E-ISSN: 2347-5129
P-ISSN: 2394-0506
(ICV-Poland) Impact Value: 76.37
(GIF) Impact Factor: 0.549
IJFAS 2025; 13(1): 113-118

www.fisheriesjournal.com
Received: 08-11-2024
Accepted: 13-12-2024

Md. Ashraful Hoque
Marine Natural Products Research Laboratory, Department of Applied Chemistry and Chemical Engineering (ACCE), Faculty of Science, University of Chittagong, Chattogram 4331, Bangladesh

Md. Sohel Shaikh
Applied Research Laboratory, Department of Chemistry, Faculty of Science, University of Chittagong, Chattogram 4331, Bangladesh

Sreebash Chandra Bhattacharjee
Bangladesh Council of Scientific and Industrial Research (BCSIR), Chattogram, Bangladesh

Mohammad Helal Uddin
Applied Research Laboratory, Department of Chemistry, Faculty of Science, University of Chittagong, Chattogram 4331, Bangladesh

Corresponding Author:
Md. Ashraful Hoque
Marine Natural Products Research Laboratory, Department of Applied Chemistry and Chemical Engineering (ACCE), Faculty of Science, University of Chittagong, Chattogram 4331, Bangladesh

Analytical characterization, fatty acid composition and microbial activities on muscle (edible portion) lipid of narrow-barred Spanish mackerel (*Scomberomorus commerson*) fish of the Bay of Bengal

Md. Ashraful Hoque, Md. Sohel Shaikh, Sreebash Chandra Bhattacharjee and Mohammad Helal Uddin

DOI: https://doi.org/10.22271/fish.2025.v13.i1b.3021

Abstract
The study of different properties of fish lipids carries immense significance, due to the ever-increasing beneficial aspects of fish lipids in human life. One of the most commercially available fish species namely narrow-barred Spanish mackerel fish (*Scomberomorus commerson*) was chosen for this study and the lipid profile was obtained using the solvent extraction method and found to be 21.00 mg/g. Physical and chemical parameters such as refractive index, viscosity, specific gravity, crude fat, crude fiber, ash content, saponification value, saponification equivalent value, acid value, iodine value, peroxide value, acetyl value, thiocyanogen value, Reichert-Meissl value, Polenske value, Henher value, Kirschner value, cholesterol content, etc. of the lipid were determined and compared with those of different standard fats or oils. Thin Layer Chromatography (TLC) indicated the presence of several fatty acids *viz*. palmitic acid, stearic acid, linolenic acid, and erucic acid respectively with some other unknown fatty acids. The lipid sample was evaluated for microbial activities (bacterial and fungal activity) by standard methods and was also analyzed quantitatively for the determination of percentages of protein and minerals (N, P, K, and Ca). Thus, it is associated with various important parameters regarding industrial, pharmaceutical, and nutritional aspects.

Keywords: *Scomberomorus commerson*, lipid, TLC, microbial activities, cholesterol, minerals

1. Introduction
Bangladesh is a first line littoral state of the Indian Ocean that has very good marine resources in the Bay of Bengal. Most of the people in our country are solely dependent on fish protein. It has been estimated that about 80% of the animal protein in our diet comes from fish alone [1, 2]. Narrow-barred Spanish mackerel fish is locally known as Matia or Champa. The fish species are an important part of the fishery resources of Bangladesh. It is found on a large scale in the Bay of Bengal but public are not conscious about the importance of this fish and enough data of the food value and pharmaceutical aspects are not available. Recently, the biochemical effects of fish oils in human health and nutrition have place renewed emphasis on the apparent differences in the compositions of fish oils [3, 4, 5]. Fish lipids are the main sources of Polyunsaturated Fatty Acids (PUFAs) especially those of the ω-3 family such as eicosapentaenoic acid (EPA; $C_{20:5}$) and docosahexaenoic acid (DHA; $C_{22:6}$) [6]. These two fatty acids cannot be synthesized by the human body (essential fatty acid) and must be obtained from the diet [7]. Effects of ω-3 fatty acids on coronary heart disease have been shown in hundreds of experiments in animals and in humans by inhibiting the biosynthesis of cholesterol in the liver as well as tissue culture studies and clinical trials [8, 9]. From the literature, it appears that the effectiveness of fish oil to reduce the cardiovascular problem has attracted the investigators extensively to analyze the fish oil and their nature of action as well. The present study has been undertaken with a view to recognizing the usefulness of this fish in oral administration for the protection against coronary heart diseases and cardiovascular problems in association with the expression of the importance and function of fish lipid in

