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Nutritional composition of penaeidean shrimps along Tamil Nadu, southeast coast of India

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Original Article

Abstract

Nutritional composition of commercial shrimps of wild origin was comparatively studied between *Melicertus canaliculatus*, *Marsupenaeus japonicus*, *Melicertus latisulcatus* and *Solenocera crassicornis* collected along the southeast coast of India. The abdominal muscle tissue were eviscerated and dried in an oven at 60° C, ground and used for the biochemical composition. The species evinced statistically significant difference in their protein, lipid and carbohydrate ($p<0.05$) levels. Higher protein level was observed in *S. crassicornis* (66.9 %) than other species. The amino acid and fatty acid profile study showed the nutritional properties of shrimp as an essential diet for human consumption. The dominating fatty acids were observed in *S. crassicornis* and *M. latisulcatus* and the major Essential Amino Acids (EAA) was observed more in *S. crassicornis, M. japonicus* and *M. canaliculatus*. The ratio of amino acids had higher EAA/NEAA and fatty acid ratio proportionately showed higher Eicosapentaenoic acid (EPA %) and Docosahexaenoic acid (DHA %) respectively. *S. crassicornis* showed 41.6 % and 17.22 % of higher EPA % and DHA % followed by 36.5 % and 16.5 % in *M. canaliculatus* respectively. Other species had higher EPA than DHA.

Keywords: *Protein, essential amino acids, fatty acids, shrimps, PUFA*

Introduction

Fish and shellfish meat is highly nutritious due to the presence of essential amino acids and proteins. The knowledge of amino acids and fatty acids of any edible organism is extremely important since the nutritive value is reflected in the biochemical contents, since they play a vital role in physical growth, development and maintenance of normal body function. The current wave of scientific literature which links diet with the incidence of certain diseases has brought seafood (fish, crustaceans, molluscs) to the attention of the health-conscious public (Hu *et al*., 2002). As the world population is increasing, the per capita consumption of seafood is also increasing rapidly due to its nutritional superiority than all other sources of food. The global market for shrimps and prawns is ever on the increase largely because of high consumption rate. (Gillett, 2008). Shrimps are a group of popular sea foods found worldwide, belonging to the order Decapoda of the class Crustacea. There are about 8,500 species of Decapods (Hulya Turan *et al*., 2011 and Wallace, 1996) including 2,000 shrimp species found and approximately 300 species are of commercial importance. They provide a number of economic purposes including source of food, foreign exchange, income and provision of employment (Akegbejo- Samson, 1997).

Nearly 8.7% of crustaceans landed along the Tamil Nadu coast (62, 121 tonnes) comprising of 36.5% of penaeid prawns and 2.2% of non-penaeid prawns (CMFRI, Annual report 2011- 2012).

Shrimp is an excellent source of protein and it is one of the most popular species of every nation's traditional meal superior to meat and poultry, having high quality of body composition including proteins, fats and amino acids etc., which are the indicators of the existence of good physiological and biochemical conditions. Shrimps are considered important in their overall biomass and represents as an important commercial resource. They are highly nutritive due to the presence of highly essential omega-3 and omega-6 fatty acids (Oksuz *et al.*, 2009 and Hulya Turan *et al.*, 2011). Since these fatty acids cannot be synthesized by human body, it can be inculcated only through diet, and are highly important for the normal brain structure and function and in preventing coronary diseases, diabetes and cancer (Richardson, 2003 and Cengiz *et al.*, 2012). Accordingly these fatty acids are inculcated in appreciable quantities only in seafoods (Gokce *et al.*, 2011) and the PUFA/SFA, n-3/ n-6 and EPA/DHA ratios are analyzed in order to suggest the nutritional value of fat. Shrimps are known to be a source of protein rich in essential amino acids (lysine, methionine, cysteine, threonine and tryptophan) (Sikorski, 1994). Essential amino acids play an important role in human nutrition and health promotion. Since the coastal regions have limited information on the species composition and their role in amino acid and fatty acid composition is restricted to shrimps of wild origin. Thus gaining knowledge on their nutritional profile, *viz.* the proteins, amino acid and fatty acid in shrimps is an important factor in the present human nutrition. With this background, in the present study an attempt was made to study the composition *viz.* proteins, lipids, amino acids, fatty acids and their ratios in the Penaeidean shrimps so that shrimps can be used as a better healthy diet.

