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Proximate and Major Mineral Composition of 23 Medium Sized Marine Fin Fishes Landed in the Thoothukudi Coast of India

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Abstract

Twenty three marine fin fishes landed in Thoothukudi Coast of India were examined for their proximate and major mineral composition to determine their nutrition value. The average moisture content ranged from 67.23 to 80.48%. Majority of fishes (69%) had the average protein contents between 15 to 20%. Coral reef fishes of the genera, *Lutjanus, Nemipterus* and *Scolopsis* had high protein content (>21%).The fat content varied widely from 0.24 to 14.72%, with *Leiognathus dussumieri* being the most fatty fish (14.72 %). The average ash contents of most of 87% of fishes were < 2% and two species, *Nemipterus japonicus* and *Epinephelus areolatus* had high values of 3.92% and 3.79%, respectively. Most of fishes are rich source of phosphorus. A Species of *Lutjanus* and *Epinephelus* had high iron and calcium contents. The total energy value seemed too high for *Leiognathus dussumieri* (174 kcal) and *Dussumieri acuta* (150 kcal), mainly due to their fat contents.

Keywords: Proximate; Calcium; Iron; Phosphorus; Finfish

Introduction

Fish is consumed by a large percentage of population in the world due to its high quality protein. It contains the most important nutritional components and serves as a source of energy for human beings [1,2]. Majority of the nutrition lists recommend that human beings should consume fish every day [3,4]. Regular consumption of fish can reduce the risk of cancer, including colon, breast and prostate [5,6], lower the risk of Dementia, and Alzheimer's diseases [7]; and prevent the cardiovascular diseases [8].

Knowledge of the proximate composition of fishes is essential to estimate their energy value and to plan the most appropriate industrial and commercial processing [9]. Generally, composition of live-weight, whole fish is 70 to 80% water, 20 to 30% protein, and 2 to 12% lipid [10]. However, in different environmental conditions, the composition of the fish may differ in relation to the differences in water quality, feeding conditions, sex, and state of maturity [11-13] and capture condition [14].

The lack of sufficient protein is one of the most widespread nutritional deficiencies in many tropical countries [15]. All of the essential amino acids needed for good protein nutrition are present in fish meat. The protein content of fish is also important when considering quality and texture of the fish meat [16]. Fish having energy depots in the forms of lipids that indicates the quality of fish. The fish oil contain high amount of polyunsaturated fatty acid that reduce the serum cholesterol to prevent a number of coronary heart diseases. Fish meat is also a rich source of minerals and the most abundant micro-elements are Zinc (Zn), Iron (Fe) and Copper (Cu) [17]. These minerals are generally higher in marine fish than in fresh water fish [18].

In India, most of the studies on the proximate composition of fishes have been carried out in relation to their reproductive cycle of fishes rather than their energy value. However, there are few studies on the nutritive and calorific value of Indian fishes. Reports are available on the proximate composition of fishes landed in the West Coast [19] and on few fish species landed in the East Coast of India [20-23]. In the East Coast, fishes of Kanyakumari, Parangipettai and Orissa Coasts are mainly examined for their proximate composition. Tuticorin being a major fishing area with an annual landing of 48,510 tonnes in 2008-2009 contributing to about 12.2% of Tamilnadu.This region has 14 approved fish processing plants with annual export reaching 6,62,603 tonnes in 2009-10 [24]. Due to the tremendous change in the climate condition, season and industrial growth, there could be wide differences in the biochemical constituents of the fishes. Hence it becomes essential to document the proximate composition of the fishes periodically in a region. This study was therefore undertaken to create a base line data on the proximate and mineral composition of the medium sized fish species landed in Tuticorin coast of India to know the energy value and possible conversion into value added food products, according to their compositional variation.

Materials and Methods

Raw materials

Twenty three commercially important marine finfishes belonging to the families Clupeidae (5), Nemipteridae (3), Lutjanidae (3), Leiognathidae (2), Lethrinidae (1), Engraulidae (2), Labridae (1), Serranidae (1), Chirocentridae (1), Synodontidae (1), Sphyraenidae (1), Scombridae (1), and Carangidae (1) were procured from Tuticorin Fishing Harbour (Latitude 8.76/Longitude 78.13) situated in the South coast of India. Fishes were individually measured for their total body weight and length. The scientific names, vernacular names, length and weight of the fishes analyzed are given in Table 1. Fish were beheaded, gutted, washed and filleted prior to analysis. They were homogenized individually using a tissue homogenizer (Krishna Scientific Suppliers, Chennai, and India.) prior to the analysis.

