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Comparative Biochemical Composition of Penaeidean shrimps from Chennai Coast, Tamil Nadu, India

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Abstract
The study was conducted to assess the nutritional qualities of Penaeidean shrimps collected along Chennai coast (13° 7' N Lat; 80° 18' E Long) during monsoon season. The species selected were *Solenocera crassicornis*, (H. Milne Edwards, 1837), *Metapenaeopsis stridulans*, Alcock (1905) and *Metapenaeopsis mogiensis*, Rathbun (1902). The species were morphometrically measured and their tissue were analyzed for their comparative proximate (Protein mg/g, Carbohydrate mg/g, Lipid %, Ash % and Moisture %), amino acid compositions (g/ 100g) and fatty acid compositions (g/ 100g) on dry weight basis. All the species showed a significant increase ($p<0.05$) in protein content and the highest was observed in *M. stridulans* (3.09 mg/g) followed by *M. mogiensis* and *S. crassicornis* (2.93 and 1.7 mg/g) respectively. Also, they showed lower lipid content and other proximate compositions varied significantly. Moisture % was 78, 78 and 72 % respectively between species. Amino acid composition showed the presence of all essential amino acids (EAAs) (g/ 100g) and the dominant were histidine, methionine, cystiene, phenylalanine, tyrosine and threonine. Also, fatty acid profiling showed the presence of saturated fatty acids (SFAs), monounsaturated fatty acids (MUFAs) and polyunsaturated fatty acids (PUFAs). PUFAs constituting higher EPA and DHA composition that was significantly higher between the species and *S. crassicornis* showed higher EPA content (3.48g/ 100g). Further the nutritional ratios n-3/n-6, EPA/DHA, DHA/EPA, PUFA/SFA, MUFA/SFA, EPA% and DHA% calculated for the shrimps suggest their nutritional efficiency for human consumption.

Keywords: Penaeid shrimps, proximate composition, EAA, EPA, DHA.

Introduction

Crustacean seafoods including shrimps are considered as the luxurious seafoods for the benefit of human health against many diseases. Shrimps are a group of popular seafoods found worldwide, belonging to the order Decapoda of the class Crustacea. There are about 8,500 species of Decapods **(**HulyaTuran et al., 2011 and Wallace, 1996) including 2,000 shrimp species found and approximately 300 species are of commercial importance. Shell fishes are the exoskeleton bearing aquatic invertebrates used as food and feed. They are excellent sources of high quality proteins that is low in saturated fat and rich in polyunsaturated fats especially the ω-3 fatty acids namely Eicosapentaenoic acid (EPA, C20:5n-3) and Docosahexaenoic acid (DHA, C22:6n-3) that are superior to meat and poultry. Biochemical studies are essential from the nutritional point of view. It is well known that the biochemical composition of the edible tissues of marine invertebrates is influenced by their nutritional habits, age, sex, season and other ecological factors (Oliveira et al., 2007 and Srilatha et al., 2013).

Protein is essential for the sustenance of life and exists in large quantity of all nutrients as a component of human body (Okuzumi and Fugi, 2000). Shrimps are known to be a source of protein rich in essential amino acids (lysine, methionine, cystiene, threonine and tryptophan) (Sikorski, 1994). Essential amino acids (EAAs) play an important role in human nutrition and health promotion. Generally, shellfishes have balanced distribution of EAAs required for an adult per day. Also, aquatic animal fats are good sources of essential fatty acids that cannot be synthesized in the human body and they are required for the maintenance of growth, reproduction and synthesis of vitamins. Carbohydrates are major energy sources in human diet. The ratio of carbohydrates was less when compared to other nutrients like proteins and lipids in animal tissues of aquatic species.

