Available online at: www.mbai.org.in doi: 10.6024/jmbai.2013.55.2.01783-0x

Comparison of proximate, amino and fatty acid composition of *Penaeus monodon* (Fabricius, 1798), *Fenneropenaeus indicus* (H. Milne Edwards, 1837) and *Aristeus virilis* (Bate, 1881) of Nagapattinam landing centre, Tamil Nadu

P. K. Karuppasamy*, R. Sri Sakthi Priyadarshini, N. Ramamoorthy, R. Sujatha, S. Ganga, T. Jayalakshmi[1] and P. Santhanam[1]

*P.G.and Research Department of Zoology, Periyar EVR College, Tiruchirappalli-620 023, Tamil Nadu, India

[1] School of Marine Sciences, Department of Marine Science, Bharathidasan University, Tiruchirappalli-620 024, Tamil Nadu, India.

*Correspondence e-mail: saams2007@gmail.com

Received: 09 Dec 2013, Accepted: 15 Jan 2014, Published: 15 Feb 2014

Original Article

Abstract

Proximate, amino and fatty acids has been compared between *Penaeus monodon* (Fabricius, 1798), *Fenneropenaeus indicus* (H. Milne Edwards, 1837) and *Aristeus virilis* (Bate, 1881) collected from the Nagapattinam landing centre (south east coast of India). The shrimps showed a significant ($p<0.05$) result and varying concentration of protein, lipid, carbohydrate and moisture. Higher concentration of the major component, protein was found in *A. virilis* (17.25) followed by *F. indicus* and *P. monodon*. The amino acid composition and their ratios evinced shrimp as a nutritional diet in the present study. The essential amino acids that cannot be synthesized in human body are prevailing more in *A. virilis* than the other two shrimps. The fatty acids including saturated fatty acids (SFAs), Mono unsaturated fatty acids (MUFAs) and Poly unsaturated fatty acids (PUFAs) were analyzed. The shrimps have higher concentrations of Eicosapentaenoic acid (EPA) and Docosahexaenoic acid (DHA) and their ratios were estimated. *A. virilis* (47.1% and 23.6% of EPA and DHA was more concentrated with the PUFAs respectively than the other two shrimps. *A. virlis* had 47% of EPA and 23.6% DHA than other two shrimps.

Keywords: *Shrimps, proximate analysis, amino and fatty acids, ratio of EAA, NEAA and fatty acids.*

Introduction

Shrimp is an excellent source of protein and it is one of the most popular species of every nation's traditional meal rich in proteins and minerals, which are superior to meat and poultry. They have a high quality of body composition including proteins, fats and amino acids etc. that are the indicators of the existence of good physiological and biochemical condition. Since the 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. Lipids are the organic resources of the crustaceans. Fats and essential polyunsaturated fatty acids (PUFA) contribute to shrimp' dietary quality and are to their nutritional and sensory values. The consumption of w-3 polyunsaturated fatty acids (PUFA), especially eicosapentaenoic acid (EPA, C20: w-3) and docosahexaenoic acid (DHA, C22:6 w-3) has both anti-atherogenic and anti-thrombotic effects as well as an important role in the control of hypertension, preventing cardiac arrhythmias, reducing the risk of coronary heart diseases, diabetes and cancer. Health problems such as asthma, arthritis, multiple sclerosis, headaches and some kidney disease may also be controlled or alleviated by ω3 fatty acids (Schmidt, 2003; Mahaffey, 2004).

PUFAs play an essential role in the development of the nervous (brain), photoreception (vision) and reproductive systems (Horrocks, and Yeo 1999). The marine phospholipids greatly facilitate the transportation of w-3 fatty acids over the blood-brain barrier and this prohibits the potential problems of w-3 fatty acid deficiency in the brain (Lovas, 2006). So the assessment of fatty acid composition in shrimps is proved to be useful for the evaluation of their contribution to human health. Also the PUFA/SFA, w-3/ w-6 and EPA/DHA ratios are also used to analyze the nutritional value of fat as well as the consumers' health. Shrimps are known to be a source of protein rich in essential amino acids like lysine, methionine, cystiene, threonine and tryptophan (Sikorski, 1994). Essential amino acids play an important role in human nutrition and health promotion.