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S.No	Family	Species	Physical parameters	
			Length (cm)	Weight (g)
1	Clupeidae	*Dussumieria acuta*	16.37 ± 2.47	68.33 ± 27.54
		Ilisha melanostoma	12.27 ± 0.42	46.67 ± 02.89
		Pellona ditchela	12.98 ± 1.36	56.67 ± 11.55
		Sardinella longiceps	12.03 ± 1.27	35.00 ± 5.00
		Sardinella fimbriata	13.90 ± 0.40	18.84 ± 0.14
2	Carangidae	*Selaroides leptolepis*	11.50 ± 01.82	50.00 ± 5.00
3	Chirocentridae	*Chirocentrus dorab*	165.33 ± 31.07	37.53 ± 01.12
4	Engraulidae	*Stolephorus commersonii*	12.30 ± 0.36	33.33 ± 05.77
		Stolephorous devisi	5.60 ± 01.54	14.67 ± 02.52
5	Labridae	*Thalassoma fuscum*	15.47 ± 1.50	93.33 ± 32.15
6	Leiognathidae	*Leiognathus dussumieri*	8.40 ± 0.62	38.33 ± 10.41
		Gazza achlamys	12.85 ± 0.07	56.50 ± 04.95
7	Lethrinidae	*Lethrinus lensus*	18.78 ± 0.93	18.33 ± 13.66
8	Lutjanidae	*Lutjanus quinquelineatus*	15.53 ± 0.58	96.67 ± 05.77
		Lutjanus lutjanus	16.40 ± 0.70	90.00 ± 17.32
		Lutjanus decussatus	19.20 ± 0.66	120.00 ± 10.00
9	Nemipteridae	*Nemipterus bleekeri*	17.60 ± 0.46	59.61 ± 0.63
		Nemipterus japonicus	19.20 ± 0.17	151.67 ± 22.57
		Scolopsis bimaculatus	20.03 ± 3.67	120.00 ± 50.00
10	Scombridae	*Rastrelliger kanagurtar*	20.80 ± 02.93	120.00 ± 36.06
11	Serranidae	*Epinephelus areolatus*	21.70 ± 0.71	225.00 ± 07.07
12	Sphyraenidae	*Sphyraena obtusata*	17.60 ± 0.66	33.33 ± 10.41
13	Synodontidae	*Saurida tumbil*	20.55 ± 0.92	72.50 ± 03.55

[1]Values are shown as mean ± standard error of triplicates.

Table 1: Physical characteristics of the fishes caught in Tuticorin coast[1].

Proximate composition analysis

Moisture: Moisture content was determined by the standard AOAC method [25] for which a known weight (10 ± 0.5 g) of sample was placed individually in a moisture dish and dried in a hot air oven (Technico, Chennai, India.) set at 105˚C until constant weights were obtained.

Crude protein: Crude protein content was determined by the standard AOAC method [25]. Approximately,0.2 ± 0.01 g of moisture free sample was weighed and digested along with conc. H_2SO_4 and a pinch of digestion mixture ($NaSO_4$: $CuSO_4$ at the ratio of 9:1) in a Kelplus digestor (Kel plus – Elite EX, Pelican Equipments, Chennai, India.) at 350°C for 4 h until the sample became colorless. The digested sample was diluted to 100 ml in a volumetric flask with distilled water. About 5 ml of aliquots was distilled for 10 min with 40 % sodium hydroxide in a Kelplus distillation apparatus (Kelplus kes 4L, Pelican Equipments, Chennai, India.) and the distillate was collected in 2% boric acid solution containing mixed indicator. The nitrogen content was determined by titration against standard N/70 H_2SO_4 solution. The crude protein content was then calculated by multiplying with the factor 6.25.

Crude fat: Crude fat content was determined by Socplus method [25]. Approximately, 2 ± 0.2 g of moisture free sample was placed individually in a thimble and kept in the pre-weighed extraction flask. The flask was filled with 2/3 volume of petroleum ether and the apparatus (Pelican Equipments, Chennai, India) was assembled. Extraction was carried out for about 2 h at 200°C. After the extraction, excess ether was carefully collected and the residual ether was evaporated to dryness. The difference between the initial and the final weight gave the crude fat content.

