SAARC J. Agri., 16(1): 215-231 (2018) *DOI: http://dx.doi.org/10.3329/sja.v16i1.37436*

NUTRITIONAL VALUES OF MINOR CARPS

B.N. Paul[1*], S. Bhowmick[1], S. Chanda[1], N. Sridhar[2] and S.S. Giri[3]

[1]Regional Research Centre of CIFA, Kolkata-700 118, West Bengal, India
[2]Regional Research Centre of CIFA, Hessaraghatta Lake, Bangalore-560 089, Karnataka, India
[3]Central Institute of Freshwater Aquaculture, Bhubaneswar-751002, Odisha, India

ABSTRACT

The nutrient profile of five carps, *viz*. *Labeo bata*, *Labeo calbasu*, *Labeo fimbriatus*, *Cirrhinus reba* and *Puntius javanicus* were studied. The samples were collected from different geographical locations of West Bengal, Odisha and Karnataka states of India. The data on proximate composition reveal that the moisture and fat content differed significantly (P<0.01) among the carp species. The fat content is significantly (P<0.01) higher in *P. javanicus*, *L. bata* and *L. calbasu* compared to *L. fimbriatus*. However, the protein and ash content did not differ significantly among the carp species. The potassium and copper contents differed significantly (P<0.01) among the fish species. Both potassium and copper contents were significantly higher in *L. bata*. The calcium content was maximum in *L. fimbriatus*. The saturated fatty acid (SFA), mono unsaturated fatty acid (MUFA) and poly unsaturated fatty acid (PUFA) differed significantly (P<0.01) among all the carp species. The palmitic acid was significantly higher in *L. fimbriatus*, which is the predominant SFA. Among MUFA, the oleic acid was significantly higher in *P. javanicus*. The total MUFA was significantly (P<0.05) higher in *C. reba*. eicosapentaenoic acid (EPA) and total PUFA is significantly higher in *L. bata*. Among the essential amino acids, methionine was maximum in *L. fimbriatus*, *P. javanicus* and *L. bata* whereas in case of non-essential amino acids, the glutamic acid and aspartic acid were high in *C. reba* and *L. calbasu*. The gross energy content of the fish was higher in *L. fimbriatus* followed by *C. reba* and *L. bata*. The nutrient profile of these fish species reveal that they were rich in essential nutrients required for human health.

Keywords: Proximate composition, fatty acid profile, vitamin, mineral, amino acid composition, freshwater carps.

INTRODUCTION

Balanced human diet should meet the requirements for energy and nutritive components including essentials fatty acids, amino acids, proteins, fat, minerals and

[*] Corresponding author email: bnpaulcifa@gmail.com

Received: 20.05.2018 *Accepted: 25.06.2018*

vitamins. Fish is an excellent food for human beings for centuries (Ayoola, 2010) and is preferred as a balanced diet not only due to its taste and quick digestibility rate but also because of having good proportions of essential amino acids, vitamins and essential fatty acids for the formation of functional and structural proteins (Kumar, 1992). The high nutritional value of fish is mainly related to their readily digestible proteins which are an excellent source of EAA (Sanchez-Alonso et al., 2007, helping in protein synthesis in human beings (Limin et al., 2006). Meat has been accepted as a good source of protein in almost all parts of the world, specially the Western countries. But this leads to some major human health problems regarding overweight and cardiovascular diseases in the developed countries (Das et al., 2009; Giri et al., 2010 and Mohanty et al., 2016). Hence, for the last couple of decades, people have become more aware of fish as a health food alternative to meat. Intake of the saturated fat in red meat is one of the main causes of cardiovascular diseases, while the unsaturated fat of fish and vegetables does not have this type of health hazards.

Consumption of fish also provides a range of essential nutrients besides energy. Flesh texture, protein and fat composition are usually the main factors that determine consumer acceptance (Pal and Ghosh, 2013). Fish has got a particular role as a source of the long-chain omega-3 fatty acids *viz*. eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), which is important for optimal brain and neural system development in children (Giri et al., 2010; Paul et al., 2015a and Mohanty et al., 2016). The n-3 PUFAs, especially the eicosapentaenoic acid (EPA and docosahexaenoic acid (DHA) are found in high concentrations in the phosphoglycerides of cellular membranes, and DHA is particularly abundant in the retina and brain, where it has a crucial role in maintaining the structure and function of the excitable membranes of these tissues (Lauritzen et al., 2001). Arachidonic acid (AA), a PUFA of the n-6 series, is a precursor of biologically important products, such as epoxides, AA-ethanolamide, anandamide and iso-prostanes, an isomer of prostaglandins (Galli and Marangoni, 1997).

Fish protein occupies an important position in human nutrition (Nargis, 2006). Fish accounts for 16.7% of the global population's intake of animal protein and it accounts for 6.5% of total protein intake. A portion of 150g of fish can provide about 50-60 percent of an adult's daily protein requirement (FAO, 2014). Awareness about the importance of diet in human health is increasing day by day. Through research over the years, it is now proved that many of the diseases and health problems of people today are due to wrong lifestyle, characterized by wrong diet. When we think about a balanced diet, fish along with cereals is a good combination. The nutrient profile of freshwater fish is very important because it provides useful information to the nutritionists with readily available sources of low fat and high protein content with finest quality of flavour and texture and safety for the consumers. The diversity in nutrient content of fish species and in particular the rich nutrient composition of small indigenous species would guide the nutritional security (Jabeen and Chaudhary, 2011).

Though some information is available on nutrient compositor of Indian Major Carp (Paul et al., 2015a, and 2016), Catfish (Paul et al., 2015) and air breathing fish (Paul et al., 2017). Keeping in view of the importance of eating fish as health food; the nutrient profile of five freshwater carp species *viz. Labeobata*, *Labeocalbasu*, *Labeofimbriatus*, *Cirrhinus reba* and *Puntius javanicus* have been studied to document the information of protein, fat, minerals, amino acids, fatty acids and along with some vitamins. These indigenous fish species are particularly available in the eastern and North Eastern states of India. Thus, a database can be developed on the basis of nutrient profile of these fish that would help the dieticians, nutritionists, researchers, fish farmers and related stake holders, policy makers to take decision, not only on manufacturing and value addition of fish food products but also for consumer guidance and to promote fish as health food.

