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A Comparative Evaluation of Nutritional Composition of Deep Sea and Coastal Shrimp off South-west Coast of India

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Abstract

The chemical composition of deep-sea shrimp *Aristeus alcocki*, *Heterocarpus gibbosus*, *Plesionika spinipus* and *Metapenaeopsis andamanensis* harvested by deep-sea shrimp trawlers operating off the south west coast of India were evaluated and the nutritional composition was compared with coastal shrimp *Fenneropenaeus indicus* and *Penaeus monodon*. Among deep sea shrimp, the highest protein content of 22.82% was observed in *H. gibbosus,* whereas protein content in other species were in the range of 18.81 – 22.33%. Protein content in *P. monodon* and *F. indicus* were estimated as 17.46 and 19.23% respectively. Higher protein content in the muscle of deep sea shrimp indicates that deep sea shrimp meat can be a good source of amino acids. Among the species studied, fat content was comparatively high in *A. alcocki* (3.18%) followed by *H. gibbosus* (2.72%). Deep sea shrimp were found to have higher mineral content and have a higher amount of calcium and sodium when compared to coastal shrimp. The essential and non-essential amino acids were found higher in *A. alcocki* (17.78 and 15.71 g 100 g respectively) than other deep sea and coastal shrimp.

Keywords: Deep sea shrimp, nutritional composition, amino acids, PUFA

Introduction

Among seafood products, crustaceans including prawns and shrimp are of great commercial interest (Heu et al., 2003) and contribute about 21.7% share by value of the world seafood trade (FAO, 2016). Apart from the delicacy, prawns and shrimp have attracted attention as an important source of nutrients in the human diet due to the presence of amino acids, peptides, proteins and other nutrients (Sriket et al., 2007). Shrimp meat is a good source of protein (Yanar & Celik, 2006), highly unsaturated fatty acids (HUFA) such as eicosapentaenoic acid (EPA), docosahexaenoic acids (DHA) (Feliz et al., 2002) and minerals such as calcium (Yanar & Celik, 2006).

Studies on biochemical and nutritional aspects of prawn muscle were carried out only for major commercial coastal shrimp species available in India such as *P. monodon*, *F. indicus*, *P. semisulcatus* and *Metapenaeus dobsoni*. Information on nutritional composition is important for the effective utilization of deep sea shrimp resources harvest from the Arabian Sea. Therefore, in this study, chemical composition of muscle of deep-sea shrimp *Aristeus alcocki* (Ramadan, 1938), *Heterocarpus gibbosus* (Bate, 1888), *Plesionika spinipus* (Bate, 1888) and *Metapenaeopsis andamanensis* (wood-Mason, 1891), were evaluated and the nutritional quality is compared with that of coastal shrimp *Fenneropenaeus indicus* (H. Milne Edwards, 1837) and *Penaeus monodon* (Fabricus, 1798).

Materials and Methods

Deep sea shrimp harvested by trawlers operating off the south west coast of India were collected from the Sakthikulangara fishing harbour of Kollam district in the Kerala State. The shrimp were caught at depths between 300 to 400 m in the area lying between Latitudes 8° 28′ 220" N – 8° 46′ 071" N and Longitudes 75° 40′ 630" E - 76° 20′ 459" E. Whole shrimp were stored in ice immediately after the catch on board the vessel. The samples were

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collected in insulated boxes containing crushed ice and transported to the laboratory. Species identification of deep sea shrimp was done as per Alcock (1901) and Suseelan (1985).

Size and weight of samples from each species group were measured and means of ten determinations ± standard deviation was calculated. The yield of muscle and body components (head and shell) for each species group were calculated and compared. Meat yield (wet weight) was calculated as

% yield: meat weight/total weight ×100.