Ash: Ash content was determined based on the standard AOAC method [25]. Approximately, 2 ± 0.2 g of moisture free sample was taken individually in a silica crucible and placed in the Muffle furnace (Krishna Scientific Suppliers, Chennai, India) set at 550˚C for 12-15 h. The difference between the initial and the final weight gave the crude ash content.

Total carbohydrate: Total carbohydrate was estimated by the Anthrone method [26]. Approximately, 2 ± 0.2 g of wet fish homogenate was taken individually and homogenized with known volume of 5% TCA. The homogenate was then centrifuged at 2500 rpm in a centrifuge (Hettich Zentrifugen D-78532, Germany) for 10 min and the supernatant was filtered. To the filtrate, anthrone reagent was added, placed in a serological water bath (Inlab Equipments, Chennai, India.) for 10-15 min for color development. The distilled water served as the control. The colored end product was measured for their optical density at 620 nm in a UV – VIS Spectrophotometer (JASCO, V-530, and Japan). D-glucose was used as the standard for computation of the results.

Energy value: The total energy value was calculated using the crude protein, crude fat and carbohydrate contents of the fish based on the following formula.

Energy value K cal/100g = Px4.0 Protein K cal/100 g +

Fx9.0 Fat K cal/100g + Cx4.00 Carbohydrates Kcal/100 g.

Major mineral analysis

Moisture free fish sample was used for the preparation of the ash solution. Approximately, 2 ± 0.2 g of sample was taken individually in a silica crucible and placed in the Muffle furnace set at 500-550˚C for 12-15 h until the residue is white or nearly white. To the residue, conc. HCl acid was added to dissolve the ash and the residual acid was evaporated to dryness by placing in a hot plate (Technico,Chennai, India). This

process was repeated again. The ash solution was then filtered through Whatman No. 1 filter paper and rinsed again with hot distilled water and made up to 50 ml with distilled water. This ash solution was used for the estimation of calcium, phosphorus, and iron contents.

Calcium: Calcium content was determined by the method described by AOAC [27]. The ash solution was first diluted with distilled water and then boiled at 100°C for 10 min in a serological water bath. To which, 10 ml of saturated ammonium oxalate solution and a drop of 8.5% methyl red indicator were added and kept at room temperature for 4 h. This solution was filtered through Whatman No.4 filter paper. The filter paper was then cut into pieces and transferred to another conical flask. To which, 10 ml of dil. H_2SO_4 acid at the ratio of 1:4 was added and boiled at 100°C in a serological water bath for 10 min. The content was diluted with, 50 ml of hot water, cooled and titrated against 0.05 N potassium permanganate solutions until appearance of a pale pink color that persists for 2 sec. The distilled water served as the blank. The calcium content was calculated from the difference between the titer values of the sample and the blank.

Phosphorus: Phosphorus content was estimated by the standard AOAC method [25]. About 0.5 ml of undiluted ash solution was taken individually in the test tubes and made up to 8 ml with distilled water. To which, 2 ml of molybdovanadate reagent was added, mixed well and left at room temperature for 10 min. The optical density of the resultant product was measured at 400 nm in a UV- VIS Spectrophotometer. Potassium orthophosphate monobasic solution was used as a standard to compute the results.

Iron: Iron content was determined by the method described by AOAC [27]. About, 0.5 ml of the undiluted ash solution was taken in the test tubes individually and made up to 7.7 ml with distilled water. To which, 0.4 ml of saturated potassium per sulphate solution was added along with 0.3 ml of conc. H_2SO_4 acid and 1.6 ml of 3 N potassium thiocyanate solution. The reagents were mixed well and the optical density of the resultant product was measured at 540 nm in a UV- VIS Spectrophotometer. Ferrous ammonium sulphate solution was used as a standard to compute the results.

