

Journal of Coastal Life Medicine

journal homepage: www.jclmm.com



Document heading

doi:10.12980/JCLM.2.2014B1282

© 2014 by the Journal of Coastal Life Medicine. All rights reserved.

Nutritional evaluation of the moonfish *Mene maculata* (Bloch & Schneider, 1801) from Parangipettai, southeast coast of India

Palanivel Bharadhirajan*, Natarajan Periyasamy, Sambantham Murugan

Centre of Advanced Study in Marine Biology, Faculty of Marine Sciences, Annamalai University, Parangipettai–608 502, Tamil Nadu, India

PEER REVIEW

Peer reviewer

Dr. Huynh Minh Sang, Institute of Oceanography, Vietnam.
Tel: +947746464
Fax: +84583590034
E-mail: hmsang2000@yahoo.com

Comments

In this study, the authors have demonstrated that moonfish *M. maculata* is a valuable food source for human consumption. The evaluation was based on common criteria such as protein, carbohydrate, lipid, amino acids, fatty acids, vitamins and minerals.

Details on Page 57

ABSTRACT

Objective: To assess the nutritions in *Mene maculata* (Bloch & Schneider, 1801) (*M. maculata*).
Methods: Fishes (14–16 cm) were obtained from the landings at Parangipettai for the evaluation of biochemical composition. The present study deals with biochemical composition such as protein, carbohydrate, lipid, amino acids fatty acids, vitamins and minerals which were evaluated in the moonfish.
Results: The results of proximate composition in *M. maculata* showed that the percentage of protein was high in the tissue (23.16%), followed by the carbohydrate (1.3%) and lipid (2.62%). Totally 20 essential and nonessential amino acids were present at the rate of 46.72% and 43.91%. In the analysis, the fatty acid profile by gas chromatography revealed the presence of higher amount of saturated fatty acid (palmitic acid 22.17%) than monounsaturated fatty acid (oleic acid 14.51%) and polyunsaturated fatty acid (alpha linolenic acid 16.07%). Vitamins were detected in *M. maculata*. Among them, vitamin A was found in higher levels (124.5 mg/g), whereas vitamin B6 was noticed as lower levels (0.34 mg/g). In the present study, totally 5 macro minerals and 2 trace minerals were reported. The macro mineral calcium (156.7 mg/g) was found at the highest level and other minerals such as sodium (31.98 mg/g), potassium (21.33 mg/g), copper (1.43 mg/g) and magnesium (0.341 mg/g) were also detected in the moonfish.
Conclusions: The result showed that the moonfish *M. maculata* tissue is a valuable food recipe for human consumption, due to its high quality protein and well-balanced amino acids.

KEYWORDS

Moonfish, *Mene maculata*, Biochemical composition, Amino acid, Fatty acids, Vitamins and minerals

1. Introduction

Marine natural products have long been used as foods, fragrances, pigments, insecticides, medicines *etc.*, Knowledge on biochemical composition of any edible organisms is extremely important since the nutritive value is reflected in its biochemical contents[1]. A new species should be recommended for human consumption only after assessing the nutritive value of the species with regards to its nutritional qualities[2]. The demand for protein rich

food is increasing, especially in developing countries, stimulating the exploration of unexploited or non-traditional resources.

Marine fish also provide high quality protein with all the dietary essential amino acids for maintenance and growth of the human body. Carbohydrates are major sources of energy in all human diets. The ratio of carbohydrate was less when compare to the other nutrients such as proteins and lipids in animal tissues, especially in aquatic animals[3]. Lipids are the major sources of metabolic energy

*Corresponding author: Palanivel Bharadhirajan, Centre of Advanced Study in Marine Biology, Faculty of Marine Science, Annamalai University, Parangipettai–608 502, Tamil Nadu, India.

Tel: 04144–243070–243071

Fax: 04144–243555

E-mail: bhardhicas@gmail.com

Foundation Project: Supported by MoES project, New Delhi, India (Ref. No. 36/OOIS/SIBER/07).

Article history:

Received 2 Jan 2014

Received in revised form 6 Jan, 2nd revised form 17 Jan, 3rd revised form 22 Jan 2014

Accepted 24 Jan 2014

Available online 28 Jan 2014

and essential materials for the formation of cell and tissue membranes[4]. The amino acids content varies not only from species to species but also from specimen to specimen and between different tissues. This variation depends upon the environmental conditions and the size of the individual species.