Moisture content, total nitrogen, crude fat and ash content of the homogenized sample were determined by AOAC (2005). The concentration of total nitrogen was estimated and conversion factor of 6.25 was used to calculate crude protein. Samples were microwave digested and analyzed for minerals and heavy metals using inductively coupled plasma spectrophotometer (Thermoscientific, iCAP 6000 Series) following the method of AOAC (2005).

The amino acid composition was determined using HPLC Amino acid analyser (Shimadzu LC-10 AT) system equipped with cation exchange column (sulphonated polyvinyl styrene column) and fluorescence detector (Lakshmanan et al. 2013). Fatty acid methyl esters of lipid extracted by the method of Folch et al. (1957) were analyzed with Trace Thermo Gas chromatography Ultra equipped with Elite-225 silica capillary column (60 m length and 0.25 ID) and Flame ionizing detector using nitrogen as carrier gas. Calibration of GC was done using standard FAME mixtures (Supelco Germany). All the analyses were repeated three times and the results were expressed as a mean±standard deviation.

Results and Discussion

The mean length and weight of the deep sea shrimp were measured as 12.75±0.91cm and 10.9±4.17 g for *A. alcocki*, 10.72±1.28 cm and 8.6±1.5 g for *H. gibbosus*, 9.12±0.38 cm and 4.5±0.58 g for *P. spinipus*, 10.26 ± 1.47 cm and 6.83±1.12 g for *M. andamanensis* respectively. Samples of *P. monodon* and *F. indicus* were collected from Thoppumpady fishing harbour, Ernakulam district, from the shrimp trawlers operating off south west coast of India. The mean length and mean weight of the coastal shrimp collected were 18.52±2.52 cm and 45.7±3.5 g for *P. monodon* and 16.63±1.14 cm and 32.7±2.15 g for *F. indicus*.

The size of the samples and yield of different body components of deep sea and coastal shrimp are shown in Table 1. Meat content in *M. andamanensis* was 47%, whereas, in *A. alcocki*, *H. gibbosus* and *P. spinipus* the yield of muscle content was comparatively less as 36.5%, 34.5%, and 37.5% respectively. Meat content was quantified as 55% in *P. monodon* and 53.5% in *F. indicus*, more than 50% of the total weight of the whole shrimp. Manjabhat et al. (2006) reported 37.4% yield of meat and 62.6% yield of body components for *A. alcocki* and 34.4% yield of meat and 65.6% yield of body components for *Solenocera indica* collected from Indian waters. Heu et al. (2003) reported muscle contents of 48.1% and 48.3% in Northern pink shrimp (*Pandalus borealis*) and Spotted shrimp (*Trachypena curvirostris*) respectively. Processing by-products such as head and

Table 1. Size and Yield of samples

Components	*Aristeus alcocki*	*Heterocarpus gibbosus*	*Plesionika spinipus*	*Metapenaeopsis andamanensis*	*Fenneropenaeus indicus*	*Penaeus monodon*
Body length (cm)	11.3 - 13.9 (12.75±0.91)[a]	8.9 - 12.6 (10.72±1.28)	7.6 - 10.7 (9.12±0.38)	6.3 - 12.2 (10.26±1.47)	14.4 - 19.8 (16.63±1.14)	16.7 - 22.3 (18.52±2.52)
Weight (g)	6 - 19 (10.9±4.17)	5 - 11 (8.6±1.5)	3 - 6 (4.5±0.58)	2 - 9 (6.83±1.12)	23.5 - 45.0 (32.7±2.15)	42.0 - 51.0 (45.7±3.5)
Yields %						
Muscle	36.5	34.5	37.5	47.0	53.5	55.0
Head	49.0	54.0	52.0	39.5	34.5	32.0
Shell	14.5	11.5	10.5	13.5	12.0	13.0
Total	100.0	100.0	100.0	100.0	100	100

[a] Values in the parenthesis are means of ten determinations±standard deviation

shell contributed more than 50% to the total weight of the deep sea shrimp. Shell including head contributed 63.5% in *A. alcocki,* 65.5% in *H. gibbosus,* 62.5% in *P. spinipus* and 53% in *M. andamanensis.*