Results and Discussion

The physical characteristics of 23 fishes belonging to the family Clupeidae (5), Nemipteridae (3), Lutjanidae (3), Leiognathidae (2), Lethrinidae (1), Engraulidae (2), Labridae (1), Serrenidae (1), Chirocentridae (1), Synodontidae (1), Sphyraenidae (1), Scombridae (1), and Carangidae (1) are given in Table 1. The average lengths of the fishes ranged widely from 5.60 to 165.53 cm. Majority of the fishes (74%) were medium sized with the average lengths between 10 to 20 cm. The fishes of the families, Engraulidae and Leiognathidae were small having the average lengths of 05.60 ± 01.54 cm and 08.40 ± 0.62 cm, respectively. The species, *Chirocentrus dorab* belonging to the family Chirocentridae was the longest fish examined with an average length of 165.33 ± 31.07 cm. The average weights of majority of the fish species (43%) were below 50 g. The fish species, *Epinephelus areolatus* belonging to the family Serranidae having an average weight of 225.00 ± 07.07 g was the largest fish while *Stolephorus devisi* of the family Engraulidae was the smallest fish (14.67 ± 02.52 g). Wide variations in lengths and weights exist due to the taxonomical differences in fish species rather than environmental factors.

Changes in moisture content

The average moisture contents of the fishes ranged from 67% to 81% (Table 2). More or less a similar variation in the moisture contents from 62.4% to 81.1% was reported by Kabahenda et al. [28]. The species, *Leiognathus dussumieri* belonging to the family, Leiognathidae

Sl.No	Family	Species	Proximate Composition (Percentage value)					Energy value
			Moisture	Protein	Fat	Ash	Carbohydrate	
1	Clupeidae	*Dussumieria acuta*	74.07 ± 0.02	20.23 ± 0.28	6.83 ± 0.34	1.22 ± 0.09	0.083 ± 0.005	150.72
		Ilisha melanostoma	75.14 ± 0.13	15.33 ± 0.66	4.06 ± 0.49	1.16 ± 0.16	0.158 ± 0.007	98.49
		Pellona ditchela	78.03 ± 0.19	15.38 ± 0.16	0.37 ± 0.39	1.21 ± 0.10	0.177 ± 0.003	65.56
		Sardinella longiceps	73.79 ± 0.30	15.94 ± 0.10	6.00 ± 0.00	1.23 ± 0.10	0.358 ± 0.004	116.95
		Sardinella fimbriata	76.49 ± 0.30	18.16 ± 1.34	3.20 ± 0.25	1.37 ± 0.10	0.100 ± 0.001	101.82
2	Carangidae	*Selaroides leptolepis*	75.01 ± 0.69	19.18 ± 1.70	2.89 ± 0.05	1.41 ± 0.16	0.228 ± 0.004	94.97
3	Chirocentridae	*Chirocentrus dorab*	75.48 ± 0.12	15.24 ± 0.62	2.57 ± 0.08	1.31 ± 0.05	0.120 ± 0.010	84.57
4	Engraulidae	*Stolephorus commersonii*	79.32 ± 0.17	16.32 ± 0.93	2.41 ± 0.17	1.31 ± 0.02	0.110 ± 0.004	87.41
		Stolephorous devisi	79.72 ± 0.26	11.98 ± 0.28	1.10 ± 0.04	1.03 ± 0.13	0.332 ± 0.020	59.15
5	Labridae	*Thalassoma fuscum*	77.28 ± 1.22	17.47 ± 0.40	1.52 ± 0.07	1.66 ± 0.08	0.38 ± 0.001	90.28
6	Leiognathidae	*Leiognathus dussumieri*	67.23 ± 0.87	10.24 ± 0.10	14.72 ± 0.30	1.20 ± 0.10	0.080 ± 0.002	174.16
		Gazza achlamys	77.34 ± 1.42	19.30 ± 0.23	0.79 ± 0.009	2.40 ± 0.18	0.07 ± 0.003	93.91
7	Lethrinidae	*Lethrinus lensus*	77.63 ± 0.74	18.48 ± 2.26	0.41 ± 0.005	1.78 ± 0.19	0.09 ± 0.001	77.97
8	Lutjanidae	*Lutjanus quinquelineatus*	75.75 ± 0.43	21.46 ± 0.47	3.43 ± 0.10	1.81 ± 0.20	0.04 ± 0.002	116.87
		Lutjanus lutjanus	76.29 ± 1.44	15.67 ± 0.11	0.24 ± 0.002	1.54 ± 0.16	0.05 ± 0.004	65.04
		Lutjanus decussatus	73.52 ± 0.09	21.13 ± 0.01	2.06 ± 0.12	0.98 ± 0.16	0.06 ± 0.01	106.98
9	Nemipteridae	*Nemipterus bleekeri*	71.44 ± 2.01	22.75 ± 0.40	4.45 ± 0.06	1.00 ± 0.04	0.044 ± 0.004	131.23
		Nemipterus japonicus	74.72 ± 0.75	18.24 ± 0.08	2.78 ± 0.14	3.92 ± 0.19	0.25 ± 0.001	74.98
		Scolopsis bimaculatus	74.76 ± 0.49	22.24 ± 0.27	3.37 ± 0.18	1.17 ± 0.20	0.07 ± 0.002	119.57
10	Scombridae	*Rastrelliger kanagurtar*	76.08 ± 0.58	15.14 ± 0.32	2.40 ± 0.33	1.18 ± 0.09	0.112 ± 0.003	83.42
11	Serranidae	*Epinephelus areolatus*	78.99 ± 0.23	16.84 ± 0.35	0.85 ± 0.09	3.79 ± 0.16	0.05 ± 0.001	75.21
12	Sphyraenidae	*Sphyraena obtusata*	80.48 ± 3.53	16.10 ± 0.11	3.53 ± 1.92	1.19 ± 0.23	0.066 ± 0.001	96.43
13	Synodontidae	*Saurida tumbil*	79.19 ± 1.36	16.28 ± 0.28	0.29 ± 0.08	1.85 ± 0.17	0.09 ± 0.002	67.93