MATERIALS AND METHODS

Collection of samples

The samples were collected from various places of different states *viz*. West Bengal, Odisha and Karnataka. The collection points were mainly at the place of harvest and fish market. From West Bengal the places of collection were Rahara Fish Farm of ICAR-CIFA; Barackpore; Doperia (Khardah), Malancha, Barasat, Bongaon, Basirhat, Kharibari, Sasan, Baranagar, Nilgaunge, Naihati are from the North 24 Paraganas district; Bali form Howrah distrct; Taratala, Kakdwip for South 24 Paraganas district; Behrampur, Lalgola from Murshidabad district; Pandua, Sreerampur, Sheoraphuli, Chanditala from Hooghly distrct; Kalyani. Chakdah, Krishnanagar from Nadia distrct; Mecheda, Kolaghat from East Midnapore distrct and Budbud from Burdwan district. From Odisha, ICAR-CIFA, Kausalyaganga and Karnataka, Hubli and ICAR-CIFA, RRC Bangalore. The length and weight ranges of collected species were i.e. 15.0-185g and14.8-45.0 cm for *L. bata*, 30.0-600.0 g and 12.5-45.0 cm for *L. calbasu*, 250-550g and 29.8-36.5 cm for *L. fimbriatus*, 20-400g and 12.5-50.0 cm for *C. reba* and 75-350g and 18.5- 40 cm for *P. javanicus*.The number of fish samples collected were *viz*. *L.bata* (n=52), *L. calbasu* (n=54), *L. fimbriatus* (n=11), *C reba* (n=51) and *P. javanicus* (n=53). The present work is part outreach Activity on Nutrient Profiling of Fish, which is an ICAR network project, wherein 7 ICAR institutes are involved *viz*. ICAR-CIFRI, Barrackpore, ICAR-CIFA-Bhubaneswar, ICAR-DCFR, Bhimtal, ICAR-CIBA, Chennai, ICAR-CIFT, Kochi and ICAR-CMFRI, Kochi. Under this network project there is a common methodology for sample collection, preparation and analysis; which is prepared by the partners of the Project (Sankar et al., 2010).

Proximate and mineral composition analysis

Proximate composition of fish tissue samples were done as per AOAC (1995). The mineral assay was done as per AOAC (2005) and Paul et al. (2014) using Atomic Absorption spectrophotometer (AAS) (Thermofisher, M Series). The data were

statistically analyzed as per Snedecor and Cochran (1968) by one-way ANOVA and the least significance difference (LSD) was used for comparison of the mean values. The energy content of fish species samples were analysed by Bomb Calorimetric Method as per the AOAC (2005).

Fatty acid analysis

Pooled samples were extracted for fatty acid analysis following the method of Folch et al. (1957) using chloroform: methanol (2:1, v/v) solvent system that contained 0.01% butylated hydroxyl anisole as an antioxidant. Fatty acid methyl esters (FAMEs) were prepared by the transmethylation with boron trifluoride (BF_3, Hi Media, Mumbai, India) in methanol from lipids fraction according to Metcalfe et al. (1996). The fatty acid methyl esters were quantified by injecting 1µL (50:1 split ratio) into a Gas Chromatograph (GC) (Perkin Elmer; CLARUS 480). The oven temperature was programmed from an initial temperature at 30^{o}C rising to 140^{o}C (hold time 4 min.) and up to 200^{o}C. Nitrogen gas was used as a carrier gas. The injection port and the flame ionization detector were maintained at 260^{o}C and 300^{o}C. GC operating software "Total Chrome" was followed. Identification of individual FA was identified by comparing with retention times to those of standards (SUPELCO, Cat. No. 47885-U) and quantified by comparing with respective areas. The data are presented as Mean± S.E.

Amino acid analysis

The amino acid analysis was done as per the method of Ishida et al. (1981). The amino acid samples were analysed from Edward Food Research and Analysis Centre Limited, Nilgunge, Kolkata- 700121 (www.efrac.org)

Vitamin analysis

The fat soluble vitamins Retinol (Vitamin A) and Cholecalciferol (Vitamin D) were assayed by High Performances Liquid Chromatography. Fish tissue (30g) was grinded with anhydrous sodium sulfate and extracted the oil using 2:1 chloroform: methanol after adding BHA as antioxidants (Folch et al., 1957).The sample preparation was done as per Sankar et al. (2010) and vitamin samples were analysed from Edward Food Research and Analysis Centre Limited, Nilgunge, Kolkata-700121 (www.efrac.org).

RESULTS AND DISCUSSION

The proximate composition of the five freshwater fish species *viz*. *L. bata*, *L. calbasu*, *L. fimbriatus*, *C. reba* and *P. javanicus* are presented in table 1. Perusal of data reveals that the moisture content was significantly ($P<0.01$) higher in *L. fimbriatus* and followed by *L. calbasu*. The protein content of the fish species ranges from 14.38 to 15.77 and the means did not differ significantly among the treatments. However, the fat content of the fish species differed significantly ($P<0.01$) among the treatments. The fat content was significantly ($P<0.01$) higher in *P. javanicus* and *C.*

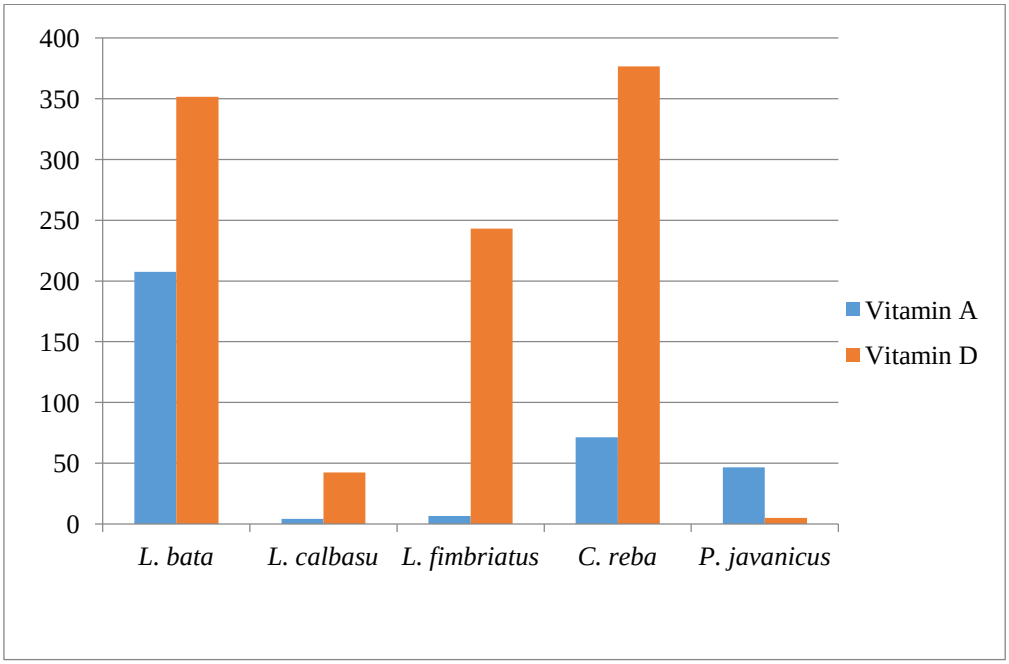
reba; followed by *L. bata* and *L. calbasu*. The ash content of the fish species did not differ significantly among the treatment groups.