Very little information is available on the quantitative occurrence of major biochemical constituents and thermal properties in these shrimps and information available in this side has been restricted to shrimps of wild origin (Sriraman and Reddy, 1977; Achuthankutty and Parulekar, 1984), while those from culture ponds have received little attention. With this background in the present study, an attempt was made to evaluate the amount of proximate components like protein, lipid, carbohydrate and moisture; amino acids and fatty acids in the following species of commercial importance.

Material and methods

Shrimps were collected from the landing centre of Nagapattinam (100 460 N lat', 790 500 E long' of southeast coast of landing) during the year 2012. They were transported to the laboratory in ice- boxes and were taxonomically identified according to the characters outlined by Perez Farfante and Kensley (1997). The selective dominant species were used for the proximate, amino and fatty acid profiling. They were *Penaeus monodon* (15-21g) (total weight in grams), *Fenneropenaeus indicus* (12-18.5 g) and *Aristeus virilis* (14.5-15 g).

The shrimps were defrosted, peeled and separated in to the exoskeleton (head and outer body shell) i.e., shell and the endoskeleton (i.e. flesh). The endoskeletons, the muscle tissues were oven dried at 95-105^0 C until dried and ground into fine powder. The fine powder i.e. dry matter was used to analyze the proximate composition, total amino acid (g/100 g) and fatty acid (g/100 g) on a dry weight basis. The proximate analysis includes the estimation of moisture content by hot- air oven method, protein by the method of Lowry *et al.* (1951), carbohydrate by Dubois *et al.* (1956) and lipid content by Folch *et al.* (1957) followed by the amino and fatty acid analysis by Lawrence Evans (2007) and Hong Wang (2007) method, respectively.

Proximate Analysis

The moisture (wg/g) content was estimated by subtracting the dry weight of the sample from the wet weight. Protein (mg/g) was estimated following the method of Lowry *et al.* (1951). Lipid (%) was estimated by the method of Folch *et al.* (1957) and Carbohydrate (mg/g) was estimated by the method of Dubois *et al.* (1956).

Amino acid (g/100g) was determined using Lawrance Evans, (2007) method. 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 on cold rolled steel 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. 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.

Fatty acid content was determined using the Hong Wang, (2007) method. 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 $\times$ 0.25 mm $\times$ 0.25 μm film thickness). The oven temperature was set at 170^{0}C for 55 min. The injector and detector temperatures were maintained at 250^{0}C and 280^{0}C, respectively. The carrier gas was hydrogen or helium for chromatography with a spit ratio of 1/200. The ω-3 fatty acids were determined using differential refractometer. The columns contained styrene-divinylbenzene copolymer column (0.3 m $\times$ 7.8 mm $\times$ 7 μm film thickness).

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

Proximate Analysis

The proximate analysis for the three shrimps were analyzed and represented in Table 1. Among these, the composition of protein (mg/g), carbohydrate (mg/g), lipid (%) and moisture (%) varied between the species.

When comparing the protein and carbohydrate among the shrimps, *A. virilis* had the higher level followed by *P. monodon* and *F. indicus*. Protein was found as the major constituent in the muscle of shrimps. The same difference in the proximate

Table 1. Proximate analysis of shrimps

Proximate Analysis		Species		
		Penaeus monodon	*Fenneropenaeus indicus*	*Aristeus virilis*
Protein	(mg/g)	11.41±0.183b	7.49±0.072c	17.25±0.144a
Carbohydrate	(mg/g)	1.55±0.070c	2.08±0.083b	2.74±0.083a
Lipid	(%)	10.66±0.333b	12.66±0.333a	7.33±0.666c
Moisture	(%)	80.89±0.175a	74.17±1.087b	41.41±0.705c

(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)

composition in the edible muscle part was reported in *F. pennicillatus, F. merguiensis, Parapenaeus longirostris* (Rosa and Nunes, 2004), black tiger shrimp and white shrimp (Sriket *et al*., 2007). In crustaceans the main storage organ for lipids is hepatopancreas (Dall *et al.* 1990). But we in this study concentrated mainly on the lipid content of muscle tissue having higher health factors as the studies of wild shrimps were limited from the Indian waters.