The proximate composition of the muscle of deep sea shrimp *A. alcocki, H. gibbosus, P. spinipus* and *M. andamanensis* and coastal shrimp *P. monodon* and *F.indicus* are given in Table 2. All the four species of deep sea shrimp studied have high moisture content compared to coastal shrimp *P. monodon* and *F. indicus.* Among deep sea shrimp, *A. alcocki* has significantly higher moisture content (84.13% on wet weight basis). In other deep sea shrimp, the moisture content was in the range of 80.38 – 81.82%. The moisture content of *P. monodon* and *F. indicus* was 79.01 and 74.62% respectively.

In India, very few studies have been carried out to estimate the composition of deep-sea shrimp, notably by Rajasree (2004), Manjabhat et al. (2006), Karuppasamy et al. (2014), Priyadarshini et al. (2015) and Rao et al. (2016). Rajasree (2004) estimated the proximate composition of two species of deep-sea prawns *Heterocarpus woodmasoni* and *H. gibbosus* with regard to sex and maturity stages and reported that the moisture content in these species varied between 75.82 to 82.93% and 77.90 to 80.71% respectively. In a recent study by Rao et al. (2016) on the proximate composition of deep sea crustaceans in the Indian EEZ reported moisture content of *H. gibbosus* as 77% in the east coast and 81.84% in the west coast of Indian EEZ. Priyadarshini et al. (2015) have reported 72% moisture content in *Solenocera crassicornis* collected from the landing centres of Chennai in Tamil Nadu. Similar moisture content was reported by Karuppasamy et al. (2014) in *P. monodon* (80.89%) and *F. indicus* (74.17%) samples collected from the landing centre of Nagapattinam, Tamil Nadu.

The protein content in deep sea shrimp species was observed to be significantly higher in quantity in the present study. *H. gibbosus* contain a high protein content of 22.82% and other species are in the range of 18.81–22.33%. Rao et al. (2016) reported protein content of 14.92% in *H. gibbosus* collected from the west coast and 17.42% in the samples collected from the east coast. Protein content reported by Rajasree (2004) in *H. woodmasoni* for females and males ranged between 13.86 to16.21% and 15.04 to 15.82% respectively. Differences in protein content might be due to variation in growth stage, feed and season (Sikorski et al., 1990). In case of coastal shrimp, *P. monodon* and *F. indicus* had protein content of 17.46 and 19.23% respectively, which is comparable to the protein content of deep sea shrimp *A. alcocki* (18.81%). Higher protein content in the muscle of deep sea shrimp indicate that deep sea shrimp meat can be a good source of amino acids.

Among the species studied, fat content was comparatively high in *A. alcocki* (3.18%) followed by *H. gibbosus* (2.72%). High ash content was noticed in the meat of *H. gibbosus* (1.96%) and *M. andamanensis* (1.16%) than other deep sea shrimp studied. Rajasree (2004) also reported higher fat content in deep sea prawns which ranged from 2.33 to 2.97% in *H. woodmasoni* females and 2.19 to 2.41% in males. In *H. gibbosus,* the fat content ranged from 1.55 to 2.38 in males and 1.57 to 1.82 in females. This study reported higher ash content in *H. woodmasoni* meat (1.54%) than in *H. gibbosus* (1.23%). In the present study, the ash content of deep sea shrimp meat ranged from 0.70 to 1.96% and in coastal shrimp; 1.21% in *P. monodon* and 1.52% in *F. indicus*.

