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Nutritional Quality of the edible Brachyuran crabs from the Southeast Coast of India

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Abstract

In the present study, nutritional quality (protein, carbohydrate, lipid, amino acids and fatty acids) of edible crabs (*Charybdis natator*, *Charybdis feriata*, *Charybdis lucifera* and *Charybdis reversendersoni*) were studied. According to the results protein and carbohydrate (%) were found to be higher in C. *lucifera* than that of other three species of crabs, as well as lipid contents were highly observed in C. *feriata*. Totally 20 amino acids were found in both species. Among these, 10 were essential amino acids and the remaining non-essential amino acids. C. *lucifera* contributed maximum amount of essential amino acids (9.13 g/100g) followed by *C. feriata* and *C. natator*. On the other hand lower amount of essential and non-essential amino acids were seen in C. *reversendersoni* (7.17 and 6.22 g/100g). The fatty acid profile of the crabs showed the presence of high PUFA and MUFA. *C. lucifera* and *C. reversendersoni* showed the highest PUFA followed by other species. Fatty acids compositions were compared and the results showed *C. lucifera* had high amount of mono unsaturated fatty acid and poly unsaturated fatty acids than the other three types of crabs. The ratio of eicosapentaenoic acid and docosahexaenoic acid showed higher ratio in *C. natator* and *C. feriata*. The results obtained from the present study indicate that *C. lucifera* showed higher nutritional value for healthy diet.

Key words: Nutritional value, Amino acids, Fatty acids, Brachyuran crabs

Introduction

Nutritional benefits from crustacean consumption include high protein content, essential elements, fatty acids and amino acids, as well as low fat and cholesterol contents in the muscle (Sara Barrento *et al*., 2009). In addition, crustaceans are highly appreciated and are considered luxury seafood items. Although their frequent consumption is not advisable in general, either because of allergenic reactions or the supposedly high cholesterol content, there are a growing number of studies promoting crustacean consumption (Rosa and Nunes 2003a; Chen *et al.*, 2007). The marine crabs are one of the valuable seafood items of great demand both in the domestic market and the export industry of India. However, it is economically important in countries such as China, France, Indonesia Japan, Philippines, Spain, Thailand and United States (Manisseri and Radhakrishnan, 2003). The crab fishery in India is fast developing and they are 44586 t landed on 2013-2014. It is ranking after shrimps in crustaceans (CMFRI, 2014).

The commercially important crabs found along southeast coast of India are *Scylla serrata*, *Scylla tranquebarica*, *Portunus sanguinolentus*, *Portunus pelagicus*, *Podopthalamus vigil*, *Charybdis feriata*, *Charybdis lucifera*, *Charybdis natator*, *Charybdis granulata* and *Charybdis truncata* (Johnsamuel *et al*., 2004), while, Charybdis crab species widely distributed in the Indo-Pacific region from Japan and China to Australia in the east, to eastern and southern Africa, Gulf of Oman and Arabian Gulf in the west, encompassing Pakistan, India, Sri Lanka and Indonesia (Ng *et al*., 1998). The most valuable crabs are those harvested in October and November, as they are fully grown and have stored enough energy for the coming winter (Guo *et al*., 2014). Crabs are a large group of invertebrates and due to the high palatability of their meat; they are focus of commercial fisheries (Latyshev *et al*., 2009). Various crab products, including traditional hard shell crab, soft shell crab, canned or refrigerated pasteurized crabmeat and cocktail claws, are consumed worldwide (Sumpton, 2005).