Shrimp consumption is considered healthy for circulating system because of the lack of significant levels of saturated fat in shrimp means that the high cholesterol content in shrimp actually improves the ratio of LDL to HDL cholesterol and lowers triglycerides. The reports on the yield and the chemical composition of body components of some species of shrimps are reported. The results were discussed that the protein was found as the major constituent in the muscles of all the shrimps. The average dry weight of the species was correspondingly implies its muscle content constituting the components like the carbohydrate, protein, lipids and fatty acids exempting the moisture, which varies greatly between species.

All the shrimps had a better amino acid composition (mg/ g) with respect to their protein level. Lipid profile was very high in *F. indicus* (12.66) and *P. monodon* (10.66). In *A. virilis* a low lipid range was seen when comparing the other two (7.33). The moisture was more in *P. monodon* (80.89) and *F. indicus* (74.17) and lesser in *A. virilis* (41.41). *A. virilis* were more protein rich and can be a supplement to the nutritional profile. The lipid composition which relates the fatty acid composition were more in *F. indicus* and *A. virilis* and the results differ significantly ($p<0.05$).

Amino Acid Analysis

Amino acid composition (g/100 g in dry weight basis) including essential amino acid (EAA) and non essential amino acid (NEAA) in different shrimps is evinced in Table 2.

P. monodon had all the amino acid composition (EAA, NEAA) at a higher level followed by *A. virilis*. When comparing the three species a lower range of amino acids was seen in *F. indicus*. Proline was higher in *F. indicus* (1.79) than in *P. monodon* (1.16) and *A. virilis* (1.13). Glycine was higher in all the three shrimps. The values were highly significant at $P<0.05$. The three shrimps, *P. monodon*, *F. indicus* and *A. virilis* had the essential composition and ratios of amino acids that are required for the normal functioning of the body. 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 *et al*., 1997; Limin *et al*., 2006).

The ratios of EAA to NEAA was (0.83) *P. monodon*, (1.15) *F. indicus* and (1.00) *A. virilis* respectively (Table 2). According to Sriket *et al*., 2007, the ratio of EAA to NEAA in *P. monodon* was 0.70 which is lower to our result (0.83). Similarly the ratios 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. The present result agrees with the results from previous studies of different shrimps.

Fatty Acid Analysis

The fatty acid (g/100g) components were saturated fatty acids (SFAs) 0.15, 0.13 and 0.18g, monounsaturated fatty acid (MUFA) 0.03, 0.03 and 0.16g and polyunsaturated fatty acids (PUFAs) 0.52, 0.74 and 0.89 g fatty acids of *P. monodon*, *F. indicus* and *A. virilis* respectively (Table 3).

Among SFAs, palmic acid and stearic acids were equally distributed in the three shrimps, whereas oleic acid, the major MUFA in the shrimps is more concentrated in *A. virilis* (0.16) than the other two shrimps. The PUFA composition had linolenic, ωlinolenic, morotic, eicosapentaenoic acid (EPA, C20:5w-3) and docosahexaenoic acid (DHA, C22:6w-3) as the dominating fatty acids among them. Linolenic acid were more in *F. indicus* (0.08) and *A. virilis* (0.08) followed by *P. monodon* (0.02). All the three shrimps had higher level of ωLinolenic acid (0.13; 0.18 and 0.18) respectively. Morotic acid was higher in *P. monodon* (0.03) and meager in *A. virilis* (0.005) and *F. indicus* (0.003).

