



BIOCHEMICAL COMPOSITION OF MANGROVE CRAB *SESARMA BROCKII* FROM PONDICHERRY SOUTHEAST OF INDIA

D. Sakthivel, N. Vijayakumar and V. Anandan

Department of Zoology

Kanchi Mamunivar Centre for Post Graduate Studies, Lawspet, Pondichery -605 008

ABSTRACT

Finfish, shellfish and other aquatic organisms suitable for food and feed are of worldwide importance. They are excellent sources of high quality proteins and biochemical composition. The present study deals with biochemical composition of common mangrove crab *Sesarma Brockii*. The proximate composition of protein, carbohydrate, lipid, moisture, ash, amino acids, fatty acids, vitamins and minerals were studied. The results of proximate composition in *S. Brockii* showed the percentage of protein was high 26.1%, followed by the carbohydrate 10.43%, lipid 3.24% moisture 43.69% and ash 16.54%. The total essential amino acids were found to be as 60.03 % and non-essential amino acids were 39.55 %. Among the essential amino acids Methionine were found high as 16.8 % on dry matter basis in crab tissue. The non-essential amino acids Glutamic acid were found maximum as 13.4 % on dry matter basis in crab tissue. In the analysis, the fatty acid profile by gas chromatography revealed the presence of higher amount of SFA (Stearic acid 26.3 %) and PUFA (Stearidonic acid 19.8 %). The details of the vitamins detected in *S. Brockii* tissue. Among them, vitamin A and C were found in higher levels (19.64 & 15.67 mg/g). In the present study, totally 5 macro minerals and 2 trace minerals were reported. The *S. Brockii* body tissue contributed maximum calcium (209.3 mg/g) potassium (115.3 mg/g) of minerals. The result shows that mangrove crab (*S. Brockii*) tissue is a valuable food recipe for human consumption, due to its high quality protein and well-balanced amino acids fatty acids.

Keywords: Mangrove crab, *S. Brockii*, proximate composition, amino acids, fatty acids, vitamins and minerals

INTRODUCTION

Seafood is an excellent source of protein of high biological value. Finfish, shellfish and other aquatic organisms suitable for food and feed are of worldwide importance. They are excellent sources of high quality proteins, superior to those in meat and poultry. Man lives on land, which occupies a quarter of the surface of the planet and takes most of his food from the land. Approximately 14% of the animal protein consumed by human beings comes from marine fisheries [1]. Biochemical assays and nutrients play a vital role on physical growth and development, maintenance of normal body function physical activity and health. The knowledge of the biochemical composition of any edible organisms is extremely important since the nutritive value is reflected in its biochemical contents [2]. The crabs rank third after shrimps and lobsters for their esteemed seafood delicacy and also the value of fishery they support [3]. Shell fish is one of the most important sources of proteins provided from sea and blue crab is one of the most important among them [4]. The crab meats contains many nutrients like vitamins, carbohydrates, minerals and free amino acids many therapeutic properties are attributed to the crab meat and it is used to cure asthma and chronic fever [5].

The crabs are delicious and protein rich in importance next to fishes and molluscs. Their nutritive value can be readily assessed by estimating the levels of protein, carbohydrate and fat in their body tissues [6]. A novel protein was isolated from the seminal plasma of the mud crab, *Scylla serrata*. The biochemical composition of marine crabs was extensively studied, but only limited studies have been done in mangrove crabs. The mangrove crabs, also forms a good source of food and cheap substitute for variety of man requirements such as food for the coastal native people throughout the species range [7]. The ratio of carbohydrates was less when compare to the other nutrients such as proteins and lipids in animal tissues, especially in aquatic animals. Lipids are major sources of metabolic energy and of essential materials for the formation of cell and tissue membranes. They are very important in the physiology and reproductive process of marine animals and reflect the special biochemical and ecological conditions of the marine environment [8].

The biochemical composition of the seminal secretions of crustaceans is highly homologous with vertebrate semen. Recent investigations on the spermatophore-carrying seminal plasma of the brachyuran crabs have indicated the predominance of protein among other components such as carbohydrates and lipids [9]. Crabs proteins are rich in essential amino acids (EAA). Aquatic animal fats are good sources of essential fatty acids that are not synthesized in the human body. Fatty acids in fish oil have a very distinctive character compared to fatty acids from other sources. They consist not only essential fatty acids, but also a significant source of omega-3 fatty acids-especially eicosapentaenoic acid (EPA, C20:5n3) and docosahexanoic acid (DHA, C22:6n3). These fatty acids play a vital role in human nutrition, disease prevention and health promotion. Marine shellfishes are excellent sources of polyunsaturated fatty acids

(PUFA) such as 20: 5n-3 and 22: 6n-3. In recent years, these PUFA have been recognized as effective factors in human health and nutrition, especially for cardiovascular disease [10]. It is important to determine the fatty acid composition of those marine invertebrates have been reported to be rich in other glycerophospholipids including alkenylacyl glycerophospholipids and alkylacyl glycerophospholipids [11].