[1]Values are shown as mean ± standard error of triplicates.

Table 2: Proximate composition of fishes caught in Tuticorin coast.

had the lowest moisture content of 67.23%. The fishes of the families, Carangidae, Clupeidae Lutjanidae and Nemipteridae had the average moisture contents between 71 and 75%. The oil sardines examined had 73.79% moisture, but earlier Gopakumar and Ravichandran et al. [19,21] had reported 67.01% and 70.02%, moisture, respectively in oil sardine. The fish species, *Nemipterus japanicus* had an average moisture content of 74.72% like that obtained by Gopakumar [21]. Majority of the fish species (61%) contained moisture contents between 75 and 80%. The average moisture content of *Epinephelus areolatus* and *Lethrinus lensus* were similar with the earlier report of Hanna [9] for *Epinephelus areolatus*, Zamil et al. [29] for *Epinephelus tauvina* and *Lethrinus nebulosus*; and Younis et al. [30] for *Lethrinus lentjan* and *Epinephelus chlorostigma*. Only a single species belonging to family, Sphyraenidae had >80% moisture similar Zamil et al. [29] findings. Gopakumar [19] had also reported that the fish species, *Hippoglossides platissoides* showed higher moisture content of about 96 % during starvation. Such high concentrations were not noticed in any of the fish species.

Changes in protein content

The average crude protein contents of the fishes ranged from 10.24 to 22.75% (Table 2). The lowest protein content of 10.24% was recorded for the species, *Leiognathus dussumieri*. Following this, a species of *Stolephorus devisi*, also had low protein content of 11.98%. Gopakumar [19] had however recorded a minimum protein content of 7.50% for the Bombay duck, *Harpodon nehereus*. Such lower values were not recorded for any of fish species examined in the East Coast of India. Majority of the fishes (69%) had the average protein contents between 15% to 20%. The average protein contents of *Sphyraena obtusata*, *Lethrinus lentjan*, and *Thalassoma fuscum* were in line with the findings of Zamil et al. [29], Mathana et al. [22] and Hanna [9], respectively. A species of the family Lutjanidae, *Lutjanus quinquelineatus* contained 21% protein and an almost similar value but in another species, *Lutjanus fulviflamma* was obtained by Hanna [9]. More number of fish species belonging to the family, Nemipteridae had higher protein content (>22%) and they were identified as *Nemipterus bleekeri* and *Scolopsis bimaculatus*. The species, *Nemipterus japonicus* alone had slightly lower protein content of 18.24%, but was similar to that obtained by Nurnadia et al. [31].

