



## NUTRITIONAL STATUS OF SWIMMING CRAB *PORTUNUS SANGUIOLENTUS* (HERBST, 1783)

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**Abstract:** The nutritional data of swimming crab *Portunus sanguinolentus* were analyzed through the proximate composition, amino and fatty acid profile, vitamin and mineral contents. *Portunus sanguinolentus* has 28.45% of protein and 8.77%, of fat. Sixteen fatty acids were found in the crab and of them, eicosapentaenoic acid was the biggest component (13.4 mg/100g). Lignoceric acid was in low quantity (0.03 mg/100g). Around twenty amino acids were found in the crab, and of them, 10 were essential amino acids and the other 10 were nonessential ones. Of the amino acids arginine was the largest constituent (1.93 mg/100g) and taurine was found in the minimum concentration (0.17 mg/100g). A total of eleven major minerals were observed and of them, calcium, magnesium, sodium, potassium, and iodine were present in higher amounts. Of these minerals, calcium (218.8 mg/100g) was observed as a major element. The present study concluded that the nutritional facts of *P. sanguinolentus* encourage an increased utilization of this crab species in larger amounts.

**Keywords:** *Portunus sanguinolentus*; proximate composition; amino acid; fatty acids; vitamins; minerals.

### INTRODUCTION

Marine food has traditionally been a popular diet in many parts of the world and in some countries it constitutes the main supply of animal protein. From the nutritional point of view, seafood such as finfishes, crustaceans, and mollusks are considered as very valuable food items. They contain a high percentage of easily digestible animal protein. Seafood also contributes sizably to the national economy and foreign exchange earnings of many developing maritime countries. In South East Asia, India is the largest exporter of seafood with a big share of 25.75%. The other important exporters are the European Union (22.02%), the US (19.17%), Japan (14.09%), China (7.06%), the Middle East (4.39%) and other countries (7.51%) (MPEDA, 2012). The Indian marine ecosystems display a rich diversity. India has an extensive coastline of 8,118 km, with an Exclusive Economic Zone (EEZ) of 2.02 million sq. km and a continental shelf area of 468,000 sq km. India is bestowed with multispecies and multi-sector marine fisheries resources, India has a total annual fish production of around 3.16 million tons (CMFRI, 2010). Crustaceans like shrimps, lobsters, and crabs contribute 16% of the total marine fish production,

of which the share of crab fishery is 9.6%. Crabs support a sustainable fishery of appreciable importance, although they occupy the third position as a delicacy after shrimps and lobsters (Mohammed and Rahavan, 2001). The marine crab fishery is supported mostly by the edible crabs belonging to the family Portunidae represented mainly by *Portunus pelagicus*, *P. sanguinolentus*, *Charybdis* spp. etc. (Rao *et al.*, 1973). Along the Indian coasts, *P. pelagicus*, *P. sanguinolentus*, and *S. serrata* are the commercially important crabs. Of the portunids, three spotted crab, *Portunus sanguinolentus* is commercially one of the important species of crabs caught in moderate quantities all along the coast throughout the year and is generally caught as a by-catch in shrimp trawling. Usually, crabs are exported as live crabs, frozen whole crabs, chilled whole crabs, frozen cut-leg crabs and crab meat products (Ramesh Kumar *et al.*, 2009).

In the Indian scenario, the consumer mostly prefers the big-sized mud crabs, viz., *S. tranquebarica* and *S. serrata*. They are exported to South East Asian countries in live conditions. Because of their delicacy and larger size, the live mud crabs are always in great demand and fetch high prices both in the national

and international markets (Kathirvel, 1993). But swimming crabs, both *P. pelagicus* and *P. sanguinolentus* are exported mostly in the frozen and canned forms. The natural availability of mud crabs is restricted to some seasons only. However, the swimming crabs (*P. sanguinolentus* and *P. pelagicus*) are abundant throughout the year.