Table 2. Proximate composition (%) of deepsea and coastal shrimp

Species	Moisture	Protein	Crude Fat	Ash
Aristeus alcocki	84.13±0.02	18.81±0.54	3.18±0.69	1.12±0.15
Heterocarpus gibbosus	81.82±0.04	22.82±0.49	2.72±0.02	1.96±0.35
Plesionika spinipus	80.57±0.03	22.33±0.81	1.13±0.04	0.70±0.12
Metapenaeopsis andamanensis	80.38±0.03	20.74±0.38	1.22±0.05	1.16±0.19
Fenneropenaeus indicus	74.62±0.15	19.23±0.51	1.09±0.09	1.52±0.33
Penaeus monodon	79.01±0.58	17.46±0.34	1.66±0.19	1.21±0.06

Values are given as mean±SD from triplicate determinations.

Manjabhat et al. (2006) also reported similar proximate composition in deep sea shrimp collected from Indian waters. They have reported moisture content of 83.6 and 81.0% in *S. indica* and *A. alcocki* meat respectively. Crude protein reported was 13.7 and 15.1% and true protein was 13.5 and 15.1% in these species. Fat content of 0.94% in *S. indica* meat and 2.7% in *A. alcocki* meat was reported. Whereas, ash content was reported as 0.68 and 0.65% respectively in these species.

Nair & Suseela (2000) reported the proximate composition of *Fenneropenaeus indicus* from Indian waters with moisture 76.80%, protein – 17.50%, fat – 0.58% and ash – 1.46%. Sriket et al. (2007) reported high moisture content in the meat of farmed, black tiger shrimp (*Penaeus monodon*) from Thailand as 80.47%. Oksuz et al. (2009) reported moisture, crude protein, crude lipid and ash content as 78.66, 20, 1.1 and 1.55% in the muscle of deep seawater Rose shrimp *Parapenaeus longirostris* and as 82.21, 14.2, 2.6 and 1.01% in red shrimp *Plesionika martia* caught from Northern Eastern Mediterranian Sea.

Mineral and trace metal contents were analyzed in deep sea shrimp species and the results were compared with that of coastal shrimp (Table 3.) Deep sea shrimp have higher amount of calcium and sodium than coastal shrimp but with a lower amount of potassium, iron and zinc. Among the deep sea shrimp studied, *H. gibbosus* had higher amounts of calcium (6348.46 ppm), sodium (15779.56 ppm) and potassium (10735.09 ppm) than other species, but copper (10.87 ppm), iron (76.17 ppm) and zinc (51 ppm) were observed in significantly higher level in *A. alcocki*. Significantly comparable amount of calcium, sodium, potassium, copper, iron and zinc were observed among coastal shrimp *P. monodon* and *F. indicus*.

Rao et al. (2016) studied the heavy metal accumulation in deep sea shrimp *A. armata, P. spinipes, H. gibbosus* and deep sea lobster *Puerulus sewelli* collected from off east and west coast of India. They reported that shrimp collected from the west coast waters contained significantly higher cadmium and zinc than those collected from the east coast and the cadmium content in *H. gibbosus* was 0.06±0.03 $\mu g\ g^{-1}$, which was below the maximum permissible levels (0.5 $\mu g\ g^{-1}$) proposed by European Union (2008) for crustaceans. The concentration of iron, copper and cobalt was higher in samples collected from east coast and maximum iron concentration was observed in *Plesionika spinipes* off the east coast (50.06 $\mu g\ g^{-1}$) and the lowest iron concentration was observed in *P. sewelli* (18.09 $\mu g\ g^{-1}$). Further, they indicated that the concentrations of heavy metals in deep sea prawns studied were well within the regulatory limits and thus do not pose any threat to the consumer health.

