Journal of Pharmaceutical Research International

33(44B): 398-408, 2021; Article no.JPRI.74144
ISSN: 2456-9119
(Past name: British Journal of Pharmaceutical Research, Past ISSN: 2231-2919, NLM ID: 101631759)

A Study on Nutritional Profile of Liver from Captured and Cultured Rohu, *Labeo rohita* (Cypriniformes: Cyprinidae)

Onkar Singh Brraich[1], Navpreet Kaur[1*] and Swarndeep Singh Hundal[2]

[1]Department of Zoology and Environmental Sciences, Punjabi University, Patiala-147002, Punjab, India.
[2]Department of Zoology, Punjab Agricultural University, Ludhiana-141004, Punjab, India.

Authors' contributions

This work was carried out in collaboration among all authors. Enlisted authors contributed to design study and concept. Preparation of material, collection and analysis of research data was done by author NK. The primary and final version of the manuscript was written by author NK. Editing of manuscript was done by author SSH Review, corrections and checking before final submission was done by author OSB. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JPRI/2021/v33i44B32690
Editor(s):
(1) Dr. Mohamed Fawzy Ramadan Hassanien, Zagazig University, Egypt.
Reviewers:
(1) Pampa Bhattacharjee, College of Fisheries, Tripura.
(2) Mahrus Ali, University of Lampung, Indonesia.
Complete Peer review History: https://www.sdiarticle4.com/review-history/74144

Original Research Article

Received 08 July 2021
Accepted 18 September 2021
Published 25 September 2021

ABSTRACT

Fish production and fish processing waste have straight connection. In India, the waste produced during the processing of fish is predicted to be approximate 3.6 million metric tonnes, 48 per cent of the total body weight of Indian and exotic major carps is thrown away as waste (non-edible). The present research, it was conducted to compare the total lipid content (TLC) and fatty acid composition from the liver of captured and cultured fish, *Labeo rohita* (Hamilton) having weight more than 500 gram during different months as well as to evaluate its nutritional quality. Maximum total lipid content (33.33±0.14%) was found in the liver of cultured fish in May month, while the minimum (15.26±0.24%) was in the liver of captured fish in the month of January. During the study, total lipid content was found to be considerably elevated in cultured than captured Fish, *Labeo rohita* (Hamilton). The amount of three major groups of fatty acids namely polyunsaturated fatty acids, monounsaturated fatty acids and saturated fatty acids was found to be maximum in captured

**Corresponding author: E-mail: Navpreet22kaur@gmail.com;*

fish during the month of March 97.19±0.96%, 61.30±0.56% and 95.39±0.31% month of April respectively. Total n-6 polyunsaturated fatty acids were observed to be highest (21.95±8.05%) in the waste of liver in cultured fish during the month of March. Hence, it is concluded that the processing waste (liver) of the captured and cultured, *Labeo rohita* (Hamilton) is a prosperous resource of the essential fatty acids i.e. PUFAs and total lipids. Further, it is observed that captured species are rich in fatty acid composition as compared to cultured species. Food industries can manufacture by-products from these high nutritional value contents of waste for human utilization. EPA and DHA also reduce the risk of various life threatening diseases.

Keywords: Labeo rohita; Fish Processing Waste; Total Lipids; Fatty Acids; nutritional value.

ABBREVIATIONS

PUFAs : Polyunsaturated fatty acids
MUFAs : Monounsaturated fatty acids
SFAs : Saturated fatty acids
EPA : Eicosapentaenoic acid
DHA : Docosahexaenoic acid
TLC : Total lipid content

1. INTRODUCTION

In this contemporary era, fish is the economical and primary resource of top- quality animal protein cheerfully accessible to the masses all over the world. Fish requirement is increasing day by day, in every nook and corner of the world due to its nutritional values. Approximate 167.2 million tonnes of fish production recorded by capture fisheries and aquaculture from which 146.3 million tonnes was consumed as foodstuff by human being left over 20.9 million tonnes was discarded as waste during the process of making of different fish products [1]. The tremendous increase of fish waste production can cause loss of finance as well as environmental pollution problems. Worldwide annually, almost63 million metric tons of waste produced during the processing of fish by the fisheries industries, which is rich in various biomolecules such as lipids, protein, chitin and carotenoids [2]. Frequently, to get rid of from this fish waste it is discarded in dump ground or throw out at sea rather than its utilization for various purposes, however, there are alternative uses that can increase economic value [3]. During fish processing, the waste water is also generated which is having fair amount of lipids and protein (6 mg /l and 2 mg /l, respectively) [4].