The knowledge of the chemical composition of any edible organism is extremely important since its nutritive value is reflected in its biochemical contents. A seafood species should be recommended for human consumption only after assessing the nutritive value of the species with regards to its nutritional merits. Even though large numbers of marine crabs are suitable for human consumption, our knowledge of their nutritive value is fragmentary. A great number of studies, in different parts of the world, have examined the proximate composition of different crab species viz., *Carcinus maenus* (Skonbrg and Perkins, 2002), *P. pelagicus* (Akbar *et al.*, 1988), queen crab, *Chionoecetes opilio* (Zafar *et al.*, 2004), *C. longimanus* (Anil and Suseelan, 2001) deep water crabs, *M. simithi* and *Chaceon affinis* (Vasconcelos and Braz, 2001), *Mesopodopsis slabberi* (Azeiteiro *et al.*, 2001), *S. tranquebarica* (Manivannan *et al.*, 2010), *Eriocheir sinensis* (Chen *et al.*, 2007), *C. lucifera* (Murugesan *et al.*, 2008) and molted *P. sanguinolentus* (Sudhakar *et al.*, 2009). But only limited data are available on the proximate composition of the crab *Portunus sanguinolentus* of Tuticorin coastal area. The aim of the present study is to determine the proximate composition and estimate the content levels of fatty acids, amino acids, vitamins and mineral of the crab *P. sanguinolentus* of Tuticorin coast.

## MATERIALS AND METHODS

### Sample collection

Healthy *P. sanguinolentus* crabs (Fig. 1) with a weight of 95 -135 g and carapace width of 57 - 88 cm were bought from the fishing harbour, (9° 20-25 N 79° 5-10 E). The collected samples were taken immediately and transferred to the laboratory in an ice box. The animals were dissected for harvesting the tissues (Fig. 2) which were then kept in a hot air oven and dried at 50 - 60° C. Care was taken to dry the tissues uniformly. The dried samples were weighed and powdered for the estimation of biochemical

components and the values were expressed in percentage of dry weight.

### Biochemical analysis

The moisture content of the sample was analyzed by drying the samples in a hot air oven (AOAC, 1995). The protein and lipid contents of *Portunus sanguinolentus* were determined according to the method of Lowry *et al.*, (1951) and Folch *et al.*, (1957). Total Carbohydrate was estimated by the phenol-sulphuric acid method of Dubois *et al.*, (1956). The ash content was determined according to AOAC (2005) by keeping the sample in pre-weighed porcelain crucible placed in a muffle furnace at 550° C for 6 hours.

### Fatty acid

For fatty acid analysis, the samples were homogenized with chloroform-methanol mixture (2:1 v/v) and the fatty acids were extracted using the method of Bligh *et al.*, (1995). After extraction, they were esterified with 1% H<sub>2</sub>SO<sub>4</sub> and fatty acid methyl esters were prepared by following the procedure of AOAC (1990). The quantification was done by the method described by Candela *et al.*, (1996) with a slight modification. Peaks were identified by comparing their retention time with those of standard mixtures (Sigma Chemical Co., St. Louis, USA, 99% purity specified for GC).

### Amino acid

The amino acid profile of the sample was determined using the method described by Baker and Han (1994). The samples were dried to a constant weight, defatted (so as to remove the non-polar component of the sample), and hydrolyzed with 7ml of 6 N HCl for 22 hours at 110°C. After hydrolysis, the acid was evaporated using a rotatory evaporator. The residue was treated with 1 ml of sodium citrate-perchloric acid sample diluents (pH 2.20). It was filtered through a 0.2µm filter and used for amino acid analysis employing HPLC (Agilent 1100 Series HPLC Value System).

### Minerals

The mineral contents were determined quantitatively by atomic absorption spectrophotometer method (Agilent 200 series AA) (AOAC, 1995).

### Vitamins

The contents of the vitamins were determined by High-Performance Liquid Chromatography (Agilent



**Fig. 1.** *Portunus sanguinolentus*



**Fig. 2.** Edible tissue of *Portunus sanguinolentus*

**Table 1.** Biochemical composition of *Portunus Sanguinolentus*

Parameters	<i>Portunus Sanguinolentus</i>
Moisture (%)	79.43 ± 0.64
Protein (%)	28.45 ± 1.21
Lipid (%)	8.77 ± 0.06
Carbohydrate (%)	8.12 ± 1.18
Ash (%)	12.34 ± 0.25

**Table 3.** Amino acid composition of *Portunus sanguinolentus*

Amino acids	Composition (mg/100g)
Aspartic acid (NEAA)	0.52
Serine (NEAA)	1.22
Histidine (EAA)	0.78
Tyrosine (NEAA)	1.12
Valine (EAA)	0.27
Threonine (EAA)	1.54
Taurine (NEAA)	0.17
Alanine (NEAA)	1.21
Asparagine (NEAA)	0.25
Proline (NEAA)	0.55
Glycine (NEAA)	0.83
Glutamic acid (NEAA)	0.92
Arginine (EAA)	1.93
Cystine (NEAA)	0.76
Methionine (EAA)	1.62
Isoleucine (EAA)	0.62
Leucine (EAA)	0.82
Phenyl alanine (EAA)	0.61
Tryptophan (EAA)	1.7
Lysine (EAA)	0.92

