Life Science Informatics Publications
Research Journal of Life Sciences, Bioinformatics, Pharmaceutical and Chemical Sciences
Journal Home page http://www.rjlbpcs.com/
RJLBPCS
ISSN 2454-6348

Original Research Article **DOI: 10.26479/2018.0405.47**

PROXIMATE COMPOSITION OF COOKED MEAT AND EXOSKELETON OF *PORTUNUS PELAGICUS* (LINNAEUS, 1758)

S. Vigneshwari*, V. Gokula

PG and Research Department of Zoology, National College, Tiruchirapalli, Tamil Nadu, India.

ABSTRACT: Blue swimmer crab *Portunus pelagicus* (Linnaeus, 1758) is an economically valuable species found along the southeast coast of India. The present study examines the proximate composition (total protein, carbohydrate, lipid, moisture and ash content) of cooked meat found in body, claw, leg and the exoskeleton (carapace) separately for male, female, berried crabs collected from Mimisal coast, Tamil Nadu, India. The highest meat yield was found in male body (11.37%) while the lowest was found in berried leg (1.91%). The nutrients were found more in the body meat than the claw meat and leg meat. Among the macronutrients, highest value of protein was found in the male body meat (38.18%) while the highest value of lipid was found in berried body meat (9.04%). Carbohydrates and ash were found maximum in female body meat (3.07% and 12.5% respectively). The highest moisture content was found in male body meat (66.2%). Similarly, in the exoskeleton, the highest value of protein was found in male (9.18%) while the highest lipid value was found in berried crabs (3.18%). Carbohydrates and ash were the maximum in female (1.81% and 2.5% respectively), while the highest moisture content was found in males (28.5%). There were significant differences in the proximate composition of cooked meat found in body, claw, leg and in the exoskeleton of male, female and berried crabs. Hence, it may be concluded that in terms of nutritional value, male and female crabs may be considered more suitable than the berried for consumers.

KEYWORDS: Cooked meat, Exoskeleton, Macronutrients, Moisture, Ash, Nutritional value.

Corresponding Author: S. Vigneshwari*

PG and Research Department of Zoology, National College, Tiruchirapalli, Tamil Nadu, India.

Email Address:vignavpm@gmail.com

1.INTRODUCTION

India has an extensive coastline of over 7,516.6 km with exploitable resources of marine organisms. Indian Aquaculture is highly promising and has grown to greater heights with its seafood industry exporting quality seafood products to major markets of the world [1]. Seafood is highly nutritious, easily digestible, and highly palatable [2,3]. Crab meat is one such seafood known for its high protein content, fatty acids and mineral composition [4,5]. Besides, it is well known for the exceptional and scrumptious taste when compared to fishes and molluscs [6] and thus it has become a favourite food for many people replacing red meat and chicken. Due to the presence of high nutritive elements, the crab meat contains lower calories than beef, pork and poultry [7]. It is particularly rich in omega-3 fatty acids, which are necessary to lower triglycerides and blood pressure, thereby reducing the risk of heart diseases [8,9]. It is also an excellent source of many vitamins (B2, B3, B12 and C) and minerals like iron, calcium, potassium, phosphorus and zinc, which aids in reducing oxidative damage to cells and tissues and acts as an antioxidant by cancelling out the carcinogenic effects [10,11,12]. Brachyuran crabs, especially those belonging to family *Portunidae,* forms an important constituent of marine fishery resources in India [13]. Among the 990 marine brachyuran crab species of India, belonging to 281 genera and 36 families [14], the main supporting coastal species in the southeast coast is *Portunus pelagicus* (Linnaeus, 1758). Because of its high commercial value *P. pelagicus* is caught abundantly along the entire southeast coast of Tamil Nadu. It is collected and exported in large scale particularly in Mimisal, Tamil Nadu. The nutritive value of any edible organism can be evaluated from its macro and micro nutrients. Several researchers have reported on the proximate composition of fresh *Portunus pelagicus* collected from southeast coast of Tamil Nadu [2,15,16,17]. However, attempts to understand the proximate composition of cooked crabs are very meagre. Hence, the present study aims to analyze proximate composition of cooked meat and exoskeleton of blue swimming crab *Portunus pelagicus* of Mimisal coast.

