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RESEARCH ARTICLE

EVALUATION OF TOTAL LIPID CONTENT (TLC) AND FATTY ACID COMPOSITION OF THE FISH PROCESSING WASTE GENERATED BY DIFFERENT WEIGHT GROUPS OF CHINESE CARP, CYPRINUS CARPIO (LINN.)

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Abstract

The fishery industry generates nearly 63 million metric tons of fish processing waste every year, globally. To assess the constituents and value of the fish waste, a laboratory study on the total lipid content (TLC) and fatty acid composition of processing waste from chinese carp, *Cyprinus carpio* was conducted by selecting three different weight groups (250-500g, 501-750g, and 751-1000g). Maximum TLC (31.30±0.45%) was found in the kidney of 751-1000g weight group, while the minimum (5.50±0.25%) was in the head of 250-500g weight group. 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 head, liver, kidney, testis, ovary and intestine. In waste comprising head, linolenic acid contributed maximum of 83%, 99% and 93% to the n-3 fatty acids in 250-500, 501-750 and 751-1000g weight groups, respectively. The total n-6 PUFAs were maximum (38.78±11.18%) in liver from 751-1000g weight group. The intestine contained maximum amount of n-3 fatty acids, highest n-3/n6- ratio and low MUFAs and SFAs contents, besides having high total lipid content. It may be concluded that the processing waste of fish (head and visceral organs) 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.

Introduction

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 (FAO, 2012). Fish is the cheapest source of good quality animal protein readily available to the masses throughout the world and its demand is always on increase (Sankar, 2000). As per an estimate, nearly 63 mmt of fish processing waste is generated globally every year (Bhaskar et al., 2010) with the fish processing waste in India consists of by-catch, waste-on-board, home waste and industrial waste contributing about 3.6 mmt (Sehgal, 2010). The waste is often disposed in landfills or dumped at sea and may lead to pollution problems. The waste water generated while processing the fish contains about 6 mg l^{-1} of lipids and 2 mg l^{-1} of protein. The discarded parts have great nutritional value in terms of protein and essential fatty acid compounds that can be used in the production of fishmeal and fish oil and are rich in minerals and enzymes that have alternative food, pharmaceutical, agricultural and industrial applications (Archer and Watson 2002; Gumisiriza et al., 2009). Highest concentrations of EPA and DHA are generally found in viscera that are discarded. Lipids rich in PUFA are potential sources of anti-aging, antithrombotic, anti-inflammatory, anti-cholesterelemic and anti-cancer drugs to immunostimulant and immunosuppressant therapeutics (Sahena et al., 2009). The present study has been carried out with the objective of evaluating the total lipids and fatty acid profiles of processing waste from Chinese carp, Cyprinus carpio (Linn.) as about 48% of the body of the carps produced in India is not edible for humans and is discarded as waste (Sehgal, 2010).

Material and methods

Collection of the Fish:

Fresh specimens of fish were obtained from the local fish market in Ludhiana 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 BDI -229) at -30°C.

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 Head and Visceral Organs:

The weight of the whole head, its soft parts, and the visceral organs including liver, kidney, testis, ovary and intestine was taken and calculated per 100g of the fish body weight.

Preparation of Samples:

The samples, head and visceral organs (liver, kidney, testis, ovary and intestine) 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 heads were recorded and soft portions of the heads were weighed 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 head and various visceral organs was estimated by Soxhlet lipid extraction/solvent extraction method (AACC, 1976).Calculations:

Total lipids (%) = $$\frac{W_2 - W_1}{a} \times 100$$

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 (AOAC, 2000).

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 Chinese carp, each of three weight groups used are presented in Tables 1. The data on weight (in g and per 100 g of the fish body weight) of head, its soft parts and visceral organs comprising the processing waste of carp of three weight groups are shown in Tables 2. The mean total weight (per 100g of the fish body weight) of the head and the visceral organs of 250-500g, 501-750g, and 751-1000g weight groups was 31.52±1.013g, 31.35±1.49g and 37.03±1.7g, respectively. It appears, therefore, that the processing waste generation in the heaviest weight group (751-1000g) of *C. carpio* was the maximum.

Total Lipid Content of the Processing Waste:

The total lipid content (TLC) of head (soft part), liver, kidney, testes, ovary and intestine of *C. carpio* has been depicted in Table 3. The TLC in all the organs of the fish increased with increase in the body weight and maximum value of TLC (31.30±0.45%) was found in the kidney of 751-1000g weight group, while the minimum (5.50±0.25%) was found in the head of 250-500g weight group. The TLC in the heads (5.50% to 17.00%) was lower than those recorded in the heads of tuna (18.8%) and seer fish (30.1%) as reported by Narayan and Hathwar (2012) but higher than that reported in the head of *C.carpio* (4.0%) as reported by Swapna et al. (2010). The TLC content in the liver of *C. carpio* from all the three weight groups (10.8% to 22.7%) has been found to be higher than in the liver of an Indian major carp, *Catla catla* (7.43%) as recorded by Hassan et al. (2010) but lower than that in wild and farmed sea bass (32% and 37.5%, respectively) as determined by Bhouri et al. (2010). The TLC of the intestine of *C. carpio* (13.83 to 29.6%) was lower than in *Anguilla anguilla* temperate fish **(**42.4%) and in *Trematomus bernacchii* an Antarctic fish **(**42.7%) as reported by Acierno et al. (1996). The TLC of the testis of the fish varied between 12.73 to 25.6%, which was much higher than that reported for Silver perch (1.2-4.1%) by Ota and Takagi (1989) and lower than that reported for Silver perch.(22.57%-33.74%) by Sulmona et al. (2012) . The ovaries of C. carpio had much higher TLC (10.93% to 21.33%) than that of *Zoarces viviparous* (2.5%) as investigated by Pakkerinen (1980) but lower than those reported for Tilapia ovary (38.68%) and close to that of silver perch (19.56%) as recorded by Sulmona et al. (2012). Similarly, the TLC of the kidneys of *C. carpio* (26.5% to 31.3%) was much higher than that observed for rainbow trout (6.88%) by Castell et al. (1972).

Fatty acid profile of processing waste

In *C. carpio*, contribution of linolenic acid to the total n-3 fatty acids was variable. It contributed 83-99% in head, 66-92% in liver, 70-82% in intestine, 54-89% in kidney, 70-90% in testis and 30-90% in ovary. EPA contributed 1-6% in head, 7-33% in liver, 9-21% in intestine, 2-23% in kidney, 4-70% in testis and 3-33% in ovary. DHA in these organs was also well represented; a maximum of 44% was found in kidney of the fish. Linoleic acid contributed (to the total n-6 fatty acids) 36-82% in head, 17-78% in liver, 34-51% in intestine, 22-59% in kidney, 45-68% in testis, and 25-69% in ovary. The only other major fatty acid contributing to the total n-6 fatty acid was the AA.

Comparison of the major fatty acids in the processing waste:

Comparison of major fatty acids groups in the head (soft part) and various visceral organs revealed that there were variations in the pattern of occurrence of different groups of fatty acids in these organs. The mean total n-3 fatty acids in *C. carpio* (Table 4) were maximum (17.86±0.68%) in the intestine and minimum (7.50±0.57%) in the head. The order of occurrence was intestine>liver>kidney>ovary>testis. The total n-3 fatty acid values of the head (3.56 to 8.72%, Table 4) are close to those reported for cultured rohu (5.92%) by Sharma et al. (2011), and lower than that reported for *Sardiella lemuru* (17.79%) by Khoddami et al. (2009). The total n-3 fatty acids were generally higher in the head which may be attributed to omnivorous feeding habit of the fish. The total n-6 fatty acids were higher in the head.

The mean total n-6 fatty acids were maximum (27.57±5.94%) in the liver and minimum (12.75±1.06%) in the head. The order of occurrence was liver>intestine>ovary>kidney>testis>head. Mean total PUFAs were maximum (39.95±6.40%) in the liver and minimum (20.26±0.66%) in the head. The order of occurrence was liver>intestine>kidney>ovary>testis>head. Similarly, the n-3/n-6 ratio was observed maximum (1.02±0.19) in intestine and minimum (0.53±0.06) in liver. The ratio occurred in the order of intestine>testis>head>ovary>kidney>liver.

The maximum mean MUFAs (35.96±7.95%) were present in head and the minimum (7.04±1.98%) in liver. These occurred in the order of head>overy>testis>kidney>intestine>liver. Similarly, the mean total SFAs were maximum (45.21±1.28%) in the kidney and minimum (32.80±1.83%)) in the head. These were present in the order of kidney>intestine>ovary>testis>liver>head.

Table 1: Biometric measurements of *Cyprinus carpio* (Linn.) of different weight groups

	250-500g (Mean ±S.E)	**501-750g (Mean ±S.E)**	**751-1000g (Mean ±S.E)**
Body weight (g)	381.7±11.22	617.3±24.32	965.4±18.43
Total length (cm)	29.4±0.30	33.2±0.72	37.7±0.62
Standard length (cm)	23.6±0.30	26.5±0.71	30.7±0.75

Body width (cm)	9.2±0.11	10.2±0.17	11.2±0.32

Table 2: Weight (in g and per 100g of the fish body weight) of head and visceral organs of *Cyprinus carpio* (Linn.) of different weight groups