The moisture content of the fish as studied are in agreement with the moisture content of IMC reported Joseph et al. (1990) and Paul et al. (2016). The protein content of these five fish did not differ significantly among the species. The fat content of these species ranges from 1.05 to 4.71 (%). The finding of our result on fat content are higher than the fat content of IMC as reported earlier (Paul et al., 2016). The ash content in the species was similar to the earlier report of Sankar et al. (2001) and Paul et al. (2015 and 2016). The proximate composition data of this study are also in agreement with Sharma et al. (2009) and Mazumdar et al. (2008).

Table 1. Proximate composition (% as such basis) of five freshwater fish species

Particulars	*L. bata*	*L. calbasu*	*L. fimbriatus*	*C. reba*	*P. javanicus*
Moisture**	73.45±0.32^{a}	74.94±0.18^{ab}	78.51±0.27^{b}	73.40±0.23^{a}	73.61±0.40^{a}
Protein	15.64±0.27	14.38±0.14	15.77±0.31	15.15±0.22	14.85±0.21
Fat**	3.74±0.13^{bc}	2.92±0.12^{abc}	1.05±0.14^{a}	4.5±0.22^{c}	4.71±0.25^{c}
Ash	2.55±0.07	2.23±0.03	2.28±0.08	2.37±0.04	2.41±0.05

$^{a, b, c}$ Means bearing different superscripts in a row differ significantly **(P<0.01)



The mineral contents of the five freshwater fish species are presented in table 2. The sodium content did not differ significantly among the treatments. The low sodium containing fish are *L. calbasu* and *L. bata*. On the other hand potassium content differed significantly (P<0.05) among the fish species. The potassium and copper contents were significantly (P<0.01) higher in *L. bata* compared to four other carp species. The trace minerals *viz.* iron, zinc and manganese did not differ significantly among the fish species. Calcium contents of the carp species are presented in figure 2. The calcium content (mg/100g) ranges from 197.00 to 325.00.The calcium content was maximum in *L. fimbriatus* and followed by *C. reba*, *L. bata* and *P. javanicus*. The calcium level reported in these fish are similar to carp as reported earlier (Shekhar et al., 2004 and Paul et al., 2016) and higher than Indian catfishes (Paul et al., 2015)

Table 2. Mineral content (ppm) offive freshwater fish species

Particulars	*L. bata*	*L. calbasu*	*L. fimbriatus*	*C. reba*	*P. javanicus*
Sodium	42.30±1.45	39.09±5.46	61.29±1.84	47.15±6.89	56.47±3.23
Potassium**	145.08±6.57^{b}	118.16±3.47^{a}	127.30±4.86^{a}	116.41±3.30^{a}	128.33±4.79^{a}
Iron	0.66±0.06	0.46±0.04	0.43±0.04	0.64±0.07	0.45±0.03
Copper**	0.59±0.07^{b}	0.21±0.03^{a}	0.38±0.08^{a}	0.18±0.03^{a}	0.41±0.04^{a}
Zinc	0.71±0.06	0.70±0.04	0.80±0.12	0.57±0.03	0.70±0.06
Manganese	0.17±0.02	0.13±0.01	0.15±0.01	0.16±0.02	0.11±0.02

$^{a, b, c}$ Means bearing different superscripts in a row differ significantly **(P<0.01)

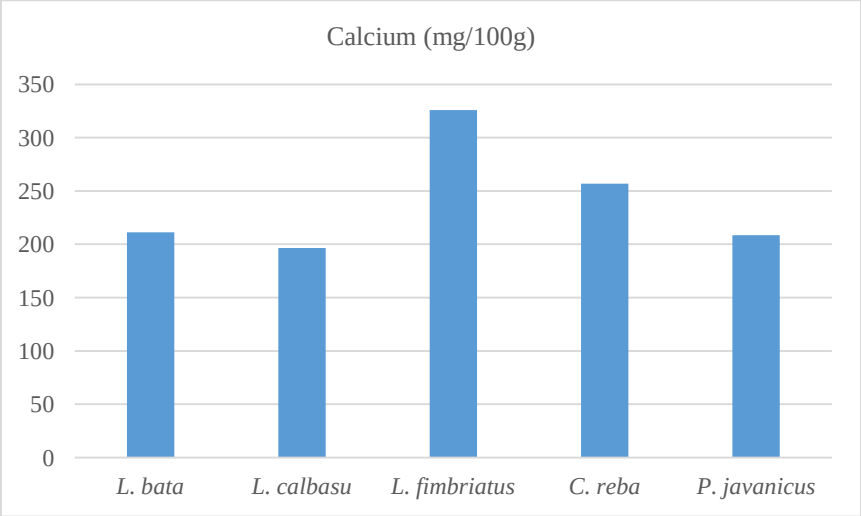


Figure 2. Calcium content (mg/100g) of five freshwater carp species

The potassium (K) level is usually higher than sodium (Na) level in both marine water and freshwater fishes (Otitologbon, 1997). The potassium (116.41-145.08 ppm) content was higher than sodium (39.09-61.29 ppm) content in our present study which is in agreement with the above findings. The present data on sodium and potassium are lower than the earlier report by Paul et al. (2016). In the context of fish as health food, an optimum balance between the K (high) and Na (low) levels is required which is present in these carp species.

The iron level of these fish species ranges from (0.45 to 0.66 ppm) which is lower in rohu, catla and mrigal as studied earlier (Paul et al., 2016) as well as in catfish (Paul et al., 2015). Iron plays an important role in oxidation-reduction reaction and electron transport associated with cellular respiration (Paul and Mukhopadhyay, 2001). The manganese content of the present study is also lower than the earlier report by Ozyurt et al. (2009) and Paul et al. (2015 and 2016).Manganese is responsible for normal functioning of brain and proper metabolism of lipid and carbohydrate as reported earlier (Chanda et al., 2015). Zinc has a structural role in nucleoproteins and involved in prostaglandin metabolism (Lall, 2002). The zinc and copper content of these fish species ranges from 0.57 to 0.80 and 0.21 to 0.59 (mg/100g) respectively. The zinc content is lower than the earlier report in Indian Major Carp (Paul et al., 2015)

The fatty acid profile of five fish species are presented in table 3. The data reveals that among the saturated fatty acid (SFA), Myristic acid, Stearic acid and Palmitic acid differed significantly ($P<0.01$) among the fish species. The Myristic acid was significantly ($P<0.01$) higher in *L. bata* and *P. javanicus*. The Stearic acid was significantly ($P<0.01$) higher in *L. Calbasu* and followed by *C. reba* and *L. bata*. The predominant saturated fatty acid (SFA) i.e. Palmitic acid is significantly ($P<0.01$) higher in *L. fimbriatus* vis-à-vis other fish species. The SFA differed significantly ($P<0.01$) among the fish species; where the level was significantly higher in *L. fimbriatus*.