The fish and fishery products are main sources of animal protein to mankind [12]. Crustaceans especially shrimps, lobsters and crabs are important diet to man with great nutritive value. Shellfishes is a good dietary source of vitamins; water soluble vitamins, B complex and C are present in muscle tissue of seafood at the same level as found in the land animals. Fat soluble vitamins A, D, E and K are present in sea food in varying amounts often in higher concentration than in land animals [13]. Marine crabs form a good source of minerals. The more soluble minerals (Ca, P, Na, K and Cl) are functioning in the maintenance of acid-base balance and membrane potentials [6]. Although some aspects of the biochemical composition of certain haemolymph and tissues of *P. pelagicus* have been investigated [14], a comprehensive study about the major constituents in various tissues and haemolymph at all the maturity stages is yet to be carried out.

As the world population is growing, the per capita consumption of seafood is also increasing rapidly. Because of health consciousness, the modern day man is interested in taking seafood more in view of its nutritional superiority than all other sources of food accessible to him. There remains no considerable study on mangrove crabs with regard to their total nutritive value. Though mangrove crabs are being consumed in coastal people other country and India. Hence, the present work was planned to study the proximate composition of *S. brockii* through estimating their major biochemical components such as total protein, carbohydrate, lipid, moisture and ash content in the body tissue apart from the amino acids, fatty acids profile, vitamins and minerals content.

MATERIALS AND METHODS

Samples of the mangrove crabs, *S. brockii* were collected from the Pondicherry mangrove area of Thengaithittu (Lat.11° 54' 23.1 N, Log 79° 48; 54.7"E) and brought immediately to the laboratory for further studies. The crabs were kept in glass trough in tap water for 24 hours, for emptying and cleaning the gut. The shell were removed and the entire body tissue was dried at 50°C (constant temperature) for 24 hours in the hot air oven. Then, the dried meat was powdered and the required quantity of powder was taken for the estimation of total protein, carbohydrate, lipid, water, ash, amino acids, fatty acids, vitamins and minerals. The Folin-Ciocalteu Phenol method of [15] was adopted for the estimation of total protein in the tissue. The estimation of total carbohydrate content, the procedure of [16] using phenol-Sulphuric acid was followed. The chloroform-methanol extraction procedure of [17] was used for extracting lipid from the various body parts. The moisture content of the bivalve was estimated by drying a known weight (1g) of

bivalve tissue in a hot air oven at 105°C for 24 hrs. The differences in weight before and after drying are the amount of moisture present and the results are expressed in percentage of wet weight of the tissue [18]. The ash content was estimated by burning oven-dried sample in a muffle furnace at 550°C [18]. The experimental samples were finely ground for estimating the amino acids in the HPLC (Merck Hitachi L-7400) following the method of [19]. For fatty acids analysis, the samples were homogenized with chloroform: methanol (2: 1 v/v) mixture and they were extracted using the method of [20]. After fat was extracted, they were esterified with 1% H₂SO₄ and fatty acid methyl esters were prepared by following the procedure of [21]. The identification and quantification of fatty acids was done using Gas Chromatography (Hewlett Packard 5890 model). The fat soluble vitamins A, D, E and K and the water soluble vitamins B₁, B₂, B₆, B₁₂ and C were analysed in the HPLC (Merck Hitachi L-74000) following the method described by [22]. The pyridoxine, pantothenic acid and vitamin B₁₂ were estimated by following methods suggested in USP NF 2000 Asian edition. The minerals were estimated by following the method of [23].

RESULTS

The proximate composition (%) such as protein, carbohydrate and lipid contents of *S. brockii* muscle are presented. The results of the present study revealed that the protein composition were high (26.1%) followed by carbohydrate (10.43%), lipid (3.24%) moisture (43.69%) and ash (16.54%). The percentage compositions of essential and non-essential amino acids are presented in muscle 99.58% (Table 2). The total essential amino acids were found to be as 60.03 % and non-essential amino acids were 39.55 %. Among the essential amino acids Methionine were found high as 16.8 % on dry matter basis in crab tissue. The non-essential amino acids Glutamic acid were found maximum as 13.4 % on dry matter basis in crab tissue.

EAA	% of amino acids	NEAA	% of amino acids
Phenylalanine	2.1	Glycine	8.52
Lysine	9.3	Serine	2.4
Histidine	5.51	Glutamic acid	13.4
Methionine	16.8	Cystine	5.8
Arginine	2.7	Glutamate	4.51
Leucine	10.4	Alanine	0.14
Threonine	4.28	Proline	1.43
Isolucine	2.54	Aspartate	2.26
Valine	3.6	Tyrosin	0.01
Tryptophan	2.8	Aspertic acid	1.08
Total	60.03	Total	39.55

