International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 3 Number 7 (2014) pp. 208-218**
http://www.ijcmas.com

Original Research Article

Fatty acid compositions of four edible fishes of Hooghly Estuary, West Bengal, India

Ashim Kumar Nath*, Anindita Patra, Babita Sen, Debalina Dey, Ipsita Das, Ipsita Mukherjee, Nabanita Ghosh and Soumi Paul

Aquatic Ecology and Fisheries Laboratory Post Graduate Department of Zoology
Serampore College Serampore, Hooghly, West Bengal, India
**Corresponding author*

Keywords

Jhonius gangeticus, Clupisoma garua, Eutropiicthys vacha,

A B S T R A C T

The aims of this paper was to investigate the component of fatty acid of some fresh water and brackish water fish species namely *Johnius gangeticus* (Locally called Bhola), *Clupisoma garua* (locally called Ghero), *Eutropiicthys vacha* (locally called Vacha) and *Pseudapocryptes lanceolatus* (locally called Gule) as well as to compare the nutritional quanlity of studied fish group by comparing the levels of essential fatty acids present. The fatty acid profiles include minor amounts of odd number, branched chain and even number fatty acids as well as saturated components, the MUFA and PUFA. The major SFA were C16:0, C18:0 and C22:0. The C18:1 was prominent MUFA. The dominant PUFA were of the ω_6 series and were found chiefly in C18:2 fatty acids. The essential fatty acids composition showed prominence in C18:2 ω_6, the branched chain fatty acids identified C16:0, C18:0 and C22:0. Overall significance of this study had been its revelation that *Jhonius gangeticus, Eutropiicthys vacha, Pseudapocryptes lanceolatus* are good source of ω_3 essential fatty acids while fresh water fish *Clupisoma garua* are good source of ω_6 essential fatty acids.

Introduction

Fish is an important source of food for mankind all over the world since time immemorial. Fishes are not only the major protein source but they also contain nutritionally valuable lipids and fatty acids. The consumption of fish and fish products is recommended as a means of preventing cardiovascular and other diseases and has greatly increased over decades in many European Countries (Cahu *et.al.*, 2004). Besides these fishes have immense anti microbial peptide in defending against dreadful human pathogens (Ravichandran *et. al.*, 2010). When fish is suggested as a means of improving health, both the lipid content and the PUFA distribution must be considered. It is generally recognized that polyunsaturated fatty acids (PUFA) composition might vary among species of fish. However, little attention has been paid to the PUFA composition of different species when selecting fish for diet (Hearn and Sgoutas, 1987). Currently all over the world, sea food is encouraged because of its beneficial effects to fight disease and for maintenance of good health (Carroll and Woodward, 1989). The nutritional importance of fish consumption is associated largely with the ω_3 polyunsaturated fatty acid content such as eicosapentaenoic acid (EPA) (C20:5 ω_3) and docosahexaenoic acid (C22:6 ω_3) (Kris-Etherton *et.al.*, 2003).

The initial discovery of the health benefits of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) took place in Greenland in the northern hemisphere, adjacent to Europe and North America. In the rest of the world, an important study has infact been carried out in Africa, called the Lugalawa study (Pautello *et.al.*, 1996 a,b). Hundreds of fish eating villagers were compared with nearby villagers whose diets were devoid of fish. The consumption of 300-600 g daily of local fresh water fish showed increased plasma concentration, all beneficial health results. This study had a parallel with marine fish consumption in Japan with similar findings (Yamada *et.al.*, 2000). *Johnius gangeticus* (Bhola) comes from the family Scianidae under order Perciformes. The fish maximum attains 120 mm length and is riverine fresh water and estuaries, bentho pelagic in nature. *Pseudapocryptes lanceolatus* (gule) belonging to the family Gobidae, under order Perciformes is low priced ones. This species grows to about 200 mm in length and found from saline to fresh water zone of the Hooghly estuary and is caught in good numbers in the premonsoon, monsoon and post monsoon months. They are found in mudflats of estuaries and the fresh water tidal zones of river. They are amiphibious air breather. *Clupisoma garua* (Ghero) comes from the family Schilbeidae under order- Siluriformes. This fish is most frequent in monsoon and post monsoon months and fresh water in habit. They are found in shoals and are bottom feeder. They are highly carnivorous and predacious. *Eutropiicthys vacha* (Vacha), belonging to the family Schilibeidae under order Siluriformes. It is tasty catfish and has good market demand in West Bengal. It is caught in good numbers in the fresh water zones of the Hooghly Estuary. They are highly carnivorous and are found in abundance during monsoon and post monsoon months. Ghero is purely fresh water but the rest three are migratory i.e., shows brackish water and fresh water adaptation. The objective of this study was to investigate the comparative composition of fatty acids between four fishes namely Bhola (*Jhonius gangeticus*), Ghero(*Clupisoma garua*), Vacha(*Eutropiicthys vacha*), and Gule (*Pseudapocryptes lanceolatus*) of the Hooghly river as there was no report of fatty acid composition of these fishes. The fatty acid profile of lipids also reflects the availability of fatty acids in aquatic food chain (Sargent *et.al.*, 2002).

