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Comparative evaluation of total lipid content (TLC) and fatty acid composition of kidneys from two Indian major carps, *Catla catla* (Ham.) and *Cirrhinus mrigala* (Ham.)

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Abstract

Fish lipids are an excellent source of essential omega-3[docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA)] polyunsaturated fatty acids (PUFAs). To assess the value of the fish waste and its constituents, a laboratory study on the total lipid content (TLC) and fatty acid composition of fish waste (kidneys) from two Indian Major carps, *Catla catla* and *Cirrhinus mrigala* was conducted by selecting three different weight groups (250-500 g, 501-750 g, and 751-1000 g). Maximum TLC ($17.80 \pm 0.45\%$ and $16.13 \pm 0.54\%$) was found in the 751-1000 g weight group, while the minimum ($14.60 \pm 0.73\%$ and $12.16 \pm 0.44\%$) was in the 250-500 g weight group of kidneys of *Catla catla* and *Cirrhinus mrigala* respectively. Three major groups of fatty acids viz. polyunsaturated fatty acids (PUFAs), monounsaturated fatty acids (MUFAs) and saturated fatty acids (SFAs) have been identified in the kidneys of three different weight groups. The total n-3 PUFAs and total n-6 PUFAs were found maximum ($27.35 \pm 2.06\%$ and $14.10 \pm 2.31\%$) in 501-750 g weight group of *Cirrhinus mrigala* respectively. It was concluded that the processing waste of fish (kidneys) is a rich source of total lipids and the essential fatty acids, particularly the polyunsaturated fatty acids, which can be utilized by the industry and processed for human consumption.

Keywords: Polyunsaturated fatty acids, eicosapentaenoic acid, monounsaturated fatty acids, total lipid content

Introduction

Globally the total freshwater fish capture production in 2014 was 93.4 million tonnes and is increasing day by day where as total fish capture production in marine waters was 81.5 million tonnes in 2014 ^[1]. India is the third largest producer of fish in the world, and second in inland fish production ^[2]. Freshwater fish is an excellent source of the essential polyunsaturated fatty acids (PUFAs), such as docosahexaenoic acid (DHA), eicosapentaenoic acid (EPA) and cheaper source of animal protein of high biological value for a large portion of the inhabitants in India ^[3]. Visceral mass constitutes approximately 20% of live weight of freshwater fishes and is a rich source of protein and lipid especially PUFAs ^[4, 5]. Fish processing waste has a huge unexploited potential for value addition. This waste can find its use in foods, functional foods and biochemical products for human consumption and preparing animal feeds. The fish processing industry generates more than 63 million metric tonnes of processing waste which is rich in various biomolecules such as lipid, protein, chitin and carotenoid ^[4]. Freshwater fish species viz., catla (*Catla catla*) and mrigal (*Cirrhinus mrigala*) are two major carps in India next to rohu (*Labeo rohita*). These carps formed the major species of the total inland fish production (953106 tonnes inland catch and 3479000 tonnes aquaculture) in India in 2008 ^[6]. In recent years, the significance of PUFAs especially the n-3 and n-6 fatty acids, has gained much attention because of their various biological activities in health and disease management. These fatty acids play an important role in the prevention and treatment of cardiovascular disease, autoimmune diseases, eye sight and the improvement of learning ability ^[7]. Thus, it is important to assess the lipid content and fatty acid composition of the Indian major carps.

Hence, the study on the total lipid content and fatty acid composition of *C. catla* was under taken. The world fish production has shown a progressive increase with capture fisheries and aquaculture supplying the world with about 154 million tonnes of fish, of which 131 million tonnes were destined as food [8]. Highest concentrations of EPA and DHA are generally found in viscera that are discarded. Lipids rich in PUFAs are potential sources of anti-aging, anti-thrombotic, anti-inflammatory, anti-cholesterolemic and anti-cancer drugs to immunostimulant and immunosuppressant therapeutics [9]. The present study has been carried out with the objective of evaluating the total lipids and fatty acid profiles of processing waste (as about 48% of the body of the carps produced in India is not edible for humans) from Indian carps, *Catla catla* (Ham.) and *Cirrhinus Mrigala* (Ham.).