Table 1: Essential and non-essential amino acids of *S. brockii*

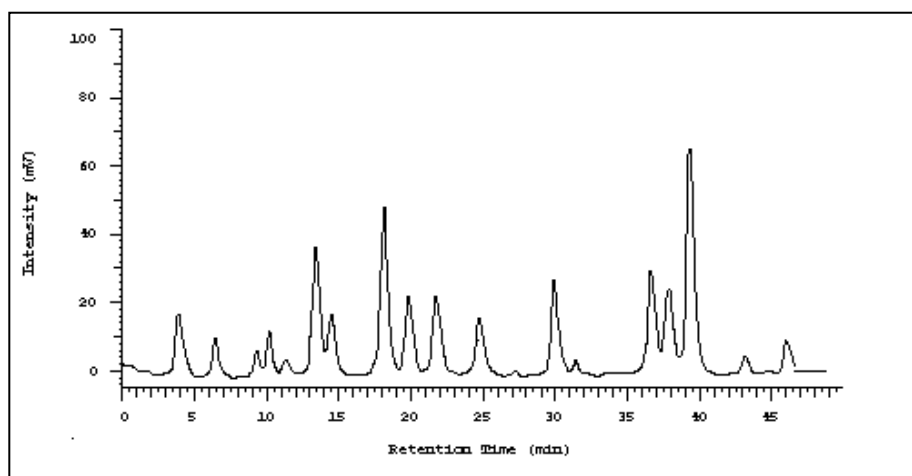


Figure 1: Standard graph for amino acids

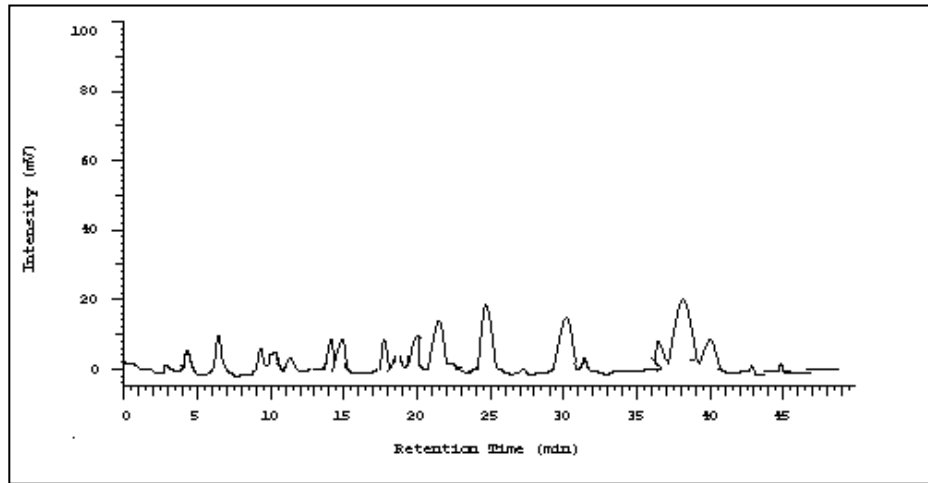


Figure 2: Estimation of essential amino acids from *S. brockii*

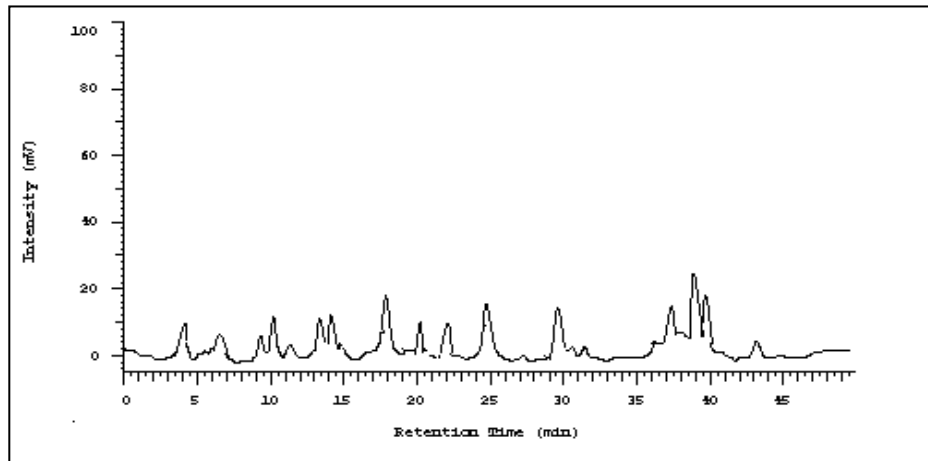


Figure 3: Estimation of non-amino acids from *S. brockii*

In *S. brockii*, 7 different fatty acids were found; they are three saturated fatty acids (SFA), one monounsaturated fatty acids (MUFA) and three polyunsaturated fatty acids (PUFA). Among the SFAs (C18:0) Stearic acid were the major acids. The percentage availability of SFA content was 49.3 % in *S. brockii*. The percentage of MUFA (9.4%) and PUFA (39.4%) contents are estimated (Table 2).