Aquatic animal fats are good sources of essential fatty acids that are not synthesized in the human body. Fatty acids in fish oil have a very distinctive character compared to fatty acids from other sources. They consist not only essential fatty acids, but also a significant source of omega-3 fatty acids—especially eicosapentaenoic acid (EPA, C20:5n3) and docosahexanoic acid (DHA, C22:6n3). These fatty acids play a vital role in human nutrition, disease prevention and health promotion. There are reports that EPA can prevent heart disease, since it decreases triglycerides and very low-density lipoprotein cholesterol[5]; whereas DHA is a primary component of membranes in the brain and possibly delays the onset of Alzheimer's disease[6].

There remains no considerable study on moonfish with regard to their nutritive value. Though moonfish are being consumed in islands and other country, in India there is no evidence to support the *Mene maculata* (*M. maculata*) as edible. Hence, the present work was planned to study the proximate composition of *M. maculata* through estimating their major biochemical components such as total protein, carbohydrate and lipid content in the whole body tissue apart from the amino acids, fatty acids profile, vitamins and minerals content.

2. Materials and methods

The moonfish, *M. maculata* were collected from the the landing centre of Parangipettai (Latitude 11°49' N Longitude 79°76' E) Southeast coast of India. *M. maculata* is purely marine fish, they were brought to the laboratory; the fish tissue was collected and dried at 55 °C in an oven and used for biochemical analysis. The proximate compositions of the experimental sample were determined by using standard methods, viz., protein, carbohydrate and lipid[7–9]. The experimental fish samples were dried at 55 °C for 24 h in an oven and the dried samples were finely ground for estimating the amino acids in the high performance liquid chromatography (Merck Hitachi L-7400) following the method[10]. For fatty acid analysis, the samples (body tissue) were homogenized with chloroform: methanol (2:1 v/v) mixture and the samples were extracted using the method[11]. After the fat was extracted, it was esterified

with 1% H₂SO₄ and fatty acid methyl esters were prepared by following the procedure of AOAC[12]. Identification and quantification of fatty acids were done using gas chromatography (Hewlett Packard 5890, USA). The minerals were estimated soft tissue *M. maculata* by following the method in previous study[13]. The vitamins were estimated the fat soluble vitamins A, D, E and K and the water soluble vitamins B1, B2, B6, B12 and C were analysed in the high performance liquid chromatography (Merck Hitachi L-74000, USA) following the method[14]. The folic acid was estimated by following the calorimetric procedure[15]. The pyridoxine, panthothenic acid and vitamin B12 were estimated by following methods suggested in USP NF 2000 Asian edition.

3. Results

The proximate composition (%) such as protein (23.16%) carbohydrate (1.30%) and lipid (2.62%) contents of *M. maculata* are presented. The percentage compositions of essential and non-essential amino acids are presented in Table 1. The total amino acids were 90.63%, among which essential amino acids were found to be as 46.72% and non-essential amino acids were 43.91%. Among the essential amino acids methionine were found high as 8.11% on dry matter basis and the other essential amino acids were found fluctuating in the following order: lysine>arginine>histidine>phenylalanine>leucine>valine>isoleucine>threonine>tryptophan in moon fish muscle (Table 1). Among the non-essential amino acids glycine were found maximum as 7.14% on dry matter basis and the other non-essential amino acids (Table 1).

Table 1

The percentage (%) of essential and non essential amino acid found in *M. maculata*.

EAA	% of amino acids	NEAA	% of amino acids
Phenylalanine	5.50	Glycine	7.14
Lysine	6.16	Serine	5.71
Histidine	5.65	Glutamic acid	6.13
Methionine	8.11	Cystine	6.14
Arginine	6.13	Glutamate	4.72
Leucine	4.61	Alanine	4.67
Threonine	2.52	Proline	3.21
Isoleucine	3.51	Aspartate	4.50
Valine	4.11	Tyrosin	1.56
Tryptophan	0.42	Aspartic acid	0.13

EAA: essential amino acids, NEAA: Non-essential amino acids.