Table 3. Fatty acid profile (% of total fatty acid) of fivefreshwater fish species

Fatty acid	*L. bata*	*L. calbasu*	*L. fimbriatus*	*C. reba*	*P. javanicus*
Butyric acid (C4:0)	0.15±0.05	0.07±0.02	ND	0.05±0.04	0.18±0.08
Caproic acid (C6:0)	ND	0.06±0.02	0.19±0.04	0.03±0.02	0.12±0.05
Caprylic acid (C8:0)	0.05±0.24	0.03±0.02	0.05±0.01	0.05±0.01	0.04±0.01
Capric acid (C10:0)	ND	0.06±0.04	ND	ND	0.03±0.02
Undecanoic acid (C11:0)	0.07±0.03	0.57±0.54	0.02±0.01	0.06±0.04	ND
Lauric acid (C12:0)	0.28±0.12	0.43±0.32	0.03±0.01	0.16±0.01	0.10±0.02
Tridecanoic acid (C13:0)	0.67±0.05	0.60±0.51	0.02±0.01	0.31±0.01	0.06±0.02
Myristic acid* (C14:0)	5.73^{b}±0.31	2.60^{a}±0.16	0.26^{a}±0.01	3.42^{a}±0.17	4.26^{b}±1.73
Pentadecanoic acid (C15:0)	2.88±1.44	0.88±0.24	0.24±0.01	1.88±0.09	1.10±0.67
Palmitic acid** (C16:0)	39.91^{ab}±6.18	30.95^{a}±1.14	81.17^{c}±0.30	41.61^{b}±4.58	43.54^{b}±3.24

Fatty acid	*L. bata*	*L. calbasu*	*L. fimbriatus*	*C. reba*	*P. javanicus*
Heptadecanoic acid (C17:0)	0.49±0.11	1.73±0.48	0.46±0.01	0.45±0.03	1.43±0.72
Stearic acid** (C18:0)	5.04±1.16	10.44^{d}±0.82	2.52^{b}±0.03	5.20^{c}±0.25	0.05^{a}±0.02
Arachidic acid (C20:0)	0.02±0.15	0.53±0.05	0.12±0.01	0.21±0.16	0.45±0.30
Heneicosanoic acid (C21:0)	ND	0.77±0.36	2.03±0.03	0.36±0.23	2.66±0.67
Behenic acid (C22:0)	0.28±0.22	0.99±0.04	ND	0.62±0.36	0.30±0.24
Tricosanoic acid (C23:0)	1.80±0.50	0.26±0.09	0.32±0.10	2.49±1.99	0.32±0.05
∑SFA**	57.45^{b}±3.95	50.71^{a}±2.88	87.41^{c}±0.10	56.87^{b}±1.65	52.61^{b}±1.23
Myristoleic acid (C14:1)	6.05±0.04	0.07±0.04	ND	0.07±0.01	0.08±0.03
Pentadecenoic acid** (C15:1)	0.26^{b}±0.06	0.12^{ab}±0.09	0.65^{d}±0.01	0.44^{c}±0.05	0.10^{a}±0.01
Palmitoleic acid (C16:1)	ND	5.75±1.60	0.31±0.03	3.12±0.83	1.81±0.25
Heptadecenoic acid (C17:1)	0.04±0.01	0.17±0.10	0.03±0.01	0.04±0.00	0.50±0.24
Oleic acid** (C18:1n9c)	18.51^{b}±0.93	23.57^{b}±3.77	4.99^{a}±0.05	20.04^{b}±1.44	32.07^{c}±2.35
Elaidic acid (C18:ln9t)	0.11±0.07	ND	ND	0.18±0.03	15.30±2.80
Eicosanoic acid (C20:ln9c)	0.10±0.05	0.91±0.38	0.21±0.02	0.08±0.02	1.18±0.26
Erucic acid (C22:1n9)	0.32±0.09	ND	ND	0.61±0.03	0.56±0.32
∑MUFA**	19.19^{b}±0.96	30.72^{c}±4.04	6.19^{a}±0.01	24.58^{b}±0.74	36.27^{d}±1.78
Linolelaidic acid (C18:2n6t)	0.11±0.03	1.01±0.80	1.00±0.01	0.10±0.01	0.12±0.03
Linoleic acid (C18:2n6c)	6.82±0.32	9.22±2.72	3.44±0.04	8.94±0.32	2.77±1.69
γ-Linolenic acid (C18:3n6)	0.44±0.21	0.59±0.38	0.13±0.01	0.04±0.01	0.24±0.11
α Linolenic acid (C18:3n3)	4.08±2.65	3.96±0.79	0.10±0.01	5.68±0.27	1.66±1.18
Eicosadienoic acid (C20:2)	0.71±0.24	1.12±0.39	0.18±0.09	ND	0.36±0.04
Eicosatrienoic acid (C20:3n6)	2.51±0.28	1.35±0.22	0.46±0.05	1.02±0.06	1.83±0.59
Eicosatrienoic acid (C20:3n3)	0.34±0.15	0.35±0.22	ND	0.26±0.01	0.09±0.01
Arachidonic acid** (C20:4n6)	1.89^{c}±0.22	0.59^{b}±0.01	ND	0.75^{b}±0.04	0.17^{a}±0.06
Eicosapentaenoic acid or EPA** (C20:5n3)	3.75^{c}±0.52	1.33^{b}±0.63	0.29^{a}±0.01	1.08^{ab}±0.06	0.59^{a}±0.20
Docosahexaenoic acid or DHA (C22:6n3)	3.21±0.84	1.44±0.70	0.82±0.08	0.72±0.16	2.62±1.40
∑PUFA*	23.36^{c}±3.31	18.58^{bc}±4.68	6.40^{a}±0.09	18.56^{bc}±0.91	10.29^{a}±0.98
ω3: ω6	0.88±0.32	0.69±0.27	0.28±0.01	0.72±0.02	1.22±0.58
∑ω3	10.88±3.61	6.87±2.79	1.37±0.01	7.73±0.49	4.93±1.40
∑ω6*	12.48^{c}±0.30	11.72^{c}±3.12	5.03^{c}±0.09	10.83^{bc}±0.42	5.36^{a}±1.40

$^{a, b, c, d}$ Means bearing different superscripts in a row differ significantly* (P< 0.05); **(P<0.01), ND: Not detected

The total monounsaturated fatty acid (MUFA) differed significantly (P<0.01) among all the five fish species. The pentadecaenoic acid was significantly (P<0.01) higher in

L. fimbriatus and followed by *C. reba*. The predominant MUFA is Oleic acid and it is found significantly (P<0.01) higher in *P. javanicus* and followed by *L. calbasu*, *C. reba* and *L. bata*. The other monounsaturated fatty acids like myristoleic acid, palmitoleic acid, heptadecenoic acid, Elaidic acid, Eicosaenoic acid and Erucic acid did not differ significantly among the carp species.