reducing serum cholesterol level [10]. Nowadays researchers are giving more emphasis on physico-chemical analysis, microbial study and proximate composition of various marine fishes. However, results of such types of studies on Matia fish are much unidentified or less reported even though this fish is found sufficiently in the Bay of Bengal. The current study is about the analytical (physico-chemical) characterization of the solvent-extracted oil from the muscle of Matia fish from the Bay of Bengal and comparing the results with the data available in literature about pharmacological aspects of muscle lipid of Matia fish. Performance of the muscle lipid of Matia fish against some common microbial species is also reported [11, 12].

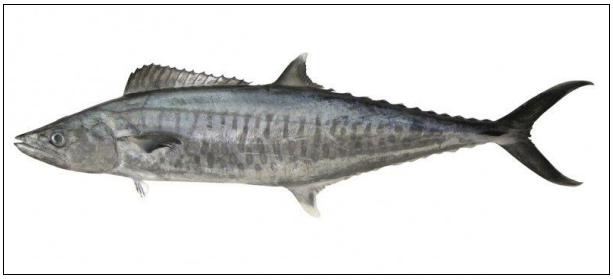

Fig 1: Narrow-barred Spanish mackerel (*Scomberomorus commerson)*

2. Materials and Methods

2.1 Marine fish species collection, preparation and identification

The export quality Matia fish (*S. commerson*) of the Bay of Bengal was collected from the local fish market, Sadarghat in port and marine city Chattogram (22°20'18.24" N 91°49'54.05" E) which is the commercial centre of southeastern Bangladesh. The weight of Matia fish was 3.10 kg. The fish was cleansed by discarding their bones, liver, stomach, and viscera. The specimen was identified at the Institute of Marine Sciences in the University of Chittagong.

2.2 Extraction and estimation of total lipid

The total lipid was extracted from the muscle of Matia fish by using acetone and ethyl acetate as solvent. Briefly, 100 g wet weight of muscle was first ground in a pestle. The resultant pulp was transferred into a conical flask (500 mL capacity) and 200 mL of acetone (1:2, w/v) was added and shaken well. For complete extraction, it was kept overnight at room temperature, mostly in the dark. After filtration, the solution was concentrated by using a rotary evaporator. The process was repeated three times. The resulting extract was partitioned with ethyl acetate to give crude lipid. The total extract was taken in a viral for complete dryness with nitrogen gas. It was also noted to keep the sample covered with aluminium foil to protect from light. This was because some lipids got polymerized or decomposed in exposure to light, heat and oxygen. Analytical-grade chemicals and reagents were used. Solutions were prepared according to the standard procedures [13, 14, 15].

2.3 Analysis of physical parameters of muscle lipid of Matia fish

To characterize the physical parameters, refractive index was detected by Abbe refractometer. Specific gravity bottle was used to measure specific gravity of the lipid. The viscosity of the lipid at different temperature was determined by Oswald's viscometer. Crude fat, crude fiber and ash content of the de-oiled muscle of the Matia fish were determined by standard methods [16].

2.4 Analysis of chemical parameters of muscle lipid of Matia fish

Chemical parameters such as saponification value and saponification equivalent value were assessed by using potassium hydroxide. Acid value and percentage of free fatty acid (as oleic acid) were analyzed to evaluate the quality of the lipid. The iodine value was determined by using Hanus method. To measure the free hydroxyl group in the lipid, acetyl value was determined. Peroxide value was determined by using potassium iodide. Besides, the thiocyanogen value, Richert-Meissl value, Polenske value, Henher value, Elaiden test, and quantity of unsaponifiable matter of the lipid were determined by established methods [17, 18, 19, 20].