The nutritional quality of the crab proteins show very favorable with that of muscle meat of mutton, chicken, duck, and fish (Newcombe, 1994). Carbohydrates are a group of organic compounds including sugars, starches and fiber, which is a major source of energy for animals. Carbohydrates in fishery products contain no dietary fiber but only glucides, the majority of which consist of glycogen. They also contain traces of glucose, fructose, sucrose and other mono and disaccharides (Okuzumi and Fujii, 2000). The taste, nutritional quality and health benefits of seafood products, including marine crabs is, to a large extend, associated with their essential amino acid (EAA) and these essential fatty acid (EFA) contents (Chen *et al*., 2007). In additionally amino acids are essential nutrients for human growth and for physical functions such as physiology, biochemistry, and immunity (Maria *et al*., 2007). High levels of amino acid may promote the pathogenesis of many diseases, such as crohn's disease (Shoda *et al*., 1996) and inflammatory disease (Gil, 2002).

Lipids are important biochemical components of marine food webs because they are carbon rich and provide a concentrated source of energy (Parrish, 1988) and also lipids are now examined routinely as biomarkers in ecological studies and as tools to understand large-scale oceanographic processes (Budge *et al*., 2006). Marine lipids are also vital nutrients for human health, and declines in seafood stocks (FAO, 2010) are currently threatening food security for human populations on a global scale (Parrish *et al*., 2008). The omega-3 polyunsaturated fatty acids (PUFAs) such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) were believed to be protective for human health in many ways. The consumption of PUFA reduces the risk of coronary heart disease and cancer and thus has both anti-atherogenic, anti-thrombotic effects, control of rheumatoid arthritis and hypertension. It also reduces the risk of diabetes and prevents cardiac arrhythmias (Mahaffey, 2004; Schmidt, 2003; Sidhu, 2003; Simopoulos, 2001). EPA and DHA are also the precursors of several metabolites that are potent lipid mediators, considered by many investigators to be beneficial in the prevention or treatment of several diseases (Serhan *et al*., 2008). PUFAs were mainly acquired from seafood and thus human obtain EPA and DHA by consuming aquatic invertebrates like crustaceans (Schmidt *et al*., 2005).

Many studies have been reported the nutritional quality of different crab species in various parts of the world (Chen *et al*., 2007; Adeyeye, 2008; Antonio Marques *et al*., 2010; Soundarapandian *et al*., 2014). But available data on the nutritional composition of *C. natator*, *C. feriata*, *C. lucifera* and *C. reversendersoni* in Nagapattinam coast are very limited. Therefore, present work aims to determine the comparative nutritional quality (protein, carbohydrate, lipid, amino acid and fatty acid composition) of these marine crabs.

Materials and Methods

Sample collection

The crabs samples were collected from the landing centre of Nagapattinam, (Lat 10˚ 45'N; 79˚ 51E) southeast coast of India, during October, 2013. Adult crabs (20 in nos) were collected and the samples were washed with water to remove contamination. They were transported to the laboratory in ice- boxes. The species were taxonomically identified as *Charybdis natator* (Herbst, 1794), *Charybdis feriata* (Linnaeus, 1758), *Charybdis lucifera* (Fabricius, 1798) and *Charybdis reversendersoni* (Alcock, 1899).

Sample preparation

The crabs were dissected to obtain body and claw meat from all crabs was carefully removed, the edible tissues of each species were pooled and sample was dried in hot air oven at a constant temperature (60°) C until the wet sample dried completely. Then dried sample were homogenized using mortar and pestle to make powder form and stored for biochemical analysis.

Estimation of Proximate composition (%)

In the present study, biochemical composition viz., protein, carbohydrate and lipid content were analyzed by using standard methods. The protein was estimated by Lowry *et al.,* 1951, carbohydrate by Dubois *et al*., 1956, followed by lipid by Folch *et al*., 1957.

Estimation of Amino acid Composition (g/ 100g)

Samples (5g) were used in estimating the amino acids composition using in the HighPerformance Liquid Chromatography (HPLC) (Merck Hitachi L-7400) following the method of Baker and Han, 1994.