Material and methods

Collection of samples and preparation of experimental materials

The fresh shrimps were collected from the landing centres along the southeast coast of Tamil Nadu India in 2013. They were transported to the laboratory in ice boxes and were taxonomically identified according to the manual of Perez Farfante and Kensley (1997) and identified as *Melicertus canaliculatus* (Olivier, 1811), *Marsupenaeus japonicus* (Bate, 1888), *Melicertus latisulcatus* (Kishinouye, 1900) and *Solenocera crassicornis* (Milne Edwards, 1837). These dominant species were selected for biochemical composition on proteins, carbohydrates, lipids, essential amino acids and essential fatty acids (dry weight basis).

Determination of proximate composition

The biochemical compositions including protein (%), carbohydrate (%) and lipid (%) were analyzed following the methods described by Lowry *et al.* (1951), Dubois *et al.* (1956) and Folch *et al.* (1957) respectively.

Determination of amino acid composition

The shrimps were peeled and the muscle tissue were removed, dried in an oven at 60° C for 24 hrs and ground. The amino acids were estimated (g/100g, dry weight basis) using the High Performance Liquid Chromatography (HPLC) (Merck Hitachi L-7400) following the method of Baker and Han (1994). The amino acid analyses were conducted in duplicates and the results were expressed as the amount (g) of amino acid with respect to total amino acids.

Determination of fatty acid composition

Total lipid was extracted from 1.5 g of dried shrimp sample using chloroform: methanol (2:1, v/v; containing BHT 0.1 mg/100 g) method of Folch *et al.* (1957). For determination of fatty acids composition, in order to have more representative samples, lipid extracts from shrimp samples were pooled together for preparation of fatty acid methyl esters (FAME), and two such pooled samples were analyzed. The lipids were trans-methyalated using 2 M methanolic sodium hydroxide followed by 2 M methanolic hydrochloric acid to obtain FAME. FAMEs were analyzed by gas chromatography (Shimadzu GC 2014, Japan) for identifying the individual fatty acids.

FAME dissolved in hexane was analyzed using Omega wax TM 320 fused silica capillary column (30 m $\times$ 0.32 mm $\times$ 0.25 μm). The conditions used for GC analysis was injection temperature of 250°C, detector (FID) temperature of 260°C and column temperature of 200°C for 60 min. The carrier gas was hydrogen or helium for using gas chromatography. The peaks were identified by comparing with authentic standards. Peak areas above 1% of total were only considered for calculation of % composition of fatty acids. The fatty acid (g/100g) analyses were conducted in duplicate.

Statistical analysis

Comparison among species was made by one way analysis of variance (ANOVA) and significance was determined by Duncan' Multiple Range test at 5 % confidence level using SPSS version 16 Statistical Package for Windows.

Results and discussion

Proximate composition

The biochemical composition of the shrimp muscle tissue on dry weight basis is shown in Table 1 and they showed significant ($p<0.05$) variation between the species with higher amount of protein (%) in *S. crassicornis* (66.9 %) followed by *M. japonicus* (40.5 %), *M. latisulcatus* (34.1 %) and the least with *M. canaliculatus* (33.2 %).

The protein level in edible muscles of suggested species in the present study indicates their high nutritive value. High protein content in crustacean species can be attributed to its omnivorous feeding habit. Carbohydrate was significantly higher in *M. japonicus* (17.9 %) and the other species showed no significant variation in their carbohydrate level.

Higher lipid content was observed in *M. latisulcatus* (15.6 %) followed by *S. crassicornis* (10.2 %) and *M. japonicus* (9.10 %). Other species showed no significant level in their lipid composition. Thus the lipid components relating the major essential fatty acids were correspondingly higher in all the species. Protein is essential for normal function, growth and maintenance of body tissues. According to Karuppasamy *et al.* (2013) protein is the major constituent in muscles of all shrimps. Lipid content is considered to be an important tool for the evaluation of physiological standards (Bhavan *et al.*, 2010). Lipids are extremely important in maintaining structural and physiological integrity of membranes. Accordingly Saglik and Imre (1997) showed the lipid study in *Parapenaeus longirostris* (0.93 %) and *P. semisulcatus* (0.58 %) which are lower when comparing with the present lipid composition. The main variation might be due to the changes in their feeding habits and habitats.

Amino acid composition

Amino acid composition (g/100 g in dry weight basis) including Essential Amino Acids (EAA) and Non Essential Amino acids (NEAA) in different shrimps were shown in Table 2 respectively. The major EAA were isoleucine, lysine, methionine, cysteine, tyrosine, leucine, histidine, threonine and arginine in all the species; while the major NEAA were alanine, glycine and glutamine. The limiting amino acids were phenylalanine, tryptophan, valine, serine, asparagine and aspartic acid. *S. crassicornis* showed the presence of major EAAs in higher level as cysteine, lysine (1.32 g), tyrosine (1.29g) and valine (1.14 g) respectively. Arginine, histidine, phenylalanine and tryptophan were more in *M. japonicus* followed by threonine (2.0 g) in *M. latisulcatus*. In *M. canaliculatus*, isoleucine (1.33 g), leucine and methionine (1.23 g) were highly present. All the results showed more significant variation between the species ($p<0.05$).