2.5 Microbial activities

The microbial activity of muscle lipid of Matia fish was studied against ten bacteria and four fungi [21]. The disc diffusion method was followed for antibacterial activities. The antifungal activity was assessed by food poison technique. Nutrient agar (NA) and potato dextrose agar (PDA) were used as basal medium for the test of bacteria and fungi respectively. Chloroform was used as a solvent to prepare the desired solution (10% and 5%) of the lipid sample. Proper control was maintained with chloroform.

2.6 Quantitative Estimation of minerals

By applying the standard methods, minerals (N, P, K and Ca) of lipid containing muscle were determined [22].

2.7 Chromatographic examinations

The muscle lipid of Matia fish was subjected to the TLC analysis and its fatty acid composition was identified by comparing the R_f values of different spots of chromatograms with those of standard fatty acids reported earlier in different solvent systems [23, 24].

3. Results and Discussion

3.1 Physical characteristics

The yield of total lipid content extracted from the muscle of Matia fish was found to be 21.00 mg/g. This may claim valuable demand for edible purposes due to its higher lipid level. From this data it is also evident that the lipid content of Matia fish per gram of lipid was much more in comparison to other fish lipid sources such as *Scomberomorus guttatus* (19.00 mg/g) [27]. The refractive index of the muscle lipid of Matia fish was found to be 1.3601 at 28 °C (Table 1). The refractive power of oils or fats varies somewhat widely and chiefly governed by the proportion and degree of unsaturation present. It is also an intensive property of any substance. The present result indicates that the muscle lipid from the specimen contained moderate amount of unsaturated fatty acids. This was also supported by its iodine value. The specific gravity of the lipid solution of the muscle lipid of Matia fish was determined and found to be 0.9765 at 28 °C (Table 1). So, this sample was found in semisolid condition. From this result, we obtained an idea about the specific gravity of the original lipid. The viscosity of the solution of the lipid sample was found to be 315.34 milipoise at 28 °C (Table 1). From this result, we can confirm the intramolecular hydrogen bonding may exist in the lipid sample. It further suggests that there may exist a few hydroxyl group and few

free acid molecules may present in the lipid sample which is favored by low acetyl value and low acid value [25, 26].

Table 1: Physical constants of the muscle lipid of Matia fish and other lipid samples

Name of the sample	Refractive Index	Specific Gravity	Viscosity (mp)
Body lipid of Tripletail fish	1.4753	0.9330	298.01
Liver lipid of Spanish fish	1.4630	0.9190	361.00
Body lipid of Vetki fish	1.4745	0.9230	290.38
Muscle lipid of Indian Mackerel fish	1.4735	0.9460	313.27
Body lipid of Spanish mackerel	1.4744	0.9200	335.25
Muscle lipid of Narrow-barred Spanish mackerel	1.3601	0.9765	315.34

The moisture content of the lipid was determined and found to be 1.98% (Table 2). The moisture content in fixed oils or fats varies slightly and only small amounts are generally present. The ash, crude fat and crude fiber content of the de-oiled muscle was calculated and found to be 2.01%, 5.25% and 0.09% respectively (Table 2).

Table 2: Moisture content of muscle lipid, crude fat, ash, and crude fiber content of the de-oiled muscle of Matia fish

Fish Species	Moisture (%)	Ash (%)	Crude Fat (%)	Crude Fibre (%)
Muscle of Narrow-barred Spanish mackerel	1.98	2.01	5.25	0.09

3.2 Chemical characteristics

The saponification value (S. V.) and saponification equivalent value (S. E. V.) of the muscle lipid of Matia fish were found to be 261.59 and 214.45 respectively (Table 3). Saponification value is inversely proportional to the average molecular weight or chain length of the fatty acids present in the fat or oil. Conversely, the saponification equivalent value is directly proportional to the average chain length of fatty acid present. These results clearly indicate that the lipid sample contains higher proportion of high molecular weight fatty acids.