2. MATERIALS AND METHODS

2.1 Specimen Collection and Morphometric analysis

Live crabs (20 males, 20 females and 20 berried individuals) were collected from Mimisal landing centre (9.9202 E and 79.1528 N) in the month of December, 2014 (Figure 1). The morphometric measurements of the collected crabs were shown in Table 1. The crabs were washed to remove the sand particles and weighed in the collection point. The crabs were categorized as males and females crabs (including berried) and were boiled in large containers in the sea food processing units for 20 minutes and 25 minutes respectively. Then they were taken out and cooled to room temperature. Then they were again weighed. Carapace was removed carefully from each animal and meat (found in body, claw and leg) were taken separately using forceps. The separated meat and carapaces were collected in ziplock covers, labelled and brought to the laboratory in an icebox. The meat was

homogenized using mortar and pestle, centrifuged at 25,000 rpm for 20 min and taken for the analysis [18]. The carapaces were dried, ground to fine powder and used for further analyses. Proximate analyses were done on these cooked meat and cooked carapaces (Figure 2).

2.2 Analytical methods

Meat content [19], total protein [18], total carbohydrates [20], total lipid [21] and moisture content [22] were estimated following standard methods [18,19, 20, 21, 22]. Total ash was estimated by incinerating the pre-weighed samples in the muffle furnace at 560°C for a period of 5-8 hours [22].

$$\text{Meatcontent}(\%) = \frac{\text{Wet meat weight (g)}}{\text{Totalweight (g)}} \times 100 = \text{Yeild } \%$$

$$\text{Protein}(\%) = \frac{\text{OD of the Sample}}{\text{OD of the Standard}} \times \frac{\text{Concentration of the Standard}}{\text{Volume of the Sample}} \times 100 = \text{mg}\%$$

$$\text{Carbohydrates} = \frac{\text{OD of the Sample}}{\text{OD of the Standard}} \times \frac{\text{Concentration of the Standard}}{\text{Volume of the Sample}} \times 100$$

$$= \text{mg}\%$$

$$\text{Lipids } (\%) = \frac{\text{OD of the Sample}}{\text{OD of the Standard}} \times \frac{\text{Concentration of the Standard}}{\text{Volume of the sample}} \times 100$$

$$= \text{mg}\%$$

$$\text{Moisture}(\%) = \frac{\text{Wet weight} - \text{Dry weight}}{\text{Wet weight}} \times 100$$

$$\text{Ash}(\%) = \frac{\text{Wet weight} - \text{Dry weight}}{\text{Wet weight}} \times 100$$

2.3 Statistical Analysis

The data were subjected to analysis of variance (one way ANOVA) and significant differences (if $P < 0.05$) between the means were compared with Turkey's post hoc test using PAST 3.09 version.

3. RESULTS AND DISCUSSION

The results revealed significant variations in the biochemical constituents of body meat, claw meat, and leg meat and also in the exoskeleton of male, female and berried *P. pelagicus* (Table 2 and 3). The results are expressed on dry meat weight basis. Meat yield of body, claw and leg significantly differed among male, female and berried crabs (Table 2). Macronutrients viz protein, carbohydrates and lipid content of body, claw and leg significantly differed among male, female and berried crabs (Table 2). These macronutrients content of cooked exoskeleton also significantly differed among

male, female and berried crabs (Table 3). The total protein content forms the highest biochemical component followed by lipid (second) and carbohydrate (third) component in the meat of the crabs.The moisture and ash content of body, claw and leg meat significantly differed among male, female and berried crabs (Table 2). In the exoskeleton, moisture content was significantly different while ash content was not significantly different among male, female and berried crabs (Table 3). Moisture content was the highest in males while ash was the highest in females.

