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NUTRIENT PROFILE OF FIVE FRESHWATER FISH SPECIES

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ABSTRACT

The nutrient profile of five freshwater fish species viz., *Mystus vittatus, Ompok bimaculatus, Channa striata, Wallago attu* and *Pangasianodon hypophthalmus* were studied. The proximate composition data shows that the moisture and fat content differed significantly (P<0.01) among the fish species. The fat content was significantly higher in *P. hypophthalmus* and *M. vittatus*. The moisture was significantly higher in *C. striata*. The potassium content was significantly (p<0.01) higher in *C.striata*. *M.vittatus* shows higher content of calcium. The other trace minerals like iron, copper and zinc contents of fish did not differ significantly among the species. The vitamin A content is maximum in *O.bimaculatus* whereas vitamin D content is higher in *Mystus vittatus*. The palmitic acid was significantly (p<0.01) higher in *M. vittatus*. The oleic acid was significantly (p<0.01) higher in *C. striata* and *W. attu.* The linoleic acid content was significantly (p<0.05) higher in *P. hypophthalmus*. One of the important PUFA i.e. DHA was significantly higher in *O. bimaculatus* and *C.striata*. The PUFA content was significantly (p<0.05) higher in *O.bimaculatus* and *P.hypophthalmus*. Among the amino acids, arginine, histidine, threonine and isoleucine were higher in *P.hypophthalmus*. *C.striata* and *W. attu* contain high amount of Tryptophan. Glutamic acid was high in *O.bimaculatus* and Aspartic acid was high in *C. striata*. The energy content was maximum in *P. hypophthalmus*. The nutrient profile of these fish species revealed that they were rich in all the essential nutrients required by human being. The information on nutrient profile of fish will give a guideline to dieticians, nutritionists, medical practitioners, researchers to advice consumers to take fish in their daily diet as a health food.

Keywords: Amino acid, Fatty acid, Freshwater fish, Mineral and vitamin, Proximate composition.

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INTRODUCTION

Fish is a healthy food and is a major player in human nutrition, ensuring about 20% of protein intake to a third of the world's population which is more evident in developing countries (Bene et al., 2007). India is a global biodiversity hotspot and harbours more than 10% of the global fish diversity and thereby has the potential to meet the daily requirement of the essential nutrients for human health and can also provide food and nutritional security (Mohanty et al., 2019). On a fresh weight basis, fish contains a good quantity of protein about 13-20% and contains all the essential amino acids. The fat content of fish ranges from 0.2 to 15% and it varies depending on the species as well as the season in general and fish has less fat than red meats. Fat from fish species contain the poly unsaturated fatty acids (PUFA) viz., EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid) are ω-3 fatty acids which are essential for growth of children and prevents the occurrence of cardiovascular diseases such as coronary heart diseases (Calder, 2004). In pregnant women, the presence of PUFA in their diet helps in proper brain development among unborn babies and prevents preterm delivery and low birth weight (Mohanty et al., 2016 and Giri et al., 2010). Fish plays an important role in human nutrition as an efficient vehicle to deliver health promoting long chain ω-3 polyunsaturated fatty acid (PUFA) in the diet (Sargent, 1997).

Micronutrients like vitamins and minerals are also present in the fish muscle. The micronutrients fulfil the hidden hunger of human population and prevent many disorders due to deficiency of such micronutrients (Mohanty et al., 2016a). Fish is soft, easy to cook, easily digestible than meat so young children can be fed fish as balanced diet with some cereals. The high nutritional value of fish is mainly related to their digestible protein which is an excellent source of EAA (Sanchez-Alonso, 2007). Fish protein occupies an important position in human nutrition (Nargis, 2006). FAO (2014) reported that a protein of 150g of fish flesh can provide 50-60% of an adult's daily protein requirements.

Some information are available on nutrient composition of Indian major carp (Paul et al., 2015a, and 2016), catfish (Paul et al., 2015), air breathing fish (Paul et al., 2017), minor carps (Paul et al., 2018) and Freshwater fish (Paul et al., 2019). Keeping in view of importance of eating fish, the nutrient profile of four freshwater fish (*M. vittatus*, *C. striata*, *W. attu* and *P. hypophthalmus*) and one freshwater catfish (*O. bimaculatus*) were studied to document on protein, fat, minerals, vitamins, amino acids and fatty acids which will be helpful to dieticians, nutritionists, researchers, fish farmers and related stakeholders to promote fish as health food in human nutrition.