Estimation of Fatty acid Composition (g/ 100g)

Total lipid was extracted from (5g) sample using the chloroform: methanol (2:1, v/v; containing BHT 0.1 mg/100 g) method (Folch *et al*., 1957). For determination of fatty acid composition, in order to have more representative samples, lipid extracts from crab samples were pooled together for preparation of fatty acid methyl esters (FAME) and two such pooled samples were analyzed. The lipids were transmethyalated using 2 M methanolic sodium hydroxide followed by 2M 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 Omegawax TM 320 fused silica capillary column (30 m × 0.32 mm × 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. The fatty acid analyses were conducted in triplicate.

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 (Differences were considered to be significant when $p<0.05$).

Results

Proximate compositions of different crabs were shown in table 1. The protein content of *C. lucifera* (37.96%) showed significantly higher ($p<0.05$) than the other three crabs. On the other hand *C. feriata* and *C. natator* contain equal amount of protein (34.78 and 34.13%). Carbohydrates content in *C. lucifera* (1.44%) have been higher than the other Charybdis crabs. At the same time *C. feriata, C. reversendersoni* and *C. natator* showed minimum differences in their composition. According to the present study, lipid content was observed in *C. feriata* (2.75%), *C. reversendersoni* (2.10%), *C. lucifera* (1.32%) and *C. natator* (1.98%) respectively.

The amino acid composition had significant difference ($p<0.05$) between the species (Table 2). *C. lucifera* had high total essential amino acids (EAA) (9.13 g/100g) when comparing others. Dominant EAA in *C. lucifera* was valine (1.03 g/100g), arginine (0.99 g/100g), isoleucine (1.04 g/100g), lysine (0.90 g/100g), histidine (1.04 g/100g) and tryptophan (0.89 g/100g). On the other hand *C. feriata* (8.06 g/100g) and *C. natator* (8.03g/100g) possessed similar EAA composition. The high amount of total NEAA composition was calculated in *C. lucifera* (9.76 g/100g) followed by *C. feriata* (8.38 g/100g), *C. natator* (7.71 g/100g), *C. reversendersoni* (6.22 g/100g). Glycine was recorded equal amount in all species except *C. reversendersoni*. Fatty acid profiles were statistically shown ($p<0.05$) between the species (Table 3). *C. lucifera* also had the SFA such as palmitic acid (4.98 g/100g), stearic acid (10.34 g/100g) and margaric acid (2.34 g/100g). On the other hand *C. reversendersoni* SFA were calculated less amount compare then others. MUFA of oleic acid were dominant in *C. lucifera* (8.54 g/100g) and less amount in *C. reversendersoni* (0.95 g/100g). *C. lucifera* muscle rich in α-linoleic acid (9.33 g/100g), linoleic acid (7.86 g/100g) and morotic acid (2.35 g/100g). This is proportionally more when comparing other three Portunid crabs. Among four species *C. lucifera* had higher EPA and DHA (2.09 and 1.88 g/100g). *C. natator* and *C. feriata* had equal amount EPA and DHA (0.70 g/100g and 0.54 g/100g) respectively.

Discussion

Biochemical studies are very important from the nutritional point of view. The nutritional value of edible tissues of any marine invertebrate is influenced by their nutritional habits, age, sex, season, seawater temperature and salinity (Oliveira *et al*., 2007). The high amount protein content recorded in *C. lucifera* (37.96%) than the other three crabs in the present study. The amount of protein was higher when comparing with the studies of *Portunus sanguinolentus* (Soundrapandiyan *et al*., 2009), *Maja brachydactyla* (Antonio Marques *et al*., 2010) and *Podopthalmus vigil* (Sudhakar *et al*., 2011). Protein is essential for the sustenance of life and accordingly exists as the largest quantity of all nutrients as a component of the human body (Okuzumi and Fujii, 2000).

When comparing four species, carbohydrate content highest in *C. lucifera* and lowest in *C. feriata*. The previous studies suggest that carbohydrate content in *P. vigil*, (Sudhakar *et al*., 2011), in hard and soft shell of *P. sanguinolentus* (Soundarapandiyan *et al*, 2009) were 1.57%; 1.17 and 0.68% respectively. Carbohydrates constitute only a minor percentage of total nutrition composition in all the species and in fishery products contain no dietary fiber but only glucides, the majority of which consist of glycogen (Okuzumi and Fujii, 2000).