Materials and Methods

Collection of the Fish:

Fresh specimens of fish were obtained from the local fish market in Field Ganj Opp. Jagraon Bridge, Near Railway Station, Ludhiana, Punjab from July to September 2012, individually wrapped in labeled clean air-tight ziplock polythene bags, embedded in abundant crushed ice and transported to the laboratory within 30-45 minutes to be stored in a quick freezer (REMI QUICK FREEZER, model-265 D BD229) at -30 °C.



Plate 1: *Catla catla* (Ham.)



Plate 2: *Cirrhinus mrigala* (Ham.)

Biometric Measurements:

Fish samples were thawed for 7 to 8 hours in a refrigerator at 5 °C and individual data for total length (cm), standard

length (cm) using a measuring scale and weight (g) were recorded with Gold tech top pan electronic weighing Balance (model GTA 6K/Fabr. Nr.01113254). Weight of kidneys was taken and calculated per 100 g of the fish body weight.

Preparation of Samples: Soon after dissection the samples were removed from the fishes and their weights were recorded. Each of these organs removed from different individuals of one weight group of fish were thoroughly mixed to form a composite samples. The whole procedure was done on ice. The individual weights of the kidneys were recorded and those from the individuals of one weight group of fish were thoroughly mixed to form a composite sample. The composite samples were then stored -30 °C in the quick freezer until analyzed.

Estimation of Total Lipid Content

The total lipid content of the soft parts of the organs was estimated by Soxhlet lipid extraction/solvent extraction method [10].

Calculations:

$$\frac{W2-W1}{a} \times 100$$

Total lipids (%) = Where, a = weight of the composite sample (fish flesh) taken.

W1 = weight of empty crucible.

W2 = weight of crucible with extracted lipids.

Fatty Acid Composition

Fatty acid composition was determined by Gas Liquid Chromatography [11].

Statistical Analysis

One way and Multifactor ANOVA were used to determine the weight group differences in the total lipids and fatty acid profiles of the waste from the fish. The analyses were performed using Microsoft EXCEL and STATGRAPHICS statistical packages.

Results and Discussion

Biometric measurements of the fish and weight of the processing waste

Data on biometric measurements of the *Catla catla* and *Cirrhinus mrigala*, each of three weight groups used are presented in Tables 1 and 8 respectively.

The mean total weight (per 100 g of the fish body weight) of kidneys of *C. catla* and *C. mrigala* of 250-500 g, 501-750 g, and 751-1000 g weight groups was 402.38 ± 10.35 g, 693.79 ± 19.10 g, 942.50 ± 17.87 g, and 430.15 ± 7.44 g, 616.75 ± 16.96 g, 951.10 ± 16.27 g respectively. It appears, therefore, that the maximum processing waste was generated in the higher weight group (751-1000 g) of both the fish species.

Table 1: Biometric measurements of *Catla catla* (Ham.) of 250-500 g weight group.

S. No.	Sex of fish	Body Weight (g)	Total Length (cm)	Standard Length (cm)	Body Width (cm)
1	M	328.00	30.30	23.50	7.50
2	M	341.50	29.60	23.50	7.60
3	M	356.00	30.10	28.50	8.00
4	M	357.00	29.90	24.70	7.40
5	M	357.50	30.00	23.50	7.70
6	F	359.00	29.90	24.00	8.00
7	M	365.00	30.50	24.70	8.10
8	M	368.50	30.40	23.40	8.20
9	M	380.50	31.50	25.00	8.50
10	F	392.50	32.70	26.00	8.20
11	F	417.50	32.40	25.00	8.70
12	M	427.00	32.00	25.00	8.60
13	M	427.00	32.60	25.60	8.70
14	F	433.50	31.60	24.30	9.30
15	F	446.00	34.50	26.00	9.40
16	F	448.50	31.60	24.20	8.60
17	F	449.00	27.20	20.50	8.90
18	F	457.50	34.00	26.70	8.80
19	F	466.00	33.00	26.50	8.80
20	M	470.00	34.20	27.00	8.50
Mean $\pm$ S.E.		402.38 $\pm$ 10.35	31.40 $\pm$ 0.40	24.88 $\pm$ 0.38	8.38 $\pm$ 0.12