S. No	Fatty acids	Carbon atom (n)	<i>S. brockii</i>
Saturated Fatty Acids (SFA)			
1	Palmitic acid	C16:0	9.2
2	Margaric acid	C17:0	13.8
3	Stearic acid	C18:0	26.3
Total			49.3
Monounsaturated Fatty Acids (MUFA)			
4	Oleic acid		9.4
Total			9.4
Poly Saturated Fatty Acids (SFA)			
5	Linolenic acid	C18:3	11.4
6	α - Linolenic acid	C18:3	8.2
7	Stearidonic acid	C18:4	19.8
Total			39.4
Grand Total			98.1

Table 2: Fatty acid profile of *S. brockii*

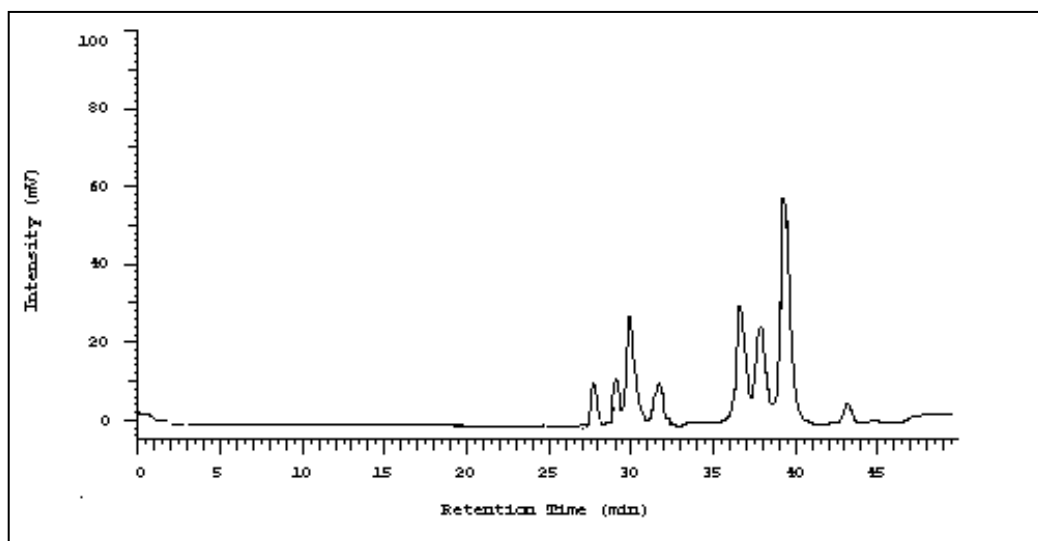


Figure 4:Standard graph for fatty acids

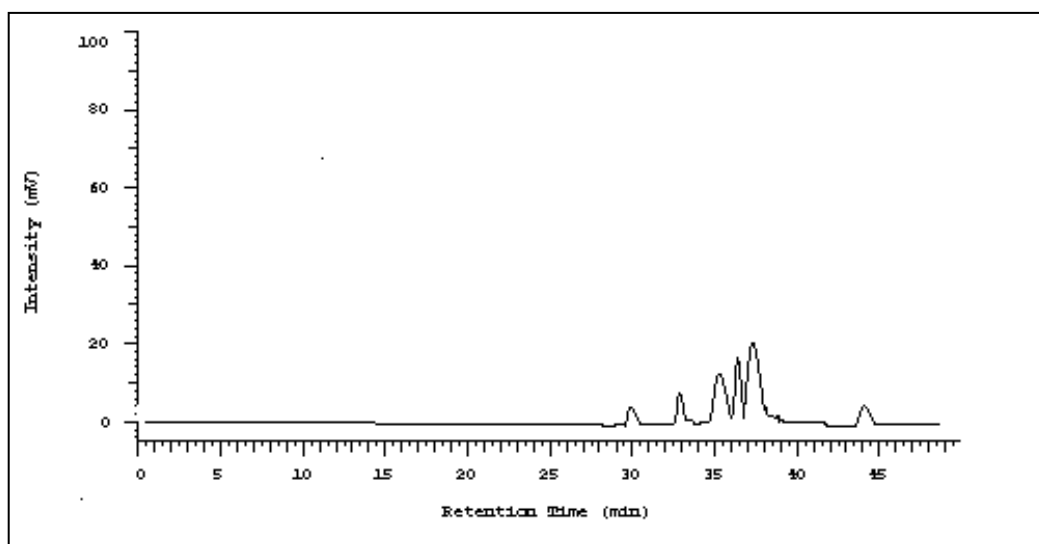


Figure 5:Estimation of fatty acids from *S. brockii*

The details of the vitamins detected in *S. brockii* are presented in Table 3. Among them, vitamin A and C were found in higher levels (19.64 & 15.67 mg/g), whereas vitamin B12 were noticed as lower levels (0.11 mg/g).

S. No	Vitamins	mg/g
1	Retinol (A)	19.64
2	Calciferol (D)	6.28
3	Tocopherol (E)	3.18
4	Vitamin (K)	0.62
5	Pyridoxin (B6)	0.34
6	Cobalamin (B12)	0.11
7	Vitamin (C)	15.67

Table 3:Vitamin content of *S. brockii*(mg/100g of the sample)

The quantity of minerals present in the crab tissue varied significantly. Totally, 5 macro minerals and 2 trace minerals were detected. Among the macro minerals, calcium (209.3 mg/g) potassium (115.3 mg/g) and copper (1.4 mg/g) were observed at higher and lower levels, whereas other macro-minerals sodium and magnesium were in negligible level. The trace minerals such as iron (3.2 mg/g) and zinc (1.67 mg/g) were also detected in this species.