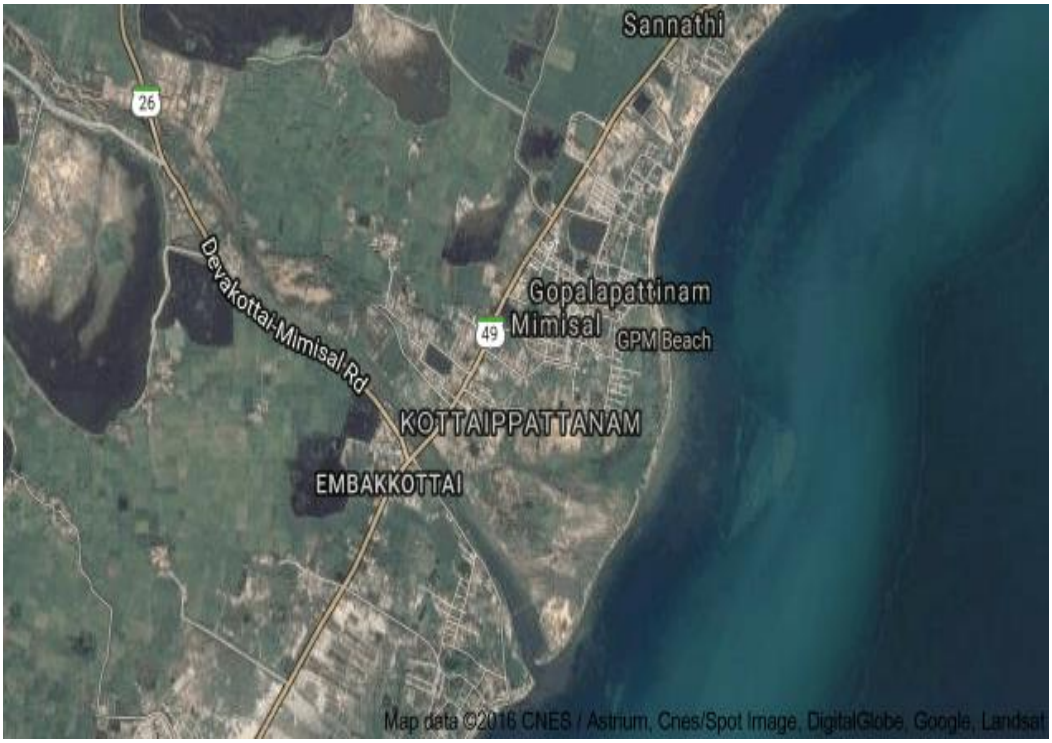

Figure 1: Mimisal – Sampling point

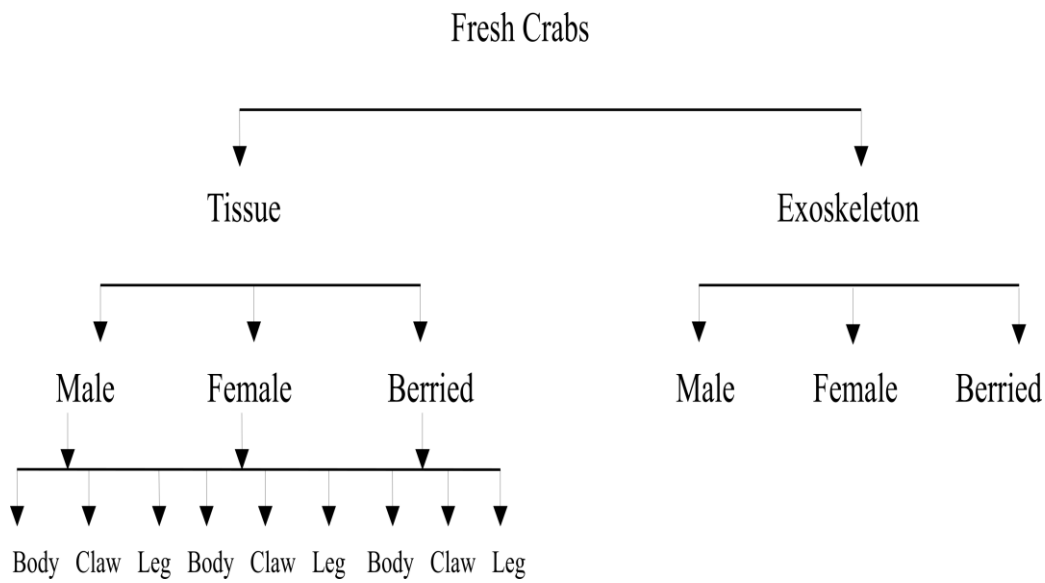

Figure 2: Grouping of crabs

Table 1: Morphometric data of male, female and berried *Portunus pelagicus* crabs

	Range (Minimum and Maximum value)			Mean & S.D		
	Male	Female	Berried	Male	Female	Berried
Body Weight	130 - 230 g	130 - 230 g	160 - 210 g	165.96 ± 15.87	175.87 ± 17.15	183.14 ± 14.09
Carapace Width	10.4 - 14.9 cm	10.6 - 16.2 cm	11.9 - 14.1 cm	12.81 ± 0.80	13.26 ± 0.72	13.10 ± 0.71
Carapace Length	5.1 - 7.5 cm	4.9 - 7.6 cm	5.9 - 7.4 cm	6.25 ± 0.50	6.50 ± 0.53	6.48 ± 0.51