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

Amino Acid Composition (g/100g)	Species		
Essential Amino Acid (EAA)	*P. monodon*	*F. indicus*	*A. virilis*
Arginine	2.22±0.026 a	1.70±0.014 b	1.45±0.236 b
Cystiene	0.36±0.017 a	0.31±0.014 a	0.35±0.012 a
Histidine	0.63±0.017 a	0.47±0.015 b	0.53±0.025 b
Isoleucine	0.95±0.017 a	0.72±0.014 c	0.84±0.024 b
Leucine	2.21±0.012 a	1.70±0.014 c	1.96±0.008 b
Lysine	2.31±0.020 a	1.85±0.014 c	2.03±0.023 b
Methionine	0.77±0.008 a	0.54±0.026 c	0.67±0.003 b
Phenylalanine	1.12±0.014 a	0.82±0.014 c	0.95±0.014 b
Threonine	1.35±0.011 a	1.07±0.023 c	1.21±0.011 b
Tryptophan	0.37±0.008 a	0.26±0.014 b	0.34±0.011 a
Tyrosine	1.12±0.014 a	0.82±0.011 c	0.94±0.020 b
Valine	1.36±0.017 a	1.06±0.005 c	1.22±0.011 b
Non Essential Amino Acid (NEAA)			
Alanine	2.30±0.017 a	1.33±0.020 c	2.12±0.014 b
Asparagine	3.51±0.017 a	1.23±0.015 c	2.34±0.020 b
Aspartic acid	2.66±0.015 a	0.97±0.009 c	2.15±0.013 b
Glutamine	2.14±0.020 a	0.93±0.020 c	1.03±0.014 b
Glycine	1.09±0.017 a	0.93±0.020 a	0.67±0.286 a
Proline	1.16±0.013 b	1.79±0.008 a	1.13±0.010 b
Serine	2.93±0.020 a	1.64±0.017 c	2.24±0.020 b
Taurine	2.05±0.013 a	1.03±0.024 b	0.84±0.019 c
EAA/NEAA	0.83	1.15	1.00

(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 3. Fatty acid Composition (g/100g) of shrimps

Fatty acid g/100g		Species		
		Penaeus monodon	*Fenneropenaeus indicus*	*Aristeus virilis*
SFA*	Palmic acid (C16:0)	0.07±0.013 a	0.05±0.011 a	0.09±0.017 a
	Stearic acid (C18:0)	0.08±0.015 a	0.08±0.017 a	0.09±0.012 a
MUFA*	Oleic acid (C18:1n-9)	0.03±0.011 b	0.03±0.014 b	0.16±0.020
PUFA*	Linolenic acid (C18:2n-6)	0.02±0.009 b	0.08±0.020 a	0.08±0.017 a
	ωLinolenic acid (C18:3n-3)	0.13±0.020 a	0.18±0.017 a	0.18±0.017 a
	Morotic acid (C18:4)	0.03±0.011 a	0.003±0.001 b	0.005±0.001 b
	EPA (C20:5w-3)	0.22±0.017 c	0.29±0.017 b	0.42±0.014 a
	DHA (C22:6w-3)	0.12±0.014 b	0.19±0.020 a	0.21±0.017 a
	w-3/w -6	23.5	8.2	1.1
	EPA/DHA	1.8	1.5	2.0
	PUFA/SFA	3.5	5.7	4.9
	MUFA/SFA	0.2	0.2	0.8
	EPA%	42.3	39.1	47.1
	DHA%	23.0	25.7	23.6

(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)

The present study agrees with the fatty acid studies on other shrimps (Rosa and Nunes, 2004; Yanar and Celik, 2005; Sriket *et al*., 2007; Oksuz *et al*., 2009). The predominant individual SFA was palmic acid (C16:0) while oleic acid (C18:1w-9) represented the most abundant individual MUFA (Tsape, 2010 and Li, 2011). Also in several shrimp species (*Parapenaeus longirostris, Aristeus antennatus, P. semisulcatus and M. monoceros*) it is 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 Ceilk, 2005) which are similar to the present study too.

The amount of EPA and DHA were more concentrated in all the three shrimps but the highest concentration was observed in *A. virilis* (0.42 and 0.21) followed by *F. indicus* (0.29 and 0.19) and *P. monodon* (0.22 and 0.12) respectively. The amount of DHA (C22:6w-3) was higher than EPA (C20:5w-3) in species like *F.indicus, Melicertus canaliculatus* and *M.japonicus* according to Bragagnolo and Rodriguez-Amaya, (2001) for Xiphopenaeus kroyeri, by Rosa and Nunes, (2004) for *Aristeus antennatus* and pink shrimp *P. longirostris*, by Sriket *et al*. (2007) for *P. monodon* and *P. vannamei* and by Oksuz *et al*. (2009) for *P.longirostris* and *Plesionika martia*. PUFA were found as the major fatty acids in several shrimp species followed by MUFA and SFA (Bragagnolo and Rodriguez-Amaya, 2001 and Luzia *et al*., 2003). Thus the present study emphasized that the fatty acid composition is species specific. Fatty acid ratios of shrimp muscle can be affected by diet, size, age, reproductive cycle, salinity, temperature, season and geographical location.