Changes in fat content

The average crude fat contents of the fishes varied widely from 0.34 to 14.72% (Table 2). Fish species are generally grouped into four categories based to their fat contents: lean fish (<2%), low fat (2-4%), medium fat (4-8%) and high fat (>8%) [32]. About 35% of the fishes were identified as lean fish, 43% as low fat fish, 17% as medium fat fish and 4% was high fat fish. The fish species of the family, Lutjanidae showed wide variation in their fat contents from 0.24 to 3.43%. The species, *Lutjanus lutjanus* had the lowest fat content of 0.24%. Similarly Gopakumar [19] reported that the species, *Lutjanus malabaricus* had 0.28% fat. The fat content of the fish species, *Lethrinus lensus* was also quite low (0.41%), almost similar to those recorded by Younis et al. [30] for *Lethrinus lentjan* (0.45%). The fat content of 0.85% obtained for the species, *Epinephelus areolatus* was also similar to that of Hanna et al. [9] who have reported, 1.07%. In the species, *Chirocentrus dorab*, the fat content was 2.57% which was more or less similar to the value of 3.0% recorded by Gopakumar [19] but a slightly lower value of 1.22% fat was obtained by Nurnadia et al. [31]. The average fat contents of *Stolephorus* species were between 1.1% and 2.4%, but slightly lower values were recorded by Gopakumar [19] for this species. The fish species, *Nemipterus japanicus* had 2.78% fat similar to that obtained by Gopakumar [19] and Nurnaida et al. [31]. The fish species, *Sphyraena obtusata* contained 3.53% fat, but Zamil et al. [29] reported only 0.98% fat for the same species. Most of the values obtained for different fishes were agreeable with the earlier reports except for few species.

The fish species of the family, Clupeidae had medium fat contents between 3.2 and 6.8% including *Sardinella longiceps*. Earlier, *Sardinella longiceps*, being a fatty fish was reported to contain even 11.70% fat [19] and 8.45% [21] and such high values were not obtained in the same species examined in the East Coast of India. Hardy and Keay [33] had demonstrated that changes in fat content vary as the sardines drain or replenish their fat reserves in response to the availability of food; spawning cycles and other factors in the sea. Only one species, *Leiognathus dussumieri* belonging to the family, Leiognathidae contained significantly higher fat content of 14.72%, and had invariably low moisture content of 67.23%. *Leiognathus dussumieri* examined in this study was caught during pre-monsoon period (October). This species mainly feeds on small crustaceans, polychaets, foraminiferans, bivalves, gastropods and nematodes [34] and this unique feeding habit could have contributed for the high fat content in their tissues. This study indicated that the fish, *Leiognathus dussumieri* which was often considered as a trash fish could be properly exploited as a potential source of health beneficial fatty acids. It has been indicated that the moisture content is an indication of its relative lipid and protein contents of the fish [35]. Similarly, some authors have quoted that the fat content is inversely proportional to the moisture content [31,36]. In general, the variations in the fat contents of the fish species are significantly higher than that of other parameters. This could be due to the inherent differences in the species, seasonal as well as geographical variations. Variations in age and maturity within the same species may also contribute to the differences in the fat contents [37].

Changes in ash content

Ash is a measure of the mineral content of any food including fish [38]. The average ash contents of the fish species ranged between 1.00% and 3.92% (Table 2). Majority of the fishes (87%) contained <2% ash contents. Ash values recorded for *Sardinella longiceps*, *Chirocentrus dorab*, *Stolephorus devisi* and *Rastrelliger kanagurta* by Gopakumar [19] were more or less similar to the values obtained for those species in this study. The ash content of the species, *Rastreliger kanagurta* was in accordance with the value of 1.26% obtained by Nurnadia et al. [31]. The species having >2% ash contents were *Gazza achlamys* (2.40%), *Epinephelus areolatus* (3.79%) and *Nemipterus japonicus* (3.92%). Such high ash contents were earlier reported in jack mackerel (4.10%) by Paul et al. [36] and in *Clupeonella cultiventris caspia* (3.30%) by Pirestani et al. [39]. A fish species, *Epinephelus areolatus* examined had 3.79% ash content but earlier authors have reported lower value of 0.38% and 1.17% [9,19] for this species. This study indicated that the fishes inhabiting coral reefs showed high ash contents. The concentrations of minerals and trace elements that contribute for the total ash contents are known to vary in fish depending their feeding behavior, environment, ecosystem and migration even within the same area [40-42].