The polyunsaturated fatty acids (PUFA) are the most important fatty acid so far the human health is concerned. Linoleic acid is significantly (P<0.05) higher in *L. calbasu* and *L. bata*. The Arachidonic acid was significantly (P<0.01) higher in *L. bata* followed by *L. calbasu* and *C. reba*. The Eicosapentaenoic acid (EPA) is significantly (P<0.01) higher in *L. bata* followed by *L. calbasu* and *C. reba*. The Docosahexaenoic acid (DHA) did not differ among the carp species as studied. The PUFA differed significantly (P<0.01) among the carp species; where PUFA content was significantly higher in *L. bata, C. reba* and *L. calbasu*. The ω3:ω6 ratio and sum total of ω3 did not differ significantly among the treatment groups. The ω3:ω6 ratio is 1.22±0.5 in *P. javanicus* which is near to ideal ratio 1.0 compared to others. The summation of ω6 differed significantly (P<0.05) among the carp species and it is significantly higher in *L. bata, L. calbasu* and *C. reba.*

Fatty acid composition of aquatic animals was influenced by intrinsic variables, such as species, sex, age and size; as well as extrinsic factors, such as diet, salinity, temperature, geographical regions, and the general rearing conditions (Abd Rahman et al., 1995; Sener et al., 2005). Fatty acids in fishes are derived from two main sources, *viz.* biosynthesis and diet (Kamler et al., 2001). The chain length varies from C_{14}-C_{24} of varying degree of unsaturation, from saturated to polyunsaturated (Swapna et al., 2010). Palmitic acid content among the SFA was maximum in these fish species which is in agreement with earlier report (Kaya et al., 2008; Jakhar et. al., 2012 and Paul et al., 2015a). Palmitic acid is considered to be a key to many metabolic processes in fish and other aquatic animals (Ackman and Eaton, 1966). Nath and Banerjee (2012) reported that the abundant quantity of SFAs shows that the less efficiency of fish species in utilizing the SFAs as core energy source. Regost et al. (2003) noticed that the two main sources of fatty acids in the muscles are diet and de novo synthesis. Level of saturated fatty acids in the body rises if the fish mostly feed on the diet containing insects and other aquatic organisms but if the fish diet mainly depends on the feed containing plant and algae sources then the level of unsaturated fatty acids become higher in the body. Continual recycling of fatty acids in feed, habitat and food web is the main reason of variation of fatty acids in the body.

Among monounsaturated fatty acid (MUFA), the oleic acid is predominant fatty acid as reported in these fish species which is in agreement with the results of other freshwater fish species (Chedoloh et al., 2011 and Paul et al., 2015a). Memon et al. (2011) and Paul et al. (2015a) reported that oleic acid was the main MUFA in *L. rohita, C. mrigala* and *C. catla*. 60-68% of the MUFA in freshwater carps was C18:1

(oleic acid) as reported by Sankar and Ramachandran (2001). Oleic acid has exogenous origin and usually reflects the type of diet of the fish (Ackman, 1989).

The PUFA content ranges from 6.40 to 23.36 in the studied fish species. Vlieg and Body (1988) reported that freshwater fish have lower content of PUFAs as the freshwater fish feed is largely based on plant materials. Fish oils are known to be rich source of essential PUFA of the omega-3 family (Kenari et al., 2009). Memon et al. (2011) also reported that Indian major carp contains good amount of long chain PUFA, which was in agreement with our present study. Several studies have reported that consumption of fish and fish oils containing ω-3 fatty acids are favorable for a number of biological factors associated with cardiovascular diseases, rheumatoid arthritis, psoriasis, etc. (Kris-Etherton and Harris, 2002).

The gross energy content of the studied carp species are presented in figure 5. The energy content is maximum in *L. fimbriatus* and followed by *L. bata* and *C. reba*. The gross energy content of the carp species of the present study are higher than energy content of eels (*Anguilla Anguilla*) as reported by Schreckenbach et al. (2001). Chrisolite et al. (2015) reported the gross energy content of fifteen freshwater species wherein the gross energy content is lower than our report in the present study. The vitamin A and D content are presented in figure 1, wherein the vitamin A content is maximum in *L. bata*, *C. reba* and *P. javanicus*. The vitamin D content is maximum in *C. reba*, *L. bata* and *L. fimbriatus*as studied in the present experiment. Fish acts as a good source of fat soluble vitamins, *viz*. A, D, E and K. Liu (2003) reported that vitamin A content from fish is easily utilized by our body than from plant source. Vitamin A is responsible for normal vision, bone growth and its derivative retinoic acid which helps in the regulation of gene expression in developmental epithelial tissue (Roos et al., 2003). Fat soluble vitamin content in fish flesh is affected by the level of fat (Ozyurt et al., 2009). The vitamin A content is maximum *L. bata*, *C. reba* and *P. javanicus*. Vitamin A content in *L. bata* is 207.00 (I.U./100g). The vitamin D content is higher in *C. reba*, *L. bata* and *L. fimbriatus.* Vitamin D plays a major role in activation of the innate and the adaptive immune systems (Hewison, 2011).

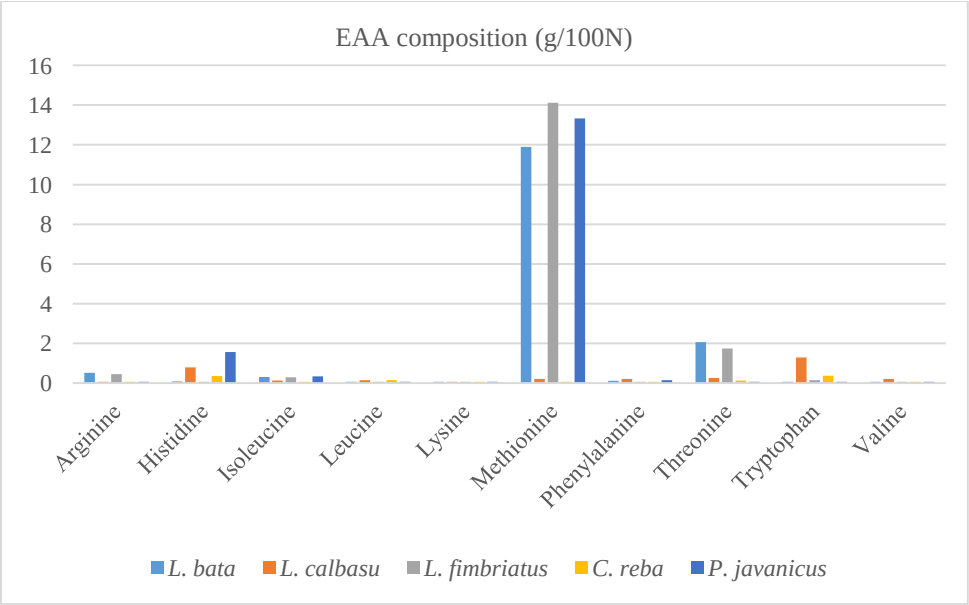


Figure 3. Essential Amino Acid composition (g/100N) of five freshwater carp species