Fish processing waste is a big menace of present times, various essential biomolecules can be recovered from it such as proteins and lipids which will not alone generate an additional returns by preparing some nutritional food items but also solves the problems of its disposal. Recently Japan has shown the way, various food processing companies have been involved in the reduction of this waste by utilizing it for production of condiments and valuable materials such as fine chemicals [5]. In different tissues of the fish for instance muscles, liver, under skin layers also, in the body cavity fat synthesis from fatty globules occurs and accumulated in all the organs which are discarded by considering it waste during the course of processing [6-8]. Liver oil extracted from the fish is commonly a rich source of numerous beneficial fatty acids which includes long -chain polyunsaturated fatty acids (PUFAs) such as omega-3 fatty acid and fat-soluble vitamins A, D and E [9-11]. Same can be extracted from non-consumable parts which are presumed as waste like skin, viscera head and central bones [12-15] [8]. Above enlisted discarded tissues possibly could play a pivotal role towards the generation of nutritional food items.

Various disorders like high blood pressure, gout, coronary heart diseases, arthritis and plethora of additional health issues which resulted, due to intake of excessive cholesterol enriched foodstuff can fend off by addition of supplements manufactured from fish lipid in diet [16]. So, waste generated during the processing of fish is loaded resource of a So, fish processing waste is a rich source of total lipid content, polyunsaturated fatty acids, specific omega-6 and omega-3 PUFAs, enzymes and minerals that can be used for food, various food products, agricultural activities, pharmaceutical and other industrial benefits [17]. Freshwater and marine water fish oils and fats were observed to be enriched with superior quality omega-3 long chain poly-unsaturated fatty acids predominantly, EPA, 20:5n-3, DHA, 22:6n-3 as well as its originator, alpha linolenic acid [18-23]. This higher content of polyunsaturated fatty acids (PUFAs) in fish and fish processing waste are helpful for cardiovascular fitness [24], arteries

and blood vessels functioning [25], reduction of blood clotting [26] [27]; [25].

Highest concentrations of omega-3 fatty acids (EPA and DHA) are generally detected in the tissues of fish parts like viscera that are discarded. Lipids rich in Polyunsaturated fatty acids fight against thrombotic, aging, cholesterelemic, inflammatory and cancer like disorders and act as inhibitory drugs which further stimulate immune system as well as used as immunosuppressant therapeutics [28]. EPA and DHA (Omega-3 fatty acids) are also helpful as of the prevention from neuropsychiatric illness [29]. Subsequently, the probability of fish waste selection as compared to muscle for lipid extraction is inexpensive source which could prospectively make remarkable profits for environment and fish processing industries. Evaluation of the oil extracted from the composite samples of liver tissue reflects the existence of the significant essential and non-essential polyunsaturated fatty acids.

2. MATERIALS AND METHODS

2.1 Sampling of the Fish

Table-sized fresh specimens of captured and cultured samples of *Labeo rohita* (Hamilton) more than 500g were obtained from the collection sites (Ludhiana district) every month from December 2015 to May 2016. Every fish sample was individually enclosed in a marked sanitary sealed zip-up plastic bag and immersed in abundant compressed ice cubes in the cold storage box. Ambient temperature was recorded at the time of collection of the samples. The samples were transferred to the fisheries research laboratory and store up in a deep refrigerator at low temperature (-20 ^{0}C), in order to keep safe its lipids and fatty acid quality as well as quantity.

2.2 Biometric Measurements

Fish samples were brought to the laboratory and defrosted approximately for 7- 8 hours in a freezer at optimum temperature 5°C and measurements such as : total length, standard length were taken in cm and weight was recorded in gram. Total length and standard length were measured using a measuring scale. The weight was taken with a Goldtech top pan electronic weighing balance model GTA 6K / Fabr. Nr.01113254.

2.3 Sample Preparation

Each fish specimen was washed with running water. Liver from captured as well as cultured fish were removed and their weights were recorded. The livers so collected from the captured and cultured species were then separately pooled jointly for the preparation of composite liver samples. The entire process was ended on crushed frost and took about 10 minutes. The prepared samples were stored at-20 ^{0}C until analyzed.

Extraction of total lipid content (%): The quantity of total lipid content had been estimated as per Soxhlet lipid extraction/ solvent extraction method [30].

$$\text{Calculations: Total lipids } (\%)\ \frac{W_2 - W_1}{A} \times 100$$

Where,

a = Weight of the composite sample (fish flesh) taken.

W1 = Weight of empty crucible.

W2 = Weight of crucible with extracted lipids.

Composition of Fatty Acids: Analysis of fatty acid composition was done on Gas Liquid Chromatography [31] from Punjab Agricultural University, Ludhiana. Fish liver fatty acids were converted into vaporized form after transferred them into methyl/ethyl esters [32]. The identity and quantity of these esters were done after injecting into GLC along with compared with standard set values of esters.

3. RESULTS

Biometric measurements of captured and cultured fish and weight of the processing waste during different months: The biometric data (Table.1) of captured and cultured *Labeo rohita* (Ham.) have been obtained. Total length, Standard length, Body width as well as Body weight have been measured. Biometric data of a fish is very important and it is specific for specific weight group as well in males and females. The lengths of the body directly correspond to the weight of the fish. It is to be concluded that the processing waste generation was highest in captured species in the May month.