MATERIALS AND METHOD:

Collection of Samples: The samples were collected from various places of different states of India viz, West Bengal and Odisha. The weight and length ranges for the five different freshwater fish species were i.e. 5-25g and 7-14 cm for *Mystus vittatus*, 20-200g and 15-30cm for *Ompok bimaculatus*, 150-850g and 25-55cm for *Channa striata*, 250-2000g and 35-65cm for *Wallago attu* and 400-2000g and 30-60cm for *Pangasianodon hypophthalmus*. The number of fish samples collected were viz., *M. vittatus* (n=59), *O. bimaculatus,* n=52, *C. Striata*, n=52, *W. Attu,* n=48 and *P. hypophthalmus*, n=56. The sampling procedure and the sample preparation for analysis were done as per Sankar et al. (2010) and Paul et al. (2018)

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) (Thermo Fisher, M Series). The energy content of fish samples were analysed by Bomb Caloric 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 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.

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) as per Paul et al. (2018).

Vitamin analysis

The fat soluble vitamins Retinol (Vitamin A), Cholecalciferol (Vitamin D) are assayed in 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 analysis was done in High Performance Liquid Chromatography from Edward Food Research and Analysis Centre Limited, Nilgunge, Kolkata- 700121 (www.efrac.org) as per Paul et al. (2018).

Statistical Analysis:

The data were statistically analysed 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 data are presented as Mean± S.E.

Results and Discussion

The proximate compositions of the five freshwater fish are presented in table 1. The moisture content was significantly (P<0.01) higher in *C.striata* vis-à-vis other fish species. The fat content was significantly (P<0.01) higher in *P. hypophthalmus* and *M.vittatus* compared to other fish species. Both protein and ash content of freshwater fish did not differ significantly among these fish.

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

Particulars	*M. vittatus*	*O. bimaculatus*	*C. striata*	*W. attu*	*P. hypophthalmus*
Moisture**	72.67^{a}±0.30	75.17^{a}±0.34	76.11^{b}±0.17	74.25^{a}±0.42	70.82^{a}±0.53
Protein	14.94±0.20	13.93±0.19	14.46±0.21	14.13±0.19	15.41±0.29
Fat**	6.91^{bc}±0.18	3.92^{a}±0.15	2.09^{a}±0.09	3.58^{a}±0.15	7.17^{c}±0.39
Ash	2.57±0.08	2.12±0.05	2.28±0.04	1.97±0.05	1.88±0.07

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

The moisture content of *C.striata* (76.11%), *O.bimaculatus* (75.17%) and *W. attu* (74.25%) were similar to the moisture content of magur and singhi as reported by Paul et al. (2015); eel (*M. armatus*) reported by Pal and Ghosh (2013) and in *A. mola*, *G. chapra* and *P. chola* as reported by Mazumder et al. (2008). The moisture content of *M.vittatus* (72.67%) and *P.hypophthalmus* (70.82%) were lower than the earlier report. Paul et al. (2017) reported that the moisture content of *Anabas testudineus* (68.00%) was lower than our findings. The protein content of these fish species in the present study was lower than the protein content of *Anabas testudineus* (16.91%) as reported by Paul et al. (2017). The fat content of freshwater fish studies ranged from 2.09 to 7.17%. There is an inverse relationship between moisture and lipid content of fish tissue (Wheeler and Morrissey, 2003 and Jankowska et al., 2007) also observed in fat and moisture content of *M. vittatus* and *P. hypophthalmus*. Our finding on fat contents were similar to magur and singhi (Paul et al., 2015), small indigenous fish species of Bangladesh (Mazumder, 2008), freshwater eel (Pal and Ghosh, 2013) and *Anabas testudineus* (Paul et al., 2017).

The ash content of five freshwater fish as studied ranged from 1.88 to 2.57%. Our results were in agreement with earlier reports (Mazumder et al., 2008, Paul et al., 2015, Bogard et al., 2015 and Chrisolite et al., 2015). The protein and ash content of *P. hypophthalmus* was similar to Thai pangas whereas fat content was lower and moisture content was higher than Thai pangas in the present work as reported elsewhere (Bogard et al., 2015). The fat (9.5%) and protein content was higher in modhu pabda compared to our data protein and fat; but ash content (2.12%) was higher (16.20%) than the modhu pabda (0.90%) as reported by Bogard et al. (2015). The fat and ash content of *C. striata* was higher than shoal but protein content (14.46%) was lower than shoal (18.70%) as reported earlier (Bogard et al., 2015). However the protein content of *C. striata* of our finding was similar to protein content of *C.stiata* (Chrisolite et al., 2015). The protein and ash content of *M. vittatus* was similar to tengra whereas fat and moisture content was higher in tengra in comparison to our findings in *M. vittatus* (Bogard et al., 2015).

The total crude protein content of five freshwater fish species ranged from 13.93 to 15.41 (% as fresh basis); which seems to be of high dietary quality, being an animal sourced protein (WHO, 2007). Fat varies to a great extent compared to other proximate component of fish and it reflects the differences in the way fat is stored in particular species. It may also vary due to seasonal/lifecycle variations and the diet/food availability of the species at the time of sampling (Ababouch, 2005).

