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Proximate Evaluation of some Economical Seafood as a Human Diet and as an Alternative Prospective Valuable of Fish Meal

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ABSTRACT

Biochemical studies are much more important from the nutritional point of view. This study was conducted to evaluate the difference in nutritional qualities of the commercial seafood *Venerupis aurea*, *Callista florida*, *Cerastoderma glaucum* and *Thais carinifera* from Suez Canal of Egypt. Wet seafood meats consist on average of 78.95, 79.84, 86.94 and 63.89% water and 21.05, 20.16, 13.06 and 36.11% dry matter for them, respectively. The dry seafood meats consist on average of 17.87, 17.24, 9.59 and 30.74% organic matter. The crude protein (54.31, 47.10, 45.08 and 54.62%), carbohydrate (26.12, 32.98, 24.12 and 23.85%), lipid (4.47, 5.42, 4.12 and 6.66%) and ash (15.10, 14.50, 26.72 and 14.87%) contents of them on dry basis were observed, respectively. Protein was the major organic component of investigated species, followed by carbohydrate. The results elucidated that *V. aurea*, *C. florida* and *T. carinifera* are good sources of protein and carbohydrate, *C. glaucum* and *T. carinifera* of minerals and all of them have low fat content. Carbohydrate, lipid and ash content of *C. glaucum* was found to be significantly ($p < 0.05$) lower than the other species. The present study provides not only the information about the proximate composition but also recommended the consumption of these 3 shellfishes species (*V. aurea*, *C. florida* and *T. carinifera*) as good quality seafood products and more suitable for marketing and consumption. In addition, the whole mount, when available with low price, may be used to push meat type producing animals especially poultry and fishes.

Key words: Proximate, seafood, fish meal, bivalves, gastropod

INTRODUCTION

The main marine invertebrates consumed are those groups conventionally termed “seafood”; that is crustaceans (mainly lobsters, prawns, crabs), bivalves and to a lesser extent gastropods. The edible bivalves and gastropods represent non-traditional and cheap protein supply in many countries, thus it might be considered as a promising food source. *Venerupis aurea* (Gmelin, 1791) is nutritional and economically important common species harvested in the Northern British Columbia, France, United Kingdom, Spain, China, Turkey and are widely distributed in Egypt (Carrilho *et al.*, 2011; Mohammad *et al.*, 2014). The bivalve species *Callista florida* (Lamarck, 1818) is considered another economically important species in the Red Sea (Zenetos *et al.*, 2010), Suez Canal (Voultsiadou *et al.*, 2010) and on the coast of Eastern Africa (Huber, 2010). The third species was the cockle *Cerastoderma glaucum* (Poiret, 1879). It is one of the most important components

of benthic fauna which had an extraordinary abundance and biomass (Derbali *et al.*, 2012). *Cerastoderma glaucum* occurs in densities that will support significant fisheries (Mohammad, 2002). Alternatively, this species may be used also as a cheap substituent of fish meal. The fourth species was *Thais carinifera* (Lamark, 1822) that commonly known as rock shell. It is a fairly large marine gastropod with high meat content. It is an important source of cheap protein for Egyptian people. This seafood is tasty, nutritious and easy to digest. They are eaten fresh or grilled and their soup is good. Generally, seafood is considered one of the most nutritionally balanced foods. The seafood diet helps to control weight and goes a long way towards preventing heart diseases (Shanmugam *et al.*, 2007).

The knowledge of biochemical composition of bivalves is important as an aspect of quality of seafood and sensory attributes (Radic *et al.*, 2014). Proteins, lipids, minerals and glycogen contribute to the nutritional value of the soft shellfishes' tissues. These macromolecules together with minerals and minor components of hydrophilic and lipophilic nature, contribute its nutritional value and organoleptic characteristics (Orban *et al.*, 2007). This means that they have a good taste and palatable to use by animal or human. Protein is the most abundant biochemical component in tissues and it may be an alternative energy reserve in some shellfishes during gametogenesis (Galap *et al.*, 1997). Carbohydrates have two major biological functions: as long term energy storage and as structural elements (Robledo *et al.*, 1995). Lipids represent an important energy reserve because of their high caloric contents.