The ratio of w-3/w-6, EPA/DHA, PUFA/SFA, and MUFA/SFA for different species is represented in Table 3. The ratio of w-3/w-6 for *A. virilis* was 1.1 and for other two species a higher ratio is obtained (*P. monodon* (23.5), *F. indicus* (8.2)). According to Simopoulos, (1989), a ratio of 1:1 for w-3/w-6 is considered optimal for nutritional purposes. Pigott and Tucker, (1990) suggested that the w-3/w-6 ratio is a better index for comparing the relative nutritional value of fish oils from different species. Sriket *et al*. (2007) reported the ratios for *P. monodon* (1.30, 0.58, 1.25 and 0.57) which was lesser when comparing the *P. monodon* of the present study. In a review by Miniadis-Meimaroglou, (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), *F. merguiensis* (4.06, 1.16, 1.17, 0.77 and *A. antennatus* (19.5, 0.90, 1.37 and 1.00). Also the w-3/w-6 ratio of different shrimps obtained were higher than the reported values by Turan *et al*. (2011) for brown shrimp, *Crangon crangon* (3.31) and other shrimps.

The percent of EPA and DHA was calculated with their total PUFAs and the results full in the range of other shrimps based on the work of Yanar and Çelik (2005) for *P. semisulcatus* and *M. monoceros*, Saglik and Imre (1997) for *P. longirostris* and *P. semisulcatus* and Bragagnolo and Rodriguez-Amaya (2001) for *P. brasiliensis* and *Penaeus schimitti*. PUFA/SFA, w-3/w-6 and EPA/DHA ratios (Simopoulos, 2008) are highly related to the human health since they are used to evaluate the nutritional value of fat and their role in human atherosclerosis. It becomes more critical as the SFA percentage increases. Since many anthropological, nutritional and genetic studies indicate that a very low w-3/w-6 fatty acid ratio in human promotes the pathogenesis of many diseases, including cardiovascular disease, cancer, osteoporosis as well as inflammatory and autoimmune diseases, whereas increased levels of w-3 PUFA exert suppressive effects.

Therefore, a higher w-3/w-6 ratio is more desirable in order to reduce the risk of many of the chronic diseases. Since the human plasma cholesterol level is dependent, not only on the dietary cholesterol concentration, but also on the fat content and fatty acid composition, the determination of these components in shrimp species is necessary (Bragagnolo and Rodriguez-Amaya, 2001). A regular consumption of EPA+DHA prevents cardiovascular diseases and neural disorders (Arts *et al*., 2001).

EPA and DHA may have individually potential roles in the function of the human organs, since EPA-enriched supplements significantly improved psychological distress and depressive symptoms during menopausal transitions and have been suggested as an effective anti-cachexia anti-inflammatory agent (Lucas *et al*., 2009). On the other hand, 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 (Navarro-Garcia, 2004). The deficiency of w-3 fatty acids in the brain is thought to induce memory, learning impairment, as well as psychological disorders (Lovas, 2006).

Shrimps provide an adequate intake of these ω-3 fats thus, improving the w-6 to w-3 fatty acid ratio. The fatty acid composition as well as the MUFA/SFA, PUFA/SFA, w-3/w-6 and EPA/DHA fatty acid ratios varied with species depending on the diet. These differences among species might be associated with the different characteristics of the shrimp species. In this study we imply that shrimps as one of the highly nutritious food when comparing meat and poultry. Thus the present study emphasizes that the three shrimps are nutritionally potent with all the proteins, lipids, amino acids and fatty acids and can be an efficient diet supplement and it can be encouraged for aquaculture under controlled environmental factors.

Acknowledgements

The authors thank the Principal, Periyar E.V.R. College (Autonomous), Tiruchirappalli, Tamil Nadu, India for encouragement and providing facilities for the study. The authors are grateful to the University Grants Commission (UGC), New Delhi, for funding the project (F.No.41-112/2012 (SR), Dated: 12 July, 2012).