Materials and Methods

Four fishes namely Bhola (*Jhonius gangeticus*), Ghero (*Clupisoma garua*), Vacha (*Eutropiicthys vacha*), and Gule (*Pseudapocryptes lanceolatus*) were collected from the Hooghly river between Barrackpore (North 24 Parganas, West Bengal, India, 22° 46'N, 88°20' E) and Tribeni (Hooghly, West Bengal, India, 22°59'N, 88°23'E) during post monsoon (November,2013 to February 2014) period with the help of Behundi net (10 - 20 mm mesh size) and Bachari net (10 – 20 mm mesh size) (locally called). Fishes were randomly chosen according to their availability. Approximately the same length and weight of each fish groups were collected. Males and females were pulled together for this study. Prior to extraction these fishes were de scaled where ever needed, de skinned, the fins, heads, livers, digestive tracts were discarded and only body flesh was weighed. 100g of fish muscle tissue was separated from each fish species groups for the determination of lipid and fatty acid composition. The experiment was replicated three (3) times. The total lipids were extracted from the fish samples following the method of Bligh and Dyer (1959) using methanol-chloroform (2:1, v/v), methanol-chloroform-water (2:1:0.8, v/v/v), and then again with the first solvent system. Preparation of methyl esters of fatty acids were done following the method of Christie (1982). Purification of fatty acid methyl esters was done by thin layer chromatography following the process of Mangold (1969) and Mishra *et. al.* (1984). GLC of fatty acid methyl esters was done on a Chemitto 1000 instrument, equipped with Flame Ionization Detecter (FID). Quantification was done by computing using Specific Clarity Lite Software. Identification of fatty acid was done by comparing their retention times with those of standards, chromatographed under identical operational conditions of GLC.