However, no information is available on the nutritional quality of these shellfishes. Research on these species in Timsah Lake has focused on its growth performance, reproductive characteristics (Mohammad *et al.*, 2006, 2014; Radwan *et al.*, 2009) and metal concentrations (Ibrahim and Abu El-Regal, 2014). For this reason, the investigation of the proximate composition of these species was aimed in this study. This will provide necessary information of the nutrient value of this seafood and relating them to genera variation. The results will be useful for indicating species that are more suitable for the marketing and consumption. Knowledge of proximate composition of these shellfishes will lead to encourage the culture of these species. Alternatively, it will document and evaluate the use of it as a cheap substituent of fish meal in animal feeding and mariculture that has more recently become an important seafood source.

MATERIALS AND METHODS

Specimens collection: All specimens were collected from Timsah and Great Bitter Lakes, Suez Canal (30°84' latitude and 32°32' longitude), Eastern Egypt (Fig. 1) during 2013 by sieving, diving and picking.

Biometric analyses: Soon after collection, samples were transported to the Laboratory of Nutrition and Clinical Nutrition, Faculty of Veterinary Medicine, Suez Canal University. Specimens were inspected and dead animals, if any, discarded. Specimens were placed without seawater for 2 h to purge their stomachs then rinsed on a paper towel. Fifty individuals from each species were randomly selected for biometric measurements. For each specimen, length, height and width were measured using a 0.05 mm precision caliper. Total and soft weight of each specimen was also determined using an electric digital balance (0.0001 g).

Sample preparation: Soft tissues of some specimens were carefully separated from the shells and washed in distilled water to remove dirt's and extraneous salts. Samples were then left on an



Fig. 1: Satellite image taken from South NASA showing Suez Canal and its Timsah and Great Bitter Lakes

absorbent surface for 20 min to remove water as much as possible. Meat was stored at 20°C until further analyses. The whole mount (shell+tissue) of only *C. florida* and *C. glaucum* were only used due to their easily broken shell according to the laboratory devices potential.

Proximate analysis: The proximate chemical composition of the seafood *V. aurea*, *C. florida*, *C. glaucum* and *T. carinifera* were determined using standard analytical methods. All measured nutrients were done in triplicates and values presented in percentages.

Moisture and dry matter determination: The moisture and dry matter content of the samples was determined using AOAC (1995) method. The porcelain dish was washed thoroughly and placed in oven to dry. Five gram of the sample was placed in a pre-weighed porcelain dish and then placed in an oven to dry at 105°C for 5 h (began when temperature reached 105°C). The dish and dry sample were transferred to a desiccator to cool at room temperature before being weighed again. The experiments were repeated until constant weight was obtained. The sample was re-weighed and the moisture was obtained by the difference.

Protein content determination: Protein content of the sample was determined using the Kjeldahl method (Pearson, 1976). The total nitrogen was determined and multiplied by a conversion factor of 6.25 to obtain the protein content. About 0.5 g of the sample was weighed into a Kjeldahl digestion flask. A tablet of selenium catalyst was added to it. 20 mL of H_2SO_4 , 10 g of NaSO_4 , 1 g of CuSO_4 were also added to the flask and digested by heating under a fume cupboard till the solution digested completely and changed to blue color. The solution was carefully removed and allowed to solidify for 24 h until a white color was obtained. The solution was dissolved with 100 mL of distilled water in a 200 mL volumetric flask. Then, 60 mL of 40% of NaOH and two pieces of zinc metal were added to the solution in the Kjeldahl distillation apparatus. The mixture was distilled until a total of 50 mL distillate was collected into 250 mL conical flask containing boric acid and was titrated with 0.1 N H_2SO_4 . The end point of the titration was observed when the color of the distillate changed to the initial color of the mixture of boric acid and screen methyl red indicator which was light pink.