Lipids are the organic resources of the crustaceans. The consumption of omega-3 polyunsaturated fatty acids (PUFA), especially EPA and DHA has both anti-atherogenic and anti-thrombotic effects as well as an

important role in the control of hypertension, reducing the risk of coronary heart diseases, diabetes and cancer (Arts et al., 2001; Bragagnolo and Rodriguez-Amaya, 2001 and Mahaffey, 2004). PUFAs play an important role in the development of the nervous (brain), photoreception (vision) and reproductive systems (Horrocks, 1999). So, the assessment of fatty acid composition in shrimps is proved to be useful for the evaluation of their nutritional contribution to human health. Also, the PUFA/SFA, MUFA/SFA, n-3/n-6, DHA/EPA and EPA/DHA ratios are also used to analyze the nutritional value of fat for the consumers' health (Karuppasamy et al., 2013).

Since the selected species of Chennai coast have limited information on their distribution, species composition and their role in proximate, amino and fatty acid composition which are more important for human health nutritional development. Also, quantitative occurrence of major constituents in these shrimps of wild origin is highly essential from the nutritional point of view.

Materials and Methods

Collection of samples and Preparation of experimental materials:

The samples were collected from the landing centres of Chennai (13° 7' N Lat; 80° 18' E Long) coast during monsoon season. They were transported to the laboratory in ice boxes and were taxonomically identified (Perez Farfante and Kensley, 1997). The selective dominant species were used for further studies on the proximate, amino and fatty acid profiling as *Solenocera crassicornis* (H. Milne Edwards, 1837), *Metapenaeopsis stridulans* (Alcock, 1905) and *Metapenaeopsis mogiensis* (Rathbun, 1902). The exoskeleton and head was removed and the entire body tissue was dried at 55° C (constant temperature) for 24 hours in hot air oven. Then the dried meat was powdered and was taken for the estimation of compositional analysis.

Proximate Analysis:

Moisture (%)

A known quantity of sample (Rajendran, 1973) was dried in a hot air oven at constant temperature of 60° C until the wet sample dried completely. The moisture content (%) was estimated by subtracting the dry weight of the sample from the wet weight of the sample.

Protein (mg/g)

To a known amount of moisture free sample, 4.5 mL of alkaline copper reagent was added and allowed to stand for ten minutes at room temperature. To this 0.5 mL of Folin's phenol reagent was added. After 20 Minutes the absorbance was read at 660nm. The same was done on the standard using BSA. The concentration of protein was estimated by the ratio of OD of sample to the OD of standard (Lowry et al., 1951).

Lipid (%)

Lipid (Folch et al., 1957) was estimated by homogenizing in 20 ml of chloroform-methanol mixture (2:1). The mixture was allowed to filter using Whattman No.1 filter paper and the filtrate wastaken in a 10ml beaker. The weight of the beaker was measured. The sample was kept in water bath at 70° C for evaporation and the weight of the beaker was taken and the % of lipid was calculated.

Carbohydrate (mg/g)

The moisture free sample was used to estimate carbohydrate (Dubois et al., 1956). 1ml of 5% phenol was added followed by 5ml of 95% con.HCl. The mixture is allowed to react for 30 min and the absorbance was read at 490nm. The concentration of carbohydrate was estimated by the ratio of OD of sample to the OD of standard.

Amino acid Analysis (g/100g)

The samples were quantified using HPLC column. The test solution was concentrated to 1.0 mg/ml with a reference solution of mixed amino acids CRS as the mobile phase of concentration 1.0 mg/ml. Separation of amino acids was achieved using octadecylsilyl silica capillary column (size: l=0.10 m, Ø = 4.6 mm) and the mobile phase, trimethylamine R. The flow rate was 1.0-1.5 ml/min (Run time: 90 min). 20 µl of test solution was added and read using spectrophotometer at 220 nm. The amino acid analyses were conducted in triplicate and the results were expressed as the amount (g) of amino acid with respect to total amino acids (Lawrence Evans, 2007).

Fatty acid Analysis (g/100g)

Fatty acids were analyzed using gas chromatography equipped with a flame ionization detector. The separation was achieved using a fused silica capillary column (30 m × 0.25 mm × 0.25 µm film thickness). The oven temperature was set at 170°C for 55 min. The injector and detector temperatures were maintained at 250°C and 280°C, respectively. The carrier gas was hydrogen or helium for chromatography R with a spit ratio of 1/200. Also, the ω-3 fatty acids were determined using differential refractometer. The columns contain estyurene-divinylbenzene copolymer R column (0.3 m × 7.8 mm × 7 µm film thickness). Results were expressed as the amount (g) of each fatty acid with respect to the total fatty acids in 1.5 g of muscle tissue. The fatty acid analyses were conducted in triplicate (Hong Wang, 2007).