Total lipid content (%) of the Fish Waste: Results obtained on the inter specific divergences in the TLC (total lipid content) and fatty acid profiles of liver tissue (processing

waste) from captured and cultured fish, *Labeo rohita* **(**Ham.) more than 500gm weight have been analyzed (Table 2). It has been observed that the liver of cultured fish during all the six months had significantly higher ($p<0.05$) TLC than captured fish. Maximum TLC (33.33±0.14%) was reported in cultured species liver during May month, while the minimum (15.26±0.24%) was found in the liver of captured fish in the month of January. The TLC in liver of cultured fish increased in all the months when compared with captured fish (Fig..1).

Fatty acid composition of processing waste: Liver of captured fish contributed maximum DHA (79%) to the n-3 PUFAs followed by EPA (21%). Similarly, in cultured fish DHA was the major contributor to the n-3 PUFAs contributing 78% followed by EPA 22% in the month of December. During the month of January liver of the captured fish contributed maximum DHA (47%) to the n-3 PUFAs followed by linolenic (34%), DPA (10%) and EPA (9%) however, in the liver of cultured fish linolenic contributed maximum (83%) followed by EPA (11%) and DPA (6%).Liver (captured) of *L. rohita* in the month of February, DHA contributed maximum (53%) to the n-3 PUFAs followed by linolenic acid (38%), DPA (8%) and EPA (1%). However, in the liver of cultured fish, linolenic fatty acid was the foremost benefactor to the omega-3 PUFAs contributing 59%, followed by EPA (22%), DPA (17%) and DHA (2%).

Liver of captured fish in the month of March contained maximum DHA (76%) in the n-3 PUFAs followed by linolenic (13%) and DPA (11%), however, in the liver of cultured fish, n-3 PUFA has contained DPA (99%) followed by1% EPA. During the month of April, EPA was the major contributor in the liver of captured and cultured fish and contained maximum 62% and 97% to the n-3 PUFAs, respectively. Liver of captured and cultured fish, DHA contributed maximum 88% and 95%, respectively to the n-3 PUFAs in the month of May. The Linoleic acid was the major contributor to the total n-6 PUFAs in the liver of captured fish contributing 100%. In cultured fish liver, AA (81%) was the major contributor followed by linoleic acid (19%).

Monthly comparison of the major fatty acids from liver of captured and cultured fish *Labeo rohita* (Hamilton) during different months: Data on major groups of FAs in liver tissue of captured and cultured fish species (*Labeo rohita)* during different months revealed that there were variations in the pattern of occurrence of different groups of fatty acids in their liver. The mean total n-3 fatty acids in *Labeo rohita* (Table 3) were maximum (78.55±1.70%) in the liver (captured) in the month of March and minimum (10.94±0.43%) in the captured fish during the month of April.

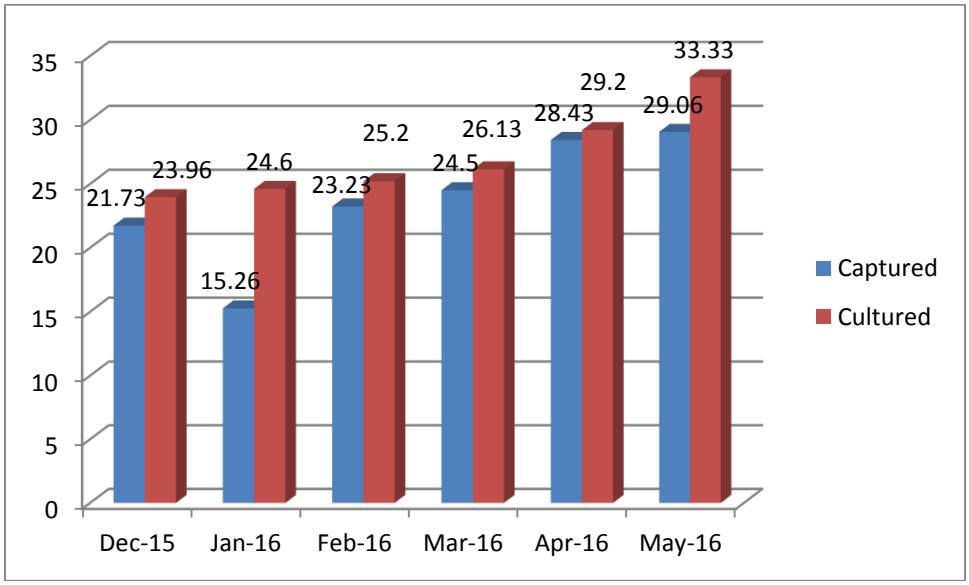

Fig. 1. Comparison of total lipid content in liver of captured and cultured fish *Labeo rohita* (Hamilton) during different months

Table 1. Biometric measurements of captured and cultured *Labeo rohita* (Hamilton) during different months