In the present study, 7 different fatty acids were found. They are three saturated fatty acids (SFA), one monounsaturated fatty acids (MUFA) and three polyunsaturated fatty acids (PUFA) in *M. maculata*. Among

the SFAs C16:0 were the major acids. In MUFA C18:1 and in PUFA C18:0 were the major fatty acids. The percentage availability of SFA content was 43.17% in the moonfish. The percentage of MUFA and PUFA contents are given in Table 2.

Table 2

The percentage (%) composition of fatty acid profile of *M. maculata*.

Fatty acids	Carbon atom (n)	% of fatty acids	
SFA	Palmitic acid	C16:0	22.17
	Margaric acid	C17:0	9.97
	Stearic acid	C18:0	11.71
MUFA	Oleic acid	C18:1	14.51
PUFA	Linolenic acid	C18:3	13.27
	Alpha linolenic acid	C18:3	16.07
	Stearidonic or moroctic acid	C18:4	1.57

The details of the vitamins detected in the moonfish are presented in Table 3. Among them, vitamin A and D were found in higher levels, whereas vitamin E and B6 were noticed as lower levels (0.45 and 0.34 mg/g).

Table 3

Vitamin content in *M. maculata*.

Vitamins	Vitamin content (mg/g)
Retinol (A)	124.50
Calciferol (D)	13.40
Tocopherol (E)	0.45
Vitamin (K)	1.13
Pyridoxin (B6)	0.34
Cobalamin (B12)	1.09
Vitamin (C)	12.45
Total	153.36

Totally 5 macro minerals and 2 trace minerals were detected in *M. maculate* tissues (Table 4). Among the macro minerals, calcium (156.7 mg/g) and magnesium (0.34 mg/g) were observed at higher and lower levels, whereas other macro-minerals sodium, potassium and copper were in negligible level. The trace minerals such as iron (0.24 mg/g) and zinc (0.14 mg/g) were also detected.

Table 4

Minerals content (mg/g) in *M. maculata*.

Minerals	Minerals content (mg/g)	
Macro	Calcium	156.70
	Sodium	31.98
	Potassium	21.33
	Copper	1.43
	Magnesium	0.34
Trace	Iron	0.24
	Zinc	0.14

4. Discussion

Biochemical components such as protein, carbohydrates and lipids are essential for body growth and maintenance. Protein is essential for the sustenance of life and exists

in largest quantity of all nutrients as a component of the human body[16]. The present investigation revealed that the maximum level of protein content in *M. maculata* is 23.16%. Similarly, Nawzet Bouriga *et al.*[17] reported that protein (19.41±1.44)%, (19.11±1.63)% and (17.86±1.14)% is the major biochemical component in *Atherina boyeri* (*A. boyeri*), *Atherina lagunae* (*A. lagunae*) and *Atherina* sp. The estimated maximum level of protein in *Gadus macrocephalus* is 17.9%[18]. The high protein contents and the moderate lipids levels in this small inshore fish are similar to that found in other species such as horse mackerel and sardine[19]. The principle constituents are protein (15%–24%) at maximum value in fishes[20]. Gopakumar K *et al.*[21] studied the lantern fish *Benthoosema pterotum* and found that protein composition is 16.1%. On a global scale, fish and fish products are the most important source of protein in human diet. This protein is relatively of high digestibility compared to other protein sources. It comprises of all the ten essential amino acids in desirable quantity for human consumption. All these properties bring the fish flesh to be in the same class as chicken protein and are superior to milk, beef protein and egg albumen[22].

In the present study the percentage of carbohydrates in the body tissue of *M. maculata* is 1.30%. Ghulam Nabi Hajam *et al.*[23] reported that the carbohydrates constituents from the ovary of *Schizothorax niger* at maturation II stage is high value (0.93±0.60)%. In *M. maculata*, generally the carbohydrate content was found to be low as it is high when compared to other fish. Lipids are highly efficient as sources of energy and they contain more than twice the energy of carbohydrates and proteins[16]. In the present study lipid content of *M. maculata* were 2.62%. Ghulam Nabi Hajam *et al.*[23] reported that the lipids constituents from the ovary of *Schizothorax niger* at maturation III and IV stage is high value (11.83±1.00)% and (16.33±1.04)%. Lipids comprise only 20% dry weight of their ovaries[24], and protein in the principle energy, source for gonadal development[18]. In a study of Gopakumar K *et al.*[21], lipid composition in the lantern fish *Benthoosema pterotum* was found to be 3.40%[21].