Statistical Analysis:

The results obtained were subjected to descriptive statistics and tested using analysis of variance and Duncan's multiple range tests using SPSS version 16 Statistical Package for Windows.

RESULTS AND DISCUSSION

The proximate analysis for the three Penaeid shrimps were analyzed and represented in Table 1. Among these, protein (mg/g), carbohydrate (mg/g), lipid (%) and moisture (%) varied significantly ($p < 0.05$) between the species.

Fig. 1 ***Solenocera crassicornis*** (H. Milne Edwards, 1837)

Fig. 2 ***Metapenaeopsiss tridulans*** (Alcock, 1905)

The present study showed higher protein content in *M. stridulans* (3.09 mg/ g) followed by *M. mogiensis* (2.93 mg/ g). Protein was found as the major constituent in the muscle of shrimps. Also the carbohydrate content was lower in all the species (0.08-0.97%). This study concentrated mainly on the muscular lipid content that is higher (10-13%) between the species. Similar works on the proximate composition in the edible muscle part was reported in *Fenneropenaeus pennicillatus*, *F. merguiensis*, *Parapenaeus longirostris* (Rosa and Nunes, 2004), black tiger shrimp and white shrimp (Sriket et al., 2007) were comparable. The average dry weight of the species correspondingly implies its muscle content constituting carbohydrate, protein, lipids and fatty acids exempting the moisture which varies greatly between species. These discussed results shows that the protein was found as the major constituent in the muscle of all the shrimps.

Amino acid composition (g/100 g in dry weight basis) including Essential Amino Acids (EAA) and Non-Essential Amino acids (NEAA) in different shrimps is evinced in Table 2. The amino acid composition showed the presence of EAA like histidine, methionine, cystiene, tyrosine and threonine. *S. crassicornis* and *M. mogiensis* showed the significant increase in the EAA composition which implies that they are protein rich sources. Maximum EAA recorded was tyrosine which was recorded in *M. mogiensis* (3.81 mg/ g). Also, the species dominated with cystiene and methionine (3.40 mg/g) content equally. The results were differing significantly ($p<0.05$) between the species. Since the species are rich in EAA, so they can be a healthy diet. The major NEAA composition was alanine, glycine, asparagine, aspartic acid and alanine. Thus, comparing between the species, *M. mogiensis* dominated with all the EAA composition followed by *S. crassicornis* and *M. stridulans*.

Fig. 3 ***Metapenaeopsis mogiensis*** (Rathbun, 1902)

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Table.1 Proximate composition (%) of Penaeid shrimps

SPECIES	Protein (mg/g)	Carbohydrate (mg/g)	Lipid (%)	Moisture (%)
Solenocera crassicornis	1.70	0.08	13	72
Metapenaeopsiss tridulans	3.90	0.97	10	78
Metapenaeopsis mogiensis	2.93	0.24	13	78

Table.2 Amino acid composition (g/100g) of Penaeid shrimps

AMINO ACID COMPOSITION (g/100g)			
Amino acids	***Solenocera crassicornis***	***Metapenaeopsiss tridulans***	***Metapenaeopsis mogiensis***
EAA			
Arginine	1.19	0.59	0.91
Histidine	1.21	1.02	3.11
Isoleucine	0.97	0.27	0.95
Leucine	0.98	1.02	0.95
Lysine	1.32	0.97	1.22
Methionine	1.04	0.17	3.40
Cystiene	1.32	0.001	3.40
Phenylalanine	1.02	0.98	1.87
Tyrosine	1.29	0.21	3.81
Threonine	0.92	0.38	2.91
Tryptophan	0.13	0.21	1.21
Valine	1.14	0.91	1.94
ΣEAA	**12.53**	**6.73**	**25.68**
NEAA			
Alanine	1.35	0.90	1.30
Serine	0.39	0.97	0.08
Asparagine	0.28	1.08	2.10
Glycine	1.10	0.18	1.40
Glutamine	1.42	0.21	0.13
Proline	0.39	0.82	0.88
Aspartic acid	0.44	1.21	1.31
Glutamic acid	0.95	0.97	2.93
ΣEAA	**6.32**	**6.34**	**10.13**
EAA/NEAA	**1.98**	**1.02**	**2.53**