The mineral content of these five species is presented in table 2. Perusal of data showed Potassium content was significantly ($P<0.01$) higher in *C.striata* and *P.hypophthalmus*. The manganese content was significantly ($P<0.01$) higher in *P. hypophthalmus*. The sodium, iron, copper and zinc content did not differ significantly among the fish species. The Calcium content is presented in figure 2. The Calcium content was maximum in *M.vittatus* and followed by *O.bimaculatus*, *W. attu* and *P. hypophthalmus*. The sodium, potassium, iron, copper, zinc and manganese content of all species are shown in (Table 2). Sodium content varied considerably with a range from 36.66 to 51.65 (ppm). The sodium content of five fresh water fish was lower than the value as reported in magur and singhi (Paul et al., 2015). The sodium content of *P. Sutchi* (99.40ppm) was higher than the value reported in *P. hypophthalmus* (Chrisolite et al., 2015); whereas sodium content of *M. vittatus* in our study was higher than the value of *M. oar* as reported elsewhere (Chrisolite et al., 2015). The potassium content of the five freshwater fish was lower than the value in *M. oar* and *P. sutchi* (Chrisolite et al., 2015) and also in singhi and magur (Paul et al., 2015). The iron content of five freshwater fish ranged from 0.46 to 0.67 (ppm). The iron content of *O. bimaculatus* (0.46ppm) was higher than the iron value of *O. bimaculatus* (0.16) as reported by Ghosh et al. (2004). The iron content of *M. vittatus* and *P. hypophthalmus* were higher than the iron content of *M. oar* and *P. Sutchi* respectively as reported earlier (Chrisolite et al., 2015). The copper content ranged from 0.24 to 0.68 (ppm) in the fish species (table 2). Our results were in agreement with the copper content of *O. bimaculatus* with the modhu pabda. The copper content of *C. striata* was higher than the copper content of Shoal and the copper content of *P. hypophthalmus* was lower than Majhari Thai pangas are reported by Bogard et al. (2015). The zinc content of *O. bimaculatus* was higher than the earlier report of zinc content of *O. bimaculatus* (Ghosh et al., 2004) and modhu pabda (Bogard et al., 2015). However, the zinc content of *M. vittatus* and *W. attu* were lower than the zinc content of *Mystus spp*. and *W. attu* as reported earlier (Chari et al., 2000). Our results on zinc content of freshwater fish were lower than the zinc content of singhi and magur (Paul et al., 2015). The manganese contents of fish in the present study were lower than the earlier reports (Paul et al., 2015 and Chari et al., 2000). The calcium content of five freshwater fish ranged from 150 to 255 (mg 100^{-1}). Our results were higher than the value of modhu pabda shoal and Thai pangas (Bogard et al., 2015); *W. attu* and *Mystus spp*. as reported by Chari et al. (2000). However, our results were in agreement with the calcium content of singhi and magur (Paul et al., 2016).

Table 2. Mineral content (ppm) of five freshwater fish species

Particulars	*M. vittatus*	*O. bimaculatus*	*C. striata*	*W. attu*	*P. hypophthalmus*
Sodium	36.92±5.24	47.70±2.74	39.66±5.30	51.58±6.25	51.65±3.88
Potassium**	70.48^{a}±16.14	126.55^{b}±6.13	170.60^{c}±4.95	112.10^{b}±5.10	129.33^{bc}±7.33
Iron	0.67±0.06	0.46±0.05	0.54±0.06	0.50±0.04	0.47±0.03
Copper	0.38±0.07	0.24±0.06	0.56±0.07	0.68±0.11	0.43±0.06
Zinc	0.54±0.03	0.68±0.07	0.49±0.06	0.38±0.02	0.49±0.06
Manganese**	0.08^{a}±0.01	0.17^{ab}±0.02	0.19^{ab}±0.02	0.11^{ab}±0.02	0.21^{b}±0.04

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

The fatty acid profile of five freshwater species are presented in table 3.The total saturated fatty acid (SFA) was significantly (P<0.01) higher in *Mystus vittatus* and followed by *W. attu*, *C. striata* and *O. bimaculatus*. The predominant SFA was palmitic acid which was significantly higher in *M. vittatus* and followed by *C. striata*. Another SFA stearic acid was significantly higher in *W. attu* and *P. hypophthalmus*. The total mono unsaturated fatty acid (MUFA) was significantly higher in *P. hypopthalmus* and followed by *C. striata* and *W. attu*. Oleic acid, a predominant MUFA was significantly (P<0.01) higher in *P. hypophthalmus*, *W. attu* and *C. striata*. Other MUFAs like myristoleic acid, pentadecenoic acid, palmitoleic acid and erucic acid also differed significantly (P<0.01) among the five fish groups.