**Table 2.** Fatty acid composition of *Portunus sanguinolentus*

Fatty acids	Composition (mg/100g)	Carbon atom
Myristic acid (SFA)	1.9	14:00
Palmitic acid (SFA)	9.6	16:00
Margaric acid (SFA)	12.9	17:00
Stearic acid (SFA)	7.5	18:00
Arachidic acid (SFA)	1.18	20:00
Behenic acid (SFA)	1.2	22:00
Lignoceric acid (SFA)	0.03	24:00:00
Palmitoleic acid (MUFA)	4.6	16:1 n-7
Oleic acid (MUFA)	6.78	18:1 n-9
Linoleic acid (PUFA)	0.8	18:2 n-6
±- linolenic acid (PUFA)	8.8	18:2 n-3
Linolenic acid (PUFA)	4.9	18:03
Stearidonic acid (PUFA)	12.3	18:04
Morocotic acid (PUFA)	0.41	C18:4 n-3
Eicosapentaenoic acid (PUFA)	13.4	20:5 n-3
Docosahexaenoic acid (PUFA)	11.9	22:6 n-3

**Table 4.** Mineral content of *Portunus sanguinolentus*

Minerals	Composition (mg/100g)
Calcium	218.8
Magnesium	65
Iron	4.44
Phosphorus	3.9
Sodium	54.6
Potassium	59.43
Copper	0.52
Manganese	0.132
Zinc	2.33
Chromium	0.75
Iodine	18.23

1100 Series HPLC Value System) as described in Ball (1996).

## RESULTS

The biochemical compositions of the crab *P. sanguinolentus* are shown in Table 1. The moisture content was the maximum with a percentage of 79.43. The proteins formed the second dominant content (28.45%) followed by ash and lipids with their values at 12.34 % and 8.77% respectively. Carbohydrate contributed the least with 8.12%.

The fatty acid compositions of *P. sanguinolentus* are presented in Table 2 & Fig. 4. A total of 16 different fatty acids were found, and of them, seven were saturated fatty acids (SFA), two monounsaturated fatty acids (MUFA) and seven polyunsaturated fatty acids (PUFA). Of the saturated fatty acids margaric acid (12.9 mg/100g) was the largest constituent followed by palmitic acid (9.6 mg/100g), stearic acid (7.5 mg/100g), myristic acid (1.9 mg/100g), behenic acid (1.2 mg/100g), arachidic acid (1.18 mg/100g) and lignoceric acid (0.03 mg/100g). The monounsaturated fatty acids such as the palmitoleic acid (4.6 mg/100g) and oleic acid (6.78 mg/100g) were present in *P. sanguinolentus*. Of the polyunsaturated fatty acids eicosapentaenoic acid (13.4 mg/100g) was the major component followed by stearidonic acid (12.3 mg/100g), docosahexaenoic acid (11.9 mg/100g),  $\alpha$ -linolenic acid (8.8 mg/100g), linolenic acid (4.9 mg/100g), linoleic acid (0.8 mg/100g) and moroctic acid (0.41 mg/100g).

A total of ten essential amino acids were observed (Table 3 & Fig.3) and of them, arginine was the

largest constituent (1.93 mg) followed by tryptophan (1.7 mg), methionine (1.62 mg) and threonine (1.54 mg). The remaining essential amino acids such as lysine (0.92 mg), leucine (0.82 mg), histidine (0.78 mg), isoleucine (0.62 mg), phenylalanine (0.61 mg) were also observed. The content of valine was the lowest in the body tissues (0.27 mg). The non-essential amino acids observed in the crab are presented in Table 3. Of them, serine was the largest component (1.22 mg/100g) followed by alanine, tyrosine, glutamic acid, glycine, cysteine, proline, aspartic acid, asparagine, and taurine.