The acid value (A.V.) of the muscle lipid of Matia fish was found to be 2.57 (Table 3). The percentage of free fatty acid (F. F. A.), as oleic, was also calculated from acid value and was found to be 0.67% (Table 3). Acid value is a measure of proportions of free fatty acids in the oil or fat. Hence, low acid value of the extracted lipid sample is an indication of freshness and low percentage of free fatty acid is an indication of suitability of the lipid for edible purpose. The ester value was calculated and found to be 259.02 (Table 3). This value indicates that amount of ester presents in the lipid sample.

The iodine value (I. V.) of the lipid was found to be101.89 (Table 3). We know iodine value gives an estimation of the degree of unsaturated fatty acid in the triglyceride molecules of the fat or oil. So, this value indicates that the lipid contains moderate proportion of unsaturated fatty acid components and is of semidrying type. This is also approved by the results of the physical properties and confirmed by the Elaiden test.

The peroxide value (P. O. V.) serves as a gauge for the amount of unsaturation in fats and oils. So, it is an indication of unsaturation present in fats and oils. The more unsaturated fats or oils absorb more oxygen, form greater amount unstable hydro peroxide and show higher peroxide value. The peroxide value of the muscle lipid of Matia fish was found to be 22.29 (Table 3). It can be concluded from the result that the muscle lipid under investigation contained good amount of unsaturated fatty acids. Thiocyanogen value (T. V.) of the sample was found to be 56.82 (Table 3). This observation is in conformity with the findings that the lipid sample has moderate iodine value and peroxide value.

Acetyl value of the investigated sample was determined 3.54% (Table 3) which is a measure of the number of hydroxyl groups present in the lipid sample. The titre value of the muscle lipid of Matia fish was found to be 26.80 ℃ (Table 3). This value indicates that the lipid sample is of fat type which supports its semisolid condition at room temperature.

The unsaponifiable matter (U. S. M.) in the muscle lipid sample was found to be 1.19% (Table 3). Unsaponifiable matter is defined as those substances which are not saponified by alkali and which are soluble in ether or petroleum ether. In general, if a fixed oil or fat contains unsaponifiable matter in excess of about 2%, there is reason to support adulteration. The result indicates that the lipid sample may contain a small amount of unsaponifiable matter such as sterols, vitamins A and D, hydrocarbons etc.

The Reichert-Meissl value (R. M. V.) indicates the amount of volatile water-soluble acid constituents of the lipid. The Reichert-Meissl value was found to be 0.95 (Table 3) which is the indication that there are relatively little volatile water-soluble fatty acids may present.

The Polenske (P.V.) value of the muscle lipid was found to be 0.70 (Table 3). The Polenske value represents a measure of volatile water insoluble but alcohol soluble fatty acids. The Polenske value as obtained is a support of the small amount volatile water insoluble but alcohol soluble fatty acids in the lipid sample.

The Henher value (H.V.) of the muscle lipid of Matia fish was found to be 72.18% (Table 3). This result indicates the higher percentage of water-insoluble, non-volatile fatty acids present in the lipid sample.

The Kirschner value of the extracted lipid of Matia fish was determined 0.35 which allude the appearance of little amount of long-chain carboxylic acid forming soluble silver salt. During the experiment, it was obtained that the muscle lipid of the Matia fish formed cloudy solution with bromine, and a precipitate formed due to the insoluble bromine. Hence the lipid is marine oil (fish oil).

Throughout the test, it was found that after 24 hours, the muscle lipid of the Matia fish had a treacle-like consistency with mercuric nitrate $Hg(NO_3)_2$ solution. Hence, the lipid is of semi-drying type (Elaiden test). Semidrying oils absorb oxygen from air slowly and thicken after keeping exposed to air for some time but do not dry up and the iodine value varies between 95 to 140.

The amount of cholesterol in the muscle lipid of Matia fish was found to be 23.71 mg/100g. A lower amount of cholesterol is observed in the muscle lipid of Matia fish. It can be suggested that the lipid of Matia fish is more suitable for edible purpose for its cholesterol level.