	December	January	February	March	April	May
Mean body weight (g) captured	1640.42	1233.26	1059.57	1363.40	1582.00	1630.2
Mean body weight (g) cultured	1493.1	1173.35	1381.92	589.45	401.74	1053.45
Mean total length (cm) captured	54.33	46.36	43.62	50.25	55.46	60.36
Mean total length (cm) cultured	56.71	49.58	52.03	37.45	33.05	46.02
Mean standard length (cm) captured	45.88	38.72	36.82	42.74	46.43	53.68
Mean standard length (cm) cultured	48.85	41.32	43.69	30.11	26.72	37.60
Mean body width (cm) captured	11.7	10.9	9.17	11.30	12.6	11.38
Mean body width (cm) cultured	12.90	10.63	11.8	7.8	9.45	9.36
Mean liver weight (g) captured	5.35	4.37	3.79	4.06	4.02	6.27
Mean liver weight (g) cultured	3.63	2.96	3.50	3.7	3.9	3.14

Table 2. Total lipid content (%age) of processing waste (Liver) during different months from Captured and Cultured Fish *Labeo rohita* (Hamilton)

Body part/ organ	**December 2015**		**January 2016**		**February 2016**	
	Captured	Cultured	Captured	Cultured	Captured	Cultured
Liver	21.73±0.54[a]	23.96±0.39[b]	15.26±0.24[a]	24.60±0.05[b]	23.23±0.12[a]	25.20±0.05[b]
Body part/ organ	March 2016 Captured	Cultured	April 2016 Captured	Cultured	May 2016 Captured	Cultured
Liver	24.50±0.05[a]	26.13±0.03[b]	28.43±0.12[a]	29.20±0.05[a]	29.06±0.06[a]	33.33±0.14[b]

Values are mean ± S.E., values with same superscript in a row between captured and cultured fish liver during individual month do not differ significantly (p>0.05)

Table 3. Comparison of major groups of fatty acids (% of total lipids) in the liver of captured and cultured *Labeo rohita* (Hamilton) during different months

Fatty Acid	Total n-3	Total n-6	n-3/n-6	Total PUFA	Total MUFAs	Total SFA
Liver captured December, 2015	31.98±4.77	3.66±0.12	5.19±1.99	35.66±4.65	3.51±0.00	2.20±0.10
Liver cultured December, 2015	30.68±7.04	3.44±0.00[a]	5.01±1.87	34.12±7.04	1.83±0.67	2.49±0.40
Liver captured January, 2015	16.27±1.61	11.51±0.23	1.40±0.10	27.78±1.84	12.89±0.49	63.28±2.67
Liver cultured January, 2016	14.20±1.02	17.73±0.75	0.80±0.08	32.34±0.88	9.92±0.17	58.21±0.82
Liver captured February, 2016	43.62±0.77	8.17±0.00	5.33±0.09	51.80±0.77	9.83±0.58	71.12±0.95
Liver cultured February, 2016	15.41±1.99	10.00±0.02	1.54±0.20	25.64±1.99	19.18±0.53	73.40±1.19
Liver captured March, 2016	78.55±0.76	18.69±0.36	4.21±0.07	97.19±0.96	61.30±0.56	42.70±0.22
Liver cultured March, 2016	49.93±2.65	21.95±8.05	4.17±2.59	73.37±5.82	10.48±0.40	39.54±1.17
Liver captured April, 2016	10.94±0.43	6.24±0.31	1.75±0.01	17.19±0.75	58.94±0.18	95.39±0.31
Liver cultured April, 2016	30.87±0.17	13.78±0.64	2.25±0.11	44.66±0.47	47.70±6.40	75.96±2.15
Liver captured May, 2016	14.15±3.71	2.51±0.89	3.20±0.96	16.66±3.43	6.25±6.06	82.72±6.22
Liver cultured May, 2016	41.73±0.85	0.13±0.11	1.41±0.15	45.64±1.57	17.76±7.67	53.57±3.33

The mean total n-6 fatty acids were maximum (21.95±8.05%) in the cultured fish in the month of March and minimum (3.44±0.00%) in cultured during the month of December. Mean total PUFAs were maximum (97.19±0.96%) in the captured fish in the month of March month and minimum (16.66±3.43%), in captured in the month of May. Similarly, the omega-3/omega-6 ratio (n-3/n-6) was observed highest (5.33±0.09%)) in captured fish in the month of February and minimum (0.80 ± 0.08) in the cultured fish in the month of January.

The maximum mean MUFAs (58.94±0.18%) were present in captured fish in the month of April and the minimum (1.83±0.67%) in cultured species during the month of December. Similarly, the mean total SFAs were maximum (82.72±6.62%) in captured rohu in May and minimum (2.20±0.10%)) in the captured fish in December. It has been inferred from the results that during different months, the processing waste of *Labeo rohita*, the liver of captured fish was best as it enclosed highest amount of omega-3 FAs, mean total PUFAs in March, highest ratio of omega-3/omega-6 in February, maximum MUFA in April, maximum SFAs contents in May when it is compared with cultured species (Table 3).