The polyunsaturated fatty acids (PUFA) are one of the key fatty acids which are important from human health point of view. The linolenic acid was significantly (P<0.01) higher in *P. hypophthalmus* and *O. bimaculatus*. The γ-Linolenic acid was significantly (P<0.05) higher in *W. attu*. Another important as well as predominant PUFA, docosahexaenoic acid was significantly (P<0.05) higher in *C. striata* and *O. bimaculatus*. The total ω3 fatty acid was significantly (P<0.05) higher in *O. bimaculatus*, *P. hypophthalmus* and *C.striata*. The other fatty acids viz., EPA, arachidonic acid, eicosatrienoic acid, eicosadienoic acid, α Linolenic acid and Linolelaidic acid did not differ significantly among the fish species.

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

Fatty acid	*M. vittatus*	*O. bimaculatus*	*C. striata*	*W. attu*	*P. hypophthalmus*
Butyric acid (C4:0)	ND	0.06±0.05	0.17±0.07	0.11±0.08	0.13±0.02
Caproic acid (C6:0)	ND	0.08±0.03	0.07±0.02	0.15±0.09	0.12±0.03
Caprylic acid (C8:0)	0.05±0.01	0.08±0.03	0.03±0.02	ND	ND
Capric acid (C10:0)	ND	ND	0.04±0.02	0.02±0.01	ND
Undecanoic acid (C11:0)	0.21±0.04	0.05±0.02	0.05±0.02	0.05±0.03	0.07±0.03
Lauric acid (C12:0)	0.01±0.02	0.47±0.07	0.25±0.23	0.43±0.07	0.32±0.20
Tridecanoic acid (C13:0)	0.15±0.10	0.53±0.22	0.95±0.09	0.66±0.40	0.16±0.06
Myristic acid** (C14:0)	1.83[a]±1.04	7.03[b]±0.35	0.45[a]±0.14	5.54[b]±0.36	5.98[b]±2.13
Pentadecanoic acid (C15:0)	0.53±0.23	3.64±1.51	0.30±0.20	2.87±0.77	1.41±0.38
Palmitic acid** (C16:0)	68.53[d]±1.88	27.60[ab]±9.09	47.03[c]±5.31	33.50[b]±0.49	17.74[a]±4.86
Heptadecanoic acid (C17:0)	1.16±0.03	1.97±0.61	0.43±0.40	1.80±0.70	0.10±0.01
Stearic acid** (C18:0)	3.29[b]±0.10	5.79[c]±0.63	1.62[a]±0.02	10.60[d]±2.82	12.00[d]±1.25
Arachidic acid** (C20:0)	0.14[b]±0.01	0.18[b]±0.03	0.12[b]±0.02	0.39[c]±0.05	0.05[a]±0.01
Heneicosanoic acid (C21:0)	1.33±0.16	2.16±1.37	0.09±0.01	0.94±0.29	0.65±0.05
Behenic acid (C22:0)	0.08±0.00	ND	0.14±0.01	0.88±0.34	0.13±0.04
Tricosanoic acid (C23:0)	0.45±0.11	1.03±0.34	0.62±0.46	0.92±0.12	0.39±0.27
∑SFA**	77.74[c]±0.80	49.53[b]±6.13	52.84[b]±3.18	57.76[b]±0.19	39.26[a]±1.29
Myristoleic acid** (C14:1)	0.04[ab]±0.01	0.07[b]±0.01	0.16[c]±0.02	0.14[c]±0.06	0.02[a]±0.01
Pentadecenoic acid** (C15:1)	0.46[a]±0.44	0.24[a]±0.12	1.15[b]±0.03	0.12[a]±0.09	0.22[a]±0.11
Palmitoleic acid** (C16:1)	5.12[c]±0.94	0.84[a]±0.78	0.91[a]±0.11	0.90[a]±0.21	2.84[b]±1.22
Heptadecenoic acid (C17:1)	0.32±0.12	0.18±0.11	0.06±0.02	ND	0.28±0.23