Lipid content determination: Lipid was determined using soxhlet extraction method (Onwuka, 2005). Boiling flask of 250 mL was washed thoroughly and dried in oven at 105°C for 30 min and then placed in a desiccator to cool. About 2 g of the dried sample was then weighed accurately into labeled thimbles. Cooled boiling flask was filled with 200 mL of petroleum ether and boiled at $40\text{--}60^\circ\text{C}$. The extraction thimble was plugged lightly with a cotton wool and the boiling flask containing the petroleum ether was placed in the extraction thimble to boil and the Soxhlet apparatus was allowed to reflux for 6 h. The thimble was removed carefully and the petroleum ether on top of the container was collected and drained into another container for reuse. When the flask was free of petroleum ether, it was removed and boiled for an hour at 105°C . It was finally transferred from the oven into a desiccator to cool before weighing.

Ash content determination: The ash content was determined using the method described in AOAC (1995). About 5 g of the sample was weighed into a crucible in a muffle furnace and heated at 550°C for overnight. The crucible was removed from the muffle furnace using crucible tong and placed in a desiccator to cool. When cooled it was re-weighed and the weight of ash was obtained by the difference.

Carbohydrate content determination: The carbohydrate content of the test samples were determined by estimation using the arithmetic difference method (Pearson, 1976) after neglecting of fiber analysis in meat tissues:

$$\text{Carbohydrate (\%)} = 100 - (\text{Protein (\%)} + \text{Lipid (\%)} + \text{Ash (\%)})$$

Caloric content determination: The caloric content of protein, lipid and carbohydrates in tissues was calculated using the factors 17.9 kJ g^{-1} (Beukema and de Bruin, 1979), 33 kJ g^{-1} (Beninger, 1984) and 17.2 kJ g^{-1} (Paine, 1971), respectively.

Statistics: An analysis of variance (one-way ANOVA) with Fisher LSD *post-hoc* test was used to test the significance of variations in biochemical components between species as well as between dry and fresh basis. Differences were considered to be significant when $p < 0.05$. Cross correlations between the biochemical constituents was also examined by Pearson's correlation test. The statistical analyses were undertaken using Excel 2010 statistical package, SPSS 16.0 and PRIMER 5.0 for Windows programs.

RESULTS

The biometric characteristics of the investigated species are listed in Table 1. The proximate analyses of the four investigated species showed the highest moisture content (86.94%) in the cockle *C. glaucum* and the lowest (63.89%) in the gastropod *T. carinifera* (Fig. 2a). Reversely, *T. carinifera* had the largest dry tissue (36.11%) (Fig. 2b). Alternatively, *T. carinifera* exhibited the highest percentage of the organic matter (30.74) as shown in Fig. 3a. Meanwhile, the clams *V. aurea* and *C. florida* had moderate and similar values. Ash content on dry basis was greater than that on fresh basis for each individual (Fig. 3b) and this variation was significant ($p < 0.05$). As clearly shown, *C. glaucum* recorded the maximum ash content, which was highly significant ($p < 0.01$) from the other species. However, the remaining proximate analysis showed the same trend, as ash content, between the components based on the dry and fresh basis which was also significant ($p < 0.05$). Generally, all the investigated species showed high protein content ranged from 45.05 (in *C. glaucum*) to 54.62% (in *T. carinifera*) as shown in Fig. 4a. Carbohydrate content (Fig. 4b) came second after protein and *C. florida* had the highest value (32.98% on dry basis). Meanwhile,