4. DISCUSSION

Sharma *et al*. [33] studied comparative FAs profile of liver, muscle and brain tissue of the cultured and captured tropical fish, *Labeo rohita.* Significantly higher ($p<0.05$) TLC (lipid contents), SFAs and MUFAs were reported in cultured fish than its wild counterpart, while in captured species highest omega-6 and omega-3 PUFAs were detected. Similarly, it has also been revealed during the present study that maximum TLC (total lipid content) was scrutinized in cultured *Labeo rohita* (33.33%) liver as compared to captured species (29.06%) and higher SFAs level in all the months (except in the month of Febuary was observed in captured *Labeo rohita* liver as compared to cultured species during different months. Further, the presence of higher TLC (total lipid content) quantity in cultured fish liver perhaps due to supplementary feed having containing high SFAs amount fed to cultured fish. The marked difference in the lipid content of wild fish (captured) seems to be due to scarcity of food. Resultantly, the scarcity of food in natural conditions can cause slow growth of fish. Hussain *et al*. [34] analyzed the comparison of nutritional profile of head from captured as well as cultured *Catla catla* and recorded lipid contents as 7.56±0.46% and 11.90±0.25% respectively.

Nazeer *et al*. [35] studied the lipid profile of Threadfin Bream (*Namipterus japonicas*) organs and observed that liverhas stored a major amount of lipids (6.22%) in comparison to muscle (2.7%) and skin (1.0%). Further it has been observed that from fish physiological point of view significant quantity of two omega-3 polyunsaturated FAs: Eicosapentaenoic and Docosahexaenoic FAs were found more 1.6% and 0.5% in skin and 1.6% and 0.6% in liver as compared to muscle 1.4% and 0.4%. Khoddami *et al*. [8] studied on oil fatty acid profile squeezed from the waste of *Sardinella lemuru* which includes viscera (intestine and liver) and head. During their study, valuable quantity of oil has been taken out from these wastes and reported less than 6% of oil which was highest in the liver (5.80%). The palmitic, stearic, oleic and docosahexaenoic acid were 27.80- 35.56 %, 5.90- 9.30%, 15.47- 21.79%, 11.87- 15.95%, respectively reported to be predominant fatty acids in the waste of sardine. However, liver, head and intestines oil samples omega-3/omega-6 ratio represented value more than 1. Sardine waste is a good nutritional resource for human diet because having, greatest quantity of omega-3 FAs , lipids and omega-3/omega-6 ratio. The above studies were found to be similar to the present studies in their fatty acid composition: palmitic acid (C16:0; 2.19-35.82%) during the month of January, stearic acid (C18:0; 0.01-5.80%) and docosahexaenoic acid (DHA; C22:6; 4.06-39.49%) during the month of May and oleic acid (C18:1c; 4.75-25.06%) in March month. The total lipid content in the present study on cultured species liver in the month of May has been found to be (33.33±0.14%). Kaur *et al*. [36] reported the total lipid contents from the liver of *C. carpio* and it was found to be22.7%, however, Hassan *et al*. [37] recorded very low lipid contents i.e. 7.43% in *Catla catla*.

Bajwa and Kondal [38] studied deviation in total protein and total lipid content of *Wallago attu (*catfish), *Channa striatus* (Snakehead Murrel) waste in diverse months. In the waste of *Channa striatus*, lowest amount of TLC (total lipid content) (2.63±0.23 gram per 100 g) was monitored in May month, however highest TLC (5.38±0.15%) was recorded in the month of February. In the waste of *W. attu*, greatest

amount 11.20+0.24 gram per 100 g TLC (total lipid content) was examined during February month and minimum TLC (7.38±0.25) recorded in May month. The TLC (lipid content) in processing waste of *W. attu* and *C. striatus* species raised extensively ($p<0.05$) primarily from December- February and afterward diminished considerably ($p<0.05$) up to May month. Conversely, from December to January (preparatory phase of spawning) total protein extracted from the waste of catfish as well as murrel was recorded least amount furthermore, attained its utmost value in March to May (pre-spawning phase). Highest and lowest values of protein content from snakehead murrel processing waste was found 88.20±1.05 mg per g and 52.30+1.30 mg per g in May and December month, respectively. In the waste of *W. attu* fish minimum total soluble protein (75.20±2.77 mg/g) was present in the month of December and maximum amount (103.0+2.63 mg/g) was recorded during the month of May. Similarly, it was observed during the present investigations on fish, *Labeo rohita* (Hamilton) that minimum TLC captured and cultured species during the December and January (starting period of spawning) and achieved its utmost value in March to May (pre-spawning phase).