Heu et al. (2003) reported that calcium (96.5 and 71.3 mg 100 g^{-1}), phosphorus (167 and 178 mg 100 g^{-1}), sodium (254 and 267 mg 100 g^{-1}), potassium (144 and 98.02 mg 100 g^{-1}) and magnesium (50.7 and 104.05 mg 100 g^{-1}) in Northern pink shrimp (*Pandalus borealis*) and Spotted shrimp (*Trachypena curvirostris*) respectively were the predominant minerals present in the muscle, while manganese (0.08 and 0.55 mg 100 g^{-1}) and iron (2.15 and 5.63 mg 100 g^{-1}) were present in trace amounts. Sriket et al. (2007) reported higher contents of iron (30.7 $mgKg^{-1}$), copper (6.31 $mgKg^{-1}$), manganese (1.00 $mgKg^{-1}$), zinc (17.3 m gKg^{-1}) and calcium

Table 3. Minerals and trace elements (ppm) in deep sea and coastal shrimp

Elements	*Aristeus alcocki*	*Heterocarpus gibbosus*	*Plesionika spinipus*	*Metapenaeopsis andamanensis*	*Fenneropenaeus indicus*	*Penaeus monodon*
Ca	6153±0.30	6348±0.43	3426±0.37	4625±0.56	2090±0.18	2612±0.13
Na	9411±0.61	15779±1.72	7538±1.43	8381±1.28	6902±0.39	7357±0.38
K	6940±0.46	10735±1.64	10638±1.23	7829±1.37	14683±0.46	11807±0.51
Ba	1.07±0.28	1.62±0.58	2.13±0.31	1.27±0.51	3.4±0.73	7.76±0.92
Cu	10.87±0.57	7.34±0.16	6.72±0.11	5.79±0.13	40.12±0.37	33.45±0.57
Fe	76.17±0.56	44.37±0.84	53.18±0.25	41.7±0.17	43.08±0.41	64.92±0.38
Mn	2.33±0.39	1.22±0.19	1.02±0.11	0.85±0.12	1.03±0.72	0.77±0.06
Zn	51±0.55	24.18±0.35	34.56±0.82	26.17±0.33	51.49±0.48	74.39±0.50

Values are given as mean±SD from triplicate determinations

(259 mgKg^{-1}) in black tiger shrimp (*P. monodon*) meat than white shrimp (*P. vannamei*) meat (12.2, 4.07, 0.48, 14.7 and 247 mgKg^{-1} respectively). The results of the present study (Table 3) indicates that calcium, sodium and potassium are the dominant minerals found in the muscles of deep sea and coastal shrimp.

Essential amino acids and non-essential amino acids have a significant role in the human diet as they are known to be the building blocks of proteins (Young, 1994; Imura & Okada, 1998; Koletzko et al. 2005). Studies on the amino acid composition of prawns by Sikorski et al. (1990) revealed that glycine, alanine, serine and threonine enrich the sweet taste in prawns while arginine, leucine, valine, methionine, phenylalanine, histidine and isoleucine give a bitter taste. In the present study, important essential and non-essential amino acids in the muscle tissue of deep sea and coastal shrimp were quantified and presented in the Table 4. Among the deep sea shrimp, the essential and non-essential amino acids were comparatively high in *A. alcocki* (17.78 and 15.71 gm 100 g^{-1} respectively) than other deep sea shrimp *H. gibbosus* (10.26 and 6.84 g 100 g^{-1}), *P. spinipus* (12.54 and 11.76 g 100 g^{-1}) and *M. andamanensis* (11.2 and 16.91 g 100 g^{-1}) and coastal shrimp *P. monodon* (7.3 and 5.81 g 100 g^{-1}) and *F. indicus* (12.81 and 21.26 g 100 g^{-1}) (Fig. 1). Among the two coastal shrimp studied, significantly higher quantities of essential and non-essential amino acids were found in *F. indicus* than *P. monodon* and the results show that the amino acid composition of deep sea shrimp is significantly comparable with that of coastal shrimp.