Table 1: Biometric characteristics of the investigated species

Parameters	<i>V. aurea</i>	<i>C. florida</i>	<i>C. glaucum</i>	<i>T. carinifera</i>
Length (mm)	22.34±1.12 (24.2-19.8)	33.19±3.38 (39-23.2)	26.83±3.80 (36.8-16)	
Height (mm)	14.15±0.67 (15.8-2.6)	23.61±2.27 (28.1-16.8)	22.91±2.34 (30.5-12.9)	53.54±5.30 (64.40-44.78)
Width (mm)	8.51±0.62 (10.3-7.4)	14.56±1.63 (23.3-9.9)	18.39±2.02 (25.6-10.1)	40.06±4.01 (49.49-29.22)
Total weight (g)	1.48±0.22 (2.01-1.06)	7.06±1.82 (11.37-2.71)	6.14±0.31 (12.51-5.69)	39.26±2.63 (74.34-18.26)
Soft weight (g)	0.40±0.09 (0.60-0.25)	2.40±0.71 (4.26-0.78)	1.69±0.17 (4.52-0.19)	9.29±1.45 (14.6-4.09)

Mean±Standard deviation (maximum-minimum)

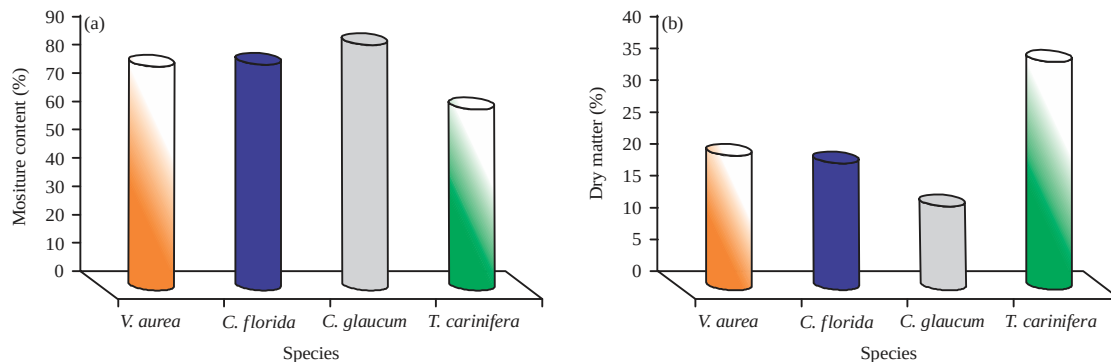


Fig. 2(a-b): (a) Moisture content and (b) Dry matter in the four studied species

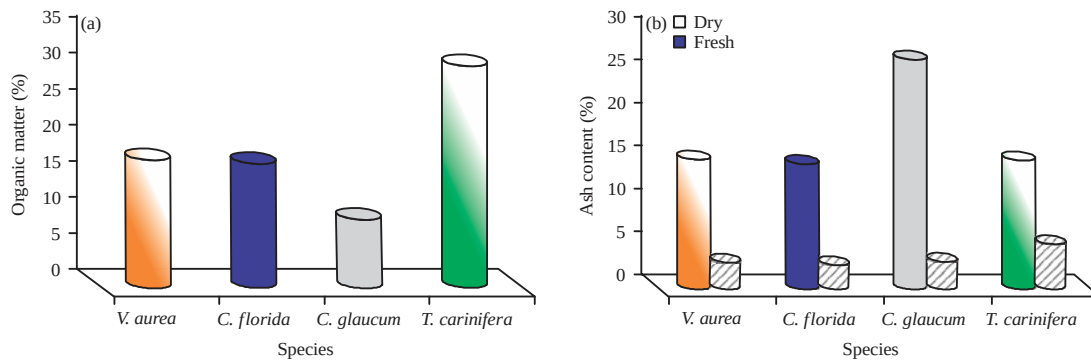


Fig. 3(a-b): (a) Organic matter and (b) Ash content of the four studied species on dry and fresh basis