Lipids are highly efficient sources of energy and they contain more than twice the energy of carbohydrates and proteins (Okuzumi and Fujii, 2000). *C. feriata* and *C. reversendersoni* had higher amount of lipid (2.75 and 2.10 g/100g). This value suggests that it is good source of low fat seafood comparing with other species. The result showed a higher level than *Portunus pelagicus* (Yongxu cheng *et al*., 2010), *Maja brachytactyla* (Antonio marques *et al*., 2010) and lower level than the *Carcinus mediterraneus* claw meat (Salim Cherif *et al*., 2008). The nutrition composition of edible tissues generally reflects their physiological functions, metabolic needs and available diet (Rosa and Nunes, 2003). Although most of the animal protein for people need is provided from land animals. Nowadays, the tendency of benefiting from seafood for protein supply is increasing rapidly worldwide (Jhaveri *et al*., 1984). Amino acids are the building blocks of protein. Food and tissue proteins contain 20 different amino acids of nutritional importance. Eight of these, threonine, valine, methionine, isoleucine, leucine, phenylalanine, lysine and histidine cannot be synthesized by the human body. They are essential or indispensable nutrients that must be obtained from the diet. The other 10 types, aspartic acid, arginine serine, glutamic acid, glutamine, glycine, alanine, tyrosine proline, taurine, are also supplied ordinarily by daily food intake, and the body can synthesize

Table 1. Proximate composition (%) of Brachyuran Crabs

Proximate composition (%)	*Charybdis natator*	*Charybdis feriata*	*Charybdis lucifera*	*Charybdis reversendersoni*
Protein	34.78±0.02[b]	34.13±0.01[c]	37.96±0.02[a]	30.41±0.05[d]
Carbohydrate	1.04±0.03 [b]	0.75±0.01 [d]	1.44±0.07 [a]	0.92±0.04 [c]
Lipid	1.98±0.03 [c]	2.75±0.02 [a]	1.32±0.01 [d]	2.10±0.03 [b]

Data are the mean values of triplicates sample ± standard deviation

Table 2. Amino acid composition (g/100g) of Brachyuran Crabs

Amino acids (g/ 100g)	*Charybdis natator*	*Charybdis feriata*	*Charybdis lucifera*	*Charybdis reversendersoni*
Threonine	1.03±0.01[a]	1.04±0.02 [a]	0.41±0.05 [c]	0.95±0.03 [b]
Valine	0.85±0.03 [b]	0.89±0.05 [b]	1.03±0.02 [a]	0.85±0.03 [b]
Arginine	0.78±0.01 [c]	0.89±0.02 [b]	0.99±0.03 [a]	0.53±0.02[d]
Methionine	0.78±0.04 [c]	1.08±0.03 [a]	0.90±0.04 [b]	0.95±0.03 [b]
Isoleucine	1.03±0.02 [a]	0.89±0.03 [b]	1.04±0.02 [a]	0.61±0.02 [c]
Leucine	1.12±0.01 [b]	0.45±0.02 [d]	1.03±0.05 [c]	1.47±0.03 [a]
Lysine	0.83±0.02 [a]	0.19±0.03 [b]	0.90±0.07 [a]	0.23±0.04 [b]
Phenylalanine	0.89±0.07 [b]	1.13±0.05 [a]	0.90±0.01 [b]	0.47±0.03 [c]
Histidine	0.03±0.02 [c]	1.04±0.04 [a]	1.04±0.03 [a]	0.62±0.02 [b]
Tryptophan	0.69±0.01 [b]	0.46±0.02 [c]	0.89±0.05 [a]	0.49±0.12 [c]
Total EAA	**8.03**	**8.06**	**9.13**	**7.17**
Aspartic acid	0.33±0.08 [b]	0.44±0.02 [a]	0.34±0.04 [b]	0.21±0.02 [c]
Glutamic acid	1.02±0.03 [b]	1.02±0.02 [b]	1.04±0.01 [b]	1.35±0.02 [a]
Cystiene	0.03±0.02 [c]	1.03±0.02 [a]	1.04±0.01 [a]	0.93±0.07 [b]
Tyrosine	0.99±0.07 [a]	0.99±0.01 [a]	0.99±0.04 [a]	0.22±0.04 [b]
Taurine	0.99±0.02 [a]	0.85±0.04 [b]	0.89±0.05 [b]	0.93±0.05 [a b]
Alanine	0.99±0.01 [a]	0.98±0.01 [a]	0.79±0.02 [b]	0.98±0.02 [a]
Asparagine	1.11±0.04 [a]	1.20±0.03 [a]	1.20±0.03 [a]	0.65±0.08 [b]
Glycine	0.99±0.02 [a]	0.95±0.05 [a]	0.98±0.05 [a]	0.43±0.02 [b]
Proline	0.83±0.03 [b]	0.44±0.04 [d]	0.99±0.05 [a]	0.65±0.05 [c]
Serine	0.43±0.02 [b]	0.50±0.03 [b]	1.50±0.07 [a]	0.27±0.04 [c]
Total NEAA	**7.71**	**8.38**	**9.76**	**6.22**
EAA/ NEAA	**1.04**	**0.96**	**0.99**	**1.15**