Fatty acid	*M. vittatus*	*O. bimaculatus*	*C. striata*	*W. attu*	*P. hypophthalmus*
Oleic acid** (C18:1n9c)	$6.03^{a}\pm1.55$	$18.95^{b}\pm0.92$	$28.81^{c}\pm1.11$	$26.30^{c}\pm3.77$	$34.12^{d}\pm1.05$
Elaidic acid (C18:ln9t)	ND	2.98±0.00	ND	ND	ND
Eicosanoic acid (C20:ln9c)	0.32±0.03	1.42±0.31	0.13±0.005	1.28±0.07	0.88±0.59
Erucic acid** (C22:1n9)	$0.20^{a}\pm0.00$	$1.04^{d}\pm0.07$	$0.48^{b}\pm08$	ND	$0.87^{cd}\pm0.15$
∑MUFA**	$12.09^{a}\pm1.19$	$22.97^{b}\pm2.05$	$31.69^{c}\pm1.14$	$28.64^{c}\pm3.98$	$39.21^{d}\pm0.94$
Linolelaidic acid (C18:2n6t)	0.07±0.02	0.10±0.03	0.11±0.04	0.13±0.03	0.03±0.02
Linoleic acid* (C18:2n6c)	$2.75^{a}\pm0.18$	$8.24^{bc}\pm2.11$	$1.39^{a}\pm0.15$	$5.77^{b}\pm1.34$	$10.30^{c}\pm3.11$
γ-Linolenic acid* (C18:3n6)	$0.29^{bc}\pm0.12$	$0.35^{cd}\pm0.05$	$0.07^{a}\pm0.03$	$0.55^{d}\pm0.05$	$0.12^{a}\pm0.04$
α Linolenic acid (C18:3n3)	3.52±1.71	8.67±2.40	1.40±0.98	1.32±0.32	4.95±2.85
Eicosadienoic acid (C20:2)	0.29±0.06	1.72±1.20	0.24±0.15	0.19±0.04	0.47±0.24
Eicosatrienoic acid (C20:3n6)	0.28±0.07	0.69±0.04	1.24±0.15	0.54±0.26	1.40±0.19
Eicosatrienoic acid (C20:3n3)	ND	1.08±0.45	0.40±0.09	0.85±0.50	0.31±0.02
Arachidonic acid (C20:4n6)	0.24±0.02	3.52±0.23	1.6±0.55	1.08±0.93	1.49±0.44
Eicosapentaenoic acid or EPA (C20:5n3)	1.61±0.51	0.13±0.03	4.81±0.46	2.80±2.51	1.54±0.56
Docosahexaenoic acid or DHA* (C22:6n3)	$2.30^{b}\pm0.18$	$4.80^{c}\pm1.87$	$4.78^{c}\pm1.15$	$0.31^{a}\pm0.15$	$1.31^{a}\pm0.33$
∑PUFA*	$9.98^{a}\pm1.30$	$27.49^{c}\pm4.34$	$15.51^{ab}\pm4.32$	$13.61^{a}\pm3.98$	$21.59^{bc}\pm0.31$
ω3: ω6	1.72±0.48	1.70±0.58	2.41±0.32	0.46±0.13	0.59±0.46
∑ω3*	$6.26^{a}\pm1.45$	$15.76^{c}\pm0.88$	$11.33^{bc}\pm3.78$	$4.31^{a}\pm2.22$	$14.80^{c}\pm4.09$
∑ω6	3.72±0.15	11.73±3.74	4.61±1.16	8.65±2.42	6.79±4.39

$^{a, b, c, d}$ Means bearing different superscripts in a row differ significantly* (P< 0.05); **(P<0.01), ND: Not detected, SFA- Saturated Fatty Acid, MUFA- Mono Unsaturated Fatty Acid, PUFA- Poly Unsaturated Fatty Acid

The fatty acid content of fish varies due to species, sex, size and other external factors like feed, temperature, salinity, geographical locations and general rearing condition (Sener et al., 2005). Kamler et al. (2001) reported that fatty acid in fish is derived from diet and its biosynthesis. The oleic acid was predominant MUFA and it was maximum in *P. hypophthalmus*. The oleic acid content of *W. attu* was similar to the oleic acid content of mrigal of size 501-2000g as reported by Paul et al. (2015). The PUFA content Mystus, Ompok, Channa, Wallago and Pangas were less than the SFA content. This result was in agreement with the earlier report in Indian Major Carp (Paul *et al*., 2015) and Koi (Paul et al., 2017). The hypothesis that the freshwater fish contains low PUFA as their feed is largely based on plant materials (Vlieg and Body, 1988). The PUFA content was maximum in *O. bimaculatus* (27.49%) which was in agreement with PUFA content of Catla of size 51-500g as reported earlier (Paul et al., 2015). Fish oils are rich in ω-3 fatty acids. The docosahexaenoic acid (DHA) content ranged from 0.31 to 4.78% and maximum in Channa; which was in agreement with DHA content of catla of size 501-2000g and rohu of size >2000g as reported by Paul et al. (2015). The Eicosapentaenoic acid was also maximum in *C. striata* (4.81%). The ω-3 fatty acids viz., DHA and EPA are essential and important fatty acids that enhance quality of life and lower the risk of premature death (Mohanty et al., 2016). DHA is proven to be essential to pre and post natal brain development whereas EPA influences mood and behaviour (Kidd, 2007). Consumption of fish and fish oils containing ω-3 fatty acids prevents cardio vascular diseases, arthritis, psoriasis etc (Kris-Etherton and Haris, 2002 and Giri et al., 2010). Freshwater fish species are also known to contain high amount of EPA and DHA (Wang et al., 1990).