S. No	Minerals	mg/100g
	Macro	
1	Calcium	209.3
2	Sodium	36.4
3	Potassium	115.3
4	Copper	1.4
5	Magnesium	21.8
6	Iron	3.2
7	Zinc	1.67

Table 4:Minerals content of *S. brockii*(mg/100g of the sample)

DISCUSSION

The crab fishery in India is fast developing and there is a vast scope for the crab meat due to its delicacy and nutritional richness. In recent days, crab meat gained global reception and they are extensively fished and marketed in all the maritime states of India and abroad [24]. Protein is essential for the sustenance of life and accordingly exists in the largest quantity of all nutrients as a component of the human body [25]. An increasing demand for good quality animal protein for the exploding population has led to effective and increasing exploitation of the aquatic resources. The acceptability and easy digestibility of crab proteins make it very valuable in combating protein malnutrition, especially in children. The protein of crab has a high biological value with its growth promoting capacity. The present investigation revealed that the maximum level of protein content in *S. brockii* body tissue was 26.1%. [26] Reported that the protein in developing eggs is progressively depleted for the possible utilization of protein during embryogenesis to meet the metabolic energy demand. [7] Noticed the protein values in mangrove crab of *S. brockii* were 29.71%. [27] reported that the protein content was higher in eyestalk ablated crabs ($39.81 \pm 1.83\%$) than those in control crabs ($36.15 \pm 1.22\%$). The protein content of soft shell was found to be 8.33% and hard shell crab was 14.93% in *S. ocanica*, [28]. [29] assessed the protein values in *C. smithii* was 59.8 to 71% in dry matter basis. The protein value in *P. vigil* was 15.75 to 20.16 %. The protein content of *P. pelagicus* and *P. sanguinolentus* was 0.47 to 15.91 % and 12.81 to 13.6 % respectively [30]. This clearly indicated the potential source for the proximate composition for human consumption. The determined in this research showed that mangrove crab *S. brockii* tissue is value food due to high quality protein.

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 [25]. In the present study the percentage of carbohydrates in the body tissue 10.43%. [7] Noticed the carbohydrate values in mangrove crab of *S. brockii* ranged from 19.62 %. The previous studies were suggested that the carbohydrate in the muscle varied from 0.3 to 0.63% in *P. vigil*, [30], 2.4 to 3.4% in *C. smithii* [29], 0.17% in body meat, 0.24% in claw meat of *S. serrata* [31]. Generally the carbohydrate content was found to be high or low when compared to other crabs.

The lipids are highly efficient as source of energy, in that they contain more than twice the energy of carbohydrate and proteins. In the present study lipid content of tissue were 3.24 %. [27] recorded that the lipid content of the control crab ($1.54 \pm 0.07\%$) was higher than eyestalk ablated crabs ($1.81 \pm 0.03\%$). In *P. vigil* the lipid values assessed from 5.13 to 9.73% by [30]. In *Chaceon affinis*, the lipid values were 0.7% [32] blue crab it was 1.5% [33]. [31] Noticed that the lipid content in *S. serrata* from body meat was 1.65% and claw meat was 2.01%. [34] Assessed the lipid values in *S. serrata* with egg (0.43%), without egg (0.7%), body meat (1.07%) and claw meat (1.0%). In crustaceans, lipids are not only the principal organic reserve and

source of metabolic energy, but also indispensable in maintaining cellular integrity. Lipids as a general rule act as major food reserve along with protein.

In the present study moisture and ash content of tissue were 43.69 & 16.52%. [27] observed that the body ash content of the crab was not affected by eyestalk ablation. The range of both control and eyestalk ablated crab 7.83±1.29% to 7.62±0.40%. Similar result has been reported in juveniles of *P. monodon*, [35]. The body moisture content of the present study was 79.15±4.58% and 78.24±3.58%, eyestalk ablated and intact control crabs. The moisture content ranged from 73.5 to 81.8% in body meat, 73.5 to 80.16% in claw meat and 73.23 to 79.6% in leg meat of *S. tranquebarica* [36]. [30] observed comparatively lower moisture values of 69.54 to 74.46% in *P. vigil*. Whereas in *C. affinis* the moisture value was noticed as 80.16 [32]. [37] reported that the ash content of *Acetes* sp. was 19.99±0.03. So mangrove crabs are declared superior over control crabs with reference to nutritive value.