Results and Discussion

The lipid content of the studied fish species are given in Table 2. *Clupisoma garua*(Ghero) showed highest lipid content(2.42% ± 0.03) followed by *Pseudapocryptes lanceolatus* (0.78%± 0.03) , *Jhonius gangeticus* (0.71%± 0.02) and *Eutropiicthys vacha* (0.53% ± 0.04). Detailed fatty acid compositions are listed in Table 1 and shown in Fig 1,2,3,4 and 5. Dominant fatty acids in lipids of all the studied fishes are palmitic acid(16:0), stearic acid(18:0), behenic acid(22:0), palmitoleic acid(16:1), oleic acid(18:1ω_9), linoleic acid(18:2 ω_6), eicosapentaenoic acid (20:5 ω_3) and docosahexaenoic acid(22:6 ω_3) (Table 1). These fatty acids (16:0; 18:0; 16:1; 18:1) are preferred substrates for mitochondrial ß-oxidation and heavily catabolized via the TCA cycle to generate metabolic energy in fish (Henderson and Sargent, 1985b). In addition Table 2 shows PUFA and SFA ratio, ω_3 to ω_6 ratio etc. in the lipids extracted from the studied fish groups. These ratios are useful to determine which fish gives out a better index in comparing relative nutritional fish oils in different species. In the present study in Gule and Ghero fish 28 fatty acids, in Bhola fish 24 fatty acids and in Vacha 22 fatty acids were found in total. In Bhola SFA was found higher than UFA and MUFA was found higher than PUFA. In Ghero and Vacha fish UFA was found higher than SFA and MUFA was found higher than PUFA whereas, in Gule fish UFA was found higher than SFA and PUFA was found higher than MUFA. Higher level of SFA in Bhola, Vacha and Gule fish than of MUFA indicates that these fishes may be unable to use SFA as an energy source efficiently when compared to MUFA and therefore SFA tends to accumulate in their tissues (Nath and Banerjee, 2012). The palmitic (C16:0) and stearic acid (C18:0) were the major types of saturated fatty acids found in the studied fish groups. Behenic acid (C22:0) is high in Bhola fish (Table1). A common constituents in liver is palmitoleic acid. It is biosynthesized from palmitic acid (C16:0) which is found in considerable amounts in all the studied fish groups. Fish having energy depots in the form of lipids will rely on this palmitoleic acid was present in considerable amount in all Bhola, Vacha and Gule fish. It is a beneficial fatty acid which increases insulin sensitivity by suppressing inflammation and inhibits the destruction of pancreatic beta-cells which are known to secrete insulin (Dutta and Dutta, 2013). Erucic acid (C22:1 ω_{11}) is known to be an anti nutritional factor which induces an increased incidence of myocardial lipidosis in animal (Dutta and Dutta, 2013) found high (4.39% ± 0.05) in Ghero fish but in very small amount in other studied fish groups (Table 1). ω_3 PUFA was found highest in Gule fish (22.94±0.16) followed by Vacha fish (11.03±0.23). EPA(20:5) content was also found higher in Gule fish (10.32±0.34) (Table 2). In all the studied fish groups 18:3 ω_3 (α-linoleic) fatty acid present but 18:3 ω_6 (γ-linoleic) fatty acid present only in *Clupisoma garua* and *Pseudapocryptes lanceolatus* fishes (Table1). Arachidonic acid was present in all four fish species. Both 18:2 ω_6 (Linoleic acid) and 20:4 ω_6 (Arachidonic acid) have significant biological role; especially with respect to eicosaenoids derived from 20:4 ω_6 are physiologically active in fish and are essential for reproduction and cellular signal transduction in fish. (Bell and Sargent, 2003). Overall ω_3 fatty acid content was found higher than ω_6 except *C. garua* which is considered as fresh water fish. Stansby (1969) and Ackman(1994) mentioned that fresh water fishes usually contained higher amount of ω_6 fatty acid than the marine fish. Vlieg and Body (1988) opined that fresh water fish have lower content of PUFA than marine fish. PUFA are integral component of cell membranes. Increased PUFA is necessary to reorganize the composition of vital membrane to maintain homeostasis. Fish have the ability to change the composition of their cell membranes throughout the year replacing saturated fats with unsaturated ones as temperature drop (Madhusoodan Rao *et. al*., 2012). MUFAs, however, appeared to be the major fatty acid in the studied fish groups. The SFA and MUFA can be synthesized de novo. De novo fatty acid production increases when diets are high in carbohydrate and protein is the preferred carbon source for energy provision in fish (Sargent *et. al.,* 2002) , SFA and MUFA are storage lipids preferentially used as energy sources (Daniela, 2005) , MUFA are good substrates for β-oxidation in fish (Sidell *et. al.*, 1995 , Stabhaug *et al.*, 2005). Zenebe *et. al.* (1998) have argued that variation in tissue lipid and fatty acid in herbivorous fish is greater than in those of carnivore fish and is due to the diversity of food habit. Proportion of plant and animal food will influence the accumulation of fatty acid (Domaizon *et. al.*, 2000). The existing interspecies variability in the composition of fatty acid of fish lipids (and of the specific PUFA in particular) is usually explained by the existence of a large number of external factors (environment , culturing method, tropic effects) and internal factors (fish species, feeding regime and digestion, life cycle, stage, quantitative and qualitative characteristics of lipids – triglycerols , phospholipids and their topographical origin – dorsal and ventral part of muscle tissue) (Chukwuemeka *et. al.*, 2008). ω_3 fatty acids can be divided into 3 main categories i.e Eicosapentaenoic acid (EPA), Docosahexaenoic acid (DHA) and α – linoleic acid. EPA and DHA are found mainly in fish oils while alpha- linoleic acid is usually derived from plant sources. ω_3 fatty acid aids in the prevention and management of heart diseases. This can help in reducing ones risk of developing an abnormal heartbeat that can lead to heart problems and even sudden death. ω_3 prevents asthma, hypertension, diabetes , cancer and kidney dialysis and tend to inhibit the development or metabolism of these diseases in the body (Muhamad & Mohamad, 2012). EPA (20:5 ω_3) has a protective effect against the thrombosis, atherosclerosis and some inflammatory diseases (Dyerberg *et. al.*, 1978, Lee *et.al.*, 1985). EPA reduces the concentration of cholesterol and triglycerides in the plasma by lowering the rate of synthesis of LDL (low density lipoprotein) & VLDL (very low density lipoprotein) by the liver & vascular tissues (Illingworth *et. al.*, 1984). Similar studies with docosahexaenoic acid 22:6 ω_6 (DHA), indicate that it is effective in skin disorders, aids brain development & also forms a good part of the retina of the eye (Lee *et. al*., 1985). Buda *et. al.* (1994) concluded that 22:6 ω_3 (DHA) plays only minor role in the thermal adaptation. The amounts of EPA were found to be the highest in *P. lanceolatus* (10.32% ± 0.34) followed *E vacha* (4.17% ± 0.18) (Table 1). DHA were also found to be the highest in *P lanceolatus* (8.07% ± 0.19) followed by *E vacha* (4.52% ± 0.42). The result agrees the view of Wang *et. al.* (1990) that marine fishes are rich in ω_3 especially EPA & DHA. Gule and Vacha moves downward in the saline zone and again move upwards. ω_6 was found to be highest in Ghero fish (10.26% ± 0.09). Ghero is a freshwater fish. It always resides in freshwater and take the waste from the river. It agrees the view of Wang *et. al.*(1990), which states that fresh water fish usually consist of more ω_6 polyunsaturated fatty acid that is Linoleic acid (C18:2) and Arachidonic acid (C20:4). ω_3:ω_6 ratio of the unsaturated fatty acid is an useful indicator for comparing relative nutritional value of fish oil and a ratio within 1:1 to 1:5 is considered healthy for human diet (Dutta and Dutta, 2013). The ω_3:ω_6 ratio of studied Bhola fish is 1.34 which suggests that this fish can be a good nutritious diet. Vacha and Gule fish also found good due to high ω_3 fatty acid content. Among four fishes Gule fish has higher nutritional value due to the unsaturated fatty acids particularly PUFAs which is higher than others & with a lower saturated acid content. Eicosatrienoic (20:3 ω_3) acid is absent in Ghero, Vacha and Gule and found in very small amount in Bhola. Fresh water fish can convert 18:2 ω_6 and 18:3 ω_6 to C20 and C22 homology through desaturation and chain elongation and cyclooxygenase & lipooxygenase enzymes are probably involved in conversion C20 PUFA to a member of Eicosanoid forms (Henderson, 1996).