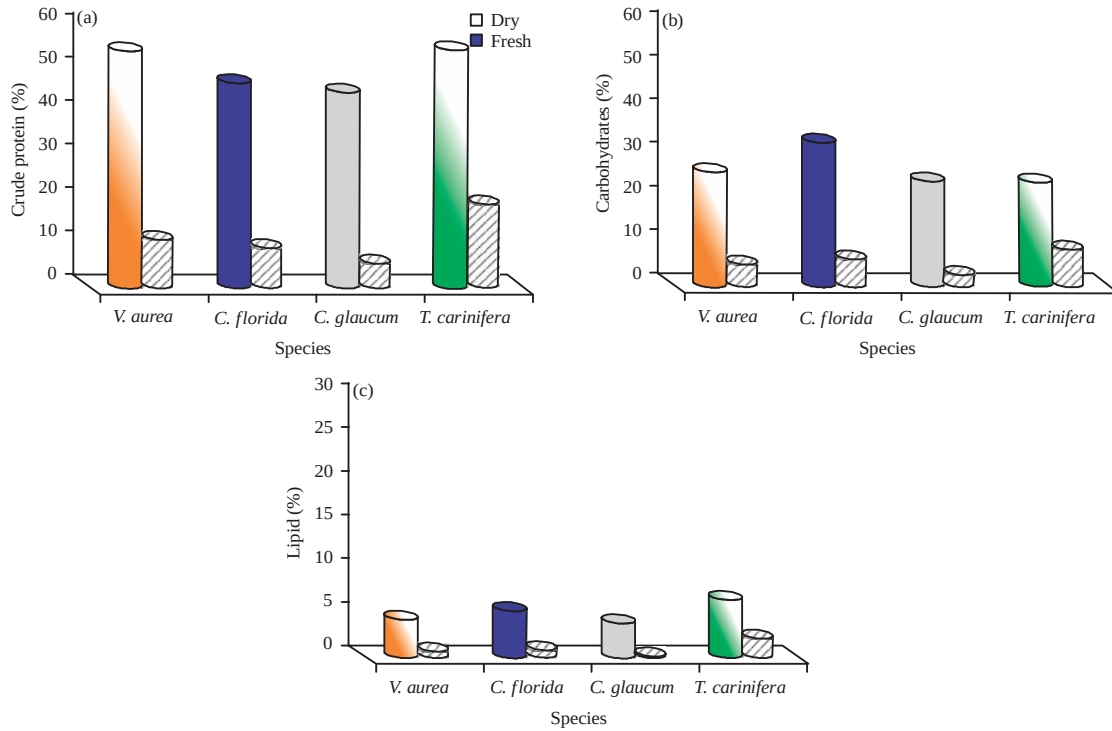


Fig. 4(a-c): (a) Crude protein, (b) Carbohydrates and (c) Lipid contents of the four studied species on dry and fresh basis

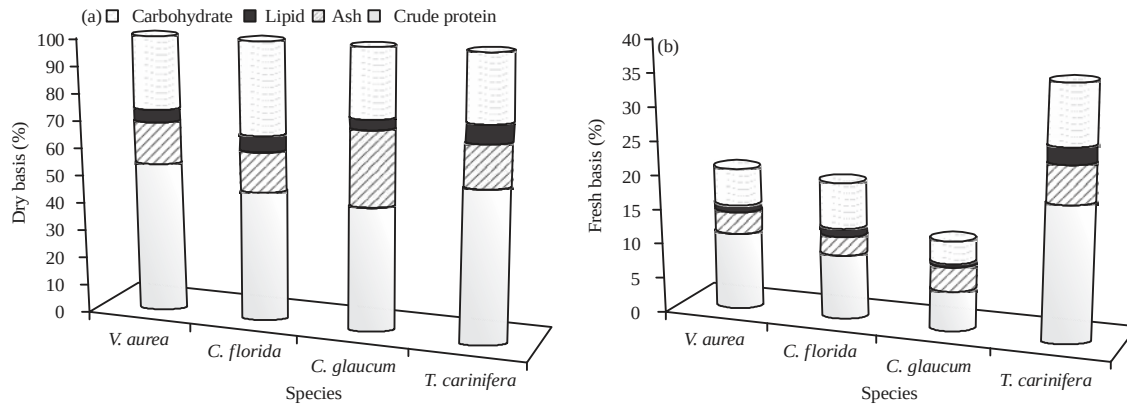


Fig. 5(a-b): Comparison of the proximate analysis between the investigated species on (a) Dry and (b) Fresh basis