Biological value of protein is obviously reflected upon its essential amino acids concentration. In general, the shellfish have a balanced distribution of all essential amino acids required for an adult per day. The essential amino acids are required for maintenance of life, growth, synthesis of vitamins and reproduction. In the present study body tissue showed the percentage compositions of essential and non-essential amino acids are presented in muscle 99.58%. The total essential amino acids were found to be as 60.03 % and non-essential amino acids were 39.55 %. Among the essential amino acids methionine were found high as 16.8 % on dry matter basis in crab tissue. The non-essential amino acids glutamic acid were found maximum as 13.4 % on dry matter basis in crab tissue. [27] recorded that the total essential amino acids with eyestalk ablated and control crabs were 47.541% and 46.535% respectively. However, the non essential amino acids were 49.126% and 48.65% in eyestalk ablated and control crabs respectively. Leucine (10.334%) was maximum followed by Arginine (9.168%) and lysine (8.117%). In general, the essential amino acids are essential for the animal because the animals not able to synthesize and it should be always through external source in the form of diets. The essential amino acid composition in *S. serrata* was reported by [31]. [33] reported arginine, lysine, leucine and isoleucine in blue crab. [38] recorded amino acids in the following order arginine, leucine, lysine, valine, isoleucine, threonine, phenylalanine, methionine and histidine in *S. tranquebarica*. [36] reported non essential amino acids in the following order: Glutamic acid, aspartic acid, alanine, glycine and serine in *S. tranquebarica*. In the present study, mangrove crabs have noticed high value of EAA methionine in tissue. The mangrove crabs have a balanced distribution of all essential amino acids required for an adult per day. This study clearly demonstrates that these mangrove crabs can be well used as the potential source of amino acid by all sections of people to do away with malnutrition.

In *S. brockii*, 7 different fatty acids were found; they are three saturated fatty acids (SFA), one monounsaturated fatty acids (MUFA) and three polyunsaturated fatty acids (PUFA). Among the SFAs C18:0 Stearic acid was the major acids. The percentage availability of SFA content was 49.3 % in *S. brockii*. The

percentage of MUFA (9.4%) and PUFA (39.4%) contents are estimated. [37] reported that the heptaenoic acid (8.43%) was maximum followed by myristic acid (7.58%) and palmitic acid (5.97%) and pentadecanoic acid (1.62%) was minimum in *Acetes* sp. fed crabs; the total monounsaturated fatty acids contents were found to be higher in *Acetes* sp. fed crabs (3.62%) than in clam meat fed crabs (3.20%); The total polyunsaturated fatty acids content were also higher in *Acetes* sp. fed crabs (11.16%) than in clam meat fed crabs (9.95%). In blue crab the saturated fatty acids contributed 19.07% [39]. [40] obtained 0.48 and 0.70% of total monounsaturated fatty acids both normal and eyestalk ablated crabs in *C. lucifera*. In the present study, body tissue showed the dominance of saturated fatty acid, Stearic acid (26.3%) are major acid were found. The *S. brockii* tissue could be a better alternative source (against bactericidal effect), since it contains Saturated fatty acids. The results of the present study provide not only the information about the fatty acid composition but also recommended the consumption of this wedge clam *S. brockii* since they are rich in Stearic acid. It could also be added that the consumption of mangrove crab is a nutritional assurance to millions of malnourished hungry people. The malnutrition problem in our country can be overcome by effective utilization of nutrient rich crab seafood.

Vitamins are organic chemical compounds essential for promoting growth, reproduction and maintenance of normal body health and function. [1] stated that the flesh of fish and shell fish flesh in nut considered to be important sources of vitamin A while high of at fishes and shell fish (e.g. eel, mackerel and bivalve) contain moderate amounts. In the present study, vitamin A and C were found in higher levels (19.64 & 15.67 mg/g), whereas vitamin B12 were noticed as lower levels (0.11 mg/g). The fat soluble vitamins like vitamin A, on the other hand, are stored in the liver and the body can draw upon the stored vitamin to meet its daily requirements periodical administration of a larger doses of the fat soluble vitamins can therefore meet the daily requirements. These mangrove crabs covered in the present study showed complete vitamin A profile as the levels required from good health.

Marine organisms form a good source of minerals. Ash is left out after complete combustion of fish meat and gives a measure of the total mineral content. Totally, 5 macro minerals and 2 trace minerals were detected. Among the macro minerals, calcium (209.3 mg/g) potassium (115.3 mg/g) and copper (1.4 mg/g) were observed at higher and lower levels, whereas other macro-minerals sodium and magnesium were in negligible level. The trace minerals such as iron (3.2 mg/g) and zinc (1.67 mg/g) were also detected in this species. [27] contributed that the hard shell crabs, calcium (2.028 mg) was maximum and zinc (0.445 mg) was minimum. In soft shell crabs also calcium (1.022 mg) was maximum and zinc was minimum (0.457 mg). [41] explained the importance of Ca, Mg, and K in the human nutrition. [42] reported that sea foods in general are excellent sources of I, Ca, P, Na, Fe, Zn and oysters are good sources of Fe and Cu. Minerals in different species of pearl shells from South China Sea were rich, particularly in Ca, P and Zn contents [43]. Shellfish can absorb minerals directly from the aquatic environment through gills and body surface. In the present study mangrove crab tissue showed higher level of calcium (209.3 mg/g) potassium (115.3 mg/g) good source of

minerals.