The mineral contents of the crab are presented in Table 4. The minerals such as calcium, magnesium, iron, phosphorus, sodium, potassium, copper, manganese, zinc, chromium and iodine were observed and of them, calcium (218.8 mg/100g) was the predominant element. The concentrations of Mg, K and Na were also high in the crab meat, their average values were 65, 59.43 and 54.6 mg/100g respectively. Copper was detected in traces (0.52 mg).

The values of vitamins detected in *P. sanguinolentus* are: vitamin C (11.08 mg/100g), A (13.45 mg/100g), D (4.11 mg/100g), E (4.23 mg/100g), K (0.59 mg/100g), B1 (0.16 mg/100g), B2 (0.12 mg/100g), B6 (0.32 mg/100g), B12 (0.19 mg/100g), Folic acid (1.66 mg/100g), Niacin (5.1 mg/100g) and pantothenic acid (0.22 mg/100g) and they are shown in Table 5. Of the vitamins, vitamin A and C had high content (13.45 & 11.08 mg/100g) whereas vitamin B2 had a low presence (0.12 mg/100g).

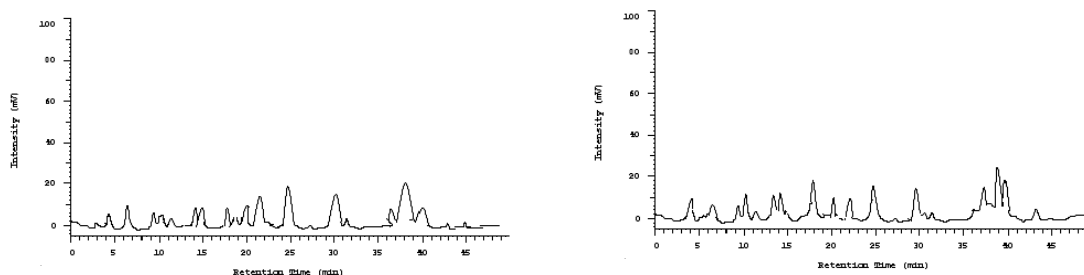
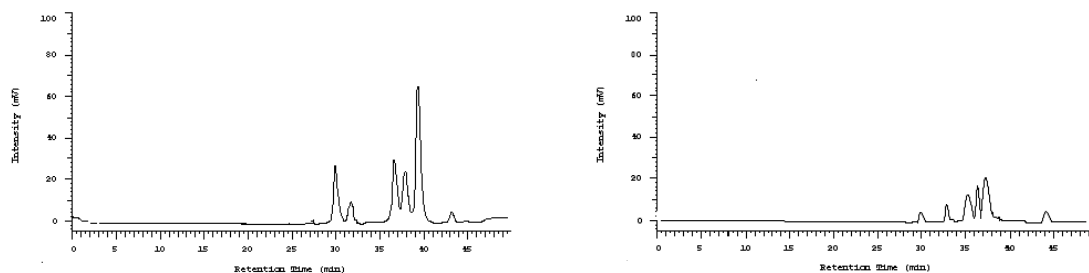


Fig. 3. Aminoacid composition of *Portunus sanguinolentus*



**Fig. 4.** Fatty acid composition of *Portunus sanguinolentus*

**Table 5.** Vitamin content of *Portunus sanguinolentus*

Vitamins	Composition (mg/100g)
Vitamin C	11.08
Vitamin A (Retinol)	13.45
Vitamin D (Calciferol)	4.11
Vitamin E (Tocopherol)	4.23
Vitamin K	0.59
Vitamin B1	0.16
Vitamin B2	0.12
Vitamin B6 (Pyridoxin)	0.32
Vitamin B12 (Cobalamin)	0.19
Folic acid	1.66
Niacin	5.1
Pantothenic acid	0.22

## DISCUSSION

Biochemical studies are very important from the nutritional point of view. Biochemical constituents in animals are known to vary with season, size of the animal, stage of maturity, temperature and availability of food etc. The moisture content of *Portunus sanguinolentus* was found to be a major component (79.43%) and this finding is supported by other studies. Srinivasagam (1979) found that in European green crabs the moisture content ranged from 79.1 to 82.30 %. In the crab *Carcinus maenas*, the moisture value was 79.0% (Skonberg and Perkins, 2002). These values are close to the findings of the present study. A more or less similar moisture content of 79.87% was found in *Portunus sanguinolentus* of Mandapam camp (Rao *et al.*, 1973). The variation in moisture content may be attributed to the influence of the season and to the water temperature. The high water content may be a disadvantage too in terms of the shelf life of the sample. In this study, the moisture

content was more. This high moisture content in organisms is considered to be advantageous because of its contribution to the stabilization of the organisms during movements (Eddy *et al.*, 2004).