Table 2: Proximate analysis of cooked tissues of male, female and berried *Portunus pelagicus*

Proximate Anaysis		**Body**	**F Value Significant Level P<0.05)**	**CLAW**	**F Value Significant Level P<0.05)**	**LEG**	**F Value Significant Level P<0.05)**
Meat Content (%)	**CM**	11.36	F = 62.51	7.11	F = 58.96	3.22	F = 25.42
	CF	9.33		4.90		1.91	
	CB	10.21		5.48		2.41	
Protein (%)	**CM**	38.18	F = 543	24.76	F = 1525	10.24	F = 396.1
	CF	36.41		21.35		8.59	
	CB	34.18		18.82		6.65	
Carbohydrates (%)	**CM**	2.45	F = 130.4	2.12	F = 128	1.81	F = 152.5
	CF	3.07		2.55		2.21	
	CB	2.91		2.40		2.02	
Lipid (%)	**CM**	5.96	F = 4620	3.61	F = 5281	2.59	F = 1134
	CF	6.39		4.16		3.31	
	CB	9.04		8.18		4.61	
Moisture (%)	**CM**	69.5	F = 619.1	65.9	F = 891.8	60.6	F = 1041
	CF	66.2		62.0		56.0	
	CB	62.4		58.1		51.4	
Ash (%)	**CM**	9.3	F = 81.6	5.5	F = 21.67	1.7	F = 10.17
	CF	12.5		7.2		3.1	
	CB	10.1		6.3		2.7	

CM – Cooked Male; CF – Cooked Female; CB – Cooked Berried crabs

Df Value: Between Groups – 2; Within Groups – 21. (Meat content)

Between Groups – 2; Within Groups – 15.

Peer review under responsibility of Life Science Informatics Publications
2018 Sept – Oct RJLBPCS 4(5) Page No.578

Table 3: Proximate analysis of Cooked carapace of male, female and berried *Portunus pelagicus*

Protein (%)	Male	9.18	F = 307.8
	Female	7.41	
	Berried	5.76	
Carbohydrates (%)	Male	1.17	F = 298.8
	Female	1.81	
	Berried	1.47	
Lipid (%)	Male	2.59	F = 3487
	Female	3.18	
	Berried	6.06	
Moisture (%)	Male	28.5	F = 945.3
	Female	21.5	
	Berried	18.7	
Ash (%)	Male	1.4	Not significant
	Female	2.5	
	Berried	1.9	

Df Value: Between Groups – 2; Within Groups – 15

DISCUSSION

The proximate composition means the percentage composition of five basic constituents such as water, protein, lipid, carbohydrate and ash [23]. Seafood contains high levels of energy yielding macronutrients like protein and lipids [24]. Large variations occur in the proximate composition of any organism as several factors like species, habitat, diet, water temperature, and seasons often influence the proximate composition [25,26]. Even slight variations occur in the proximate composition within the same species due to several factors sex, sexual maturity and spawning [27]. Nutrient and mineral composition of fresh meat of marine crabs have been investigated in different parts of the world [28,29,30,31,32] while very limited works have been seen on cooked or processed crab meat. Proximate composition of southern king crab (*Lithodes santolla* Molina, 1782) showed more protein, moisture, fat and ash content (g/100 g meat) in raw meat than in cooked meat [33]. Biochemical composition of *Penaeus monodon, Portunus sanguinolentus, Perna viridis* of fresh meat were higher than the cooked meat [23]. Similarly, the biochemical and microbiological evaluation of raw and processed meat of *P. pelagicus* collected from Thondi, Tamil Nadu found with total protein, free sugars, lipids, and phospholipids in raw meat when compared with processed meat [2]. Recently, different cooking methods were reported to the proximate composition and mineral content among fishes after various cooking methods [34]. In general, consumers select species with