The effect of storage time on the muscle lipid of Matia fish showed a significant variation in different values. Acid value, peroxide value increased with increasing time of storage and R-M value, thiocyanogen value, titre value and iodine value decreased with increasing time of storage. That means, the quality of the lipid degraded with increasing time of storage [27, 28].

Table 3: Chemical constants of muscle lipid of Matia fish and some related other fats and oils

Name of the Sample	S.V.	S.E.V.	A.V.	F.F.A. (%) (as oleic)	E.V.	I.V.	P.O.V.	T.V.	Acetyl Value (%)	Titre value (°C)	U.S.M. (%)	R.M.V.	P.V.	H.V. (%)	K.V.
Whale oil	184-200	---	0.3-51	---	---	126.90	---	---	---	---	---	---	---	---	---
Muscle lipid of Hilsa	203.25	276.01	3.10	1.56	---	92.55	55.05	52.54	10.25	---	0.74	0.96	0.76	93.27	---
Brain lipid of Baghda Chingri	229.255	244.71	1.11	0.56	28.14	95.83	194.95	43.63	10.58	27.2	0.56	1.04	0.79	95.32	---
Liver lipid of Sting ray	283.58	197.83	1.43	0.71	282.15	118.87	112.72	63.87	13.71	26.8	1.64	0.97	0.66	78.86	0.37
Muscle lipid of Cuttle fish	260.87	215.05	1.78	0.89	258.77	106.82	109.45	54.82	12.95	27.5	1.10	0.91	0.72	77.98	0.42
Liver lipid of Petambori fish	274.19	204.60	2.20	0.45	271.99	106.66	33.55	62.79	12.46	25.2	1.48	0.06	0.64	58.11	---
Muscle lipid of Matia fish	261.59	214.45	2.57	0.67	259.02	101.89	22.29	56.82	3.54	26.80	1.19	0.95	0.70	72.18	0.35

Abbreviations: S.V.= Saponification Value; S.E.V.= Saponification Equivalent Value; A.V.= Acid Value; F.F.A.= Free fatty acid; E.V.= Ester Value I.V.= Iodine Value; P.O.V.= Peroxide Value; T.V.= Thiocyanogen Value; U.S.M.= Unsaponifiable Matter; R.M.V.= Reichert-Meissl Value; P.V.= Polenske Value; H.V.= Henher Value; K.V.=Kirschner Value

3.3 Microbial activities of the lipid sample

In the present study, the muscle lipid of Matia fish was screened for bacterial activities against ten pathogenic bacteria and antifungal activities against four phyto-pathogenic fungi.

3.3.1. Bacterial activity test

The antibacterial activities of the lipid sample were studied against four gram positive and six-gram negative bacteria. Paper discs soaked in lipid solutions (10% and 5%) were used. It is evident from (Table 4) that the lipid solution was found to be active against *Vibrio cholerae*, *Staphylococcus aureus*, *Psudomonus xanthomonas*, *Shigella dys*, *B. megaterium* but not active against *Bacillus subtilies*, *B. cereus*, *E. coli*, *Salmonella typhe* and *Shigella somnie* (Table 4). Matia fish showed higher zone of inhibition (12 mm) against *Vibrio cholerae* and *Shigella dys*.

Table 4: Antibacterial activity of the muscle lipid of Matia fish

Name of bacteria	Type of sample	Zone of inhibition (diameter in mm) after 48 hours		
		Treatment	Control (Ciprofloxacin)	Differences
Vibrio cholerae (gram negative)	10% 5%	12 6	25 12.5	13 6.5
Staphylococcus Aureus (gram positive)	10% 5%	11 6	25 12.5	14 6.5
Psudomonus xanthomonas (gram negative)	10% 5%	10 5	25 12.5	15 7.5
Shigella dys (gram negative)	10% 5%	12 7	25 12.5	13 7.5
B. megaterium (gram positive)	10% 5%	10.5 6	25 12.5	14.5 6.5
Bacillus subtilies (gram positive)	10% 5%	0 0	25 12.5	25 12.5
B. cereus (gram positive)	10% 5%	0 0	25 12.5	25 12.5
E. coli (gram negative)	10% 5%	0 0	25 12.5	25 12.5
Salmonella typhe (gram negative)	10% 5%	0 0	25 12.5	25 12.5
Shigella somnie (gram negative)	10% 5%	0 0	25 12.5	25 12.5