Protein is essential for the sustenance of life. An increasing demand for good quality animal protein for the exploding human population has led to an 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 with its growth-promoting capacity has a high biological value. Anonymous (1999) reported that the protein value in blue crab was 17.17%. The present investigation revealed that the maximum level of protein content in *Portunus sanguinolentus* was 28.45%. The average protein content obtained in this study is higher than the average value reported for *Portunus pelagicus* (26%) (Abdurrahman and Mohammed, 2005); also higher than the value recorded for *Eriphia verrucosa* (26.2%) (Yalcin *et al.*, 2009) but lower than the value of the mangrove crab of *S. brockii* (29.71%) (Rajagopal *et al.*, 2016). The protein content observed in the crab in the present study is similar to the estimate of an earlier report (28.1%) for *P. sanguinolentus* (Radhakrishnan, 1979). This clearly indicates that the environmental characteristics influence the proximate composition. The present study reveals that the crab *Portunus sanguinolentus* is valued seafood because of its high-quality protein. Generally, in marine invertebrates, the lipid is the most variable fraction. Again, in general, marine invertebrates have lesser lipid content, and it varies with the seasons. Lipids are highly efficient sources of energy and they contain more than twice the energy

of carbohydrates and proteins (Okuzumi and Fujii, 2000). The crab *Portunus sanguinolentus* had 8.77% of lipid content whereas in the case of *P. vigil* it ranged from 5.13 to 9.73% (Radhakrishnan and Natarajan, 1979). Balasubramanian and Suseelan (2001) reported that the lipid value of *C. smithii* ranges from 6.2 to 7.6%. In *Chaceon affinis*, the lipid value was 0.7% (Vasconcelos and Braz, 2001) and in the blue crab, it was 1.5% (Anon, 1999). Prasad and Neelakantan (1989) estimated the lipid content of *S. serrata* at 1.65%. In *P. pelagicus* the lipid value was 3.6% and in *P. sanguinolentus* it was 3.8% (Radhakrishnan, 1979). Murugesan *et al.*, (2008) assessed the lipid content of hard shell crabs at 5.65%. Lipids are the principal organic reserves and sources of metabolic energy in crustaceans. This is in addition to their indispensable role in maintaining cellular integrity. Lipids along with proteins are the major food reserves, and they are subject to periodic fluctuations caused by environmental variables like temperature.

Chemically, carbohydrates, a group of organic compounds, may be defined as aldehyde - or ketone derivatives of higher polyhydric alcohols, which include sugars, starches, and fiber, and form a major source of energy for animals. Carbohydrates constitute only a minor percentage of the total biochemical composition. The carbohydrates of fishery products contain no dietary fiber but only glucides, most of which consist of glycogen. They also contain traces of glucose, fructose, sucrose and other mono and disaccharides (Okuzumi and Fujii, 2000). In the present study, the carbohydrate content of *Portunus sanguinolentus* was found to be at 8.12%. Similar results were observed by Rajagopal *et al.*, (2016) in rainbow crab *Cardisoma rotundum* (8%) of Puducherry coast. Many earlier studies had suggested that the carbohydrate content in the muscle varied from 5.3 to 7.63% in *P. vigil* (Radhakrishnan and Natarajan, 1979); from 2.4 to 3.4% in *C. smithii* (Balasubramanian and Suseelan, 2001); was 5% in *S. serrata* (Prasad and Neelakantan, 1989) ranged from 0.16 to 5.55% in *P. pelagicus* and was at 4.73% in *P. sanguinolentus* (Radhakrishnan, 1979). In *S. tranquebarica*, the carbohydrate value was 7.76% (Thirunavukkarasu, 2005). Generally, the carbohydrate content had been found to be high or

low depending upon the environmental characteristics.

The ash content of *Portunus sanguinolentus* was 12.34%. This is a measure of the mineral elements in the sample, and this value is in agreement with the average value reported by Kelly *et al.*, (2007). Further, the amount of ash content found in this study was more or less similar to the values found in other such studies. Manivannan *et al.*, (2010) reported 17 - 19% ash content in crab *S. tranquebarica* whereas Sudhakar *et al.*, (2009) recorded 7.62 - 8.98% in *P. pelagicus*.