Large crustaceans are becoming increasingly important to coastal, continental shelf, fisheries and seafood's. In general, seafood is one of the most nutritionally balanced foods. The seafood diet helps to control weight and goes a long way towards preventing heart diseases. Studies on amino and fatty acid composition of commercial seafood in India are limited particularly in mangrove crabs. This might be due to lack of awareness on benefits of these nutrients particularly from mangrove crab tissue. The nutritional values of mangrove crab are not brought to the limelight so far, so consumption of these nutrient rich mangrove crabs has not attracted attention. The results of the present study provide information about the amino acids and fatty acid composition, but also suggest the consumption of this mangrove crab tissue. It is rich in amino acids (methionine), fatty acids (Stearic acid). Further, the presence of protein, amino acids (methionine), fatty acids (Stearic acid), vitamin A & C and minerals calcium & potassium in *S. brockii* tissue adds more value through the possibility. From the above observation it is clear that the body tissue of *S. brockii* with rich nutritive value can be used for alternate source as a regular sea food which supplies nutrients for the growing children, pregnant women and people suffering from malnutrition.

REFERENCES

1. Pigott, G M. and B W. Tucker, 1990. Seafood: Effects of Technology on nutrition, Marcel Dekker, Inc., New York and Basel, 362 pp.
2. Nagabhushanam, R. and V H. Mane, 1978. Seasonal variation in the biochemical composition of *Perna viridis* at Ratnagiri on the West Coast of India. *Hydrobiologia*, 57(3): 69-72.
3. Mohammed Savad, A. and P. Rajeev Ragavan, 2001. Mud crab-culture and fattening techniques, status and prospects. *Seafood Export Journal*, 32(11): 25-29.
4. Enzenross, R, L. Enzenross and F. Bingel, 1997. Occurrence of blue crab, *Callinectes sapidus* (Rathbun, 1896) (Crustaceae, Brachyura) on the Turkish Mediterranean Adjent Aegean Coast and its size distribution in the Bay of Iskenderun. *Turkish J. Zool.*, 21: 113-122.
5. Raja, S, 1981. The edible crab *Scylla serrata* and fishery in indo-pacific region. A review. *M.Sc. Dissertation*, Annamalai University India, pp: 113.
6. Sudhakar, M, 2011. Biodiveristy, resources, nutrition status and shell utilization of crabs from cuddalore coast, southeast coast of India. *PhD thesis*, Annamalai University, 230p.
7. Kannupandi, T, G. Vijayakumar and P. Soundarapandian, 2003. Yolk utilization in a mangrove crab

Sesarma brockii . *Indian J. Fish.*, 50(2): 199-202.

8. Sargent, J R, 1995. Origins and function of egg lipids nutritional implications. In; Bromage. N. R. R. J. Roberts. (Eds), *Broodstock Management and Egg and Larval Activity*. Black Well Sciences, 353-372.
9. Jayasankar, V, 1996. Biochemical studies on the seminal secretions of the mud crab *Scylla serrata* (Forsk.) (Decapoda: Portunidae), with special reference to protease and glycosidase activities. *PhD thesis* submitted to the University of Madras, India.
10. Bruckner, G, 1992. Fatty acids and cardiovascular diseases: In: Fatty acids in foods and their health Implications Chow, C. K. (Eds) New York: Marcel Dekker, 35-52.
11. Dembitsky, V.M, 1979. Plasmalogens in phospholipids of marine invertebrates, *Biol. Moray.*, 5: 86-90.
12. FAO, 2012. Statistics reported in this section are based on data from the Food Balance Sheets published in FAO yearbook.
13. Periyasamy, N, 2012. Biochemical, Antimicrobial and Anticoagulant Potential of *Acanthochitona Mahensis* (Winckworth, 1927) (Polyplacophora: Acanthochitonidae) From Tranquebar, *MPhil thesis* Southeast Coast of India. 69 pp.
14. Siddiqui PJA, Akbar Z and Qasim R. Biochemical composition and calorific values of the three edible species of Portunid crabs from Karachi. *Pale. J Sci Ind Res* 1987; 30: 119-121.
15. Lowry, O H, N J. Rosebrough, A L. Farr and R J. Randall, 1951. Protein measurement with the tolin phenol reagent. *J. Biol. Chem.*, 193: 265-273.
16. Dubois, M , K A. Giller, J K. Hamilton, R A. Roberts and F. Smith, 1956. Colorimetric method for determination of sugars and related substances. *Analyt. Chem.*, 28: 350-356.
17. Floch, J, M. Lees and G.H. Sloane-Stanley, 1956. A simple method for the isolation and purification of total lipids from animal tissues. *J. Biol. Chem.*, 226: 497-509.
18. AOAC, 2000. Association of Official Analytical Chemists Official Methods of Analysis. (17th ed.). W. Hortuntzed (Ed), Washington.
19. Baker, D H. and Y. Han, 1994. Ideal amino acid profile for broiler chicks during first three weeks post hatching. *Poult. Sci.*, 73: 1441-1447.
20. Bligh, E G. and W J. Dyer, 1959. A rapid method for total lipid extraction and purification. *Can.J.Biochem. Physiol.*, 37: 911-917.