The presence of NEAA between the species showed a significant variation of alanine dominating in *M. canaliculatus* (1.33 g) and 1.35 g in *S. crassicornis*. Glutamine was equally present in *M. canaliculatus* and *M. japonicus* but higher in *S. crassicornis* (1.42 g). The presence of glycine and proline were seen more in *M. japonicus* (1.20 and 1.21 g) respectively. Other NEAAs were in lesser amount but their presence evinces their nutritional value. Amino acids play an important role in human nutrition and health promotion. The amount of amino acid content varies by intrinsic (species, size, and sexual maturity) and extrinsic factors (food resources, fishing season, water salinity, and temperature) (Akiyama, 1997 and Limin *et al.*, 2006).

Ratio of EAA to NEAA

The ratios of EAA to NEAA were 1.72 (*M. canaliculatus*), 2.17 (*M. latisulcatus*), 2.10 (*M. japonicus*) and 1.98 (*S. crassicornis*) respectively (Table 2). The ratio was higher when compared with the study on *P. monodon, F. indicus* and *A. virilis* and was reported as 0.83, 1.15 and 1.00 (Karuppasamy *et al.* (2013) respectively. Also the work on *P. monodon* (0.70), *P. semisulcatus* (0.60) by Sriket *et al.* (2007) and Yanar and Celik (2006) revealed a higher value from the present study. Thus the ratios of amino acids suggest their higher nutritional value.

Fatty acid composition

Fatty acid composition (g/100 g, dry weight) of different shrimps determined in this study were saturated fatty acids (SFAs) 2.86, 4.37, 2.68 and 4.28 g, monounsaturated fatty acids (MUFAs) 1.31, 1.85, 1.29 and 2.02 g and

Table 1. Proximate analysis (%) of muscle tissue (Dry Matter) of Penaeid shrimps

Proximate Analysis	*Melicertus canaliculatus*	*Melicertus latisulcatus*	*Marsupenaeus japonicus*	*Solenocera crassicornis*
Protein (%)	33.29±1.004 c	34.18±0.706 c	40.50±0.162 b	66.90±0.810 a
Carbohydrate (%)	13.22±0.862 b	12.75±0.588 b	17.94±2.171a	12.48±0.780 b
Lipid (%)	9.67±0.333 b	15.63±0.348 a	9.10±0.379 b	10.20±0.306 b

(Results are the mean value of triplicates ± standard error followed by different superscripts are significantly different along the row at ($p<0.05$) according to Duncan' Multiple Range Test)

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

	Amino Acid Composition (g/ 100g)	Species			
S. No.	Essential Amino acid (EAA)	*Melicertus canaliculatus*	*Melicertus latisulcatus*	*Marsupenaeus japonicus*	*Solenocera crassicornis*
1	Arginine	0.85±0.016 d	0.96±0.012 c	1.36±0.018 a	1.19±0.006 b
2	Histidine	1.19±0.001 b	1.02±0.014 c	1.22±0.002 a	1.21±0.001 ab
3	Isoleucine	1.33±0.023 a	0.98±0.008 c	1.03±0.019 b	0.97±0.010 c
4	Leucine	1.22±0.001a	0.97±0.004 c	1.10±0.001 b	0.98±0.003 c
5	Lysine	0.33±0.009 d	1.03±0.012 c	1.15±0.010 b	1.32±0.014 a
6	Methionine	1.23±0.002 a	1.02±0.001 d	1.19±0.001 b	1.03±0.006 c
7	Cystiene	1.27±0.010 b	0.95±0.019 d	1.21±0.010 c	1.32±0.010 a
8	Phenylalanine	0.32±0.013 d	0.96±0.017 c	1.12±0.011 a	1.02±0.014 b
9	Tyrosine	1.23±0.022 b	0.97±0.012 d	1.05±0.013 c	1.29±0.012 a
10	Threonine	1.14±0.011 ab	2.00±0.576 a	1.32±0.013 ab	0.92±0.013 b
11	Tryptophan	0.12±0.008 b	0.94±0.022 a	0.97±0.012 a	0.13±0.010 b
12	Valine	0.91±0.007 c	0.95±0.020 bc	0.97±0.009 b	1.14±0.013 a
	Non essential amino acid (NEAA)				
13	Alanine	1.33±0.020 a	0.81±0.017 b	0.68±0.293 b	1.35±0.014 a
14	Serine	0.95±0.014 a	0.80±0.017 b	0.28±0.020 d	0.39±0.011 c
15	Asparagine	0.38±0.023 b	0.38±0.026 b	0.51±0.011 a	0.25±0.019 c
16	Glycine	0.96±0.014 c	0.89±0.020 d	1.20±0.020 a	1.10±0.014 b
17	Glutamine	1.35±0.010 b	0.97±0.012 c	1.35±0.012 b	1.42±0.013 a
18	Proline	0.22±0.013 d	0.95±0.010 b	1.21±0.010 a	0.39±0.011 c
19	Aspartic Acid	0.35±0.013 c	0.29±0.011 a	0.92±0.013 a	0.40±0.006 b
20	Glutamic Acid	0.94±0.024 a	0.79±0.007 b	0.36±0.012 c	0.95±0.015 a
	EAA/ NEAA	1.72	2.17	2.10	1.98