Weight groups / Organs	250-500g (Mean ±S.E)		501-750g (Mean ±S.E)		751-1000g (Mean ±S.E)	
	Wt (g)	**Wt(g/100g fish body wt)**	**Wt (g)**	**Wt(g/100g fish body wt)**	**Wt (g)**	**Wt(g/100g fish body wt)**
Head	92.5±3.70	24.29±0.75	132.7±3.34	21.64±0.83	196.2±8.92	20.32±0.82
Head (soft portion)	17.6±0.88	4..60±0.17	24.8±0.51	4.04±0.15	40.0±0.40	4.14±0.11
Liver	1.00±0.19	0.29±0.05	2.30±0.14	0.37±0.01	10.3±1.06	1.07±0.11
Intestine	8.90±0.55	2.33±0.11	17.42±2.88	2.86±0.45	35.5±3.51	3.67±0.34
Kidney	2.80±0.50	0.76±0.14	2.70±0.39	0.43±0.06	9.30±1.49	0.96±0.14
Testes	16.2±3.98	4.03±0.89	25.1±0.66	3.83±0.15	104.6±9.59	10.75±1.00
Ovary	12.76±1.73	3.50±0.56	34.7±8.12	5.77±1.19	110±0.00	11.00±0.00
Totals (head + visceral organs)	120.0±5.04	31.52±1.01	192.7±9.90	31.35±1.49	357.5±19.97	37.03±1.70

Table 3: Total lipid content (%) of head and visceral organs *Cyprinus carpio* of different weight groups

Body part/ organ	**250-500g (Mean ±S.E)**	**501-750g (Mean ±S.E)**	**751-1000g (Mean ±S.E)**
Head	5.50±0.25	11.33±0.33	17.00±0.57
Liver	10.8±0.29	13.13±0.82	16.00±0.57
Kidney	26.50±0.28	29.73±0.46	31.30±0.45
Testis	12.73±0.58	20.63±0.54	25.66±0.33
Ovary	10.93±0.29	16.00±0.17	21.33 ±0.33
Intestine	13.83±0.52	20.36± 0.48	29.66±1.20

Table 4: Comparison of major groups of fatty acids (% of total lipids) in the head and visceral organs of *Cyprinus carpio* (Linn.)

Fatty Acid		Total n-3	Total n-6	n-3/n-6	Total PUFA	Total MUFAs	Total SFA
Head	Minimum	6.36±0.09[a]	11.80±0.08[a]	0.51±0.02[a]	18.79±0.67[a]	28.19±11.92[a]	30.01±2.58[a]
	Maximum	8.72±0.13[b]	14.01±2.46[a]	0.73±0.00[a]	21.45±1.12[b]	35.45±0.98	37.30±2.57[b]
	Mean± S.E	7.50±0.57	12.75±1.06	0.62±0.09	20.26±0.66	35.96±7.95	32.80±1.83
Liver	Minimum	5.71±0.66[a]	17.58±6.19[a]	0.19±0.08[a]	26.13±7.87[a]	0.33±0.18[a]	18.34±1.26[a]
	Maximum	31.22±1.39[b]	38.78±11.18[b]	0.85±0.02[c]	69.23±0.27[b]	18.71±4.98[c]	49.29±13.24[b]
	Mean± S.E	15.15±1.24	27.57±5.94	0.53±0.06	39.95±6.40	7.04±1.98	37.58±5.15
Intestine	Minimum	9.65±0.60[a]	16.69±0.68[a]	0.44±0.54[a]	31.58±0.83[a]	4.05±0.37[a]	32.43±0.23[a]
	Maximum	23.07±0.78[c]	21.92±1.43[b]	1.38±0.02[c]	39.76±1.45[b]	20.61±0.83[c]	47.75±1.23[b]
	Mean± S.E	17.86±0.68	18.44±0.73	1.02±0.19	36.31±1.00	10.94±0.46	42.26±0.58
Kidney	Minimum	8.24±0.25[a]	12.83±0.26[a]	0.40±0.02[a]	23.23±0.66[a]	22.67±0.99[a]	43.15±2.04[a]
	Maximum	11.00±0.42[a]	21.53±1.74[b]	0.89±0.02[b]	30.95±1.68[b]	25.01±1.13[a]	46.57±1.33[a]
	Mean± S.E	10.22±0.24	14.79±1.08	0.57±0.14	27.93±1.32	23.74±1.32	45.21±1.28
Testis	Minimum	6.99±0.30[a]	10.33±0.09[a]	0.47±0.04[a]	21.57±1.69[a]	10.66±0.61[a]	32.12±1.10[a]
	Maximum	17.64±0.64[c]	16.49±0.55[b]	1.19±0.08[b]	34.14±0.59[b]	37.76±1.10[c]	42.42±1.81[c]
	Mean± S.E	9.98±0.60	13.89±0.69	0.91±0.06	26.12±1.04	25.16±0.67	37.62±0.99
Ovaries	Minimum	5.93±0.55[a]	8.56±0.20[a]	0.40±0.00[a]	14.49±0.73[a]	8.14±1.19[a]	31.49±1.52[a]
	Maximum	13.29±0.47[c]	33.09±0.73[c]	1.02±0.15[c]	46.35±1.19[c]	35.47±0.48[b]	48.29±0.91[c]
	Mean± S.E	9.96±0.54	17.44±0.70	0.70±0.06	27.42±1.01	25.13±1.64	41.21±1.31

Values are mean ± S.E. Values with same superscript in a row 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. Kidney of fish had the maximum TLC. Amongst various organs forming the processing waste, the intestine of fish was the best as it contained maximum amount of n-3 fatty acids, highest n-3/n6- ratio and low MUFAs and SFAs contents, besides having high TLC. 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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