Cholesterol index (h/H)	1.30±0.03 ^a	1.74±0.04 ^a	2.28±0.04 ^b	1.35±0.05 ^a	1.39±0.04 ^a	1.29±0.07 ^a

¹Values reported are mean±SE (n=3). Values of each feeding level with different superscript letters in the same row are significantly different (P<0.05). ¹WA, *Wallago attu*; ²OP, *Ompak pabda*; ³CG, *Clarias gariepinus*; ⁴PH, *Pangasidon hypophthalmus*; ⁵CS, *Channa striatus*; ⁶CP, *Channa punctatus*

Discussion

Condition factor (CF) is a biological index which depicts about the nutritional status, feeding intensity, age and growth rate of the fish.¹⁴ In the present study, the CF of *W. Attu* (0.49) was similar to

that of reported by Thella et al.¹⁵ on length-weight relationship and condition factor (0.53-0.58) of large predatory catfish, *Wallago attu* from the rivers of central Kerala, India. The CF of *O. Pabda* from the river Gomti, a tributary of the river Ganga, India, was reported from 0.67 to 0.74.¹⁶ which is close to the CF of *O. pabda* (0.60) of

the present study. Similarly, the catfishes and murels of the present study showed CF same to that of catfishes and murels from Asian and African region reported in preceding studies.^{17,18}

The fillet moisture content of *C. gariepinus* was the lowest among the species studied and because of inverse correlation between moisture and lipid, the highest amount of lipid was also obtained in *C. gariepinus*. The lipid content of the experimental species ranged between 1.16-13.45%, categorizes the murels as lean fish (<2% fat) and catfishes as medium-fat (4–8%) fish except *C. gariepinus* which is a high fat (>8%) fish.¹⁹ According to the classification on the basis of tissue protein content by Stansby²⁰ these experimental species can be considered as the high protein content fish. Among the catfishes, *Wallago attu* is considered having more nutritive value.²¹ In the present experiment, the highest fillet protein was obtained from *C. striatus* and fillet protein of *C. punctatus* was that of *W. attu*. This indicated that *channa* species have superiority in protein retention efficiency over catfishes.

The SFA percentage in the fillets of the fish species of the present experiment is almost up to 50% of the total fatty acid except *C. gariepinus* (34.41%) which exhibited the lowest SFA in comparison to other catfishes as well as murels. In general, fish are relatively low in SFAs (<30%), other than certain species.²² However, in the present experiment all the six species studied exhibited more than 30% SFA which agrees with 40.17% SFA value in *W. attu* from Indus River,²³ 42.63% SFA in muscles of farmed Tra catfish (*Pangasius hypophthalmus*) from Vietnam,²⁴ 48.3–57.4% SFA in muscles of wild caught *C. striatus* from Malaysia.²⁵ In this work, the FA distribution for catfishes and murels are SFA>MUFA>PUFA. This result is in agreement with the data presented on US cultivated catfish.²⁶

In other wild caught catfishes, *C. Macrocephalus* and *Pangasius bocourti*, 20-35% MUFA content has been reported in their muscle^{27,28} which matches with the present observation of the experimental species except *C. Gariepinus* (45.70%). MUFA is the preferred metabolic energy source reported earlier in other fish species.¹¹ In this experiment, *W. attu* exhibited the lowest MUFA content. A possible explanation for this finding is that MUFA might have spent for different bodily process like tissueogenesis, metamorphosis, fast growth, and basal metabolism agrees with the observation of Abi-Ayadet *al.*²⁹ However, less fillet SFA than MUFA in *C. gariepinus* indicated the ability for efficient utilization of SFA over MUFA. MUFA has also several health benefits for human being like lowering cardiovascular disease,³⁰ lowering cancer,³¹ and controlling diabetics.³² Among PUFAs, the 18 carbon PUFAs (18:3n-3 and 18:2n-6) are very essential for normal physiological functions of freshwater fish.³³ In this present experiment, the difference in total n-6 PUFA and n-3 PUFA was noticed which could be for several reasons like difference in feeding habit, fishing ground, season, food availability, water temperature, age and size of the fish and the maturation status.^{34–36} The highest fillet n-6 PUFA was recorded in the fillets of *C. gariepinus* and the lowest was in the fillets of *C. punctatus*. *C. gariepinus* may be pond grown with supply of artificial diet or poultry offal which is a very common way of culture of this species.³⁷ The culture method could be the reason for highest content of fillet n-6 PUFA in *C. gariepinus*. The total fillet n-3 PUFA, EPA and DHA content in *W. attu* and two murel species were similar and highest among the fish species. Bibi *et al.*,³⁸ reported almost similar amount of muscle EPA and DHA in large *W. Attu* from Pakistan. *Channa* species are very efficient in storing DHA evidenced from the study conducted by Aliyu-Paiko *et al.*²⁵ and found up to 13.3% DHA in the wild caught *Channa striata* which is almost double than that found in the present study. The n-6/n-3 ratio of fatty acids in

fish is an important nutritional indicator. The ratio of n-6/n-3 PUFAs of total lipids of freshwater fishes ranges between 0.5 and 3.8.⁴⁰ In this present study, n-6/n-3 ratios in five species except *C. gariepinus* were below 4.0, suggested beneficial for human health.⁴¹

The lipid quality indices are the dietetic quality of lipids. The IA and IT for the all the catfishes except *P. Hypophthalmus* and murels in the present experiment were below 1 and h/H levels for all species were above 1, beneficial for human nutrition. Merdzhanova *et al.*⁴² reported similar IA (0.55), IT (0.53) and h/H (1.57) rates compared to our results in channel catfish (*Ictalurus punctatus*) from Bulgaria. These values are lower than those found in beef or chicken, indicating that the catfishes and murels can be considered healthful food in terms of the risk of cardiovascular diseases.¹²

Conclusion

The results revealed that all the fish species studied in the experiment are good source of protein and unsaturated fatty acids with fairly high amount of n-3 fatty acids. Observing the fatty acid profile, *W. attu*, *C. striatus* and *C. Punctatus* can provide more EPA and DHA than that of *O. Pabda*, *C. gariepinus* and *P. hypophthalmus*. The n-6/n-3 ratios in five species except *C. gariepinus* were below 4.0 and considered beneficial for human nutrition. Overall, the lipid quality indices, IA, IT and h/H were also in the suitable range for human health.

Conflicts of interest

The author declares that there is no conflict of interest.

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