From the above discussion it is clear that Bhola fish has considerable amount of SFA than UFA whereas Ghero, Vacha and Gule fish has considerable amount of UFA than SFA. ω_3 PUFA was found to be highest in Gule fish. The ω_3 PUFA which is primarily DHA and EPA was found in higher amount in Gule and in appreciable amounts in Ghero and Vacha fish. This results would be helpful for taking the fish group as food as they contain highly unsaturated low-fat diet and help to prevent diseases. Presently, the production of fish oil is becoming more demanding, as there is a sizeable and growing world market demand for high quality fish oils (Muhamad and Mohamad 2012) , present study would also be helpful in this respect. The fatty acid composition of the studied fish groups specially Gule, Vacha and Bhola indicate that these fish groups have considerable nutritional capacity.But the fish groups gradually becoming vulnerable and critical one due to indiscriminate fishing and habitat loss. A management programme for these species conservation should be undertaken

Table.1 Fatty Acid composition of four Hooghly river fishes
(Presented as mean ± standard deviation (n=5) Saturated Fatty Acid (SFA)

Fatty acid Composition (%)	Name of the Fatty acid	***Jhonius gangeticus***	***Clupiisoma garua***	***Eutropiichthys vacha***	***Pseudapocryptes lanceolatus***
$C_{12:0}$	Lauric acid	-	0.51 ± 0.10	0.14 ± 0.04	-
$C_{14:0}$	Myristic acid	1.22 ± 0.05	3.20 ± 0.07	2.75 ± 0.10	1.80 ± 0.07
$C_{15:0}$	Pentadecanoic acid	0.38 ± 0.05	0.54 ± 0.08	0.80 ± 0.06	1.11 ± 0.29
$C_{16:0}$	Palmitic acid	31.76 ± 0.13	28.30 ± 0.51	28.60 ± 0.86	25.11 ± 0.30
$C_{17:0}$	Margaric acid	1.16 ± 0.03	0.45 ± 0.07	0.51 ± 0.05	0.10 ± 0.02
$C_{18:0}$	Stearic acid	10.34 ± 0.08	6.19 ± 0.06	9.15 ± 0.22	7.92 ± 0.24
$C_{20:0}$	Arachidic acid	0.12 ± 0.05	0.04 ± 0.01	-	0.11 ± 0.04
$C_{22:0}$	Behenic acid	7.66 ± 0.10	1.87 ± 0.06	4.29 ± 0.08	5.34 ± 0.36
$C_{24:0}$	Lignoceric acid	1.65 ± 0.10	0.34 ± 0.07	0.39 ± 0.05	4.02 ± 0.33

Monounsaturated Fatty Acid (MUFA)

Fatty Acid Composition (%)	**Name of the Fatty Acid**	***Jhonius gangeticus***	***Clupisoma garua***	***Eutropiichthys vacha***	***Pseudapocryptes lanceolatus***
$C_{14:1}$	Myristoleic acid	-	0.30 ± 0.07	0.21 ± 0.06	0.13 ± 0.03
$C_{15:1}$	Pentadecanoic acid	-	0.18 ± 0.05	-	0.11 ± 0.03
$C_{16:1}$	Palmitoleic acid	10.26 ± 0.11	4.06 ± 0.17	7.37 ± 0.42	6.64 ± 0.48
$C_{17:1}$	Margaroleic acid	-	-	-	0.47 ± 0.05
$C_{18:1}(\omega_9)$	Oleic acid	16.87 ± 0.44	31.32 ± 0.10	28.04 ± 0.58	12.42 ± 0.43
$C_{20:1}(\omega_9)$	Eicoseneic acid	1.00 ± 0.34	2.11 ± 0.20	0.55 ± 0.07	1.17 ± 0.09
$C_{22:1}(\omega_{11})$	Erucic acid	0.31 ± 0.06	4.39 ± 0.05	0.34 ± 0.06	0.27 ± 0.05
$C_{24:1}$	Nervonic acid	0.62 ± 0.06	0.29 ± 0.07	0.57 ± 0.05	0.29 ± 0.08

Polyunsaturated Fatty Acid (PUFA)