more meat content and high nutritive value. During cooking, meat can lose a large quantity of mass in the form of meat juice in temperature and time dependent manner [35]. Thus, while boiling the crabs in large containers in the seafood processing units, shrinkage of meat occurs due to water expulsion from the meat. In the present study, meat yield was observed in the following order: Male>Female>Berried. More meat yield was seen in male crabs than in female crabs of *Callinectes sapidus* species [36] *Ucides cordatus* [37] and of *P. pelagicus* [15]. In general higher proportion of meat yield was seen in males than in females because they have bigger claws when compared with female crabs. It helps the male crabs to grasp and feed on a wider variety of food items than females [38]. Proteins act as biological catalysts in the form of enzymes, hormones, immune molecules and forms structural parts of organisms. It participates in cell signalling and recognition; transmit nerve impulses, transports nutrients, balancing water content and acts as protective molecules of immunity [39]. In the present study, protein content was observed in the following order Male>Female>Berried. Protein content in the body meat of male *P. pelagicus* was found to be more in female crabs collected from Karachi coast [40]. They also reported more protein content in the trashes of males than in females. However, *C. sapidus* and *Podophthalmus vigil* crabs showed more protein content in females than in males [36,41]. Protein content of shell wastes of male and female *P. pelagicus* found in Rea Sea showed that protein content was more in males than in females [28]. In general, animal based protein sources deliver all the essential amino acids while plant based protein lack one or more essential amino acids [42]. Proteins are recurrently used for growth and repair of tissues caused by moulting in crustaceans [43]. Males recorded higher protein content than females and berried crabs as they moult many times while females cease to moult after mating. Moreover, male reproductive system has more protein in the seminal plasma and spermatophores [44]. Male crabs have more muscles and thus they have more proteins than the female and berried crabs. During cooking, heat causes the protein molecules to denature and unfold its native structure [45]. As proteins constitutes over half of the dry weight of the animal, cooking results in slight decrease in protein content due to the inhibition of protein synthesis in it. Carbohydrates are the essential part of human diet, which forms primarily a source of immediate energy for all body cells. This macronutrient will be in minimum quantities in animal meat in the form of glycogen with more molecular branching. Glycogen content in various edible tissues of bivalves in West Japan showed significant decrease with sexual maturity [46]. In the present study, carbohydrate content was higher in the following order: Berried>Female>Male. Carbohydrate content was higher in hard shell crabs than soft shell crabs [47]. In *P. pelagicus*, more glycogen in body and claw meat of males than in female crabs [40]. Proximate composition of *Callinectes amnicola* showed more carbohydrate content in crunchy chest followed by in walking legs and in tissues [48]. But elevated levels of carbohydrates in berried than males and females of *P. vigil* crabs was also recorded [41]. Reproduction and moulting are the two major physiological events in crustaceans life cycle, thus

females have recorded higher carbohydrate composition followed by berried crabs when compared with male crabs. Lipids tend to be saturated and packed tightly in living organisms and they are the main biochemical constituents of membranes in all cells to help in storage and acts as intermediates in signalling pathways by maintaining cellular integrity. They act as major reserve food along with protein and are subject to periodic fluctuations influenced by environmental variables [49]. Our results are in agreement with [41] in *P. vigil* crabs, [50] in the meat of *Scylla serrata,* [51] in *Charybdis natator,* [52] in Chinese mitten crab (*Eriocheir sinensis*). The biochemical composition of eggs of *P. pelagicus* showed more lipid content [53]. During embryonic development in decapods, eggs utilize more fat than protein [54]. Hence, berried crabs may have more lipids to nourish the developing eggs than female and male crabs. Moisture content is an important indicator in determining the shelf life of food items. It also influences the taste, texture and weight of the food. In the present study, moisture content was higher in the following order: Male>Female>Berried [36,50,55]. However, more water content in berried females followed by males and females in *P. vigil* was also reported [41]. Low moisture contents in organisms reveals that they have long shelf life periods. They are maintained in good conditions in packed food and sealed cans during export to foreign countries. The ash content is an inorganic residue obtained by burning away all organic content within the food. It gives the total amount of minerals present in a food. Ash is one of the least studied biochemical constituents in crustaceans [56]. Ash content was found more in female than others [40,41]. However, more ash in males than in females was also reported [15]. More ash content in walking legs than in tissues and crunchy chest of *C. amnicola* was also reported [48]. Fresh food ash content rarely exceeds 5%. The higher value recorded in the present study could be due the presence of rich minerals.

4. CONCLUSION

The present study revealed that the meat of male and female crabs contain higher macronutrients and ash content than the berried crabs. The high nutritive value and great palatability of this species encourage its suitability for being appropriate seafood. The exoskeleton of this species also showed high proximate components and thus it may also be given as additive for animal feeds besides extracting chitin, chitosan and carotenoids.

ACKNOWLEDGEMENT

Authors are thankful to the Principal and the Management, National College (Autonomous), Trichy -620 001 for providing the necessary facilities.

CONFLICT OF INTEREST

Authors have no conflict of interest.