Sriket et al. (2007) found arginine as the most abundant amino acid in farm raised *P. monodon* (4273 mg 100 g^{-1}) and *Litopenaeus vannamei* (3494 mg 100 g^{-1}). They reported amino acid contents glycine (1182 mg 100 g^{-1}), phenylalanine (2277 mg 100 g^{-1}), isoleucine (2586 mg 100 g^{-1}) and glutamic acid

Table 4. The amino acid composition of Deep sea and Coastal shrimp muscle (gm 100 g^{-1})

Amino acids	*Aristeus alcocki*	*Heterocarpus gibbosus*	*Plesionika spinipes*	*Metapenaeopsis andamanensis*	*Fenneropenaeus indicus*	*Penaeus monodon*
Essential amino acids						
Valine	1.18	0.63	0.72	1.40	1.36	0.38
Methionine	3.62	0.03	0.14	0.28	0.34	0.07
Isoleucine	0.61	0.08	0.71	1.31	1.02	0.40
Leucine	2.29	2.09	1.72	1.30	2.89	0.71
Tyrosine	0.84	0.39	0.18	0.41	0.38	0.16
Phenylalanine	0.54	0.72	0.34	0.89	0.92	0.68
Histidine	6.82	3.32	3.23	2.97	3.65	2.94
Lysine	1.33	2.67	4.90	1.74	1.42	1.5
Threonine	0.55	0.33	0.60	0.90	0.83	0.46
Total	17.78	10.26	12.54	11.2	12.81	7.3
Non-essential amino acids						
Aspartic acid	3.83	1.07	3.18	4.02	4.89	0.96
Arginine	0.80	0.95	1.64	0.78	2.07	1.53
Serine	1.14	0.36	0.66	1.22	1.14	0.27
Glutamic acid	6.70	1.52	2.89	6.12	6.23	1.39
Proline	0.01	0.18	0.09	0.16	0.44	0.29
Glycine	0.74	1.28	1.92	1.25	1.50	1.35
Alanine	2.49	1.48	1.38	3.36	4.99	0.02
Cysteine	0.0	0.0	0.0	0.0	0.0	0.0
Total	15.71	6.84	11.76	16.91	21.26	5.81

(1854 mg 100 g^{-1}) in *P. monodon*. Karuppasamy et al. (2014) reported a lower range of amino acids in *F. indicus* than *P. monodon* and *Aristeus virilis.* But in the present study, *F. indicus* had all the major amino acids at a higher level than *P. monodon* and the major essential amino acids are in comparable quantity with deep sea shrimp. Banu et al. (2016) evaluated the amino acid content in the muscle of penaeid prawns *Penaeus indicus*, *Penaeus monodon*, *Penaeus semisulcatus*, *Metapenaeus monoceros*, *Metapenaeus dobsoni* and *Litopenaeus vannamei* and reported relatively higher quantities of essential amino acids compared to non-essential amino acids in the muscle tissues in all the species studied. In the present study, all the species except *F. indicus* and *M. andamanensis* have significantly higher quantities of essential amino acids than non-essential amino acids. Akiyama et al. (1997), Rosa & Nunes (2003) and Limin et al. (2006) stated that the amount of amino acid content can vary in fishes by the effect of various factors such as species, size, sexual maturity, food resources, fishing season etc.

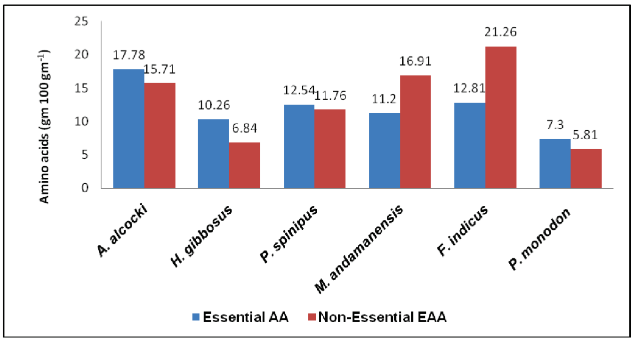

Fig. 1. Comparison of essential and non-essential amino acids (g 100 g^{-1}) in deep sea and coastal shrimp

Major fatty acids present in the muscle of four deep sea shrimp were compared with coastal shrimp *P. monodon* and *F. indicus*, presented in Table 5. Poly-unsaturated fatty acids (PUFA) such as linoleic aicd, arachidonic acid, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) were found significantly higher level than saturated and mono-unsaturated fatty acids in all the species. EPA and