Fatty acid composition (%)	**Name of the Fatty acid**	***Jhonius gangeticus***	***Clupisoma garua***	***Eutropiichthys vacha***	***Pseudapocryptes lanceolatus***
ω_6					
$C_{18:2}$	Linoleic acid	5.48 ± 0.11	8.82 ± 0.32	3.30 ± 0.30	6.34 ± 0.37
$C_{18:3}$	G Linolenic acid	-	0.13 ± 0.03	-	0.27 ± 0.06
$C_{20:4}$	Arachidonic acid	0.26 ± 0.05	0.82 ± 0.05	0.25 ± 0.07	0.28 ± 0.08
$C_{22:5}$	Docosapentanoic acid (Osbond)	0.12 ± 0.02	-	-	0.12 ± 0.03
$C_{20:2}$	Eicosadienoic acid	0.02 ± 0.01	0.13 ± 0.02	-	-
$C_{20:3}$	Dihomo Gama Linolenic Acid (DGLA)	0.51 ± 0.03	0.36 ± 0.05	0.40 ± 0.05	0.80 ± 0.10
ω_3					
$C_{18:3}$	α Linolenic acid	0.40 ± 0.07	0.82 ± 0.12	1.11 ± 0.29	1.10 ± 0.15
$C_{20:3}$	Eicosatrienoic acid	0.16 ± 0.05	-	-	-
$C_{20:4}$	Eicosatrienoic acid	-	0.03 ± 0.01	-	0.11 ± 0.04
$C_{20:5}$	Eicosapentanoic	3.39 ± 0.12	0.40 ± 0.07	4.17 ± 0.18	10.32 ± 0.34

	acid				
$C_{21:5}$	Hen Eicosapentanoic acid	0.02 ± 0.01	0.10 ± 0.003	-	0.28 ± 0.03
$C_{22:5}$	Docosapentanoic acid (Clupanodonic)	-	0.48 ± 0.05	1.23 ± 0.04	3.06 ± 0.21
$C_{22:6}$	DHA	3.18 ± 0.05	2.05 ± 0.42	4.52 ± 0.42	8.07 ± 0.19
Other types					
$C_{16:2}$		1.22 ± 0.05	0.50 ± 0.07	0.52 ± 0.04	0.47 ± 0.01

Table.2 Lipid and Fatty Acid Profile In The Studied Sample

	Jhonius gangeticus	***Clupisoma garua***	***Eutropiicthys vacha***	***Pseudapocryptes lanceolatus***
LIPID	0.71	2.42	0.53	0.78
FATTY ACID				
SFA	54.29	41.44	46.63	45.51
UFA	45.26	57.29	52.49	52.71
MUFA	29.06	42.65	37.07	21.49
PUFA	16.20	14.64	15.49	31.22
ω_5	1.22	0.50	0.52	0.47
ω_3	8.59	3.88	11.03	22.94
ω_6	6.39	10.26	3.94	7.81
ω_3 / ω_6	1.34	0.37	2.79	2.93
ω_6 / ω_3	0.74	2.64	0.35	0.34
UFA/SFA	0.83	1.38	1.12	1.15
PUFA/SFA	0.29	0.35	0.33	0.68
EPA($C_{20:5}$ ω_3)	3.59	0.40	4.17	10.32
DHA($C_{22:6}$ ω_3)	3.18	2.05	4.52	8.07
DHA/EPA	0.93	5.12	1.08	0.78