3.3.2. Antifungal activity test

The antifungal activities of the lipid sample were studied against four phyto-pathogenic fungi. It is evident from (Table 5) that the muscle lipid of Matia fish did not show any inhibition on mycelial growth of *Alternaria alternata* but highly stimulated (Table 5). Except this, the mycelial growth of almost all test fungi was inhibited by the lipid sample. The muscle lipid of Matia fish showed higher zone of inhibition (14.8243 mm) against *Fusarium equiseti* than others.

Table 5: Percent growth inhibition of test fungi by the muscle lipid of Matia fish

Name of the Fungi	Type of Sample	Muscle Lipid of Matia Fish (% Inhibition after 5 Days)
Fusarium equiseti	10%	14.8243
Aspergillus fumigateus	10%	6.3011
Alternaria alternata	10%	-13.4535
Curvularia lunata	10%	4.3780

(-) means no inhibition

3.4 Estimation of minerals (N, P, K and Ca)

A considerable number of people in our country have been severely suffering to a great extent from protein deficiency. Matia fish is contain a good amount of nitrogen (3.160%), Besides protein (proteineous nitrogen) which is well balanced in respect of essential amino acids (Table 6). The percentage of phosphorus (1.278%) indicates that phospholipid may be present in the lipid sample. People having low blood pressure, the potassium content (1.124%) in the muscle of Matia fish may be helpful to increase blood pressure. The percentage of calcium in the muscle of Matia fish was found to be 0.454% (Table 6). It may be helpful for the children who consume this marine species in their growing ages in the formation of rigid bone structure or more solid bone structure.

Table 6: Percent of N, P, K, and Ca in muscle lipid of Matia fish

Name of the sample	N (%)	P (%)	K (%)	Ca (%)
Muscle lipid of Tripletail	8.480	1.182	1.133	0.645
Brain lipid of Baghda Chingri	3.540	0.726	1.123	0.914
Muscle lipid of Indian mackerel	5.125	1.736	1.153	0.653
Body lipid of Spanish mackerel	9.440	1.173	0.150	0.135
Muscle lipid of Giant tiger prawn	3.540	0.726	1.123	0.914
Liver lipid of Petambori fish	3.080	1.255	1.150	0.650
Muscle lipid of Matia fish	3.160	1.278	1.124	0.454

3.5 Chromatographic analysis

The muscle lipid of Matia fish was subjected to TLC examination and their fatty acid composition were identified by comparing the R_f values of different spots of chromatograms with those standard fatty acids as reported (Table 7) in different solvent systems. It was found from the chromatograms that the lipid sample produced about 3-5 spots. Among the spots, four spots were identified as palmitic acid, stearic acid, linoleic acid and erucic acid in the muscle lipid of Matia fish. The chromatograms showed other spots which could not be identified due to mismatch of data or non-availability of suitable standards.

Table 7: The Retention (R_f) of thin layer chromatographic examination of the muscle lipid of Matia fish

Solvent system	R_f value of standard fatty acids				R_f values obtained from the spots of the lipid sample			
	PA	SA	LA	EA				
P:E (80:20)	0.941	0.943	0.933	0.361	0.933	0.940	0.361	0.410
P:E:A (80:20:1)	0.822	0.839	0.893	0.479	0.823	0.898	0.481	0.316
H:E (80:20)	0.823	0.812	0.641	0.201	0.823	0.811	0.642	0.201

PA = Palmitic Acid, SA = Stearic Acid, LA = Linoleic Acid, EA = Erucic Acid.
P:E = Petroleum ether: Ether, P:E:A = Petroleum ether: Ether: Acetic acid, H:E = Hexane: Ether