The minerals serve as components of bones and soft tissues (sulfur amino acids, metalloproteins), and as cofactors and co-activators of various enzymes important in human metabolism. Calcium, phosphorus, magnesium and the electrolytes (sodium and potassium) are considered to be macro elements whereas iron, copper, zinc, iodine, chromium, and manganese are said to be trace elements that are required for normal functioning. In this crab, a total of 11 minerals were found, and they were calcium, magnesium, potassium, sodium, iodine, iron, phosphorus, zinc, chromium, copper and manganese. In the present study, the element calcium was found in the maximum concentration. Similarly higher amount of calcium was observed by Anon (1999) and Thirunavukkarasu (2005) in the blue crab *S. tranquebarica*. In the present investigation, the individual contribution of the minerals is more or less similar. The value of calcium in the meat of *P. sanguinolentus* is in agreement with the value reported by Akpan (1997), higher than those found in the works of Ojewola and Udom (2005). The calcium content of the crab is capable of satisfying the recommended dietary requirement of 250 mg/100g (FNB, 2002, The Food and Nutrition Board, Institute of Medicine, 2002). The higher calcium content in the meat of *Portunus sanguinolentus* was perhaps due to the opportunistic feeding of this invertebrate, to the good quality of its exoskeleton and also to its cannibalistic feeding on a rich mineral source in the aquatic habitat. The potassium content of *Portunus sanguinolentus* was 59.43 mg/100g. The potassium levels of the crab appeared higher than those reported by Akpan (1997) in edible blue crab of *Callinectes sp.* (37.03 mg/100g). The magnesium

content of the meat of *Portunus sanguinolentus* was 65 mg/100g. This is lower when compared with the value of *Ucides cordatus*, which is 123.37 mg /100g (Chen *et al.*, 2007) and higher than the magnesium value of the meat (64.53 mg/100g) and the shell (23.17mg/100g) of *Callinectes sapidus* (Otwell and Koburger, 1985).

The crab under study has lower sodium content (54.6 mg/100g) than *Callinectes sapidus* (486 mg /100g) and *Ucides cordatus* (1410.37 mg /100g) (Wheaton and Lawson, 1985). In earlier studies, a sodium value of 297.80 mg/100gm of had been recorded for land crab *C. armatum* (Omotoso, 2005), 30 mg/100g for *P. vigil* (Sudhakar *et al.*, 2011), and 90 mg/ 100gm for Chinese mitten crab *E. sinensis* (Chen *et al.*, 2007). The Iron content of the crab appeared to be lower than that of *Callinectes sapidus* (Wheaton and Lawson, 1985) and that of *Ucides cordatus* (Chen *et al.*, 2007). Elegbede and Fashina (2013) suggested that a semi-terrestrial animal could have higher iron content than its aquatic counterpart. The manganese content of the crab is lower than that of *Ucides cordatus* (0.38mg /100g) (Chen *et al.*, 2007), higher than that of *Callinectes sapidus* (0.033 mg/100g) (Akpan, 1997). Wheaton and Lawson (1985) reported a value of 6.0/100g in the same crab. Elegbede and Fashina (2013) suggested that the manganese content of the crab depends on the manganese uptake in the aquatic environment. Zinc has been found to be beneficial to prostate health in man. The zinc content of *Portunus sanguinolentus* was higher (2.33 mg/ 100g) than that of *Callinectes sapidus* (0.013 mg/ 100 g) (Chen *et al.*, 2007). The copper content of the meat of *Portunus sanguinolentus* was 0.52 mg/100g. This is higher than the values reported by Wheaton and Lawson (1985) for *Callinectes sapidus* (4.28 mg/ 100 g), and lower than those reported by Akpan (1997) for *Callinectes sapidus* (0.003 mg/100 g). The copper content of the crabs depends on feeding habit, ecological interaction, habit factors and stomach content. The concentration of minerals in the meat of the crab species can be influenced by a number of factors such as seasonal and biological differences (species, size, age, sex and sexual maturity), food source, and environment (water chemistry, salinity, temperature, and contaminants). The mineral composition of the aquatic organisms can be affected

by differences in the proportion of food intake. Wardiatno *et al.*, (2012) stated that the proportion of food intake depends on the physiological needs of the invertebrates or on endogenous factors such as sex, age, and environmental condition as well as the solubility of mineral in water and food. The differences in mineral contents of the crabs used in our study and those reported in the literature can be attributed to the above-mentioned reasons (Skonberg and Perkins, 2002).