The chain length varies from C14 to C20 of varying degree of unsaturation from saturated to poly unsaturated (Swapna et al., 2010). The different classes of fatty acids are saturated fatty acids (SFA), mono unsaturated fatty acids (MUFA) and poly unsaturated fatty acids (PUFA). Among the saturated fatty acids the palmitic acid was predominant which was in agreement with earlier reports (Paul et al., 2015, 2017 and Jakhar et al., 2012). The total SFA content of *M. vittatus* (77.74%) was maximum among other fish species and this content was similar to that of Rohu (Paul et al., 2015). The palmitic acid is considered to be as key to many metabolic processes in fish and other aquatic animals (Ackman and Eaton, 1966). The myristic acid was high in *O. bimaculatus* (7.03%). The myristic acid is used as flavouring agents in food items (Burdock et al., 2007). The tasty flavour of *O. bimaculatus* could be due to high content of myristic acid present in it. The MUFA content of *P. hypophthalmus* was similar to rohu, catla and magur as reported earlier (Paul et al., 2015, 2016).

The energy content of five freshwater fish species are presented in figure 5. The gross energy content was maximum in *P. hypophthalmus*, *W. Attu* and *O. bimaculatus*. The total energy content varied with a range of 504-591 Kcal $100g^{-1}$ which is related to the variation in fat content of freshwater fish and our result was higher than the earlier reports (Schreckenbach et al., 2001, Chrisolite et al., 2015 and Bogard et al., 2015).

The vitamin A and D content (I.U. $100g^{-1}$) are presented in figure 1. Vitamin A content was maximum in *O. bimaculatus* and followed by *M. vittatus* whereas the vitamin D content was higher in *M. Vittatus* and *C. Striata* vis-à-vis other freshwater fish. Vitamin A content of these five fish ranged from 5.0-1058.0 (I.U $100g^{-1}$). The vitamin A content was maximum in *O. bimaculatus* and was higher than the vitamin A content of *A. testudineus* (Paul et al., 2017). Our data on vitamin A content of five freshwater fish was higher than the vitamin A content of some important fish of Bangladesh (Bogard et al., 2015). Liu (2003) reported that vitamin content from fish is readily available to the body compared to plant sources. Vitamin A plays a vital role for normal vision and bone growth; its derivative retinoic acid regulates gene expression in the development of epithelial tissue (Roos et al., 2003). The vitamin D content ranged from 5.0 to 384.0 (IU $100g^{-1}$). The vitamin D activate the innate immune system whereas dampen the adaptive immune system (Hewison, 2011); in addition to its role in bone development. Vitamin D content of *M. vittatus* was higher than the vitamin D content of *A. testudineus* (Paul et al., 2017). The vitamin D is also higher than the freshwater fish as reported by Bogard et al. (2015). Our data on vitamin A content of fish was higher than the vitamin A content of some important fish of Bangladesh (Bogard et al., 2015).

The essential amino acid content is presented in figure 3, where the Arginine, Threonine and Isoleucine were more in *P. hypophthalmus*. The histidine content was high in *P. hypophthalmus* and followed by *M. vittatus* and *O. bimaculatus*. The tryptophan was higher in *C. striata* and *W. attu* as depicted in figure 3.The Non Essential Amino Acid is presented in table 4. The Glutamic acid was more in *O. bimaculatus* and *M. vittatus*.

Figure 3 and 4 show the amino acid composition of the fish muscle of five freshwater fish species. Fish muscle is known to contain balanced amino acid composition (Venugopal et al., 1996 and Mohanty et al., 2014). Among the fish species Arginine, Histidine and Isoleucine were in higher amount in *P. hypophthalmus* vis-à-vis other fish species. Arginine plays an important role in wound healing, immune function, cell division, ammonia removal and hormone release. It is also the precursor for the biological synthesis of nitric oxide which plays an important role in neurotransmission, blood clotting and maintenance of blood pressure (Mohanty et al., 2014). The arginine content in *P. hypophthalmus* was similar to *A. testudineus* as reported by Mohanty et al., (2014). The histidine content in *P. hypophthalmus* was similar to *C. mrigala*, *S. weitei*, *S. commersonii* as reported earlier (Mohanty et al., 2014). Histidine is needed for growth and repair of tissue, for maintenance of myelin sheaths (Heimann, 1992). Histidine content was also rich in *M. vittatus* and *O. bimaculatus*. Isoleucine content of *P. hypophthalmus* was lower than the isoleucine content of other food fishes reported earlier (Mohanty et al., 2014).