Rani and Sehgal [39] reported maximum values of TLC in liver (17.80±0.45%) and kidney (21.90±0.80%) in 751-1000g weight group of freshwater food fish, *Catla catla* (Ham.) when thrice (250-500g, 501-750g and 751-1000g) weight clusters of the *Catla catla* were evaluated for comparison. The above mentioned values (TLC) were close to liver (15.26±0.24%) in February in March of the present studied captured fish, *Labeo rohita..* Saify and [40] estimated fatty acid constitution of lipid extracted from the liver of two salt water habitat fishes, *Carcharhinus bleekeri* and *Eusphyra blochii* and reported 66.19%, 39.94% lipid value in the liver tissue of *Eusphyra blochii*was and *Carcharhinus bleekeri*, respectively. Similar values of lipid content was reported in cultured fish (33.33±0.14%) during the present studies in the month of May.

Fatty acid composition in liver, muscle of *Perca fluviatilis* (wild perch) reared in pond reported significantly highest values of arachidonic acid (7.44±0.80%), EPA (7.81±2.69%) and DHA (24.94±2.94%) in wild perch as compared to pond cultured species. DHA was found to be comparable in pond cultured and wild fish. Similarly, total SFAs (31.82±2.78%), total n-6 PUFAs (13.01±0.77%), total n-3 PUFAs (36.46±4.08%) and n-3/n-6 ratio (3.7±0.46%) was recorded considerably escalated in wild perch than pond cultured perch [41]. Similarly during the presently studies conducted on the fish *Labeo rohita* (captured + cultured fish comparison) in which the captured fish liver is the best as it contains maximum amount of n-3 fatty acids, mean total PUFAs in March, highest omega-3/omega-6 (n-3/n-6) ratio in February, maximum MUFA during April, maximum SFAs contents in the month of May.

Mohamed and Sabahi [42] studied the fatty acid constituents of various organs (muscle, liver and fat tissues) of the *Protopterus annectens* (African lungfish). Total fatty acid values were recorded 10.9 ± 0.81 g/100 g, 50.68 ± 4.72g/100 g and 62.06 ± 3.4 g/100 g respectively, in muscle, liver and fat tissues. In addition, highest monounsaturated fatty acids (MUFAs) and polyunsaturated fatty acids (PUFAs) values were found 9.59 ± 1.1 and 8.38 ± 1.9 g/100 g, 19.52 ± and 5.37±2.7g/100g respectively, in fat and liver tissue than muscle (1.56 ± 0.3 and 1.42 ± 0.3 g/100 g). Similar results have been observed from the liver of captured fish which contains MUFAs (9.83±0.58%) during February month and PUFAs (16.66±3.43%) during the present studies in the month of May.

It is revealed from the above discussion that the fish processing waste is very nutritious having high TLC (total lipid content) and FAs (fatty acids) from the captured and cultured fishes. From the fish processing industries, fish waste and wastewater goes into the freshwater lakes, ponds and on land which causes environmental pollution. Although, mostly fisheries industries putting efforts for utilization and treatment of waste that is produced during the processing of fishes, the techniques adopted for them are not fulfilled completely chiefly because of plethora of factors such as, fish waste nature, little returns while sold for trade purpose in fish market and limited land hence it is dumped in the open. Considering the appropriate quantity of lipids, omega-3 (n-3) fatty acids and omega-3/omega-6 (n-6/ n-3) ratio, liver tissue of captured and cultured *Labeo rohita* may perhaps utilized as a respectable alternate resource for fish lipid extraction. The foremost benefit of fish processing waste lipid is that this by-product is much economical than lipid extracted from fish muscle. Lipid collected from fish waste is taking into account as the vastly

eye catch seeking resource for industrial utilization in addition to human consumption.

5. CONCLUSION

Captured *Labeo rohita* (Hamilton) generated higher amounts of waste than cultured fish during their processing in all the six months. Minimum TLC in captured and cultured species was observed during the December and January (preliminary period of spawning stage) furthermore, attained its highest value in March to May (pre-spawning stage). It is observed that in liver tissue of captured species total omega-3 (n-3) fatty acids were significantly elevated as compared to cultured *L. rohita* in all the months. The occurrence of privileged quantity of total lipid content in cultured fish liver may be due to the consequences of feeding supplementary (having high quantity of saturated fatty acids) to the studied fish. Presence of highest amount of fatty acids in liver of captured species might be attributed to the voracious and omnivorous features of the presently studied fish or to a accessibility of food during diverse seasons which influences feeding of captured *Labeo rohita*. Thus, this can be concluded, processing waste (liver) of the captured and cultured, *Labeo rohita* (Hamilton) is a good resource of lipids and the essential FAs, the PUFAs collected from both the habitat, out of which the captured species are best as compared to cultured species in terms of fatty acid composition.

Statistical Analysis: Values in all tables were given as Mean ± S.E (mean ± Standard error of mean). Statistical difference among the mean of lipid and fatty acids of captured and cultured and fish liver during individual month between captured and cultured fish were determined using one way and multifactor ANNOVA. The analysis was done using Microsoft Excel and STATGRAPHICS statistical packages.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

ETHICAL APPROVAL

As present work is on fish and fish is cultivable organism, hence, no ethical approval is required.

CONSENT

It is not applicable.