References

Achuthankutty, C.T. and A.H. Parulekar. 1984. Biochemical composition of muscle tissue of penaeid prawns, *Mahasagar Bull., National Institute of Oceanography.*, 17: 239-242.

Akiyama, T., I. Oohara and T.Yamamoto. 1997. Comparison of essential amino acid requirement with A / E ratio among fish species (Review Paper). *Fish. Sci.*, 63: 963-970.

Arts, M. T., R.G. Ackman and B.J. Holub. 2001. Essential fatty acids in aquatic ecosystems: a crucial link between diet and human health and evolution. *Can. J. Fish. Aquatic Sci.*, 58, 122.

Bragagnolo, N and D. B. Rodriguez-Amaya. 2001. Total lipid, cholesterol, and fatty acids of farmed freshwater prawn (*Macrobrachium rosenbergii*) and wild marine shrimp (*Penaeus brasiliensis, Penaeus schimitti, Xiphopenaeus kroyeri). J. Food Comp. Anal.*, 14: 359-369.

Dall. W. J. Hill., P.C. Rothlisberg and D.J. Shaples. 1990. The Biology of the *Penaeidae.* Academic press, San Diego. CA. *Advances Mar. Biol.*, 27: 1-489.

Dubois, M., K.A. Gilles., J.K. Hamilton., P.A. Rebers and F. Smity. 1956. Colorimetric method for determination of sugars and related substances. *Anal.Chem.*, 28: 350-356.

Folch, J., M. Lees and G.H.S. Stanley. 1957. A simple method for the isolation and purification of total lipid from animal tissues, *Journ. Biol. Chemi.*, 226: 497-509.

Hong Wang. 2007. (EM205) Excipient Monographs 2USP29-NF24. pp.3383, Pharmacopeial Forum. *US Pharmacopeia.*, 31(3): pp.815.

Horrocks, L.A. and Y.K. Yeo. 1999. Health benefits of Docosahexaenoic acid (DHA). *Pharmac. Res.*, 40(3): 211-225.

Hulya Turan., Yalcin kaya and M. Emin Erdem. 2011. Proximate composition, Cholesterol and Fatty acid content of Brown shrimp (*Crangon crangon* L. 1758) from Sinop region, Black sea. *J. Aquat. Food Prod. Technol.*, 20: 100-107.

Lawrence Evans. 2007. Pharmacopeial Forum, *US Pharmacopeia.*, 30(2): 449.

Limin, L., X. Feng and H. Jing. 2006. Amino acids composition difference and nutritive evaluation of the muscle of five species of marine fish, *Pseudosciaena crocea* (large yellow croaker), *Lateolabrax japonicus* (common sea perch), *Pagrosomus major* (red seabream), *Seriola dumerili* (Dumeril's amberjack) and *Hapalogenys nitens* (black grunt) from Xiamen Bay of China. *Aquacult. Nutr.*, 12: 53-59.

Lovas, E. 2006. Proceedings of the 9th ICPL Congress on Phospholipids, Pecs, Hungary. Lowry, O.H., N.J. Rosebrough., A.L. Farr and R.J. Randall. 1951. Protein measurement with the Folin-Phenol reagents. *J. Biol. Chem.*, 193: 265-275.

Lucas, M., G. Asselin., C. Merette., M.J. Poulin and S. Dodin. 2009. Ethyl-eicosapentaenoic acid for the treatment of psychological distress and depressive symptoms in middle-aged women: a double-blind, placebo-controlled, randomized clinical trial. *Am. J. Clin. Nutr.,* 89(2): 641-651.

Luzia, L.A., G.R. Sampaio., C.M.N. Castellucci and E.A.F.S. Torres. 2003. The influence of the season on the lipid profiles of five commercially important species of Brazilian fish. *Food Chem.*, 83(1), 93-97.

Mahaffey, K.R. 2004. Fish and shellfish as dietary sources of methylmercury and the omega-3 fatty acids, eicosahexaenoic acid and docosahexaenoic acid: risks and benefits. *Environ. Res.*, 95(3): 414-428.