all species showed low lipid content (Fig. 4c). For each species separately, the proximate composition was as follow in a descending manner: crude protein, carbohydrates, ash and lipid (Fig. 5). Our results elucidated that there was little variation in the total energy between species (Fig. 6a) and this variation was not significant between *C. florida* and either of *V. aurea* and *T. carinifera* ($p = 0.18$ and 0.16 for them, respectively). Whilst *C. glaucum* showed significant variation with other species ($p > 0.05$). Figure 6b-c also show that proteins are highly efficient as

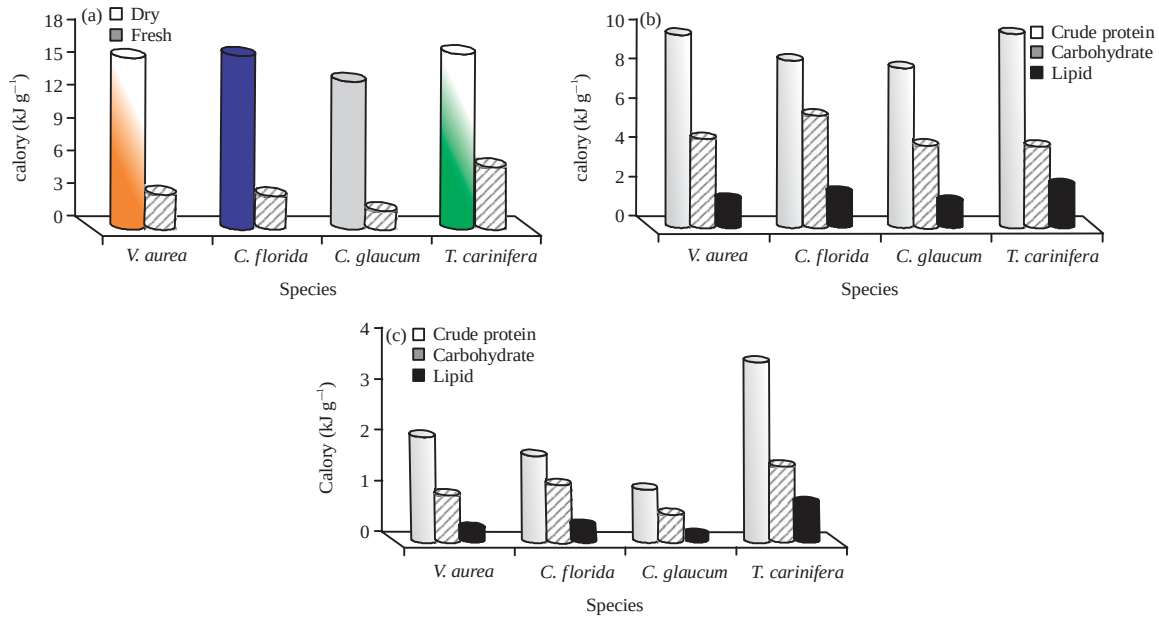


Fig. 6(a-c): (a) Total calorific values and the calorific values of the three proximate components, (b) On dry and (c) Fresh basis of the four studied species

Table 2: Pearson correlation between the proximate components and the total energy of the investigated seafood