Data are the mean values of triplicates sample ± standard deviation

EAA and NEAA represent essential and non-essential amino acids, respectively

Table 3. Fatty acid profile (g/100g) of different Brachyuran Crabs

Fatty acid profile (g/ 100g)		*Charybdis natator*	*Charybdis feriata*	*Charybdis lucifera*	*Charybdis reversendersoni*
SFA	Palmitic acid	1.34±0.03[c]	1.65±0.03[b]	4.98±0.01[a]	1.03±0.05 [d]
	Stearic acid	1.64±0.01 [c]	2.23±0.02 [b]	10.34±0.08 [a]	1.19±0.05 [d]
	Margaric acid	0.34±0.05 [d]	0.78±0.02 [b]	2.34±0.02 [a]	0.63±0.07 [c]
MUFA	Oleic acid	1.22±0.05 [c]	1.33±0.01 [b]	8.54±0.05 [a]	0.95±0.03 [d]
PUFA	α-Linoleic acid	0.99±0.04 [c]	1.04±0.04 [c]	9.33±0.01 [a]	1.89±0.02 [b]
	Linoleic acid	1.43±0.04 [c]	1.65±0.02 [b]	7.86±0.04 [a]	1.24±0.02 [d]
	Morotic acid	0.33±0.02 [d]	0.45±0.07 [c]	2.35±0.03 [a]	0.75±0.02 [b]
	EPA	0.70±0.04 [b]	0.70±0.02 [b]	2.09±0.03 [a]	0.69±0.07 [b]
	DHA	0.54±0.01 [b]	0.54±0.02 [b]	1.88±0.01 [a]	0.47±0.04 [c]
	EPA/DHA	1.29	1.29	1.11	0.47

Data are the mean values of triplicates sample ± standard deviation

SFA, **MUFA** and **PUFA** represent Saturated, Mono unsaturated and Poly unsaturated fatty acids respectively.

EPA and **DHA** represent Eicosapentaenoic and Docosahexaenoic acid respectively them. Therefore, they are nutritionally dispensable or nonessential. They are nevertheless equally as important as the indispensable amino acids for the nutrition of cells and for normal cell and organ function (Harper and Yoshimura, 1993).