4. Conclusion

The present study can be considered as an attempt to evaluate the local marine resources for total lipid and lipid types, especially for PUFAs (ω-3 and ω-6 fatty acids) which play a vital role in reducing cardiovascular problems and obesity. In this regard, lipid was extracted from the muscle of Matia fish and physico-chemical constants, microbial activities were tested. Here the results indicate the presence of moderate amounts of unsaturated fatty acids in the extracted lipid which was confirmed by R.I., I.V., and T.V. Percentage of F. F. A. validated the suitability of the fish oil for edible purpose. Semidrying nature of the muscle lipid of Matia fish was pointed by I.V. and confirmed by Elaiden test. Thin Layer Chromatographic (TLC) analysis substantiated the presence of some important PUFA's such as palmitic acid, stearic acid, linoleic acid and erucic acid which have medicinal role to reduce blood triglycerides. Due to the inhibitory activities of the extracted lipid against few bacteria and fungi, it may also be possible to produce topical medicaments such as antifungal ointments, antibacterial creams, germicides etc. from the extracted lipid. It can be concluded that due to the presence of good amounts of fat, protein and minerals makes them a good diet choice in the forms of fish products such as fish burgers, fish cake, fish crackers. As they are good sources of lipids human beings can safely consume them. Besides, the waste recovered can be consumed as animal feed. Hence, they are suitable as potential industrial material for possible utilization for different products.

5. Acknowledgement

The authors are highly indebted to Professor Dr. Hossain Jamal and Professor Dr. Abdul Kader, Institute of Marine Sciences, University of Chittagong, for identifying the marine species and for their thoughtful suggestions during this work. Thanks to the Research and Publication Cell of Chittagong University for the financial support in conducting this research work (No-148/pao/7-37(4)/2018.

6. References

1. Paul DK, Islam R, Sattar MA. Physico-chemical studies and Nutrient contents of *Channastriatus* and *channamarulius*. Turk J Fish Aqua Sci. 2013;13:487-493.
2. Begum M, Ahmed ATA, Das MS, Parveen S. A comparative microbiological assessment of five types of selected fishes collected from two different markets. J Advan Biol Res. 2010;4:259-265.
3. Ackman RG. Perspectives on Eicosapentaenoic Acid (EPA). n-3 News, Massachusetts General Hospital, Boston. 1986;1(4):1-4.
4. Lands WEM. Fish and Human Health, Academic Press, London; c1986. p. 1-186.
5. Ackman RG. Fatty Acid Composition of Fish Oils, Nutritional Evaluation of Long Chain Fatty Acids in Fish Oil, Edited by SM. Barlow and ME. Stansby, Academic Press, London; 1982. p. 25-88.
6. Osman H, Suriah AR, Law EC. Fatty Acid Composition and Cholesterol Content of selected Marine Fish in Malaysian Waters. Food Chem. 2001;73:55-60.