REFERENCES

1. Sam Siril Nicholas S, Maheswaran ML, Gunalan B. Indian seafood Industry strength, weakness, opportunities and threat in the global supply chain. Int. J. Fish. Aquat. Stud. 2015; 3(2): 199-

205.

2. Sugumar V, Mahalakshmi M, Kokila K, Subramanian J. Biochemical and microbiological evaluation of raw and processed meat with a note on bioluminescent bacteria in the blue swimmer crab, *Portunus pelagicus*. African Journal of Basic & Applied Sciences. 2012; 4 (2): 38-48.
3. Ali SSR, Ramachandran, M, Chakma SK, Sheriff, MA. Proximate composition of commercially important marine fishes and shrimps from the Chennai coast, India. Int. J. Fish. Aquat. Stud. 2017; 5(5): 113-119.
4. Skonberg DI, Perkins BL. Nutrient composition of green crab (*Carcinus maenus*) leg meat and claw meat. Food Chem. 2002; 72: 401-404.
5. Sudhakar M, Raja K, Anathan G, Sampathkumar. P. Compositional characteristics and nutritional quality *Podopthalmus vigil* (Fabricius). Asian Journal of Biological Sciences. 2011; 2(4): 166-174.
6. Sudha Devi AR, Smija MK. Analysis of dietary value of the soft tissue of the freshwater crab *Travancoriana schirnerae*. Indian Journal of Applied Research. 2013; 3(7): 45-49.
7. Jimmy UP, Arazu VN. The Proximate and mineral composition of two edible crabs *Callinectes amnicola* and *Uca tangeri* (Crustecea: Decapoda) of the cross river, Nigeria. *Pakistan* J. Nutr. 2012; 11(1): 78-82.
8. Martinez, MV, de Quiros ARB, Hernandez JL, Lage Yusty MA. Fatty acid profile and total lipid content of *Chionoecetes opilio* shells. The Open Food Science Journal. 2009; 3: 93-97 93.
9. Williams IO, Ekpenyong E, Lawal OO, Essien NC, Edemumoh TO. Nutrient and energy composition of flesh, limbs and carapace of *Callinectes amnicola* (Blue Crab) from Great Kwa river, South East Nigeria. African Journal of Food Science and Technology. 2016; 7(3): 060-065.
10. Kucukgulmez A, Celik M, Yanar Y, Ersoy B, Cikrikci M. Proximate composition and mineral contents of the blue crab (*Callinectes sapidus*) breast meat, claw meat and hepatopancreas. Int J Food Sci Tech. 2006; 41: 1023-1026.
11. Kaya Y, Turan H, Erdem ME. Determination of nutritional quality of warty crab (*Eriphia verrucosa* Forsskal, 1775). J. *Anim. Vet.* Adv. 2009; 8 (1): 120-124.
12. Soundarapandian P, Varadharajan D, Ravichandran S. Mineral composition of edible crab *Podophthalmus vigil* Fabricius (Crustacea: Decapoda). Arthropods. 2014; 3(1): 20-26.
13. Prasad RR, Thampi PRS. An account of the fishery and fishing methods for *Neptunus pelagicus* near Mandapam. J. Zool. Soc. India. 1952; 3(2): 335-339.
14. Rajaraman P, Durairaj K, Prabhakaran D, Priyadharshini K. Diversity of brachyuran crabs captured and landed by trawl at Akkaraipettai landing station, Nagapattinam, Tamil Nadu. Indo-Asain Journal of Multidisciplinary Research. 2016; 2(2): 576-579.