In general, the finfish have a balanced distribution of all essential amino acids required for an adult per day. In the present study the essential amino acids in *M. maculata*, methionine (8.11%) was maximum and the minimum tryptophan (0.42%); and nonessential amino acids, glycine (7.14%) was maximum and minimum as aspartic acid (0.13%), both essential and nonessential amino acids comprise totally 90.63%. Nonessential amino acids as glycine were 79.34, 63.06 and 82.4 in *A. boyeri*, *A. lagunae* and *Atherina* sp.[17], and essential amino acids, methionine was 0.73, 0.60 and

0.71 in *A. boyeri*, *A. lagunae* and *Atherina* sp. Feng Zhao, et al.^[25] analysed amino acid and fatty acid nutritional quality of muscles of *Pampus* sp. and they reported that pomfret protein contained a high amount of glutamic acid. Oluwaniyi OO et al.^[26] reported the higher amount of glutamic acid in all four species (*Clupea harengus*, *Scomber scombrus*, *Trachurus trachurus* and *Urophycis tenuis*) in their study. Veeramani T reported the higher amount of essential amino acids and non-essential amino acids in *Myrophis platyphynchus* in which the amino acids range from 47.28% to 52.72%^[27]. The present study showed that total of 10 essential amino acids exhibited high levels of methionine followed by lysine and arginine, based on the quantum of availability of essential amino acids in the tissue of *M. maculata*. The result revealed in this study showed that moonfish, *M. maculata* muscle is a potential source for food value due to high quality protein, as well as balanced essential amino acids.

In the present study, 7 different fatty acids were identified, three SFA, one MUFA and three PUFA. Among the SFAs C16:0 were the major acids. In PUFA C18:3 were major acids. The percentage availability of SFA, MUFA and PUFA contents was 43.85%, 14.51% and 30.91% respectively in *M. maculata*. Ravichandran S, et al.^[28] reported that the palmitic acid showed its higher level in both species (5.78% and 3.89%) in *Dussumieria acuta* and *Sardinella brachysoma*, respectively. Fresh water fish oils contain small amount of C22, but large amount of palmitic acids and C18 unsaturated acids^[29]. In the present study, *M. maculata* showed the dominance of saturated fatty acids, palmitic acid (16:0) which were found to be 22.17%. The moon fish could be a better alternative source (against tubercle bacilli and bactericidal effect), since it contains palmitic acids.

The suggested fats are all monounsaturated or polyunsaturated fats because of their benefits to health. In the present observations *M. maculata* showed 18:1 acid levels of 14.51%. Bouriga N et al.^[17] contributed that the total monounsaturated fatty acids (especially C16:1 and C18:1) were more abundant in *A. lagunae*, *A. boyeri* and *Atherina* sp. (36.2%, 25.37% and 32.65% respectively).

Polyunsaturated fatty acids are energy source and also function in the body as components of membranes, modulators of gene expression and precursors for eicosanoids (self-healing agent). The percentages of PUFA were higher than the percentages of SFA and double the percentages of MUFA^[30]. Kumaran R et al.^[31] studied the nutritional value of *Stolephorus waitei*, *Chirocentrus nudus* and *Pomadasys kaakan* and their suitability for consumption. In which the SFA, MUFA and PUFA fatty acids range from 35.87% to

0.39%, 28.74% to 0.41% and 18.81% to 0.42%, respectively. The dominant PUFA was docosahexaenoic (22:6n-3), followed by eicosapentaenoic acid (20:5n-3), arachidonic acid (20:4n-6), linoleic acid (18:2n-6) and alpha-linolenic acid (18:3n-3). These results are in agreement with studies of fatty acids composition of fishes^[32]. The PUFA content in the case of marine fish ranges from 28% to 57% with C20:5 and C22:6 predominating and constituting about 50% in most cases^[33]. In the present study, *M. maculata* showed the dominance of alpha linolenic acid (α C18:3) and linolenic acid (C18:3) of polyunsaturated fatty acids which constituted 16.07% and 13.27%.