According to the table values, the ratios were *S. crassicornis* (1.98), *M. stridulans* (1.02) and *M. mogiensis* (2.53) respectively. Accordingly, (Sriket et al., 2007) the ratio of EAA to NEAA in *P. monodon* was 0.70. Similarly, the ratio for *P. semisulcatus* was reported as 0.60 (Yanar and Celik, 2006). The ratios for *Macrobrachium vollenhovenii* and *Tympanotonus fuscatus* were reported as 1.05 to 1.09. When comparing these results the present study reveals these species as an nutrient supplemental diet.

Fatty acid composition (g/100 g, dry weight) of the three shrimps determined by this study is summarized in Table 3. The fatty acid composition (g/100g) included the SFA, MUFA and PUFA. Significant difference ($p < 0.05$) was observed in saturated fatty acids (SFAs) like palmic, margaric and stearic acid, monounsaturated fatty acid (MUFAs) like oleic acid and polyunsaturated fatty acids (PUFAs) like linoleic, α-linoleic, morotic, EPA and DHA in between the species respectively. All the species showed the presence of essential fatty acids in the edible muscle tissue. Among SFAs, palmic acid and stearic acids were present highly in *M. mogiensis* (6.97 g/ 100g), whereas oleic acid, the major MUFA in the shrimps is more concentrated in the same species (3.53 g/ 100g) followed by *S. crassicornis* (2.02 g/ 100g). PUFA content dominated among all the fatty acids. *M. mogiensis* showed the PUFA content exceeding with linoleic (8.42 g/ 100g), α- linoleic (7.92 g/ 100g) and morotic acid (4.33 g/ 100g). Other shrimps showed lower level but the presence of these fatty acids. The present study is comparable with shrimps of similar studies (Saglik and Imre, 1997; Bragagnolo and Rodriguez-Amaya, 2001; Rosa and Nunes, 2004; Yanar and Celik, 2005; Sriket et al., 2007 and Oksuzet al., 2009). The predominant individual SFA was palmic acid (16:0) while oleic acid (18:1n-9) represented the dominant individual MUFA (Tsape et al., 2010). Also in shrimps (*Parapenaeus longirostris*, *Aristeu santennatus*, *Penaeus semisulcatus* and *Metapenaeus monoceros*) it have been reported that palmic acid (C16:0), stearic acid (C18:0), DHA and EPA were the most abundant fatty acids (Rosa and Nunes, 2004 and Yanar and Celik, 2005). The amount of EPA and DHA resulted as the highest concentration in the shrimp, *S. crassicornis* (3.48 and1.44 g/ 100g).

Table.3 Fatty acid profile (g/100g) of Penaeid shrimps

FATTY ACIDS (g/100g)		*Solenocera crassicornis*	*Metapenaeopsiss tridulans*	*Metapenaeopsis mogiensis*
SFA*	Palmic acid	1.78	1.35	6.97
	Stearic acid	1.92	1.32	5.30
	Margaric acid	0.58	0.09	0.96
MUFA*	Oleic acid	2.02	0.88	3.53
PUFA*	Linoleic acid	1.35	0.64	8.42
	α- Linoleic acid	1.89	0.43	7.92
	Morotic acid	0.20	0.10	4.33
	EPA	3.48	0.20	1.05
	DHA	1.44	0.10	0.97
	n-3/n-6	5.04	1.14	1.18
	EPA/DHA	2.4	2.0	1.0
	DHA/EPA	0.4	0.5	0.9
	PUFA/SFA	1.9	0.5	1.7
	MUFA/SFA	0.4	0.3	0.2
	EPA%	41.6	13.6	4.6
	DHA%	17.2	6.8	4.2