15. Ameer Hamsa KMS. Chemical composition of the swimming crab *Portunus pelagicus* Linnaeus. Indian J Fish. 1978; 25(1&2): 271-273.
16. Ramesh Kumar G, Ravichandaran S, Chandan K, Ajith Kumar TT. Comparsion of fatty acid profile in the edible crabs *Scylla serrata* and *Portunus pelagicus*. Global J Environ. Res. 2009; 3(1): 42-45.
17. Soundarapandian P, Singh RK. Biochemical composition of the eggs of commercially important crab *Portunus pelagicus* (Linnaeus). International Journal of Zoological Research. 2008; 4(1): 53-58.
18. Lowry OH, Rosebrough NJ, Farr AL, Randall RJ. Protein measurement with the Folin phenol reagent.J Biol Chem. 1951; 193(1): 265-75.
19. AOAC Association of Official Analytical Chemist. Official Methods of Analysis. 2007; 15th edition, Arlington, Virginia, USA.
20. Roe JH. The Determination of sugar in blood and spinal fluid with anthrone reagent. J Biol Chem. 1955; 212: 335-343.
21. Folch J, Lees M, Sloane Stanley GH. A simple method for the isolation and purification of total lipids from animal tissues. J Biol Chem. 1957; 226: 497-509.
22. AOAC Association of Official Analytical Chemists. Official Methods of Analysis. 1990; 15th edition, Washington, DC.
23. Pushparajan N, Soundarapandian P, Varadharajan D. Proximate composition of fresh and prepared meats stored in tin free steel cans. J Marine Sci Res Dev. 2012; 2 (4): 1-5.
24. Van Ruth SM, Brouwer E, Koot A, Wijtten M. Seafood and water management. Foods. 2014; 3: 622-631.
25. Bilgin S, Fidanbas ZUC. Nutritional properties of crab (*Potamon potamios* Olivier, 1804) in the lake of Egirdir (Turkey). Pakistan Veterinary Journal. 2011; 31: 239-243.
26. Langer S, Manhas P, Bakhtiyar Y, Rayees S, Singh G. Studies on the seasonal fluctuations in the proximate body composition of *Paratelphusa masoniana* (Henderson) (Female), a local freshwater crab of Jammu Region. Advance Journal of Food Science and Technology. 2013; 5: 986-990.
27. Ayas D, Ozogul Y. The chemical composition of sexually mature blue swimmer crab (*Portunus pelagicus*, Linnaeus 1758) in the Mersin Bay. J Fish Sci.com. 2011; 5(4): 308-316.
28. Abdel-Salam HA. Assessment of biochemical compositions and mineral contents of carapace of some important commercially crustaceans and mollusks organisms from Egyptian and Saudi Arabia coasts as a new animal feed. American Journal of BioScience. 2013; 1(2): 35-43.
29. Elegbede IO, Fashina Bombata HA. Proximate and mineral compositions of common crab species. [*Callinectes pallidus* and *Cardisoma armatum*] of Badagry Creek, Nigeria. Poult. Fish. Wildl. Sci. 2013; 2:1.

30. Chen K, Li E, Yu N, Du Z, Chen L. Biochemical composition and nutritional value analysis of Chinese mitten crab, *Eriocheir sinensis*, grown in pond. Glob. Adv. Res. J. Agric. Sci. 2013; 2(6): 164-173.
31. Zotti M, Del Coco L, De Pascali SA, Migoni D, Vizzini S, Mancinelli G, Fanizzi FP. Comparative analysis of the proximate and elemental composition of the blue crab *Callinectes sapidus*, the warty crab *Eriphia verrucosa*, and the edible crab *Cancer pagurus*. Heliyon. 2016; e00075: 1-15.
32. Hamdi SAH. Muscle and exoskeleton extracts analysis of both fresh and marine crustaceans *Procambarus clarkii*and *Erugosquilla massavensis*. Afr J Pharm Pharmacol. 2011; 5(13): 1589-1597.
33. Risso SJ, Carelli AA. Nutrient composition of raw and cooked meat of male Southern King crab (*Lithodes santolla* Molina, 1782). J Aquat. Food Prod. T. 2012; 21: 433-444.
34. Marimuthu K, Thilaga M, Kathiresan S, Xavier, Mas RHMH. Effect of different cooking methods on proximate and mineral composition of striped snakehead fish (*Channa striatus*, Bloch). J Food Sci Technol. 2012; 49(3): 373–377.
35. Warner RD. The Eating Quality of Meatd IV Water-Holding Capacity and Juiciness. Lawrie's Meat Science. 8th edition, edited by Fidel Toldra. Woodhead Publishing Series in Food Science, Technology and Nutrition. 2017. pp. 419-459.
36. Ayas D, Ozogul Y. The chemical composition of carapace meat of sexually mature blue crab (*Callinectes sapidus*, Rathbun 1896) in the Mersin bay. Journal of Fisheries Sciences.com. 2011; 5(3): 262-269.
37. Pinheiro MAA, Souza CA, Borba H. Meat yield of the mangrove crab, *Ucides cordatus* (Linnaeus, 1763) (Crustacea, Brachyura, Ucididae). Bol. Inst. Pesca. 2015; 41(1): 43 – 56.
38. Erickson AA, Feller IC, Paul VJ, Kwiatkowski, Lee W. Selection of an omnivorous diet by the mangrove tree crab *Aratus pisonii* in laboratory experiments. J Sea Res. 2008; 59(1-2): 59-69.
39. Fredrick WS, Sadeesh kumar V, Ravichandran S. Protein analysis of the crab haemolymph collected from the trash. Int. J. Pharm. Pharm. Sci. 2013; 5(4): 304-308.
40. Akbar Z, Qasim R, Siddiqui PJA. Seasonal variations in biochemical composition of (*Portunus pelagicus* Linneaus). J. Islamic. Acad. Sci. 1988; 1(2): 127-133.
41. Soundarapandian P, Ravichandran S, Varadharajan D. Biochemical composition of edible crab, *Podophthalmus vigil* (Fabricius). J. Mar. Sci. Res. Dev. 2013; 3(2): 1-4.
42. Millward DJ. The nutritional value of plant-based diets in relation to human amino acid and protein requirements. Proceeding of the Nutrition Society. 1999; 58(2): 249-260.
43. Mente E. Protein nutrition in crustaceans. CAB Reviews: Perspectives in agriculture, veterinary Science, nutrition and natural Resources. 2006; 1(43): 1-8.