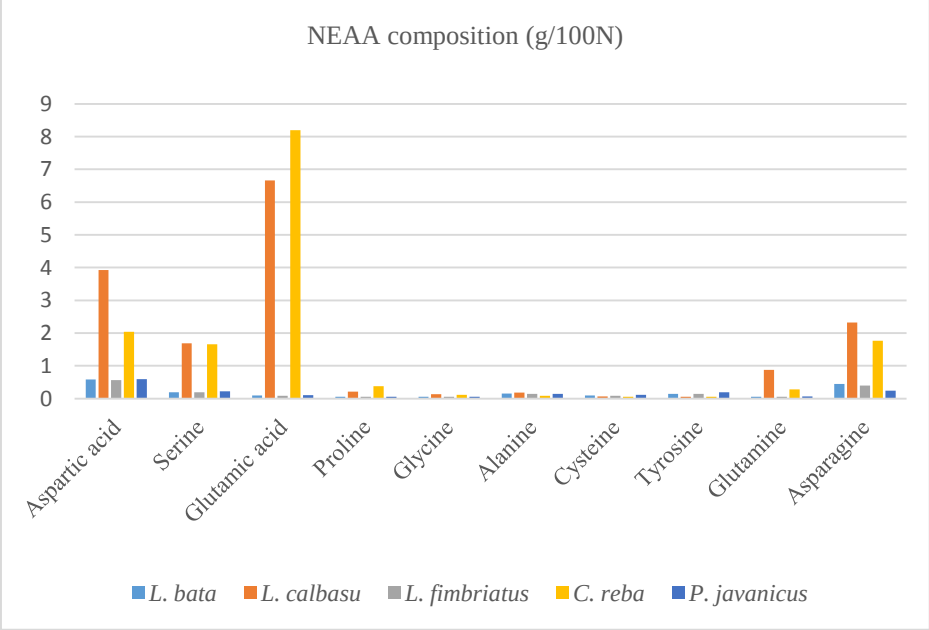


Figure 4. Non-Essential amino acid composition (g/100N) of five freshwater carp species

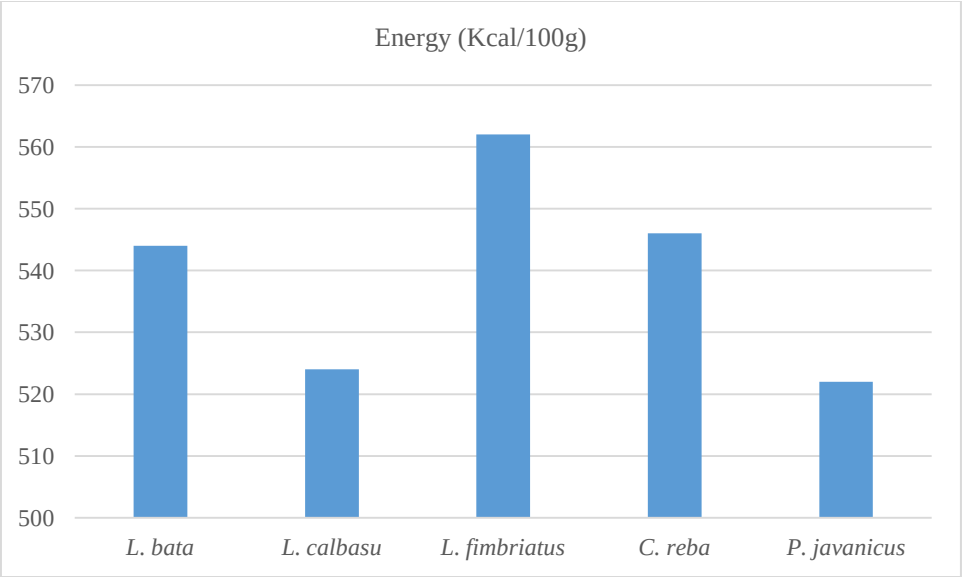


Figure 5. Energy content (Kcal/100g) of five freshwater fish

The figure 3 represents the essential amino acid content of all the five carp species. Perusal of figure 3 depicts that the methionine content is maximum among all the essential amino acids, wherein the methionine content is maximum in *L. fimbriatus*, *P. javanicus* and *L. bata*. Threonine content is high in *L. bata* and *L. fimbriatus*. Histidine content is more in *L. calbasu* and *P. javanicus*. The tryptophan content is high in *L. calbasu* and *C. reba*. The non-essential amino acids (NEAA) content of the five fish species are presented in figure 4. Among the NEAA, glutamic acid is predominant and it is followed by aspartic acid, asparagine and serine. Aspartic acid, glutamic acid and asparagine are maximum in *L. calbasu* and *C. reba*. Iwasaki and Harada (1985) reported that the main amino acids of fish are aspartate, glutamate and lysine. Over the last 20 years, increasing evidence suggests the importance of glutamine for the proper functioning of many organ systems (Christina et al., 1999). The most abundant free amino acid in the body, comprising nearly 60% of the intracellular amino acid in the skeletal muscle (Kenari et al., 2009). It serves as an important carrier for the ammonia (nitrogen) from muscle to the splanchnic area and immune system (Deutz et al., 1992). Glutamine also acts as donor of nitrogen in the synthesis of purines and pyrimidines and helps in the proliferation of cells (Limin et al., 2006). Similar values of glutamic acid have also been reported earlier in mackerel (Hou et al., 2011) and Indian Freshwater food fishes (Mohanty et al., 2014). The present study shows the presence of a better amount of essential and non-essential amino acids in *L. bata, L. calbasu, L. fimbriatus, C. reba* and *P. javanicus.*

CONCLUSION

The nutrient profile of five carps *viz*. *Labeo bata*, *Labeo calbasu*, *Labeo fimbriatus*, *Cirrhinus reba* and *Puntius javanicus* reveal that they are rich in essential nutrients like protein, fat, ash, energy, minerals, vitamins, amino acid and fatty acid content which are required for human health. The important fatty acids eicosapentaenoic acid and docosahexaenoic acid are present in these carps. The nutritional information of these fish species are not documented properly so these findings will help in preparation of database. The data on the nutrient composition of these fish species will help the nutritionists, researchers medical practitioners, dieticians and other related stakeholders to advise consumers to take fish as health food.

ACKNOWLEDGEMENT

This work was supported by Ministry of Agriculture, Government of India under ICAR Outreach Activity on Nutrient Profiling and Evaluation of fish as a Dietary component. The authors greatly acknowledge the help of DDG (Fy, ICAR) and Director, CIFA for providing necessary support and facility to conduct the work. The help extended by Mrs. Puja Singh during analysis of samples is duly acknowledged.

REFERENCES

Abd Rahman, S., Osman, T.S.H., Hassan, O., and Daud, N.M. (1995). Fatty acid composition of some Malaysian fresh water fish. *Food Chemistry,* 54, 45-49.

Ackman, R.G., and Eaton, C.A. (1966).Some commercial Atlantic herring oils; Fatty acid composition. *Journal of Fishery Research Board of Canada*, 23, 991-1006.

Ackman, R.G. (1989).Ackman (Ed.), Marine Biogenic Lipids, Fats and Oils. 145-178. Boca Raton: CRC Press

AOAC. (1995).*Official methods of Analysis.* 16th ed.Association of Official Analytical Chemists, Washington, DC.