In the present study, moon fish showed the dominance of vitamin A and vitamin D which constituted 124.5 and 13.4 mg/100 g. Nair PGV et al.^[34] reported that fish contained approximately as much riboflavin as beef. i.e. 0.2–0.3 mg/100 g, vitamin C to the extent of 1–5 mg/100 g and whole vitamin D ranged from 500–3000 IU/100 g. These findings are supported by the present study with respect to vitamin B level. Fish liver oils are the richest sources of vitamin A and D, and the flesh is rich in vitamin B complex, especially niacin and B6^[35]. Vitamin A (retinol) is not synthesized by the fish, but reflects the vitamin A content of its food^[36]. The vitamin A content of fish flesh ranged from 0 to 18000 IU/100 g^[37]. Mori T et al.^[38] established that the vitamin E content was highest in liver oil, followed by the oil in the pyloric appendages. Certain geographical and climatic factors influence the content B vitamin cod fish (*Gadus morhua*) from northern areas. In the present study vitamin B12 and B6 were reported as 1.09 mg and 0.34 mg on dry weight basis, respectively.

Minerals also constitute important components of hormones, enzymes and enzyme activators in human nutrition^[39]. Mineral deficiencies can cause biochemical, structural and functional pathologies which depend on several factors, including the duration and degree of mineral deprivation. Totally 5 macro minerals and 2 trace minerals were detected. The macro mineral, calcium (156.7 mg/g) at highest and other minerals such as sodium (31.98 mg/g), potassium (21.33 mg/g), copper (1.43 mg/g), magnesium (0.34 mg/g) were also detected in *M. maculata*. Rajagopalan N et al.^[41] explained the importance of Ca, Mg, and K in the human nutrition. Devadas R et al.^[31] reported that sea foods in general are excellent sources of I, Ca, P, Na, Fe, Zn and oysters are good sources of Fe and Cu. When compared to the other fish, the calcium content of raw rainbow trout was found to be 63.2 mg/100 g^[42]. Dean LM noticed the sodium content of finfish ranging from 30 to 150 mg with an average of 60 mg/100 g of muscle^[37]. The potassium content of raw

rainbow trout was found to be 306 mg/100 g^[42]. In the present study, the calcium and sodium were more in moon fish.

In general, from the above observation it is clear that the tissue of the moon fish with rich nutritive value can be used for alternate source as a regular sea food which supplies nutrients for the growing children, pregnant women and people suffering from malnutrition.

Conflict of interest statement

We declare that we have no conflict of interest.

Acknowledgements

Authors are thankful to MoES project (Ref. No. 36/OOIS/SIBER/07), and former Dean and Director Prof. T Balasubramanian, CAS in Marine Biology, Faculty of Marine Sciences, Annamalai University for providing facilities and constant encouragement during the study period.

Comments

Background

The demand for protein rich food is increasing, especially in developing countries, stimulating the exploration of unexploited or non-traditional resources including moonfish. Thus information about nutrition value of the fish is needed.

Research frontiers

The current study evaluated the nutrition value of the moonfish *M. maculata* from Parangipettai, Southeast coast of India focusing on the biochemical composition including protein, carbohydrate, lipid, amino acids, fatty acids, vitamins and minerals.

Related reports

There are some reports on the nutrition value of moonfish, but not in India.

Innovations and breakthroughs

Fish protein source comprises the important parts supporting for human consumption. In this paper, the author demonstrated that the moonfish is a valuable food recipe for human consumption, due to its high quality protein and well-balanced amino acids.

Applications

The paper demonstrates that, moonfish can be used as valuable food for human. The research is also a valuable reference for other study related to nutrition value of other fishes.

Peer review

In this study, the authors have demonstrated that moonfish *M. maculata* is a valuable food source for human consumption. The evaluation was based on common criteria such as protein, carbohydrate, lipid, amino acids, fatty acids, vitamins and minerals.