(**SFA***-Saturated Fatty Acid; **MUFA***- Mono Unsaturated Fatty Acid; **PUFA***-Poly Unsaturated Fatty Acid)

Among the species, EPA was more than DHA. Also (Bragagnolo and Rodriguez-Amaya, 2001) for *Xiphopenaeus kroyeri*, (Rosa and Nunes, 2004) for *Aristeus antennatus* and pink shrimp *Parapenaeus longirostris*, by Sriket et al., (2007) for *Penaeus monodon* and *Penaeus vannamei* and by Oksuz et al., (2009) for *Parapenaeus longirostris* and *Plesionika martia* studied the similar fatty acid profile (Karuppassamy et al., 2013). Thus, the present study emphasized on their nutritional composition that is species specific.The ratio of n-3/n-6, EPA/DHA, DHA/EPA, PUFA/SFA, and MUFA/SFA for different species is represented in Table 3. A ratio of 1:1 for n-3/n-6 is considered optimal for nutritional purposes (Simopoulos, 1989). The current study showed the species with the above ratios for *S. crassicornis*, *M. stridulans* and *M. mogiensis* as (5.04, 2.4, 0.4, 1.9 and 0.4; 1.14, 2.0, 0.5, 0.5 and 0.5; 1.18, 1.0, 0.9, 1.7 and 0.2) respectively. The UK department of Health formulated PUFA/SFA ratio for human diet as 0.45, which can be compared with the present result (HMSO, 1994). Also, the ratios were reported for *P. monodon* (1.30, 0.58, 1.25 and 0.57) (Sriket et al., 2007). In a review, (Sofia Miniadis-Meimaroglou and Vassilia Sinanoglou, 2012) reported for *P. vannamei* (1.00, 0.95, 1.18, and 0.61), *F. pennicillatus* (5.0, 1.1, 1.54 and 0.84), *Fenneropenaeus merguiensis* (4.06, 1.16, 1.17, 0.77) and *Aristeu santennatus* (19.5, 0.90, 1.37 and 1.00). Also, the n-3/n-6 ratios of different shrimps obtained were lower than the reported values for brown shrimp (Hulya Turan et al., 2011), *Crangon crangon* (3.31) and other shrimps.

From table 3, all the results of fatty acid composition were highly significant ($p<0.05$) and the % of EPA and DHA was calculated with their total PUFAs and the following results were interpreted. It was compared with earlier studies of Yanar and Çelik, (2005) for *Penaeu ssemisulcatus* and *Metapenaeus monoceros*. PUFA/SFA, n-3/n-6 and EPA/DHA ratios (Simopoulos, 2002) are highly related to the human health since they are used to evaluate the nutritional value of fat and their role in human atherosclerosis. A very low n-3/n-6 fatty acid ratio in human promotes the pathogenesis of many diseases, whereas increased levels of ω-3 PUFA exert suppressive effects.

Thus, a higher ω-3/ω-6 (n-3/n-6) ratio is more desirable to reduce the risk of many of the chronic diseases. A regular consumption of EPA+DHA prevents cardiovascular diseases and neural disorders (Arts et al., 2001). Nutrition recommendations for daily intakes of ω-3 PUFAs (DHA+EPA), ranging from 1.6 g to 0.5 g for healthy adults, infants, pregnant and lactating women have been published by several international scientific authorities (Health and Welfare Canada, 1990; Simopoulos et al., 1999 and British Nutrition Foundation (BNF), 2000). DHA is essential for the growth and functional development of the brain in infants and is also required for the maintenance of normal brain function in adults, while it is taken up by the brain in preference to other fatty acids (Sidhu, 2003 and Horrocks and Yeo, 1999). The deficiency of ω-3 fatty acids in the brain is thought to inducememory, learning impairment, as well as psychological disorders (Lovas, 2006). Thus the study implies the genus Metapenaeopsis and Solenocera representing the above species can be a better source of aqua food for consumption with further nutritional characterization.

CONCLUSION

Thus the present study emphasize on the comparative study of the shrimps that are unexcavated

from nutritional point of view. The species were enriched with nutritional components for healthy living against the invasion of many diseases and can be a better nutrient supplement.

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