(Results are the mean value of triplicates ± standard error followed by different superscripts are significantly different along the row at ($p<0.05$) according to Duncan' Multiple Range Test)

polyunsaturated fatty acids (PUFAs) 4.16, 6.51, 4.68 and 8.36 g in *M. canaliculatus, M. latisulcatus, M. japonicus* and *S. crassicornis* respectively (Table 3). Among the SFAs the dominant were 16:0 (palmitic acid), 18:0 (Stearic acid) and 17:0 (margaric acid). Oleic acid were present as the only MUFA followed by the PUFAs as α-linoleic (18:3n-3), linoleic acid (18:2n-6), EPA (20:5n-3) and DHA (22:6n-3). The predominant individual SFA was palmitic acid (16:0) while oleic acid (18:1n-9) represented the most abundant individual MUFA (Tsape *et al*., 2010; Fatima *et al*., 2012; Tag El-Din *et al*., 2009). PUFA was higher when comparing MUFA and SFA. In shrimps like *Parapenaeus longirostris, A. antennatus, P. semisulcatus* and *Metapenaeus monoceros,* it is reported that palmitic acid (C16:0), stearic acid (C18:0), DHA and EPA were the most abundant fatty acids (Karuppasamy *et al*., 2013) which are similar to the present study.

A significant higher level of linoleic (1.35 g), α-linoleic (1.89 g), EPA (3.48 g) and DHA (1.44 g) acids were observed in *S. crassicornis*. No significant variation was observed in the species *M. latisulcatus* and *M. japonicus* in the PUFA level. Morotic acid was higher in *M. latisulcatus* (0.56 g). The fatty acid result on shrimps suggested by Karuppasamy *et al.* (2013) is revealing fatty acid composition with higher PUFA is highly rich in shrimps. Also the studies by Bragagnolo and Rodriguez-Amaya, 2001; Sriket *et al*., 2007; Yanar Y and Celik, 2005; Saglik and Imre, 1997; Oksuz *et al*., 2009 and Rosa and Nunes, 2004) in shrimps suggests their fatty acid composition in shrimps.

The amount of DHA (C22:6n-3) was higher than EPA (C20:5n-3) in *M. canaliculatus* and *M. japonicus* by the study of Bragagnolo and Rodriguez (2001), in *A. antennatus* by Rosa and Nunes (2004) and pink shrimp, *Parapenaeus longirostris* by Sriket *et al.* (2007) and in *P. monodon, Parapenaeus longirostris* and *Plesionika martia* by Oksuz *et al.* (2009). On comparing the above studies, it is observed that the species studied have more EPA than DHA. PUFA constituting EPA and DHA were found as the major fatty acids in several shrimp species followed by MUFA and SFA (Ouraji *et al*., 2011 and Yanar *et al*., 2011). The results obtained through this study showed similar and certain variations to the findings of the above mentioned studies. The difference may be due to the geographical variation, seasonal conditions and their feeding system.