AOAC. (2005).*Official methods of Analysis.* 18th ed. Association of Official Analytical Chemists, Washington, DC.

Ayoola, A.A. (2010). Replacement of fishmeal with alternative protein source in aquaculture diets. M.Sc. Thesis, North California State University, North Carolina, USA.

Chanda, S., Paul, B.N., Ghosh, K., and Giri, S.S. (2015).Dietary essentiality of trace minerals in aquaculture: an overview. *Agriculture Review*, 36,100-112.

Chedoloh, R., Karrila, T.T., and Pakdeechanuan, P. (2011).Fatty acid composition of important aquatic animals in Southern Thailand. *International Food Research Journal*, 18, 783-790.

Christina, J., Palmer, A., and Griffiths, R.D. (1999).Randomized clinical outcome study of critically ill patients given glutamine supplemented internal nutrition. *Nutrition,* 15, 108-115.

Chrisolite, B., Shanmugam, S.A., and Arumugam, S.S. (2015).Proximate and mineral composition of fifteen freshwater fishes of Toothukudi, Tamilnadu. *Journal of Aquaculture in the Tropics*, 30 (1-2), 33-43.

Das, S., Paul, B.N., Sengupta, J., and Datta, A.K. (2009). Beneficial effects of Fish oil to Human Health. *Agriculture Review*, 30(3), 199-205.

Deutz, N.E.P., Reijven, P.L.M., Athanasas, G., and Soeters, P.B. (1992). Post operative changes in hepatic, intestinal, splenic and muscle fluxes of amino acids and ammonia in pigs. *Clinical Science*, 83, 607-614.

FAO. (2014).*The State of World Fisheries and Aquaculture: Opportunities and Challenges*.FAO Rome, Italy.www.fao.org

Folch, J., Less, M., and Stanley, G.H.S. (1957).A simple method for the isolation and purification of total lipids from animal tissues. *Journal of Biochemistry*, 226, 497-509.

Galli, C., and Marangoni, F. (1997).Recent advances in the biology of n-6 fatty acids. *Nutrition*, 13, 978-985. doi:10.1016/S0899-9007(97)00341-9.

Giri, S.S., Paul, B.N., Sahoo, S.K., Rangacharyulu, P.V., Rath, S.C., and Mohanty, S.N. (2010).Fish oils and cardio vascular health. *Fishing Chimes*, 30(2), 37-39.

Hewison, M. 2011. Vitamin D and innate and adaptive immunity. *Vitamin Hormones*, 86, 23–62.

Hou, H., Li, B., and Zhao, X. Enzymatic hydrolysis of defatted mackerel protein with low bitter taste. (2011). *Journal of Ocean University China (Oceanic and Coastal Sea Research)*, 10, 85-92.

Ishida, Y., Fujita, T., and Asai, K. (1981).New detection and separation method for amino acids by high-performance liquid chromatography. *Journal of Chromatography*, 204, 143-148.

Iwasaki, M., and Harada, R. (1985). Proximate and amino acid composition of the roe and muscle of selected marine species. *Journal of Food Science*, 50, 1585-1587.

Jakhar, J.K., Pal, A.K., Reddy, A.D., Sahu, N.P., Venkateshwarlu, G., and Vardia, H.K. (2012). Fatty acid composition of some selected Indian fishes. *African Journal of Basic & Applied Science*, 4(5), 155-160.

Jabeen, F., and Chaudhary, A.S. (2011).Chemical compositions and fatty acid profiles of three freshwater fish species. *Food Chemistry*, 125, 991-996.

Joseph, J., Perigreen, P.A., Surendran, P.K., and Gopakumar, K.(1990).I.I.F-I.I.R, Commission 2, pp. 117, Aberdeen, U.K.

Kamler, E.B., Krasicka, S., and Rakusa-Suszczewski. (2001).Comparison of lipid content and fatty acid composition in muscle and liver of two Notothenioid fishes from Admiralty Bay (Antartica): An eco-physiological perspective. *Polar Biology*, 24, 735-743.

Kaya, Y., Turan, H., and Erdem, M.E. (2008).Fatty acid and Amino acid composition of raw and hot smoked sturgeon (*Husohuso*, L. 1758). *International Journal of Food Science and Nutrition*, 59(7-8), 635-642.

Kenari, A.A., Regenstein, J.M., Rezai, M., Tahergorabi, R., Nazari, R. M., Mogaddasi, M., and Kaboli, S.A. (2009).Amino acid and fatty acid composition of cultured Beluga (*Husohuso*) of different ages. *Journal of Aquatic Food Product and Technology*, 18, 245-265.

Kris-Etherton, P.M., and Harris, W.S. (2002).Fish consumption, Fish oil, Omega 3-fatty acids and Cardiovascular disease. *Circulation*, 106, 2747-2757.

Kumar, D. (1992).Fish culture in Un-drainable ponds. *A manual for extension FAO Fisheries Technical Paper,* No. 235, 239.

Lall, S.P. (2002).The minerals. In: *Fish Nutrition* (J.E. Halver and R.W.Hardy, Eds.) 3rd edn., Academic Press, New York, pp. 260-301.

Lauritzen, L., Hansen, H.S., Jorgensen, M.H., and Michaclsen, K.F. (2001).The essentiality of long chain n-3 fatty acids in relation to development of the brain and retina. *Progress in Lipid Research*, 40(1-2), 1-94.

Limin, L., Feng, X., and Jing, H. (2006).Amino acid composition difference and nutritive evaluation of the muscle of five species of marine fish, *Pseudosciaenacrocea* (large yellow croaker), *Lateolabraxjaponicus* (common sea perch), *Pagrosomus major* (red seabream), *Serioladumerili* (Dumeril's amberjack) and *Hapalogenysnitens* (black grunt) from Xiamen Bay of China. *Aquaculture Nutrition*, 12, 53-59.

Liu, R.H. (2003).Healthy benefits of fruits and vegetables are from additive and synergistic combinations of phytochemicals. *American Journal of Clinical Nutrition*, 78, 517S-520S.

Mazumder, M.S.A., Rahman, M.M., Ahmed, A.T.A., Begum, M., and Hossain, M.A. (2008). Proximate Composition of Some Small Indigenous Fish Species (SIS) in Bangladesh. *International Journal of Sustainable Crop Production*, 3, 18-23.

Memon, N.N., Farah, N.L., Bhanger, M.I., and Balouch, A. (2011).Changes in fatty acid composition in muscle of three farmed carp species (*Labeorohita, Cirrhinusmrigala, Catlacatla*) raised under the same conditions. *Food Chemistry*, 126, 405-410.

Metcalfe, L.D., Schmitz, A.A., and Petha, J.R. (1996).Rapid preparation of fatty acid esters from lipids for gas chromatographic analysis. *Analytical Chemistry*, 38, 514-515.