Amino acids are the building blocks of proteins and they play a central role as intermediates in metabolism. The kind of protein that results is indicated by the types of amino acids involved and the sequence in which they are arranged (Farr, 2002). The muscle is apparently the main protein-storage location in crustaceans. In decapods, free amino acids in the tissues reach levels ten times higher than those observed in vertebrates. The biological value of protein obviously depends on the concentration of essential amino acids. In the present study, a total of 10 essential and non-essential amino acids were observed in *Portunus sanguinolentus*. The essential amino acids were found in greater proportions: arginine (1.93 mg/100g), tryptophan (1.7 mg/100g), and methionine (1.62 mg/100g). Of these, methionine is a powerful antioxidant and a good source of sulfur, which prevents disorders of the hair, skin, and nails, and assists in the breakdown of fats. Thus it is helpful in preventing a buildup of fat in the liver and arteries that might obstruct blood flow to the brain, heart, and kidneys. Arginine helps to detoxify harmful agents such as lead and other heavy metals, to diminish muscle weakness, to prevent brittle hair, and to protect against the effects of radiation. Tryptophan is beneficial because it promotes the excretion of estrogen, and reduces the level of histamine in the body which can cause the brain to relay wrong messages. Tryptophan is also helpful to individuals suffering from schizophrenia (Bruce Barber, 2013). The content of histidine was estimated in *P. sanguinolentus* at 0.78 mg/100g, and this value is higher than that of *P. pelagicus* (0.39 g/ 100g) and that of *P. gladiator* (0.33 g/100g) as reported by Ramamoorthy *et al.*, (2016). Similar results had been reported for Chinese mitten crab *Eriocheir sinensis* (Chen *et al.*, 2007). Histidine is

an indispensable amino acid that is involved in many metabolic functions including the production of histamines, which take part in allergic and inflammatory reactions. Lysine was recorded in *P. sanguinolentus* at 0.92 mg/100g and this value is higher than 0.58 mg/100g estimated for *P. pelagicus* (Ramamoorthy *et al.*, 2016). It is necessary for the formation of hemoglobin; it stabilizes and regulates blood sugar and energy levels. It plays very important role in maintaining the osmoregulatory process; it is related to energy production; or is used in other metabolic pathways during certain harsh conditions of emergencies (Abe and Ohmama, 1987). A total of 10 nonessential amino acids were recorded in the present study. Of them serine (1.22 mg/100g), alanine (1.21 mg/100g), tyrosine (1.12 mg/100g), glutamic acid (0.95 mg/100g) and glycine (0.83 mg/100g) were relatively in high concentrations in *P. sanguinolentus* than in *Callinectes sapidus* (Kucukgulmez and Celik, 2008), *Charybdis natator* (Soundarapandiyani *et al.*, 2014) and the shrimp *Aristeus virilis* (Karuppasamy *et al.*, 2014). These amino acids may participate in osmoregulation and be in control of cellular volume (Schein *et al.*, 2004). Fatty acids in lipids are important biochemical components of marine food webs because they are rich in carbon and provide a concentrated source of energy. Lipids are now examined routinely as biomarkers in ecological studies and as tools to understand large-scale oceanographic processes (Budge *et al.*, 2006). An analysis of fatty acid composition was done in *P. sanguinolentus* with special regard to Saturated Fatty Acids, Mono Unsaturated Fatty Acids (MUFA) and Poly Unsaturated Fatty Acids (PUFA). Of the saturated fatty acids, margaric acid was found in a fairly large quantity of 12.9 mg/100g. The quantity of palmitic acid in *P. sanguinolentus* was higher (9.6 mg/100g) than that of *Portunus pelagicus* (7.2 mg/100g) as reported by Ramamoorthy *et al.*, (2016), *Portunus gladiator* (5.45 mg/100g) and *Charybdis lucifera* (7.14 mg/100g). The present results were similar to the results of other studies on *Callinectes sapidus* (9.12 mg/100g) (Celik *et al.*, 2004), on *Portunus pelagicus* (9.45 mg/100g) (Wu *et al.*, 2010) and on the shrimp *Melicertus canaliculatus* (9.54 mg/100g) (Sri Sakthi Priyadarshini *et al.*, 2015). Celik *et al.*,

(2004) have reported that the values of stearic acid in blue crab *Callinectes sapidus* ranged from 5.56 to 6.29%, this being slightly lower than the species under experiment.