21. AOAC, 1995. *Official Methods of Analysis*, 16th Ed., Association of Official Analytical Chemists, Washington, DC.
22. Sadasivam, S and A. Manickam, 1996. *Biochemical Methods*. 2nd Edition, New Age International (p) limited, Publishers, 179-186.
23. Guzman, H M. and C E. Jimenez, 1992. Concentration of coral reefs by heavy metals along the caribbean coast of central Africa (costarica and panama) *Mar. Poll. Bull*, 24(11): 554-561
24. Rao, P V, M M. Thomas and G S. Rao, 1973. Crab Fishery Resources of India. Proceeding of Symposium on Living Resources of the Seas around India, pp: 581-591.
25. Okuzumi, M and T. Fujii, 2000. Nutritional and Functional Properties of Squid and Cuttle Fish 35th Anniversary of Commemorative Publication, 223pp.
26. Kannupandi, T, T. Krishnan, P. Soundarapandian and A. Shanmugam, 1999. Yolk utilization in an estuarine edible crab *Thalamita crenata* (Latreille). *Indian J. Fish.*, 46 (3): 289- 294.
27. Sudhakar, M , K. Manivannan, P. Soundarapandian and G. Ananthan, 2009. Effect of Unilateral Eyestalk Ablation on the Biochemical Changes of Edible Portunidae Crab *Portunus sanguinolentus*; *East Journal of Scientific Research* 4 (3): 153-157.
28. Anil, M K and C. Suseelan, 2001. Experimental fattening of the green mud crab *Scylla oceanica* prespectives mariculture, Book, pp: 95-110.
29. Balasubramanian, C P and C. Suseelan, 2001. Biochemical composition of the deep water crab *Charybdis smithii*. *Indian J. Fish.*, 48(3): 333-335.
30. Radhakrishnan, C K and R . Natarajan- 1979. Nutritive value of the crab *Podophthalmus vigil* (Fabricius). *Fish Technol.*, 16: 37-38.
31. Prasad, P N. and B. Neelakantan, 1989. Proximate and essential amino acid composition in edible crab *Scylla serrata*. *Comp. Physiol. Ecol.*, 14(1): 34-37.
32. Vasconcelos, P and N R. Braz, 2001. Proximate composition of the deep-sea crab, *Chaceon affinis* from an exploratory fishery off Maderi island (Portugal - Eastern Central Atlantic). Northwest Atlantic Fisheries Organization. pp: 1- 6.
33. Anon, 1999. Results from the USDA, nutrient database for standard reference crustaceans, Crab. blue, cooked, moist head. Blue crab-nutrition html., pp: 1-3.

34. George, C. and K. Gopakumar, 1987. Biochemical studies on crab *Scylla serrata*. Fish. Tech., 24: 57-61.
35. Sriraman, K. and P S. Reddy, 1977. Biochemical studies in planktonic juveniles and adults of *Penaeus indicus* and *Penaeus monodon*. Proc. Stm. Wat. Zooplankton, Spec. Publ., NTO/UNESCO, pp: 693-699.
36. Thirunavukkarasu, N, 2004. Biology, nutritional evaluation and utilization of mud crab *Scylla tranquebarica* (Fabricius, 1798). Ph.D. Thesis, Annamalai University, India, pp: 126.
37. Manivannan, K, M. Sudhakar, R. Murugesan and P. Soundarapandian, 2010. Effect of Feed on the Biochemical Composition of Commercially Important Mud Crab *Scylla tranquebarica*; *International Journal of Animal and Veterinary Advances* 2(1): 16-20.
38. Khan, P A, 1992. Biochemical composition, minerals (calcium and iron) and chitin content of two portunid crabs *Scylla serrata* Forskal and *Portunus pelagicus* Linnaeus available in and around the coastal regions of Bangladesh. *M.Sc. Thesis*, Institute of Marine Sciences, Chittagong University. pp: 112.
39. Anonymous, 1999. Results from the USDA, nutrient database for standard reference crustaceans. Crab. Blue, Cooked, Moist Head. Blue Crab-Nutrition html, pp: 1-3.
40. Murugesan, R, P. Soundarapandian and K. Manivannan, 2008. Effect of Unilateral Eyestalk Ablation on the Biochemical changes of edible portunid crab *Charybdis lucifera* (Fabricius). *J. Fish. Aqua. Sci.*, 3(1): 82-86.
41. Rajagobal, S, P S. Lyla and S. Ajmalkhan, 1993. Seafood the nutritional insurance. *Seafood Exp. J.*, 45-46.
42. Devadas, R, 1994. Foods of aquatic origin in human nutrition and their importance in the Indian context. *Symposium on Nutrients and Bioactive Substances in Aquatic Organisms*. Cochin, India 16-17 September. 177-194.
43. Laihao, L, D. Shigians, C. Peigily, W. Xiangiang, Yanyan and W. Maojiar, 1999. Evaluation on nutrition components of pearl shell meat. *J. Fish. China*, 23(4): 392-397.