ACKNOWLEDGEMENT

The authors are grateful to the Head, Department of Zoology and Environmental Sciences, Punjabi University, Patiala and Head, Department of Zoology, Punjab Agricultural University, Ludhiana for giving necessary research provisions.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Food and Agriculture Organization., Year book of fishery statistics; 2016.
   Available:
   http://www.fao.org/fishery/statistics/en.
   Accessed 26 May 2017.
2. Bhaskar N, Sachindra NM, Suresh PV, Mahendrakar NS. Microbial reclamation of fish industry by-products. In: D. Montet and R.C. Ray (eds) Aquaculture Microbiology and Biotechnology, USA: Enfield, NH, Science publication Inc. 2010;2.
3. Mariojouls C, Sharp M. Report: SPC/IFREMER Seminar on fish waste utilization; 2012.
   Available: http // www.spc.int/Digital library/Events/Fish_ waste_2012.
4. Gumisiriza R, Mshandete AM, Rubindamayugi MST, Kansiime F, Kivaisi AK. Nile perch fish processing waste along Lake Victoria in East Africa: Auditing and characterization. Afric. J. Environ. Sci. Tech. 2009;3(1):013–020.
5. Saito HRY, Alsalvar C, Konno T. Influence of diet on fatty acids of three subtropical fish, subfamily caesioninae (Caesio diagram and C. tile) and family siganidae (*Siganuscanaliculatus).* Lipids. 1999;34:1073-1082.
6. Sheridan MA. Lipid dynamics in fish: Aspects of absorption, transportation, deposition and mobilization. Comp. Biochem. Physiol. 1988;90(B):679-690.

7. Ben Smida MA, Marzouk BE, Cafsi M. The composition of fatty acids in the tissues of Tunisian swordfish *(Xiphias gladius)*. Food Chem. 2009;115:522-552.
8. Khoddami A, Ariffin AA, Bakar J, Ghazali HM. Fatty Acid Profile of the Oil Extracted from Fish Waste (Head, Intestine and Liver) *(Sardinel lalemuru).* World App. Sci. J. 2009;7(1):127-131.
9. Covadonga RC, Acosta P, Badía JR, Cejas FJ, Santamaría A, Lorenzo. Assessment of lipid and essential fatty acids requirements of black sea bream *(Spondylioso macantharus)* humpback salmon (*Oncorhynchusgorbuscha)* by comparison of lipid composition in muscle and liver of wild and captive adult fish. Comp. Biochem. Physiol, Part B. 2004;139:619-629.
10. Mnari A, Bouhlel I, Chraief I, Hammami M, Romdhane MS, Cafsi ME, Chaouch A. Fatty acids in muscles and livers of Tunisian wild and farmed gilthead sea bream (*Sparus aurata*). Food Chem. 2007;1001393-97.
11. Guil-Guerrero JL, Venegas-Venegas E, Rincón-Cervera MA, Suárez MD. Fatty acid profiles of livers from selected marine fish species. Jfca. 2010;24(2):217-222.
12. Shahidi F, Naczk M, Pegg RB, Synowiecki J. Chemical Composition and Nutritional Value of Processing Discards of Cod (*Gadusmorhua*). Food Chem. 1991;42:145-151.
13. Sathivel S, Prinyawiwatkul W, Grimm CC, King JM, Lloyd S. Fatty acid Composition of crude oil recovered from catfish viscera. Amer. J. Res. Communication. 2002;79:989-992.
14. Stocknes IS, Okland HMW, Falch E, Synnes M. Fatty acid and lipid class composition in eyes and brain from teleosts and elasmobranches. Comp. Biochem. Physiol. 2004;138:183-191.
15. Nuraini J, Norziah MH, Tagally BZ, Lim SF, Norita M, Fazilah A. Extraction of Fish Oil from Fish Waste from Surimi Processing Plant. In: International Conference on Environmental Research and Technology (ICERT); 2008.
16. Jakhar JK, Pal AK, Reddy AD, Sahu NP, Venkatesh warlu HK, Vardia. Fatty Acids Composition of Some selected Indian Fishes. Department of Fish Processing Technology, College of Fisheries, Kawardha, Kamadhenu Viswa Vidyalaya, Chhattisgarh, India. African J. Basic &Appl. Sci. 2012;4(5):155-60.
17. Archer M, Watson R. Improved utilization of fish waste in UK. Aquaculture Seafish technology report no. 2002;SR537: 1-63.
18. Bays H, Lansing AM. Fish oil omega-3 fatty acids in treatment of hypertriglyceridemia. A practical approach for the primary care. physician. J. Ky. Med. Assoc. 1994;92(3):105-108.
19. Shahidi F, Wanasundara UN. Omega-3 fatty acid concentrates: nutritional aspects and production technologies. Food Sci. Technol. 1998;9:230-240.
20. Saba G, Muhammad Z. Determination of omega-3 fatty acid composition in freshwater fish. Int. J. Agric. Biol. 2000;4:342-343.
21. Ackman RG, Mcleod CS, Rakshit KK, Misra. Lipids and fatty acids of five freshwater food fishes of India. J. Food Lipids. 2002;9:127–145.
22. Su XQ, Antonas KN, Li D. Comparison of n-3 polyunsaturated fatty acid contents of wild and cultured Australian abalone. Int. J. Food. Sci. Nutr. 2004;55(2):149-154.
23. Bergé JP, Barnathan G. Fatty acids from lipids in marine organisms: Molecular biodiversity, roles as biomarkers, biologically active compounds, and economical aspects. Mar. Biotech. Adv. Biochem. Eng/Biotech. 2005;96:49-125.
24. Sanderson P, Finnegan YE, Williams CM, Calder PC, Burdge GC, Wootton SA, Griffin BA, et al. UK Food standards agency alpha-linolenic acid workshop report. Br. J. Nutr. 2002;88:573–579.
25. Givens DI, Kliem KE, Gibbs RA. The role of meat as a source of n-3 polyunsaturated fatty acids in the human diet. Meat. Sci. 2006;74:209-18.
26. Calder PC. n-3 Fatty acids and cardiovascular disease: evidence explained and mechanism explored. Clin. Sci. 2004;107:1-11.
27. Harris WS. Omega-3 fatty acids, thrombosis and vascular disease. International Congress Series. 2004;12(62):380-83.
28. Sahena F, Zaidul ISM, Jinap S, Saari N, Jahurul HA, Abbas KA, Norulaini NA. PUFAS in fish: Extraction, fractionation, importance in health. Comp. Rev. Food Sci. Food Safety. 2009;8:59-74.
29. Freeman MPJR, Hibbeln KL, Wisner JM, Davis D, Mischoulon M, Peet PE, Keck JLB, et al. Omega -3 fatty acids: Evidences