Tryptophan is a precursor for serotonin, a neurotransmitter. Free tryptophan enters the brain cells to form serotonin. The tryptophan content of *C. reba* and *W. Attu* were similar to *S. waitei* and *S. Commersonii* as reported elsewhere (Mohanty et al., 2014). The glutamic acid content of *M. vittatus* and *O. bimaculatus* was lower than *H. fossilis* and *C. batrachus* as reported by Mohanty et al. (2014). Glutamic acid plays an important role in transmission reactions and required for key molecules viz., glutathione, required for removal of toxic peroxide and the poly glutamate folate cofactors. The Aspartic acid was maximum in *C. striata* and followed by *W. attu* and *M. vittatus*. Another NEAA glutamine was higher in *M. vittatus* and *O. bimaculatus*. The Asparagine was more in *W. attu* and *C. striata*.

The amino acid contents vary from fish species to species. Therefore, in general, arginine, histidine and isoleucine were rich in *P. hypophthalmus*. Tryptophan, asparagine and glutamine content were higher in *C. Striata* and *W. attu*. Aspartic acid was rich in *C. striata* and glutamic acid was rich in *O. bimaculatus*.

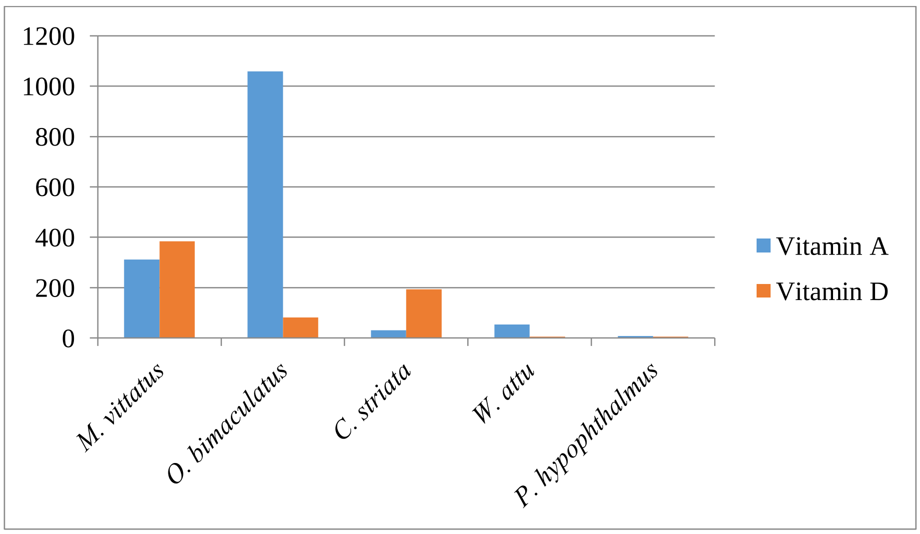

Figure 1. Vitamin A and D content (IU $100g^{-1}$) of five freshwater fish species