Table 2: Biometric measurements of *Catla catla* (Ham.) of 501-750 g weight group.

S. No.	Sex of fish	Body Weight (g)	Total Length (cm)	Standard Length (cm)	Body Width (cm)
1	F	629.50	37.50	30.00	9.90
2	M	640.00	36.50	28.50	10.40
3	M	691.50	36.30	29.00	10.60
4	M	694.50	39.40	31.00	10.80
5	M	728.50	37.40	29.00	11.00
6	F	735.50	37.00	28.80	10.90
7	M	737.00	37.40	29.00	10.20
Mean $\pm$ S.E.		693.79 $\pm$ 19.10	37.36 $\pm$ 0.38	29.33 $\pm$ 0.32	10.54 $\pm$ 0.15

Table 3: Biometric measurements of *Catla catla* (Ham.) of 751-1000 g weight group.

S. No.	Sex of fish	Body Weight (g)	Total Length (cm)	Standard Length (cm)	Body Width (cm)
1	F	872.50	39.00	32.00	11.60
2	M	893.00	39.80	31.00	12.00
3	M	913.00	40.00	31.00	11.90
4	M	925.00	38.00	30.50	12.50
5	M	941.50	40.00	31.40	12.10
6	M	995.00	40.40	32.00	12.30
7	M	1000.00	41.40	33.40	12.80
8	F	1000.00	41.50	32.50	12.80
Mean $\pm$ S.E.		942.50 $\pm$ 17.87	40.01 $\pm$ 0.41	31.73 $\pm$ 0.33	12.25 $\pm$ 0.15

Table 4: Biometric measurements of *Cirrhinus mrigala* (Ham.) of 250-500 g weight group.

S. No.	Sex of fish	Body Weight (g)	Total Length (cm)	Standard Length (cm)	Body Width (cm)
1	M	360.00	33.50	26.50	6.30
2	F	370.50	33.60	27.60	7.10
3	F	372.50	33.50	27.50	6.80
4	F	410.00	34.80	27.80	6.80
45	F	411.00	34.20	27.80	7.10
6	M	420.50	33.80	27.50	6.80
7	M	428.00	35.90	28.10	6.90
8	M	429.50	33.60	27.40	8.00
9	F	430.00	35.00	28.50	7.40
10	F	430.50	33.50	27.30	7.40
11	F	433.00	34.40	28.20	7.00
12	F	440.00	35.30	28.80	7.00
13	M	440.50	33.40	27.00	7.70
14	M	442.00	34.80	28.30	7.40
15	M	451.50	36.20	29.20	7.20
16	M	452.50	35.90	28.50	7.50
17	F	455.00	35.10	28.70	7.50
18	M	465.00	35.50	29.00	7.10
19	M	470.50	34.80	28.80	7.80
20	F	490.50	36.30	29.50	7.80
Mean $\pm$ S.E.		430.15 $\pm$ 7.44	34.66 $\pm$ 0.22	28.10 $\pm$ 0.17	7.23 $\pm$ 0.09

Table 5: Biometric measurements of *Cirrhinus mrigala* (Ham.) of 501-750 g weight group.