From the present study, the amino acid compositions of different crabs were represented. Presence of essential amino acids (EAA) and non-essential amino acids (NEAA) reported in all the species. *C. lucifera* had high amount of total EAA when comparing others. Isoleucine was maximum in *C. lucifera* and *C. natator*. This values were highest than the previous work in *Chionoecetes opilio* (Maria *et al*., 2007). In additionally leucine in *C. reversenersoni* observed higher amount (1.47 g/100g) than the others. Isoleucine and leucine helps to promote healing of muscle tissue, skin and bones. Leucine is recommended for those recovering from surgery, carbohydrate and lipid metabolism and growth hormone production (Shen and Wang, 1990). In *C. natator*, histidine was lower (0.03 g/100g) when comparing other crabs. This value was lower than the previous studies in *Maja brachytactyla* (Antonio marques *et al*, 2010) and *Callinectus sapidus* (kucukgulmez and Celik, 2008) respectively.

Among the various species, *C. lucifera* had significantly higher NEAA than the other three crabs. *C. feriata* contributed maximum and minimum was in *C. reversendersoni* crabs. Tyrosine was equally present in all the crabs except in *C. reversendersoni*. Similar results were recorded in *C. natator* from Parangipettai coast (Soundrapandiyan *et al*., 2014). The ratio of EAA/NEAA calculated in *C. lucifera* has been high (9.76 g/100g) when comparing other Charybdis crabs. Similar pattern were recorded in previous studies by *S. tranquebarica* (Thirunavukkarasu, 2005) and blue crab (Anon, 1999). Protein and amino acid variations may indicate an increase in the biosynthesis of various proteins, including hormones, enzymes, and lipoproteins involved in mating, fertilization and normal development of embryo in decapods (Rosa and Nunes, 2003a).

The human health aspects of eating seafood have primarily been linked to marine lipids because epidemiological studies have evidenced that seafood consumption has a potential protective role against coronary heart diseases, mainly attributed to the effects of long-chain polyunsaturated fatty acids and their cardio protective action (Kris-Etherton *et al*., 2002). In the present study, fatty acid compositions of different crab species were evinced and they showed saturated fatty acids (SFA), mono unsaturated fatty acids (MUFA) and poly unsaturated fatty acids (PUFA). Among SFA, palmitic acid, margaric acid and stearic acids were the three most dominant saturated fatty acids in all the species analyzed. The present result showed the results higher than the studies in green crab *Carcinus mediterraneus* (Slim Cherif *et al*., 2008), shrimp, *Peneaus monodon* (Karuppasamy *et al*., 2014) and the American lobster, *Homarus americanus* (Sara Barrento *et al*., 2009). The PUFA composition had linoleic, α-linoleic, morotic, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) as the dominating fatty acids. Linoleic, α-linoleic acids were more dominated both in *C. lucifera* (9.33 and 7.86 g/100g). The result showed higher level than the previous studies on other crabs (Sudhakar *et al*., 2011, Soundarapandiyan and Rajnish Kumar Singh, 2008).

PUFA from the n-3 series, especially EPA and DHA, have been identified in recent decades as essential nutrients for marine invertebrates (Sargent *et al*., 1999). In crabs, these fatty acids are essential for maturation and reproduction and might be implicated in the molting process (Wu *et al*., 2007). Based on the present results, EPA and DHA level was highly found in *C. lucifera* (2.09 and 1.88 g/100g). It had three times more than the other species. Also the ratio of EPA/DHA showed only minimum variation between the species. It indicated, all species can be suggested as a nutrient rich diet. DHA and EPA have been shown to be beneficial in reducing coronary heart disease (Harper and Jacobson, 2005), cancer (Roynette *et al*., 2004) and PUFA is known to prevent the development of hypertension by reducing cholesterol absorption (Zheng *et al.*, 1999).

Conclusion

This study clearly shows that the two Brachyuran crabs have higher edible values. Among the four edible crabs, the tissue of *C. lucifera* has the highest protein level, a better source of essential and non-essential amino acids. Additionally, it had fatty acids especially EPA and DHA. These indices suggest that the above species is a very healthy diet for human consumption comparing other crabs species and also suitable for processing into different crab products.

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