7. Linko YY, Hayakawa K. Docosahexanoic Acid: A Valuable Nutraceutical? Trends in Food Sci-Tech. 1996;7:59-62.
8. Leaf A, Xiao YF, Kang JX, Billman GE. Prevention of sudden cardiac death by n-3 polyunsaturated fatty acids. Pharmacology and Therapeutics, 2003;98:355-377.
9. Uauy R, Valenzuela A, Marine oils. The health benefits of n-3 fatty acids. Nutrition. 2000,16:680-684.
10. Islam MS, Molla TH, Alam MT, Habib MR. Physico-Chemical Behavior of the Fish lipid from *Lepidocephalus guntea* (Hamilton) and Variation of Lipid Profile with Size. Pak J Bio Sci. 2008;11(10):1342-1347.
11. Rajagopalan V, Abinaya G, Balasubramanian U. A Study on Biochemical and molecular characterization of a marine fish *Lutjanus campechanus* from Nagapattinam, Tamilnadu, J Sci& Inn Res. 2013;2:303-319.
12. Sankar S, Sujith P, Jayalakshmi S. Microbial study and proximate Composition of six marine fish species in mudasaladai coastal region. Int J Pharm Bio Sci. 2013;3:398-404.
13. Vogel AI. A Text Book of Practical Organic Chemistry, Addission Wesley Longman Ltd, London, 1975, 163.
14. Uddin MH, Majid MA, Mistry AC, Manchur MA. Isolation, Characterization and Study of the Microbial Activities of the Brain Lipid and Chemical Analysis of the Brain of Baghda Chingri (*Penaeus monodon*) of the Bay of Bengal. Pak J Sci Ind Res. 2004;41:121-125.
15. Ranganna S. Handbook of Analysis and Quality Control for Fruit and vegetable Products, 2nd Edn., Tata McGraw-Hill Publishing Company Ltd., New Delhi, India, 1991, 3-226.
16. Griffin RC. Technical Method of Analysis, 2nd Edn., McGraw-Hill Book Company, Inc., New York, 1972;309:319:342.
17. Morris BJ. The Chemical Analysis of Foods and Food Products, D. Van Nostrand Company. Inc., New York. 1965; 375:382.
18. Das RK. Industrial Chemistry, Part II, Kalyani Publishers, New Delhi, India; c1989. p. 250-259.
19. Williams KA. Oils, Fats and Fatty Foods, 4th Edn., J. & A. Churchill Ltd., London, 1966, 124, 275, 329, 334, 356, 391.
20. Ahmed S, Rahaman MS, Chowdhury JU, Begum J, Anwar MN. Antimicrobial Activities of Leaf Extracts and Crude Alkaloids of *Glycosmis pentaphylla*. Chittagong Univ J Sci 1998;22:77-81.
21. Randerath K. Thin-layer Chromatography. Rein-Hold Publishing Corp., Chapmann and Hall Ltd. London. 1988;47:10-137.
22. Ahmed HAU, Uddin MH, Mannan MA, Barua S, Hoque MA. Studies on the Isolation, Physico-chemical Characterization and Microbial Activities of Melon (*Cucumis melo*) Seed Oil. Int J Innov Sci Res. 2014;11(1):105-111.
23. Azim MR, Afrin A, Hossain MM, Mukut S, Uddin MH. Extraction, Physico-Chemical Analysis and Microbial Activities Evaluation of the Body lipid of Tripletail (*Lobotes surinamensis*) of the Bay of Bengal. Amer J Appl Chem. 2023;11(1):14-20.
24. Hoque MA, Uddin MH, Amin MA, Roni MAH. Isolation, physico-chemical characterization and microbial studies of liver lipid of sting ray fish (*Dasyatis sephen*) of the Bay of Bengal. Int J Fish Aqua Stu. 2015;2(3):87-92.
25. Azim MR, Hossain MM, Moushumy MA, Hoque MA, Uddin MH. Physico-chemical characterization and microbial studies of the muscle lipid of Indian mackerel (*Rastrelliger Kanagurta*) of the Bay of Bengal. Int J Fish Aqua Stu. 2018;6(6):268-272.
26. Hossain MM, Azim MR, Afrin A, Hoque MA, Uddin MH. Analytical characterization and biological evaluation of the muscle lipid of Bombay duck (*Harpadon nehereus*) of the Bay of Bengal. Int J Fish Aqua Stu. 2022;10(6):131-135.
27. Afrin A, Azim MR, Hossain MM, Bhattacharjee SC, Uddin MH. Extraction, Analytical Analysis and Biological Activities Evaluation of the Body Lipid of Spanish Mackerel (*Scomberomorus guttatus*) of the Bay of Bengal. Amer J Appl Chem. 2024;12(1):22-28.
28. Tsighea N, Wawireb M, Bereketa A, Karimib S, Wainaina I. Physicochemical and microbiological characteristics of fresh Indian mackerel, spotted sardine and yellow tail scad, from Eritrea Red Sea waters. Jour Food Comp Anal. 2018;70:98-104.