As for MUFA, oleic acid (6.78 mg/100g) and palmitoleic acid (4.6 mg/100g) were observed in *P. sanguinolentus*. Ramamoorthy *et al.*, (2016) have reported the presence of oleic acids in *P. pelagicus* (12.89 g/100g), *C. lucifera* (1.09 g/100g) and *P. gladiator* (0.40 g/100g). Ayas and Ozogul (2011) have assessed the fatty acid level in blue crab *Callinectes sapidus*. They have reported that levels of oleic acid, a major MUFA, ranged between 14.66 - 14.75% in the meat of all male and female crabs. Kuley *et al.*, (2007) have estimated the amount of oleic acid and palmitoleic acid in blue crab *Callinectes sapidus* at 3.4 - 17.1% and 3.0 - 3.3% in male and female crabs respectively. This variation almost certainly has a correlation to the size of the species investigated in the separate studies or to the variation in seasonal conditions at the time of the study. The present study indicates that *P. sanguinolentus* possesses a large amount of MUFA in its meat.

As for PUFA,  $\alpha$ -linolenic acid (8.8 mg/100g), linolenic acid (4.9 mg/100g), and stearidonic acid (12.3 mg/100g) were present in large amounts in *P. sanguinolentus*. The value of morotic acid (0.41 mg/100g) agreed with that of *P. pelagicus* (0.40 g/100g) as reported by Ramamoorthy *et al.*, (2016). The value of stearidonic acid of *P. sanguinolentus* is higher than the values determined in other studies on *P. sanguinolentus* species (Soundrapandian and Singh, 2008). The long-chain PUFA, namely eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), may be acquired mainly from seafood. They are 'conditionally essential' for infant growth and development. Therefore, increased consumption of marine lipids has been recommended in order to increase the dietary intake of PUFA. The present investigation discloses high levels of EPA (13.4 mg/100g) and DHA (1.9 mg/100g) in *P. sanguinolentus*. It indicates that the species can be suggested as a nutrient-rich diet. Several previous studies conducted on the fatty acids of the crabs *Carcinus meanus* (Benjakul and sutthipan, 2009), *Callinectes sapidus* (Celik *et al.*, 2004), *Cancer pagurus* (Anacleto *et*



*al.*, 2011) have shown that they are rich sources of both eicosapentaenoic acid (EPA) and docosahexaenoic acids (DHA). Lipids, particularly polyunsaturated fatty acids (PUFA), have long been known to be essential for the maintenance of good health of any individual. Omega-3 long-chain PUFA, including EPA and DHA, are dietary fats with an array of health benefits and are essential for the proper foetal development and for healthy aging (Dunstan *et al.*, 2007).

A total of 12 vitamins were observed in the crab samples and of them, vitamin A had the largest content (13.45 mg/100g) In crustaceans vitamin A is a source of carotenoids in the pigmentation of muscle, and it acts as an antioxidant protecting the body from peroxidation. Seafood is best known as sources of fat-soluble vitamins; although they are sumptuous providers of some B vitamins and a little or no vitamin C. Nutritionally they are better known for the dietary minerals they supply (Adeyeye, 2002). In the present study, contrary to expectation, the level of vitamin C was high (11.08), and vitamins B6 and B12 were present in considerable amounts. The amount of Vitamin E (Tocopherol) was 4.23 mg/100g and the presence of Vitamin E in shell crabs makes them a potential source of organic food for consumers (Tejera *et al.*, 2007). A few research works have suggested that due to the high content of vitamins in the crab it can be a potential anticancer agent (Palozza *et al.*, 2009). Further, the results of many research projects support the assumption that crab meat can protect body tissues from oxidative damage.

## CONCLUSION

It can be concluded that *P. sanguinolentus* of Tuticorin coast has good proximate compositions, highest levels of amino acids, vitamins and minerals. Further, the meat of crab could be a good source of fatty acids, especially EPA and DHA. These indices and suggest that the crab is very much fit for human consumption, and is also suitable for being processed into different crab products. The results presented in this study are in agreement with other studies, and they also indicate that *P. sanguinolentus* may serve as an excellent nutritional input for future applications in the health and food sectors. The problem of malnutrition in our country can be overcome by the effective utilization of nutrient-rich crab seafood.

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