Figure.1 Lipid and fatty acid profile in the studied fish groups

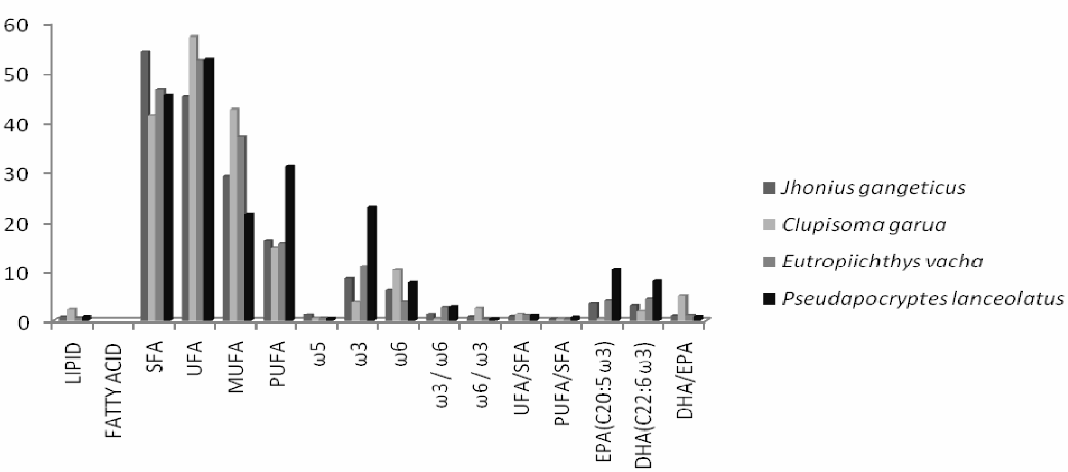


Figure.2 Percentage of Saturated Fatty acids in studied fish groups

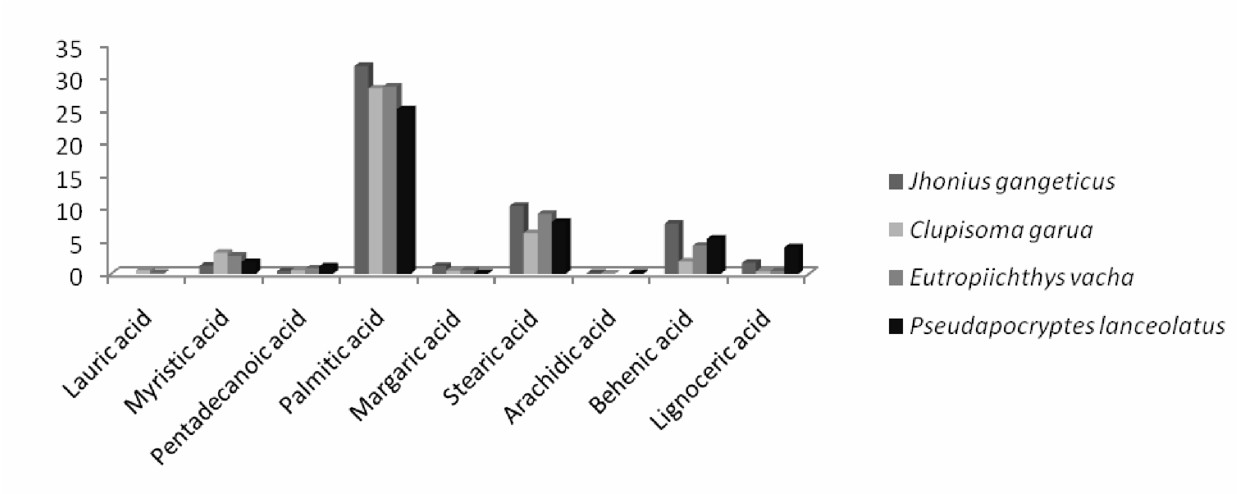


Figure.3 Percentage of mono unsaturated fatty acids in the studied fish groups

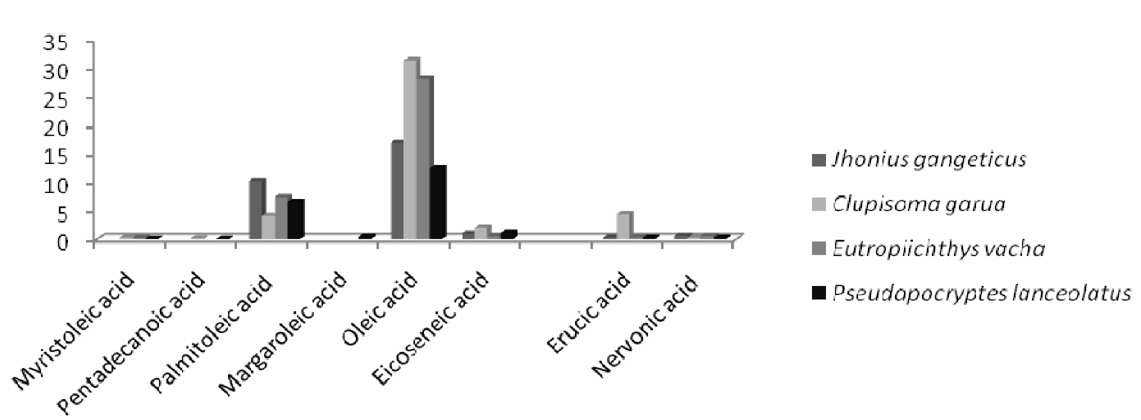


Figure.4 Percentage of ω_3 Fatty Acids in the studied fish groups

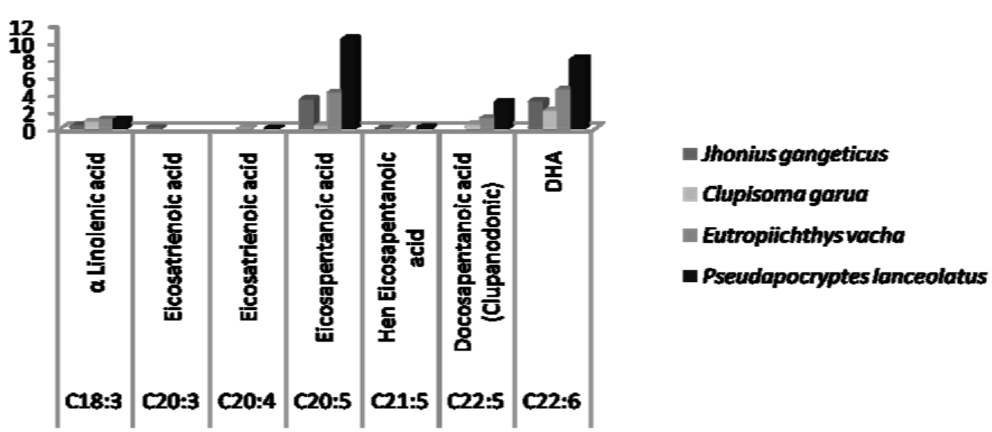
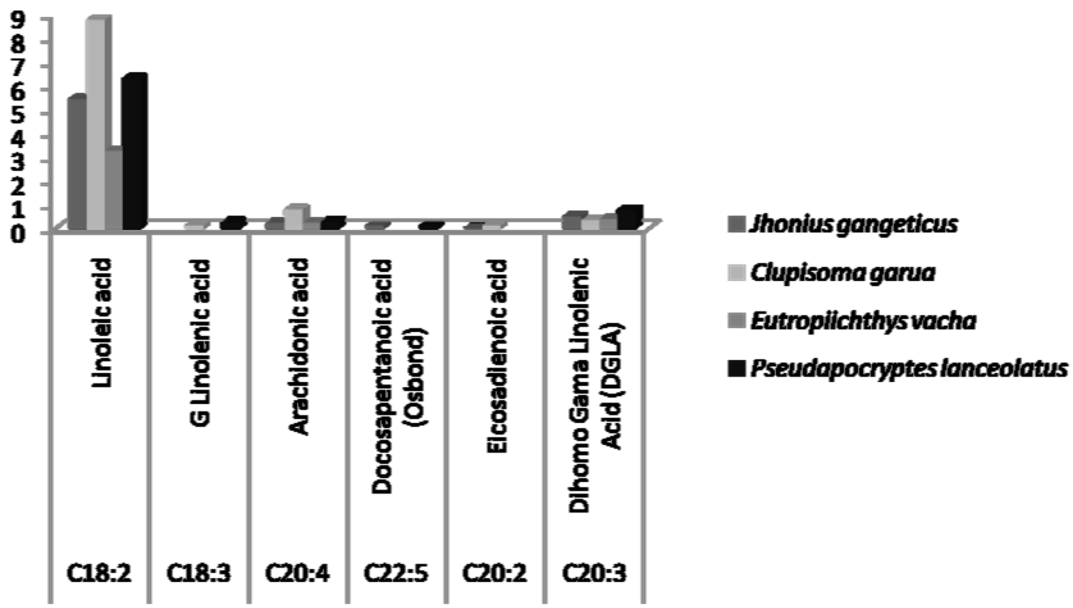


Figure.5 Percentage of ω_6 Fatty Acids in the studied fish groups



Acknowledgement

Authors are grateful to the Principal, Serampore College for giving permission to do the work. Thanks are due to Head, Dept. of Zoology, Serampore College for inspiring us to do the work.

References

Ackman, R.G.1994. Animal and Marine lipids In: Blackie Academic and Professional (Ed) Technological advances in improved and alternate sources of lipids. B.S. Karnel and Y. Yakuda edn pp. 292-328. Chapman and Hall.

Bell, J.G and Sargent, R. J. 2003. Arachidonic acid in aquaculture feeds: current status and future opportunities. Aquaculture, 218: 491 – 499.

Bligh, E.G.and Dyer, W. J. A. 1959. Rapid method of total lipid extraction and purification. Can. J. Biochem. Physio 37: 911-917.