Changes in carbohydrates

Fish generally have very low levels of carbohydrates [43]. The average carbohydrate contents in the fishes ranged between 0.04 and 0.36% (Table 2). The low carbohydrate values could be due to the fact that glycogen does not contribute much to the reserves in the fish body tissue [20,44]. Very few species showed slightly higher values. They were *Sardinella longiceps* and *Stolephorus devisi* with about 0.358% and 0.332%, respectively.

Changes in Energy values

The energy values of fishes differ among the species and it ranged widely from 59.15 to 174.16 kcal (Table 2). Majority of the fishes (65%) had energy values between 50 to 100 k cal. About 30% of fishes had energy values >100 kcal, due to either high fat or high protein contents. The fish species, *Stolephorus devisi* showed the lowest energy value of 59.15 k cal due to low fat (1.1%) as well as protein (11.98%) contents. The highest energy value of 174.16 k cal was obtained for *Leiognathus dussumieri* due to the high fat content of 14.72%. According to Judith and Jenny [45], large variations in the fat content would reflect in a wide range of calorific values. In this study, the fish species having high protein contents (>20%) also showed higher calorific values. The energy values are thus influenced by both fat as well as protein contents.

Major minerals

The presence of three major minerals viz. calcium, phosphorus and iron contents in the fishes are given in Table 3. The average calcium contents in the fish species ranged from 64 to 1887 mg%. The fish meat generally contains high calcium content than the animal meat [46]. Majority of the fishes, 44% had the average calcium contents between 500 and 1000 mg/100 g. The fish species, *Lutjanus decussatus* had the highest calcium content of 1887 mg/100 g, while the species, *Nemipterus bleekeri* and *Leiognathus dussumieri* had lower calcium values of 64.24 mg/100 g and 90.41 mg/100 g, respectively. The fishes of families, Clupeidae and Lutjanidae, generally had high calcium values of 846-1026 mg/100 g and 721-1887 mg/100 g, respectively except *Sardinella fimbriata* which had only 164.29 mg/100 g. The other two fishes that contained calcium contents above 1000 mg/ 100 g were *Epinephelus areolatus* and *Rastrelliger kanagurtar*. Gopakumar [19] earlier stated that there existed no similarities in the calcium content of the fishes belonging to the same family. But in this study, there existed some simulates in the calcium contents of the fishes of the family, Clupeidae and Engraulidae but not within the species of other families.

The average iron contents of the fishes varied widely from 0.05 to 28.46 mg/100 g. Majority of the fishes, 78% had the average iron contents < 5 mg%. The species, *Saurida tumbil* of the family, Synodontidae had the lowest iron content of 0.05 mg/100 g. Four fish species, *Chirocentrus dorab, Dussumieria acuta, Lujantus quinquelineotus* and *Epinephelus areolatus* had high iron contents of 11.50, 14.18, 18.69 and 28.46 mg/100 g, respectively and could serve as the best source of dietary iron. However, they do not belong to the same family. There existed no similarities in the iron contents of the fishes belonging to the same family. For instance, *Dussumieria acuta* of the family Clupeidae alone had high iron contents, while the other few species had lower iron content ranging between 2.06 to 4.31 mg/100 g. The iron contents of fishes of the same species, via *Stolephorus* sp, *Lutjanus* sp and *Nemipterus* sp even did not show similar values. Also no correlation existed between the calcium and iron values of the fishes.

The average phosphorus contents of the fishes varied widely from 15.52 to 413.91 mg/100 g. Most of the fishes, 78% contained values between 100-500 mg/100 g. The species, *Stolephorous devisi* of the family, Engraulidae had the lowest value of 15.52 mg/100 g while the species, *Ilisha melanostoma* of the family, Clupeidae had the highest value of 413.91 mg/100 g. According to Elagba et al. [47], the richness in phosphorus values in the species can be attributed to the fact that phosphorus is a component of protein. This fact did not seemed to be true, as there existed no correlation between the fish species having high protein and phosphorus contents, in majority of the cases. However, the phosphorus contents of the fish species within the same genera, *Stolephorus* sp, *Lutjanus* sp and *Nemipterus* sp did showed some correlation with more or similar values.Also, there was no relationship