basis for treatment and future research in psychiatry. J. Clin. Psychiat. 2006;67(12):1954-1967.
30. American Association of Cereal Chemists. Approved Methods. St Paul Minneapolis: The American Association. 1976;1-795.
31. AOAC, 20877-2417. In: Meat and meat products Official Methods of Analysis, 17thedn. Association of analytical communities, North Frederick Avenue Gaithersburg, Maryland**,** USA. 2000;39:3-481.
32. Applequist LA, Boynton JE, Stumpf PK, Wettstein DV. Liquid biosynthesis in relation to chloroplast development in barley. J. Lipid Res. 1968;9:425-36.
33. Sharma P, Kumar V, Sinha AK, Ranjan J, Kithsiri HMP, Venkateshwarlu G. Comparative fatty acid profiles of wild and farmed tropical freshwater fish rohu (*Labeorohita*). Fish Physiol. Biochem. 2010;36:411-17.
34. Hussain B, Mahboob S, Hassan M, Liaqat F, Sultana T, Tari H. Comparative analysis of proximate composition of head from wild and farmed *Catla catla*. J. Anim. Plant. Sci. 2011;21(2):207-210.
35. Nazeer RA, Kumar NSS, Nagash SY, Radhika R, Kishore R, Bhatt SR. Lipid profiles of threadfin bream (*Nemipetrus japonicas*) organs. Indian J. Marine Sci. 2009;38 (4):461-63.
36. Kaur N, Hundal SS, Sehgal HS, Sehgal GK. 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*. Inter. J. Advanc. Res. 2014;2 (12):861-866.
37. Hassan M, Chatha SAS, Tahira I, Hussain B. Total lipids and fatty acid profile in the liver of wild and farmed *Catla catla* fish. Grasas. Y. Aceites. 2010;61 (1):52-57.
38. Bajwa P, Kondal JK. Monthly variation in Total lipid content (TLC) and Total soluble protein content (TSPC) of the fish processing waste generated from snakehead murrel, *Channa striatus* and catfish, *Wallago attu*. Intern. J. Advanc. Res. 2016;4(5**)**:506- 510.
39. Rani N, Sehgal GK. Studied on the total lipid content and fatty composition of the processing waste from a freshwater food fish, *Catla catla* (Ham.). Inter. J. Advanc. Res. 2015;3(3):457-465.
40. Saify ZS, Akhtar S. A study on the fatty acid composition of fish liver Oil from two marine fish, *Eusphyrablochii* and *Carcharhinusbleekeri*. Turk. J. Chem. 2003;27:251 – 258.
41. Łuczyńska J, Tońska E, Krejszeff F, Żarski D. Comparison of fatty acids in the muscles and liver of pond- cultured and Wild Perch, *Percafluviatilis* (L.), in Poland. Turk. J. Fish Aquat. Sci. 2016;16:19-27.
42. Mohamed HA, Elagba JN. Al-Sabahi. The composition of fatty acids stored in liver, muscle and fat tissues of the African lungfish *Protopterus annectens*. Afr. J. Biochem. Res. 2014;8(1):19-24.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle4.com/review-history/74144