Table 5. Fatty acid composition of shrimp muscle (%)

Carbon No.	Fatty acids	*Aristeus alcocki*	*Heterocarpus gibbosus*	*Plesionika spinipus*	*Metapenaeopsis andamanensis*	*Fenneropenaeus indicus*	*Penaeus monodon*
Saturated fatty acids							
C14	Myristic acid	0.72	1.32	1.82	1.14	1.87	1.25
C15	Pentadecyclic acid	0.73	1.47	0.78	0.83	2.12	1.42
C16	Palmitic acid	10.67	9.72	18.63	17.37	15.28	9.57
C17	Margaric acid	0.71	1.78	1.24	1.01	1.87	1.84
C18	Stearic acid	8.78	7.86	5.65	6.38	10.01	6.62
	Total SFA	21.61	22.15	28.12	26.73	31.15	20.7
Mono-unsaturated fatty acids (MUFA)							
C16:1	Palmitoleic acid	4.82	4.64	3.44	4.63	4.37	3.08
C17:1	Cis-10 Heptadecenoic acid	0.65	0.81	1.24	0.73	0.88	0.88
C18:1	Oleic acid	2.63	3.67	4.53	4.28	3.39	4.11
C20:1	Gadoleic acid	3.62	3.75	2.38	3.47	ND	ND
	Total MUFA	11.72	12.87	11.59	13.11	8.64	8.07
Poly-unsaturated fatty acids (PUFA)							
C18:2	Linoleic acid	8.24	6.49	5.16	5.62	4.31	3.94
C18:3	α-Linolenic acid	ND	0.46	2.57	1.74	2.40	2.87
C20:4	Arachidonic acid	12.51	14.74	11.28	11.59	12.80	20.66
C20:5	Eicosapentaenoic acid	17.23	16.68	15.46	17.18	18.87	26.30
C22:6	Docosahexaenoic acid	28.65	26.56	25.63	23.93	21.77	17.39
	Total PUFA	66.63	64.93	60.1	60.06	60.15	71.16

DHA were found at levels ranging between 15.46 – 17.23% and 23.83 – 28.65% respectively in deep sea shrimp, whereas comparatively higher EPA and lower DHA were found in coastal shrimp muscle as EPA - 26.30 and 18.87% and DHA – 17.39 and 21.77% in *P. monodon* and in *F. indicus* respectively. Among the four deep sea shrimp species studied, *A. alcocki* showed higher EPA (17.23%) and DHA (28.65%) followed by *M. andamanensis* (EPA-17.18%) and *H. gibbosus* (DHA-26.56%). Palmitic acid and stearic acid were the predominant saturated fatty acids and oleic acid and palmitoleic acid were the major mono-unsaturated fatty acids present in the species studied. Lombado et al. (2007) also reported higher EPA and DHA content in fish tissues and stated that both benefit bone formation and metabolism in humans. Palmitic acid was reported as the dominant fatty acid in total saturated fatty acid in the muscle of *Parapenaeus longirostris* (20.27%) and *Plesionika martia* (20.14%) caught from North Eastern Mediterranian Sea (Oksuz et al. 2009). Comparison of saturated fatty acids (SFA), mono-unsaturated fatty acids (MUFA) and poly-unsaturated fatty acids (PUFA) present in the deep sea and coastal shrimp is given in Fig. 2.