S.No	Family	Species	Mineral contents (mg/100g)		
			Calcium	Iron	Phosphorus
1	Clupeidae	*Dussumieria acuta*	879.97 ± 2.00	14.18 ± 0.08	124.35 ± 3.43
		Ilisha melanostoma	846.20 ± 1.50	2.06 ± 0.06	413.91 ± 2.00
		Pellona ditchela	890.38 ± 7.00	2.96 ± 0.00	226.19 ± 1.01
		Sardinella longiceps	1026.85 ± 1.10	4.31 ± 0.28	352.6 ± 2.60
		Sardinella fimbriata	164.29 ± 1.80	2.25 ± 0.10	346.83 ± 3.80
2	Carangidae	*Selaroides leptolepis*	859.24 ± 1.50	1.89 ± 0.06	66.1 ± 1.80
3	Chirocentridae	*Chirocentrus dorab*	915.21 ± 2.00	11.50 ± 0.21	64.07 ± 0.94
4	Engraulidae	*Stolephorus commersonii*	715.48 ± 2.20	2.80 ± 0.10	34.07 ± 0.25
		Stolephorous devisi	727.03 ± 2.10	0.57 ± 0.02	15.52 ± 0.10
5	Labridae	*Thalassoma fuscum*	155.47 ± 2.00	0.18 ± 0.01	294.36 ± 0.86
6	Leiognathidae	*Leiognathus dussumieri*	90.41 ± 1.80	2.66 ± 0.11	190.27 ± 0.27
		Gazza achlamys	200.08 ± 0.90	3.95 ± 0.13	182.20 ± 1.83
7	Lethrinidae	*Lethrinus lensus*	583.89 ± 1.70	7.94 ± 0.37	250.06 ± 1.55
8	Lutjanidae	*Lutjanus quinquelineatus*	721.10 ± 00.79	18.69 ± 0.38	214.66 ± 0.79
		Lutjanus lutjanus	1135.05 ± 0.70	2.95 ± 0.18	305.25 ± 2.65
		Lutjanus decussatus	1887.10 ± 5.05	3.08 ± 0.12	204.70 ± 2.06
9	Nemipteridae	*Nemipterus bleekeri*	64.24 ± 2.40	4.11 ± 0.15	203.43 ± 0.45
		Nemipterus japonicus	0798.63 ± 1.40	0.16 ± 0.06	255.16 ± 1.89
		Scolopsis bimaculatus	1175.00 ± 1.80	0.42 ± 0.03	266.54 ± 1.33
10	Scombridae	*Rastrelliger kanagurtar*	1170.89 ± 0.89	2.33 ± 0.08	86.91 ± 2.47
11	Serranidae	*Epinephelus areolatus*	1452.41 ± 02.00	28.46 ± 0.73	326.96 ± 1.11
12	Sphyraenidae	*Sphyraena obtusata*	177.18 ± 1.80	0.24 ± 0.005	326.16 ± 1.16
13	Synodontidae	*Saurida tumbil*	475.26 ± 1.40	0.05 ± 0.02	321.48 ± 1.49

[1]Values are shown as mean ± standard error of triplicates.

Table 3: Major mineral composition of fishes caught in Tuticorin coast[1].

between the iron, calcium and phosphorus contents of the fishes except in *Epinephelus areolatus* which had high calcium, iron and phosphorus contents.

The concentrations of several minerals in the fishes were significantly different among the species in each country [39]. The variation is mainly related to seasonal and biological differences like species, size, muscle complexion, age, sex, sexual maturity, geographical location, processing method, food source and environmental conditions like water chemistry, salinity, temperature and contaminants [46,48-51].

Conclusion

From this study, it was inferred that the fish species, *Leiognathus dussumieri* belonging to the family Leiognathidae was the most fatty fish along the East Coast of India with the fat content above 14%, although the oil sardine, *Sardinella longiceps* have been report as the fatty fish in India. The fishes inhabiting coral reefs, such as *Lutjanus sp, Nemipterus sp* and *Scolopsis* sp were rich in protein (>21%). The fishes rich in calcium and iron contents were mainly *Lutjantus sp* and *Epinephalus* sp. Most of the fishes had invariably high phosphorus content between 200 to 400 mg/ 100 g. The total calorific value of these food fishes are mainly influenced by the total fat content, and also to a greater extent by the total protein content. The base line data on the proximate and major mineral composition of the commercially available fishes along the Thoothukudi Coast provide information on the biochemical constituents; thereby suggesting possible utilization of these fishes for conversion into suitable products. However, further studies on the fatty acid and amino acid compositions of these fishes are required to provide detailed data on the nutritive values of fishes.

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