S. No.	Sex of fish	Body Weight (g)	Total Length (cm)	Standard Length (cm)	Body Width (cm)
1	M	565.00	37.80	30.50	7.70
2	F	569.50	35.20	29.00	8.10
3	F	574.00	39.50	32.00	7.80
4	F	606.00	39.20	32.00	7.50
5	F	630.00	38.20	31.70	8.50
6	F	640.50	39.50	32.50	7.80
7	M	644.00	38.30	31.30	8.20
8	M	705.00	39.80	32.20	8.60
Mean $\pm$ S.E.		616.75 $\pm$ 16.96	38.44 $\pm$ 0.53	31.40 $\pm$ 0.41	8.03 $\pm$ 0.13

Table 6: Biometric measurements of *Cirrhinus mrigala* (Ham.) of 751-1000 g weight group.

S. No.	Sex of fish	Body Weight (g)	Total Length (cm)	Standard Length (cm)	Body Width (cm)
1	F	905.00	43.00	36.00	8.60
2	F	930.50	43.40	36.20	8.70
3	F	950.00	44.40	36.60	9.10
4	M	970.00	46.10	38.00	9.60
5	M	1000.00	44.50	37.00	10.00
Mean $\pm$ S.E.		951.10 $\pm$ 16.27	44.28 $\pm$ 0.53	36.76 $\pm$ 0.35	9.20 $\pm$ 0.26

Total Lipid Content of the Processing Waste

The total lipid content of Kidneys of two Indian major carps “*C. catla* and *C. mrigala*” has been depicted in Table 7. The total lipid content in both fish species has increased with the increase in weight group. Higher lipid content was recorded in *C. catla* as compared to *C. mrigala*. The kidneys of *C. catla* of all the three weight groups had significantly higher TLC than those of *C. mrigala* of the same weight group. The TLC in the kidney of *C. catla* and *C. mrigala* (12.16-17.80%) was much higher than observed for rainbow trout (6.88%) [12]. The cause of this high TLC in the kidney of the Indian major carps needs to be ascertained.

Table 7: Total lipid content of the processing waste (Kidney) from *C. catla* (Ham.) and *C. mrigala* (Ham.) of different weight groups.

Fish species	Kidney		
	250-500 (g)	501-750 (g)	751-1000 (g)
<i>C. catla</i>	14.60 $\pm$ 0.73 ^b	15.90 $\pm$ 0.70 ^b	17.80 $\pm$ 0.45 ^b
<i>C. mrigala</i>	12.16 $\pm$ 0.44 ^a	13.06 $\pm$ 0.58 ^a	16.13 $\pm$ 0.54 ^a

Values are mean $\pm$ S.E. values with same superscript in a row with respect to one body part/organ do not differ significantly ($p > 0.05$)

Fatty Acid Profiles of Kidney

Polyunsaturated fatty acids (PUFAs)

Table 8: shows data on PUFAs composition in the kidney of *C. catla* and *C. mrigala*. The total n-3 fatty acids were significantly different in the kidney of *C. catla* and *C. mrigala* of the three weight groups. The maximum (27.35 $\pm$ 2.06%) was found in *C. mrigala* of 501-750 g weight group

(Table 8). The kidney of *C. catla* and *C. mrigala* contained total n-3 PUFAs in the ranges from 3.34 $\pm$ 0.29% to 7.64 $\pm$ 0.10% and 3.42 $\pm$ 1.16% to 27.35 $\pm$ 2.06%, respectively. A comparison of the n-3 fatty acid profiles revealed that the maximum linolenic acid (10.32 $\pm$ 2.46%) occurred in *C. mrigala* of the weight group of 501-750 g. The highest value of EPA (17.00 $\pm$ 0.51%) was also recorded in *C. mrigala* of the same weight group. The Total PUFAs were 13.30 $\pm$ 0.11%, 8.43 $\pm$ 0.47% and 13.71 $\pm$ 1.03% in *C. catla* of the weight groups of 250-500 g, 501-750 g, and 751-1000 g respectively. In *C. mrigala*, these were 12.14 $\pm$ 0.99%, 41.46 $\pm$ 0.35% and 12.17 $\pm$ 0.81%, respectively. The PUFAs largely consisted of linolenic and linoleic acids.