Buda, C., I. Dey., N. Balogh., L.I. Harvath., K. Maderpach., M. Juhasz., Y.K. Yeo and Farkas, T. 1994.Structural order of membranes and composition of phospholipids in fish brain cells during thermal acclimatization. Proc. Natl. Acad. 91: 8234 - 8238.

Cahu, C., P. Salem and Lorgeril, M.D. 2004. Farmed and wild fish in the prevention of cardiovascular diseases : Assessing possible differences in lipid nutritional values. Nutr. Metab. Cardiovasc. Dis. 14: 34- 41.

Carroll, K.K and Woodward, C.J.H. 1989. Marine Biogenic Lipids, Fats and Oils (R.G. Ackman Ed) CRC Press. Inc, BOCA Raton, Florida, USA, 2: 435-479

Christie, W.W. 1982. Lipid analysis. 2nd edn. Pergamon Press. Oxford. England

Daniela, C.B. 2005. Fatty acids distribution in marine, brackish and fresh water plankton during mesocosm experiments, Dissertation (Ed). 73 pp. Kiel, Germany, University of Kiel.

Dutta, M and Dutta, P. 2013. A study of the fatty acid profile in muscle of *Monopterus chuchia*. Oriental J. of Chemistry. Vol. 29(4): 1501-1505.

Dyerberg, J., H.O. Bang., E. Stoffersen., S. Moncoda and Vane, J.R. 1978. Eicosapentaenoic acid and prevention of thrombosis and atherosclerosis. Lancet, 15: 117-119.

Domaizon, I., C. Desvilettes., D. Debroas and Bourdier, G. 2000. Influence of zooplankton and phytoplankton on the fatty acid composition of digesta and tissue lipids of silver carp: mesocosm experiment. J. Fish Biol. 57: 417-432.