Navarro-García, G., R. Pacheco-Aguilar., L. Bringas-Alvarado and Ortega-Garcia. 2004. Characterization of the lipid composition and natural antioxidants in the liver oil of *Dasyatis brevis and Gymnura marmorata* rays. *Food. Chem.*, 87(1): 89-96.

Oksuz, A., A. Ozyilmaz., M. Aktas., G. Gercek and J. Motte. 2009. A comparative study on proximate, mineral and fatty acid compositions of deep seawater rose shrimp (*Parapenaeus longirostris*, Lucas 1846) and red shrimp (*Plesionika martia*, A. Milne-Edwards, 1883). *J. anim. Vet. Adv.*, 8(1): 183-189.

Perez Farfante, I. and B. Kensley. 1997. Penaeoid and Sergestoid shrimps and prawns of the World. Keys and Diagnosis for the Families and Genera. *Memoires Du Museum National D'Histoire Naturelle*, Paris. 175: 1-223.

Pigott, G. M. and B.W. Tucker. 1990. Seafood: Effects of Technology on Nutrition. Maral Dikker, Inc. p.368

Rosa and L. Nunes. 2004. Nutritional quality of red shrimp, *Aristeus antennatus* (Risso), pink shrimp, *Parapenaeus longirostris* (Lucas) and Norway lobster, Nephrops norvegicus (Linnaeus). *J. Sci. Food. Agric.,* 84(1): 89-94.

Saglik, S. and S. Imre. 1997. Fatty acid composition and cholesterol content of mussel and shrimp consumed in Turkey. *Tr. J. Mar. Sci.,* 3(3): 179-189.

Schmidt, E.B. 2003. Marine n-3 fatty acids and thrombosis (Editorial). *Thromb. Res.*, 111: 9-10.

Sikorski, Z. E., A. Kolakkowska and B.S. Pan. 1990. The nutritive composition of the majorgroups of marine food organisms. In Sikorski, Z.E., (eds). *Seafood Resources, Nutritional composition and preservation*. CRC. Press Florida, pp.29-54.

Sikorski, Z. E. 1994. Charakterystyka białek głownych surowcow zywnos´ciowych. In Chemiczne i funkcjonalne włas´ciwos´ci składnikow zywnos´ci.WN-T, Warszawa.

Simopoulos, A.P. 1989. Summary of NATO Advanced Research Workshop on Dietary n-3 and n-6 Fatty Acids: Biological Effects and Nutritional Essentiality. *J. Nutr.*, 199: 512-528.

Simopoulos, A.P. 2008. The importance of the omega-6/omega-3 fatty acid ratio in cardiovascular disease and other chronic diseases. Review. *Exp. Biol. Med.*, 233(6): 674-688.

Sofia Miniadis-Meimaroglou and J. Vassilia Sinanoglou. 2012. A review on lipid profile and nutritional evaluation of shrimps. *Lipidomics: Sea Food, Marine based dietary supplement, Fruit and Seed.*, 21-40.

Sriket, P., S. Benjakul., W. Visessanguan and K. Kijroongrojana. 2007. Comparative studies on chemical composition and thermal properties of black tiger shrimp (*Penaeus monodon*) and white shrimp (*Penaeus vannamei*) meats. *Food Chem.*, 103: 1199-1207.

Sriraman, K. and P. S. Reddy. 1977. Biochemical studies in planktonic juveniles and adult of *Penaeus indicus* and *Penaeus monodon.* Proc. Symp. Warm Water Zooplankton, Special Publication. NIO, UNESCO. pp.693-699.

Yanar, Y. and Celik, M. 2005. Note. Seasonal variations of fatty acid composition in wild marine shrimps (*Penaeus semisulcatus* De Haan, 1844) and speckled shrimp (*Metapenaeus monoceros* Fabricus, 1789) from the Eastern Mediterranean Sea. *Food Sci. Tech. Int.*, 11(5): 391-395.

Yanar, Y. and Celik, M. 2006. Seasonal amino acid profiles and mineral contents of green tiger shrimp (*Penaeus semisulcatus* De Haan, 1844) and speckled shrimp (*Metapenaeus monoceros* Fabricus, 1789) from the Eastern Mediterranean. *Food Chem.*, 94: 33-36.