Components	Crude protein	Carbohydrates	Fat	Ash	Calories
Crude protein	1	0.749**	0.887**	-0.979**	0.980**
Carbohydrates	0.749**	1	0.749**	-0.866**	0.861**
Fat	0.887**	0.749**	1	-0.908**	0.918**
Ash	-0.979**	-0.866**	-0.908**	1	-1.000**
Calories	0.980**	0.861**	0.918**	-1.000**	1

**Correlation is significant at the 0.01 level (2-tailed)

sources of energy. This was confirmed from Table 2 as it showed the highest correlation with the total calories ($r = 0.98$). The Protein-Energy ratio (PE ratio) recorded its highest values (2.34 1.67) in *C. glaucum* and *C. florida*, respectively (Fig. 7). By using the whole mount (tissue+shell) of *C. florida* and *C. glaucum*, for animal nutrition purpose, it was obvious that they had high level of ash content (78.47 and 90.05% on dry basis) followed by carbohydrates (13.48 and 6.04%), crude protein (5.74 and 3.53%) and less fat content (2.30 and 0.38%) on dry basis for them, respectively (Fig. 8). There was not significant variation ($p > 0.05$) between the components except ash content which exhibited highly significant variation ($p > 0.001$) with the other components in the two species. Also, the same trend was the case on the fresh basis. However, ash content was higher in *C. glaucum* than *C. florida* but the other components as well as the total energy and PE ratio were higher in *C. glaucum* than in *C. glaucum*. Generally, the difference between these two bivalves was not significant ($p = 0.46$ and 0.36 on dry and fresh basis, respectively). This was confirmed by Fig. 9 which elucidates the similarity between the investigated species.

DISCUSSION

Shellfishes have long been a part of the diet of coastal human populations. As the world population is growing, the per capita consumption of aquatic food is also increasing rapidly. An

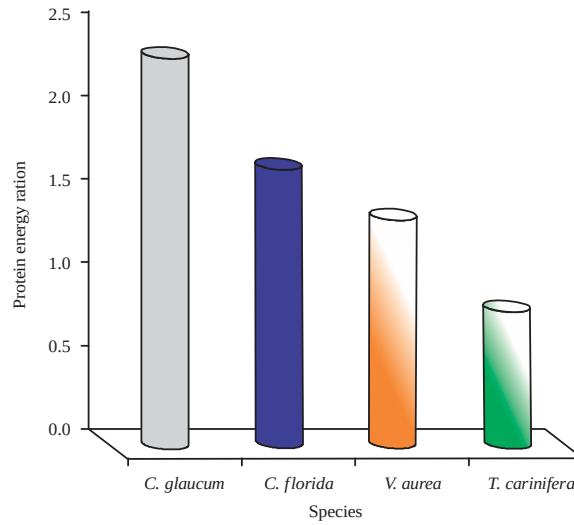


Fig. 7: Protein-energy ratio of the investigated species

increment of the consumption of seafood is recommended by the current dietary guidelines (Simopoulos, 2003). Because of health consciousness, the modern day man is interested in taking aquatic food more in view of its nutritional superiority than all other sources of food accessible to him (Padidela and Thummala, 2015). Therefore, the balanced and healthy diet is a prerequisite for good health. Hence, the evaluation of the proximate composition of the recent investigated species was established and compared with each other as well as with the previously described species in the literature.

Moisture: Most molluscs have open circulatory systems, which mean that their organs are surrounded by watery blood that contains nutrients and oxygen. Changes in watery environment represent a challenge for the tissues of these molluscs. Additionally, as the main constituent of shellfish flesh is water, which is tightly bound to the proteins in the structure in such a way that it cannot readily be expelled even under high pressure, it is considered an index of freshness as Murray and Burt (2001) reported. The evaluation of the moisture content of the four seafood demonstrated that it ranged from 63.88% (*T. carinifera*) to 86.94% (*C. glaucum*) and this indicates a good mark.