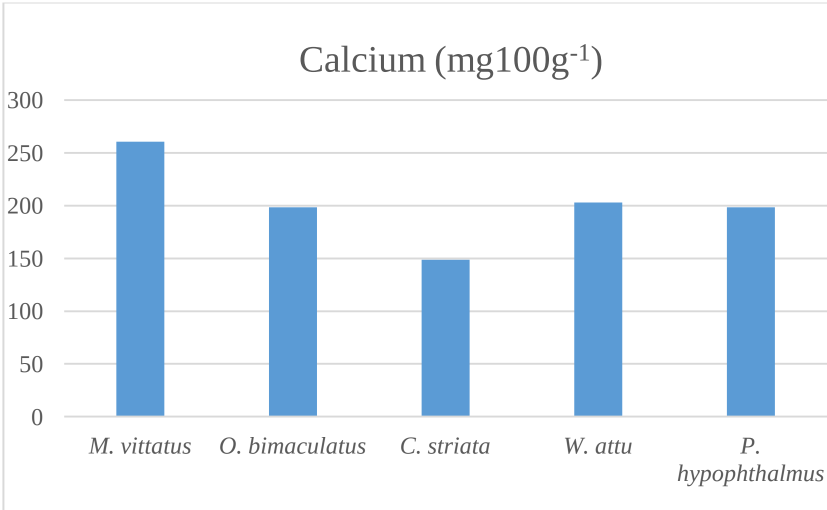

Figure 2: Calcium content (mg100g^{-1}) of five freshwater fish species

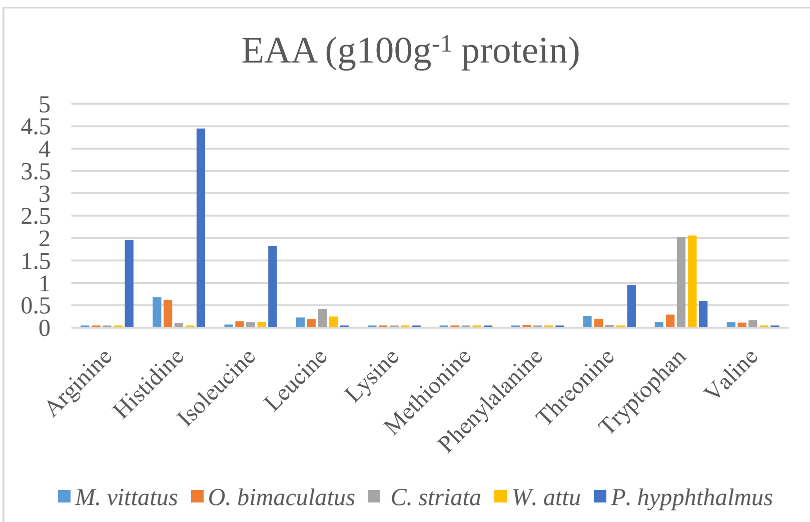

Figure 3. Essential Amino Acid composition (g 100g^{-1} protein) of five freshwater fish species

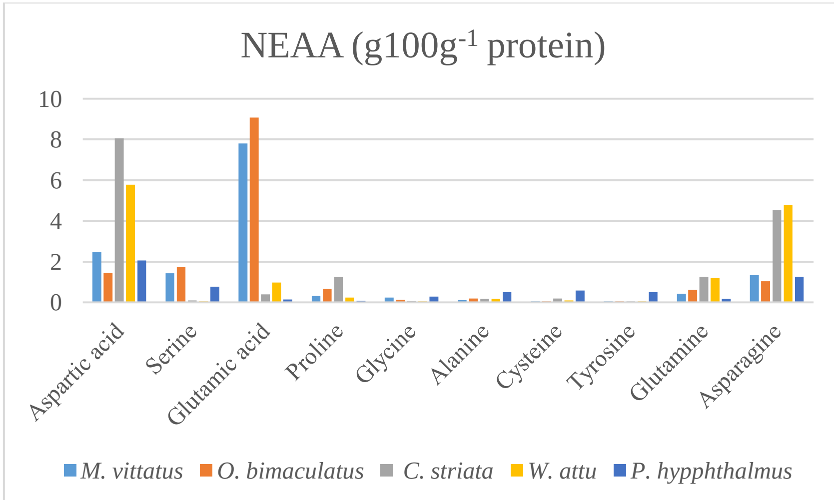

Figure 4. Non-Essential Amino Acid composition (g $100g^{-1}$ protein) of five freshwater fish species

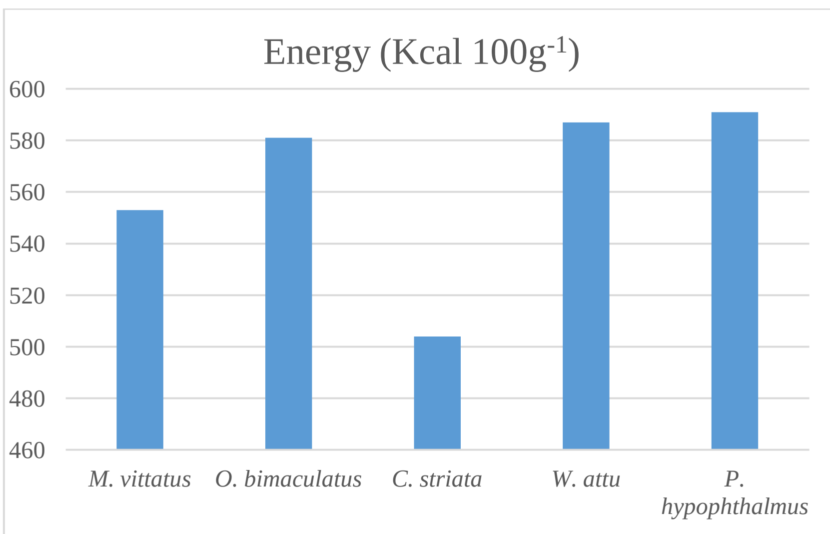

Figure 5. Energy content (Kcal $100g^{-1}$) of five freshwater fish

CONCLUSION

The nutrient profile of five freshwater fish species viz., *Mystus vittatus*, *Ompok bimaculatus*, *Channa striata*, *Wallago attu* and *Pangasianodon hypophthalmus* revealed that they are rich in protein, fat, ash, energy, minerals, vitamins, amino acid and fatty acid contents which are required for human health. The important fatty acids eicosapentaenoic acid and docosahexaenoic acid are present in these fish species. Arginine, threonine, isoleucine, histidine contents are rich in *P. hypophthalmus*. The vitamin A and D content are higher in *O. bimaculatus* and *M. vittatus* respectively. The obtained data on the nutrient profile of fish will help the nutritionists, researchers, medical practitioners, dieticians and other related stakeholders to advise consumers to take fish as health food.

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