44. Jeyalectumie C, Subramoniam T. Biochemistry of seminal secretions of the crab *Scylla serrata* with reference to sperm metabolism and storage in the female. Mol. Reprod. Dev. 1991; 30: 44-55.
45. Yu TY, Morton JD, Clerens S, Dyer JM. Cooking-induced protein modifications in meat. Comprehensive Reviews in Food Science and Food Safety. 2016; 1-19.
46. Yurimoto T. Seasonal changes in glycogen contents in various tissues of the edible bivalves, Pen shell *Atrina lischkeana*, Ark shell *Scapharca kagoshimensis*, and Manila clam *Ruditapes philippinarum* in West Japan. J Mar Biol. 2015; 1-5.
47. Sudhakar M, Manivannan K, Soundrapandian P. Nutritive value of hard and soft shell crabs of *Portunus sanguinolentus* (Herbst). International Journal of Animal and Veterinary Advances. 2009; 1(2): 44-48.
48. Moronkola BA, Olowu RA, Tovide OO, Ayejuyo OO. Determination of proximate and mineral contents of crab (*Callinectes amnicola*)living on the shore of Ojo river, Logos, Nigeria. Chem Commun. 2011; 1(1): 1-6.
49. Nagabhushanam R, Farooqui UM. Mobilization of protein, glycogen and lipid during ovarian maturation in marine crab *Scylla serrata* (Forskal). Indian J Mar Sci. 1982; 11: 184-189.
50. Sarower MG, Bilkis S, Rauf MA, Khanam M, Islam S. Comparative biochemical composition of natural and fattened mud crab *Scylla serrata.* Int J Sci Res. 2013; 5 (3): 545-553.
51. Sallam WS, Gaballa AAFA. Edibility assessment of the swimming crab *Charybdis natator* (Brachyura: Portunidae) from the Gulf of Suez, Red Sea, Egypt.Egyptian Jorunal of Aquatic Biology and Fisheries. 2009; 13 (1): 43-54.
52. Wu N, Wang XC. Comparison of gender differences in nutritional value and key odor profile of hepatopancreas of Chinese mitten crab (*Eriocheir sinensis*). J. Food Sci. 2017; 82: 536-544.
53. Khoei JK, Bastami AA, Esmailian M. The Biochemical composition of the eggs Blue swimming crab, *Portunus pelagicus*(Linnaeus, 1758) in the Persian Gulf Coasts, Iran.Middle-East J. Sci. 2012; 12 (7): 915-920.
54. Hamid A, Wardiatno Y, Djamar TF, Batu L, Riani E. Changes in proximate and fatty acids of the eggs during embryo development in the blue swimming crab, *Portunus pelagicus* (Linnaeus 1758) at Lasongko Bay, Southeast Sulawesi, Indonesia. Indian Journal of Science and Technology. 2015; 8: 501–509.
55. Olgunoglu IA, Olgunoglu MP. Major mineral (P, K, Ca) contents and proximate compositions of the male and female Blue swimming crab (*Portunus segnis*) Forskal, 1775) from Northeastern Mediterranean Sea, Mersin Bay, Turkey. Journal of Biology, Agriculture and Healthcare. 2017; 7(14): 50-54.
56. Devi DVP, Hareesh K, Reddy S. Studies on the proximate composition of tropical freshwater prawn *Macrobrachium rosenbergii.* Int. J. Fish. Aquat. 2015; 3(1): 329-336.