Hearn, T. L and Sgoutas, D.S. 1987. Poly unsaturated Fatty Acid and fat in fish flesh for selecting species for health benefits. Journal of Food Science 52: 1209.

Henderson, R.J. 1996. Fatty acid metabolism in freshwater fish with particular reference to polyunsaturated fatty acids. Archive fur Tierenahr 49: 5-22.

Henderson, R. J. and Sargent, J.R. 1985b. Chain length specificities of mitochondrial and peroxisomal oxidation of fatty acids in liver of rainbow trout (*Salmo gairdneri*). Comp. Biochem. Physiol. 828: 79-85.

Illingworth, D. R., W.S. Harris., and Connor, W. E. 1984. Inhibition of low density lipoprotein synthesis by dietary omega - 3 fatty acid in humans. Arteriosclerosis, 4: 270-275.

Kris- Etherton , P.M., W.S. Harris., and Appel, L.J. 2003. Fish consumption, fish oil, omega – 3 fatty acid and cardiovascular disease, Arterioscler, Thromb.Vasc. Biol., 23:20-31.

Lee, T. H., R.L. Hoover., J.D. Williams., R.I. Sperling., J. Ravalese., B.W. Spur., D.R. Robinson., E.J. Corey., R.A. Lewis and Austin, K.F. 1985. Effect of dietary enrichment with eicosapentaenoic and docosahexaenoic acids on in vitro netrophil and monocyte leucotriene generation and netrophil function. New Eng J. Med., 312: 1217.

Madhusudana Rao, B., L.N. Murthy., Suseela Mathew., K.K Asha., T.V. Sankar, and Prasad, M.M. 2012. Changes in the nutritional profile of Godavari Hilsa shad, *Tenualosa ilisha* (Hamilton, 1822) during its anadromous migration from Bay of Bengal to the river Godavari. Indian J. Fish. 59(1): 125-132.

Mangold, H.K. 1969. Aliphatic lipids. In Stahl E (cd) Thin Layer Chromatography. Springer, New York, pp- 363-415

Mishra, S., A. Chowdhury., A.K. Dutta and Ghosh, A. 1984. Sterols and Fatty acids from three species of mangrove. Photochemistry, 23: 2823-2827.

Muhamad, N.A. and Mohamad, J. 2012. Fatty acids composition of selected Malaysian Fishes. Sains Maslaysiana 41 (1): 81-94.

Nath, A.K. and Banerjee, B. 2012. Comperative evolution of body composition of Hilsa, *Tenualosa ilisha* (Hamilton, 1822) in different size groups with special reference to fatty acid, in Hooghly Estuarine system, West Bengal, India, Indian J. Fish. 59 (2):141-146.

Pauletto, P., M. Puato., M.T. Angeli., A.C. Pessina., A. Munhatubo., G. Bittolo- Bon and Galli, C. 1996 a. Blood pressure, serum lipids and fatty acids in populations on a lake-fish diet or on a vegetation diet in Tenzania, Lipids 31, S-309-S-312.

Pauletto, P., P. Puato., Cavoli, M. G. 1996b. Blood pressure and athergenic lipoprotein profile of fish diet and vegetarian villagers in Tanzania: the Lugalawa study. Lancet 348, 784-788.

Ravichandran, S., Kumaravel, K., Rameshkumar, G. and Ajithkumar, T. T. 2010. Antimicrobial peptides from the marine fishes. Res. J. Immunol. 3:146-156.

Stansby. M. E. 1969. Nutritional properties of fish oil. World review of nutrition dietary 11:46.

Sargent R.J, R.D. Tocher and Bell, J. G. 2002. The Lipids. In Fish Nutrition Halver E. J and Hardy W. R (Eds.) 3rd edition pp. 181-246 London, U. K: Academic Press

Siddel B. D, E.L. Crockett and Driedzic W. R. 1995. Antarctic fish tissues preferentially catabolize. J. Exp. 2001. 271: 73-81

Staubhaug I., R.D. Tocher., J.G. Bell., R.D. James and Tortensen, E. B. 2005. Fatty acid metabolism in Atlantic salmon (*Salmo salar* L.) hepatocyte and influence of dietary vegetable oil. Biochimica et. Biophysica acta (BBA) - Molecular and Cell Biology of Lipids. 1734: 277-288.

Vlieg. P. and Body, B.D.R.. 1988. New Zealand Journal of marine and fresh water research 22: 151-162.

Wang, Y.J., L.A. Miller., M. Perren and P.B. Addis. 1990. Omega 3 fatty acid in the lake Superior fish. Journal of Food Science 55:71-76.

Yamada, T., J.P. Strong., T. Ishii., T. Ueno., M. Koyana., H. Wagayama., A. Shimizu., T. Sakai., G.T. Malcom and Guzman, M.A. 2000. Atherosclerosis 153, 469-481.

Zenebe, T., G. Ahlgren and Boberg, M.1998. Fatty acid content of some fresh water fish of commercial importance from tropical lakes in the Ethiopian Rift Valley. J. Fish Biol. 53: 987-1005.