Table 3: Fatty acid composition (g/ 100g) (dry matter) of Penaeid shrimps

Fatty acid composition (g/ 100g)			Species			
			Melicertus canaliculatus	*Melicertus latisulcatus*	*Marsupenaeus japonicus*	*Solenocera crassicornis*
SFA*	1	Palmitic acid (C16:0)	1.34±0.017 b	1.78±0.017 a	1.30±0.020 b	1.78±0.017 a
	2	Margaric acid (C17:0)	0.08±0.017 c	0.83±0.020 a	0.09±0.017 c	0.58±0.020 b
	3	Stearic acid (C18:0)	1.44±0.017 c	1.75±0.029 b	1.29±0.008 d	1.92±0.020 a
MUFA*	4	Oleic acid (C18:2n-6)	1.31±0.017 c	1.85±0.014 b	1.29±0.023 c	2.02±0.014 a
PUFA*	5	Linoleic acid (C18:2n-6)	0.93±0.020 c	1.23±0.023 b	0.89±0.020 c	1.35±0.020 a
	6	α-Linoleic acid (C18:2n-3)	1.23±0.020 c	1.36±0.020 b	1.18±0.017 c	1.89±0.014 a
	7	Morotic acid (C18:4)	0.07±0.014 c	0.56±0.020 a	0.09±0.023 c	0.20±0.017 b
	8	EPA (C20:5n-3)	1.52±0.014 d	2.33±0.020 b	1.65±0.020 c	3.48±0.020 a
	9	DHA (C22:6n-3)	0.69±0.017 d	1.03±0.020 b	0.87±0.017 c	1.44±0.015 a
	10	Σ (SFA)	2.86	4.37	2.68	4.28
	11	Σ (MUFA)	1.31	1.85	1.29	2.02
	12	Σ (PUFA)	4.16	6.51	4.68	8.36
	13	n3/n6	5.29	3.83	4.15	5.04
	14	EPA/DHA	2.20	2.26	1.89	2.41
	15	PUFA/SFA	1.45	1.45	1.74	1.90
	16	MUFA/SFA	0.45	0.41	0.48	0.46
	17	EPA%	36.53	35.79	35.25	41.62
	18	DHA%	16.58	15.82	18.58	17.22

(Results are the mean value of triplicates ± standard error followed by different superscripts are significantly different along the row at ($p<0.05$) according to Duncan' Multiple Range Test

(SFA*- Saturated fatty acid; MUFA*- Mono unsaturated fatty acid; PUFA*- Poly unsaturated fatty acid)

A regular consumption of EPA+DHA prevents cardiovascular diseases and neural disorders (Arts *et al.*, 2008). 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 (British Nutrition Foundation, 2000; Food and Nutrition Board, 2002; Health and Welfare Canada, 1990; International Society for the Study of Fatty Acids and Lipids, 2004 and Simopoulos *et al.*, 1999).

Ratio of n-3/n-6, EPA/DHA, PUFA/SFA, and MUFA/SFA

The ratio of n-3/n-6, EPA/DHA, PUFA/SFA, and MUFA/SFA for different species was analyzed (Table 3). Accordingly (Simopoulos, 1989), the ratio of 1:1 for n-3/n-6 is considered optimal for nutritional purposes. The ratios were 5.29, 3.83, 4.15 and 5.04 for *M. canaliculatus, M. latisulcatus, M. japonicus* and *S. crassicornis* respectively and it is evincing as a nutrient diet. The % of EPA and DHA was calculated with their total PUFAs and the following results were obtained. The highest EPA and DHA% were observed in *S. crassicornis* (41.62; 17.22%). EPA and DHA percentage of 47.19 and 23.59 respectively were observed in *A. virilis* (Karuppasamy *et al.*, 2013). These observed results were studied for *P. semisulcatus* and *Metapenaeus monoceros* (Yanar and Celik, 2005), for *Parapenaeus longirostris* and *P. semisulcatus* (Saglik and Imre, 1997) and for *P. brasiliensis* and *P. schimitti* (Bragagnolo and Rodriguez-Amaya, 2001) suggesting their nutritional composition in different shrimp species.

The indices of PUFA/SFA are widely used to evaluate the nutritive value of fat for healthy nutrition. PUFA/SFA ratio in human diets is to be above 0.45 according to Alfaia *et al.* (2010) and when analyzing the present result it has 1.45 (*M. canaliculatus, M. latisulcatus*) and 1.74 (*M. japonicus*) and 1.90 (*S. crassicornis*) respectively. The n-3/n-6 ratios of different shrimps obtained were higher than the values reported in the earlier study by Karuppasamy *et al.* (2013) for brown shrimp *Crangon crangon* (3.31) and other shrimps (Hulya Turan *et al.*, 2011). It becomes more critical as the SFA percentage increases. Therefore, a higher ω-3/ω-6 (n-3/n-6) ratio is more desirable in order to reduce the risk of many of the chronic diseases. EPA and DHA may have individually potential function in humans. The present study on wild shrimps which have varying nutritional composition in the essential amino acid, fatty acid composition and n3/n6 ratio suggest that these shrimps can be used as a diet, and their consumption can be increased for global nutrition.

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