Among the deep sea shrimp, meat of *P. spinipus* had a higher amount of palmitic acid (18.63%) followed by *M. andamanensis* (17.37%) and *A. alcocki* (10.67%). The amount of palmitic acid present in deep sea shrimp muscle is comparable with that of coastal shrimp. Among the two species of coastal shrimp studied, *F. indicus* has higher palmitic acid content (15.28%). Yanar & Celik (2005) and Rosa & Nunes (2004) also reported a higher amount of palmitic acid, stearic acid, eicosapentaenoic acid and docosahexaenoic acid in shrimp *A. antennatus*, *P. longirostris*, *P. semisulcatus* and *M. monoceros*. Linoleic acid (8.24%), Arachidonic acid (12.5%), eicosapentaenoic acid (17.23%) and docosahexaenoic acid (28.65%) constitute the major components of poly-unsaturated fatty acids (PUFA) in *A. alcocki.* Oksuz et al. (2009) reported the highest percentage of total poly-unsaturated fatty acids compared to total saturated fatty acid and total mono-unsaturated fatty acid in the edible muscle of *P. longirostris* and *P. martia.* Banu et al. (2016) also reported higher PUFA content in the muscle tissue of penaeid prawns *P. indicus*, *P. monodon*, *P. semisulcatus*, *M. monoceros, M. dobsoni* and *L. vannamei*. The present study agrees with earlier reports which indicate that the tissue of deep sea shrimp have PUFA in comparable amounts to that of coastal shrimp.

Studies on chemical composition will give information on the nutritional value, sensory qualities and shelf life of the seafood products, which help in the application of different technological processes in fish preservation, processing and value added product development. Results of proximate composition of deep sea shrimp and coastal shrimp studied show that deep sea shrimp contain a significant amount of protein such as 22.82% in *H. gibbosus,* 22.33% in *P. spinipus,* 20.74% in *M. andamanensis* and 18.81% *in A. alcocki* whereas protein content in coastal shrimp were estimated as 17.46 and 19.23% in *P. monodon* and *F. indicus* respectively. Higher protein content in muscle of deep sea shrimp

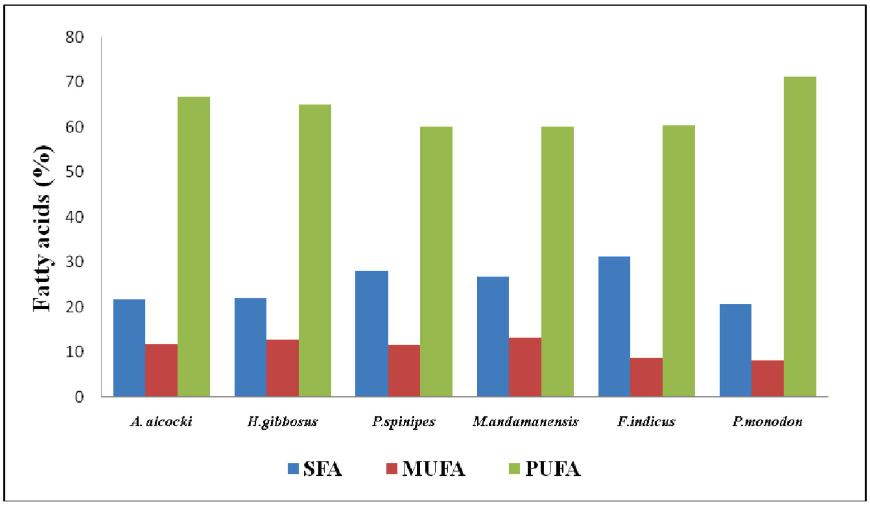

Fig. 2. Comparison of fatty acid composition (%) in deep sea and coastal shrimp muscle

indicates that deep sea shrimp can be a good source of amino acids. Among the species studied, fat content (3.18%) and essential and non-essential amino acids (17.78 and 15.71 g 100 g^{-1} respectively) were found higher in *A. alcocki* than other deep sea and coastal shrimp. The nutritional composition of deep sea shrimp has revealed the presence of a good amount of essential amino acids, minerals and fatty acids in comparable quantity to that of coastal shrimp. These results clearly indicate that all deep sea shrimp selected in the investigation possess a good amount of protein with low fat and high PUFA. Thus these species can be considered as a healthier choice of daily diet for humans.

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