Monounsaturated fatty acids (MUFAs)

Total MUFAs were maximum (37.58 $\pm$ 1.98%) in 751-1000 g weight group of *C. catla* and minimum (7.96 $\pm$ 0.29%) in 501-750 g weight group of *C. mrigala*. Differences in total MUFAs were statistically significant with respect to the three weight groups of *C. catla* and *C. mrigala* (Table 8).

Saturated fatty acids (SFAs)

Variations in individual SFAs are shown in Table 8. Total SFAs differed significantly with respect to the weight groups of *C. catla* and *C. mrigala*. Total SFAs in *C. catla* decreased with increase in weight groups. In *C. mrigala*, the total SFA content in the 250-500 g and 501-750 g weight groups was similar (Table 8).

Table 8: Fatty acids (% age of total lipids) in the kidneys of *Catla catla* (Ham.) and *Cirrhinus mrigala* (Ham.) of different weight groups.

Fatty Acids	<i>C. catla</i>			<i>C. mrigala</i>		
	250-500 g	501-750 g	751-1000 g	250-500 g	501-750 g	751-1000 g
Total n-3 PUFAs	7.64 $\pm$ 0.10 ^c	3.93 $\pm$ 0.23 ^b	3.34 $\pm$ 0.29 ^a	5.68 $\pm$ 0.03 ^a	27.35 $\pm$ 2.06 ^b	3.42 $\pm$ 1.16 ^a
Total n-6 PUFAs	5.66 $\pm$ 0.02 ^a	4.49 $\pm$ 0.33 ^a	10.37 $\pm$ 0.9 ^b	6.45 $\pm$ 0.72 ^a	14.10 $\pm$ 2.31 ^b	8.75 $\pm$ 1.53 ^a
TOTAL PUFAs	13.30 $\pm$ 0.11 ^b	8.43 $\pm$ 0.47 ^a	13.71 $\pm$ 1.03 ^b	12.14 $\pm$ 0.99 ^a	41.46 $\pm$ 0.35 ^b	12.17 $\pm$ 0.81 ^a
TOTAL MUFAs	22.35 $\pm$ 0.14 ^a	25.61 $\pm$ 2.77 ^a	37.58 $\pm$ 1.98 ^b	35.36 $\pm$ 1.78 ^b	7.96 $\pm$ 0.29 ^a	33.55 $\pm$ 1.74 ^b
Total SFAs	53.26 $\pm$ 0.27 ^b	57.51 $\pm$ 0.14 ^c	44.60 $\pm$ 0.81 ^a	49.49 $\pm$ 2.84 ^a	48.23 $\pm$ 0.27 ^a	48.80 $\pm$ 1.52 ^a

Only major FAs have been included; Values are mean $\pm$ S.E. Values with same superscript in a row with respect to one fish species do not differ significantly ($p > 0.05$).

Conclusion:

The heaviest weight group of the fish produced relatively more processing waste than its lightest and the medium

weight groups. The total lipid content in both fish species has increased with the increase in weight group. Kidney of *C. catla* had the maximum TLC. The TLC in the kidney of

C. catla and *C. mrigala* (12.16-17.80%) was much higher than observed for rainbow trout (6.88%). Kidneys of both the fish species had maximum content of PUFAs. It was concluded that processing waste of carp is a rich source of total lipids and essential fatty acids particularly polyunsaturated fatty acid.

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Authors Contributions

All authors contributed to designed the study. Material preparation, data collection was performed by Neha Rani and Navpreet Kaur. The first, final draft and of the manuscript was written by Neha Rani and Navpreet Kaur. Editing of manuscript was done by Deepia Kalsi and Preeti. Data analysis was done by Parteek Kumar and Lakhwinder Singh. Review, corrections and checking before final submission were done by Dr. Navpreet kaur and Dr. Pranesh V Yeotikar.

Conflict of Interest: All the authors have no conflict of interests.

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