References

- [1] Nagabhushanam R, Mane VH. Seasonal variation in the biochemical composition of *Perna viridis* at Ratnagiri on the West Coast of India. *Hydrobiologia* 1978; **57**(3): 69–72.
- [2] Ajayabhaskar D. Nutritional evaluation of molluscan sea food. [D]. India: Annamalai University; 2002, p. 129.
- [3] Babu A, Kesavan K, Annaduri D, Rajagopal S. *Bursa spinosa*—A mesogastropod fit for human consumption. *Adv J Food Sci Tech* 2010; **2**(1): 79–83.
- [4] Sargent JR. Origins and function of egg lipids nutritional implications. In: Bromage NR, Roberts RJ. *Brood stock management and egg and larval activity*. USA: Wiley–Blackwell; 1995, p. 353–372.
- [5] Frenoux JM, Prost ED, Prost JL. A polyunsaturated fatty acid diet lowers blood pressure and improves antioxidant status in spontaneously hypertensive rats. *J Nutr* 2001; **131**: 39–45.
- [6] Cunnane SC, Plourde M, Pifferi F, Begin M, Feart C, Barberger–Gateau P. Fish, docosahexanoic acid and Alzheimer’s disease. *Prog Lipid Res* 2009; **48**: 239–256.
- [7] Lowry OH, Rosebrough NJ, Farr AL, Randall RJ. Protein measurement with the tolin phenol reagent. *J Biol Chem* 1951; **193**: 265–275.
- [8] Dubois M, Giller KA, Hamilton JK, Roberts RA, Smith F. Colorimetric method for determination of sugars and related substances. *Anal Chem* 1956; **28**: 350–356.
- [9] Folch J, Lees M, Sloane–Stanley GH. A simple method for the isolation and purification of total lipids from animal tissues. *J Biol Chem* 1956; **226**: 497–509.
- [10] Baker DH, Han Y. Ideal amino acid profile for chicks during first three weeks post hatching. *Poult Sci* 1994; **73**: 1441–1447.
- [11] Bligh EG, Dyer WJ. A rapid method of total lipid extraction and purification. *Can J Biochem Physiol* 1959; **37**: 911–917.
- [12] Association of Official Agricultural Chemists. *Official methods of*