Mohanty, B.P., Ganguly, S., Mahanty, A., Sankar, T.V., Anandan, R. Chakraborty, K., Paul, B.N., Sarma, D., Dayal, J.S., Venkateshwarlu, G., Mathew,S., Asha, K.K., Karunakaran, D., Mitra, T., Banerjee, S., Chanda, S., Shahi, N., Das, P., Das P., Akhtar, M.S., Vijayagopal, P. and Sridhar, N. (2016). DHA, EPA content and Fatty acid Profile of 39 Food Fishes from India. *Biomed Research International*, doi.10.1155/2016/4027437

Mohanty, B.P., Mahanty, A., Ganguly, S., Sankar, T.V., Chakraborty,K., Anandan,R., Paul, B.N., Sarma, D., Mathew, S., Asha, K.K., Behera, B.K., Afftabuddin, M., Debnath, D., Vijaygopal, P., Sridhar, N., Akhtar, M.S., Sahi, N., Mitra, T., Banerjee, S., Paria, P., Das, D., Das, P., Vijayan, K.K., Lamanan, P.T., and Sharma, A.P. (2014). Amino Acid composition of 27 Food fishes and their importance in Clinical Nutrition. *Journal of Amino acid*, 1, 1-7. Doi.org/10.1155/2014/269797

Nargis, A. (2006).Seasonal variation in the chemical composition of body flesh of Koi fish, *Anabas testudineus* (Bloch), (Anabantidae: Perciformis). *Bangladesh Journal Scientific and Industrial Research*, 41: 219-226

Nath, A.K., and B. Banerjee. (2012).Comparative evaluation of body composition of hilsa, *Tenualosailisha* (Hamilton, 1822) in different size groups with special reference to fatty acid, in Hooghly estuarine system, West Bengal, India. *Indian Journal of Fisheries*, 59, 141-146.

Otitologbon, S.A., Agbaji, E.B., Peters, O.A., and Oniye, S.J. (1997).Proximate and mineral composition of three Nigerian freshwater fishes. *Journal of the Science of Food and Agriculture,* 75, 312-314.

Ozyurt, G., Polat, A., and Loker, G.B. (2009).Vitamin and mineral content of pike perch (*Sander lucioperca*), common carp (*Cyprinuscarpio*) and European catfish (*Silurusglanis*). *Turkish Journal of Veterinary Animal Science*, 33, 351-356.

Pal, M., and Ghosh, M. (2013).Assay of Biochemical Compositions of two Indian freshwater Eel with special emphasis on accumulation of toxic heavy metals. *Journal of Aquatic Food Product Technology,* 22, 27-35.

Paul, B.N., Chanda, S., Bhowmick, S., Sridhar, N., Saha, G.S., and Giri, S.S. (2017).Nutrient Profile of Indian Climbing Perch, *Anabas testudineus*. *SAARC Journal Agriculture*. 15(1), 99-109. DOI: http://dx.doi.org/10.3329/sja.vl5il.33156

Paul, B.N., Chanda, S., Sridhar, N., Saha, G.S., and Giri, S.S. (2016).Proximate, mineral and vitamin contents of Indian Major Carp. *Indian Journal of Animal Nutrition,* 33(1), 102-107. doi: 10.5958/2231-6744.2016.00018.9

Paul, B.N., Chanda, S., Sridhar, N., Saha, G.S., and Giri, S.S. (2015a).Fatty acid profile of Indian Major Carp. *Indian Journal of Animal Nutrition,* 32(2), 221-226.

Paul, B.N., Chanda, S., Sridhar, N., Saha, G.S., and Giri, S.S. (2015).Proximate and mineral composition of Magur (*Clariasbatrachus*) and Singhi (*Heteropneustesfossilis*). *Indian Journal of Animal Nutrition*, 32(4), 453-456. Doi: 10.5958/2231-6744.2015.00017.1

Paul, B.N., Chanda, S., Das, S., Singh, P., Pandey, B.K., and Giri, S.S. (2014).Mineral Assay in atomic absorption spectroscopy. *Beats of Natural Science,* 1, 1-17.

Paul, B.N., and Mukhopadhyay, P.K. (2001).Importance of trace minerals in aquaculture nutrition. *Fishing Chimes*, 21, 34-36.

Regost, C., Arzel, J., Robin, J., Rosenlund, G., and Kaushik, S.J. (2003).Total replacement of fish oil by soybean or linseed oil with a return to fish oil in turbot (*Psetta maxima*): 1. Growth performance, flesh fatty acid profile and lipid metabolism. *Aquaculture*, 217, 465-482. Doi: 10.1016/S0044-8486(02)00259-4

Roos, N., Islam, M.M., and Thilsted, S.H. (2003).Small indigenous fish species in Bangladesh: Contribution to Vitamin A, Calcium and Iron intakes. *The Journal of Nutrition* (Suppl), 4021S-4026S

Sanchez-Alonso, I., Jimenez-Escrig, A., Saura-Calixto, F., and Borderias, A.J. (2007). Effect of grape antioxidant dietary fiber on the prevention of lipid oxidation in minced fish: Evaluation by different methodologies. *Food Chemistry,* 101, 372-378.

Sankar, T.V., and Ramachandran, A. (2001).Changes in biochemical composition in Indian Major Carps in relation to size. *Fishery Technology,* 38, 22-27.

Sankar, T.V., Susheela, M., Anandan, R., Asha, K.K., and Mohanty, B.P. (2010).Nutrient Profiling of Fish. ICAR-Central Institute of Fisheries Technology, Handbook, Cochin. pp 1-61.

Schreckenbach, K., Knosche, R., and Ebert, K. (2001).Nutrient and energy content of freshwater fishes. *Journal of Applied Ichthyology*, 17, 142-144.

Sener, E., Yildiz, M., and Savas, E. (2005).Effects of dietary lipids on growth and fatty acid composition in Russian sturgeon (*Acipensergueldenstaedtii*) juveniles. *Turkish Journal of Veterinary and Animal Science*, 29, 1101-1107.

Sharma, P., Kumar, V., Sinha, A.K., Ranjan, J., Kithsiri, H.M.P., and Venkateshwarlu G. (2009).Comparative fatty acid profiles of wild and farmed tropical freshwater fish rohu (*Labeorohita*). *Fish Physiological and Biochemistry,* 36, 365-379.

Shekhar, C., Rao, A.P., and Abidi, A.B. (2004).Changes in muscle biochemical composition of *Labeorohita*(Ham.) in relation to season. *Indian Journal of Fisheries*, 51, 319-323.

Snedecor, G.W., and Cochran, W.G. (1968).*Statistical Methods.* 6th ed. Oxford and IBH Publishing Company, Calcutta, India.

Swapna, H.C., Kumar, R.A., Bhaskar, N., and Sachindra, N.M. (2010). Lipid classes and fatty acid profile of selected Indian freshwater fishes. *Journal of Food Science and Technology,* 47(4), 394-400.

Vlieg, P., and Body, D.B. (1988). Lipid contents and fatty composition of some New Zealand freshwater finfish and marine finfish, shellfish and roes. *New Zealand Journal of Marine and Freshwater Research*, 22, 151-162