- analysis of the association of official agricultural chemists. 16th ed. Washington DC, USA: AOAC; 1995.
- [13] Guzman HM, Jimenez CE. Concentration of coral reefs by heavy metals along the Caribbean coast of central Africa (costarica and panama). *Mar Poll Bull* 1992; **24**(11): 554–561.
- [14] Sadasivam S, Manickam A. *Biochemical methods*. 2nd ed. New Delhi, India: New Age International (P) Ltd.; 1996, p. 179–186.
- [15] Sethil PD. *Quantitative analysis of drugs in pharmacological formulations*. 3rd ed. New Delhi, India: CBS Publishers & Distributors; 1997, p. 589–590.
- [16] Okuzumi M, Fujii T. *Nutritional and functional properties of squid and cuttle fish*. Tokyo: National Cooperative Association of Squid Processors; 2000; p. 223.
- [17] Bouriga N, Selmi S, Faure E, Trabelsi M. Biochemical composition of three *Tunisian silverside* (fish) populations caught in open sea, lagoon and island coasts. *Afr J Biotechnol* 2010; **9**(26): 4114–4119.
- [18] Stansby ME. Proximate composition of fish. In: Heen E, Kreuzer R, editors. *Fish in nutrition*. London: News (Books) Ltd; 1962, p. 55–60.
- [19] Zaboukas N, Miliou H, Megalofonou P, Moraitou–Apostolopoulou M. Biochemical composition of the *Atlantic bonito* *Sarda sarda* from the Aegean Sea (Eastern Mediterranean Sea) in different stages of sexual maturity. *J Fish Biol* 2006; **69**: 347–362.
- [20] Jacquot R. Organic constituents of fish and other aquatic animal foods. In: Bergstrom G, editor. *Fish as food. Vol. 1*. New York: Academic Press; 1961, p. 145–209.
- [21] Gopakumar K, Nair KGR, Nair PGV, Nair AL, Radhakrishnan AG, Nair PR. Studies on the lantern fish (*Benthosema pterotum*). I. Biochemical and microbiological investigations. *Fish Technol* 1983; **20**(1): 17–19.
- [22] Srivastava CBL. *A text book of fishery science and Indian fisheries*. Odisha, India: Kitab Mahal; 1999, p. 527.
- [23] Hajam GN, Mir IH, Channa A, Nengroo AA, Saxena AK. Biochemical changes associated with the ovary maturation of a freshwater teleost, *Schizothorax niger* Heckel (Teleost, Cypriniformes, Cyprinidae). *Indian J Fundam Appl Life Sci* 2012; **2**(1): 18–21.
- [24] Tocher DR, Sargent JR. Analyses of lipids and fatty acids in ripe roes of some northwest European marine fish. *Lipids* 1984; **19**(7): 492–499.
- [25] Ravichandran S, Joseph FRS, Kanagalakshmi R, Ramya MS. Variation in nutritive composition of two commercially important marine fin fishes. *Int J Zool Res* 2012; **8**: 43–51.
- [26] Kinsella JE, Shimp JL, Maiand J, Weihrauch J. Fatty acid content and composition of freshwater finfish. *J Am Oil Chem Soc* 1977; **54**: 424–430.
- [27] Sanchez–Muniz FJ, Viejo JM, Medina R. Deep–frying of sardines in different culinary fats. Changes in the fatty acid composition of sardines and frying fats. *J Agric Food Chem* 1992; **40**: 2252–2256.
- [28] Viswanathan–Nair PG, Gopakumara K. Fatty acid compositions of 15 species of fish from tropical waters. *J Food Sci* 1978; **43**: 1162–1164.
- [29] Nair PGV, Mathew S. *CIFT technology advisory series. Biochemical composition of fish and shell fish*. India: Central Institute of Fisheries Technology; 2000, p. 14.
- [30] Devadas R. Foods of aquatic origin in human nutrition and their importance in the Indian context. In: Devadasan K, editor. *Nutrients and bioactive substances in aquatic organisms: International symposium, nutrients and bioactive substances in aquatic organisms*. Kochi, India: Society of Fisheries Technologists; 1994. 177–194.
- [31] Pigott GM, Tucker BW. *Seafood: effects of technology on nutrition*. 1st ed. Florida, USA: CRC Press; 1990, p. 45–46.
- [32] Dean LM. Nutrition and preparation. In: Martin RE, Flick GJ, editors. *The seafood industry*. New York, USA: Van Nostrand Reinhold; 1990, p. 255–267.
- [33] Mori T, Naito K, Mejiika K. Vitamin E in fish products. II. Vitamin E contents in fish and shellfish. *Vitamin* 1957; **13**: 537.
- [34] Lall SP. Macro and trace elements in fish and shell fish. In: Ruiter A, editor. *Fish and fishery products, composition, nutritive properties and stability*. Wallingford, USA: CAB International; 1995, p. 187–214.
- [35] Rajagopalan N, Rasheed AMA, Datta DK. Strategic decision processes: critical review and future directions. *J Manag* 1993; 349–384.
- [36] Gokoglu N, Pinar Y, Emal C. Effects of cooking methods on the proximate composition and mineral contents of rainbow trout *Oncorhynchus mykiss*. *Food Chem* 2004; **84**: 19–22.
- [37] Zhao F, Zhuang P, Song C, Shi ZH, Zhang LZ. Amino acid and fatty acid compositions and nutritional quality of muscle in the pomfret *Pampus purnatissimus*. *Food Chem* 2010; **118**: 224–227.
- [38] Oluwaniyi OO, Dosumu OO, Awolola GV. Effect of local processing methods (boiling, frying and roasting) on the amino acid composition of food marine fishes commonly consumed in Nigeria. *Food Chem* 2010; **123**: 1000–1006.
- [40] Veeramani T. Studies on the biology, biochemical and trace metal analysis of the worm eel, *Myrophis platyphynchus* (Breder, 1927) from Parangipettai coastal waters, southeast coast of India[D]. Tamil Nadu, India: Annamalai University; 2012.
- [41] Kumaran R. Studies on nutritional aspects of trash/ low coast fishes of Thoothukudi, southeast coast of India[D]. Tamil Nadu, India: Annamalai University; 2013, p. 62.
- [42] Memone NN, Talpur FN, Bhanger MI, Baalouch A. Changes in fatty acid composition in muscle of three farmed carp fish species (*Labeo rohita*, *Cirrhinus mrigala*, *Catla catla*) raised under the same conditions. *Food Chem* 2011; **126**: 405–410.