Dry matter: The basic building blocks of the living organisms such as proteins, fats and carbohydrates are transformed during metabolisms by living organisms, forming specific synthetic products, which contribute to meat yield. Dry matter content is a parameter indicating the quality and physiological condition of shellfish and hence the best species for consumption. In our study, *T. carinifera* had the highest dry matter content (36.11%) followed by *V. aurea* and *C. florida*. The least dry matter was *C. glaucum* (13.06). On the view of these results, we can recommend that *T. carinifera*, *V. aurea* and *C. florida* are more suitable for the marketing and consumption. This interprets people frequenting on these species which are also cheap in coast.

Crude protein: Molluscan proteins are rich in essential amino acids and they are required for the maintenance of growth, reproduction and synthesis of vitamins (Rajkumar, 1995). Okuzumi and

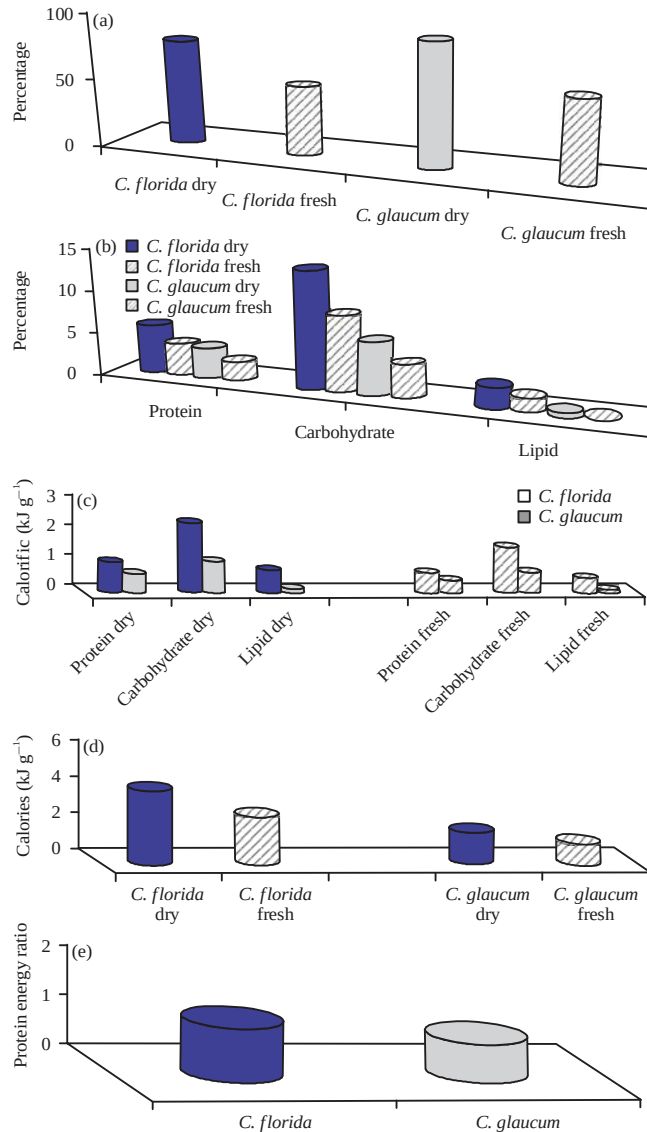


Fig. 8(a-e): Comparison between the whole mounts of *C. florida* and *C. glaucum* in (a) Ash content, (b) Other proximate compositions, (c) Calorific value, (d) Total calories and (e) Protein Energy Ratio (PE Ratio)

Fujii (2000) stated that protein is essential for the sustenance of life and accordingly exists in the largest quantity of all the nutrients as a component of the human body. The acceptability and easy digestibility of shellfish proteins make it very valuable in meeting protein malnutrition, especially in children. In the present investigation, protein was the major organic component of investigated species. This may be due to the inflow of freshwater from Ismailia Canal into Suez Canal. That may cause decrease of salinity, increase of NO_3 and SiO_4 concentrations in seawater and consequently increase of organic matter in shellfish meat as Radic *et al.* (2014) concluded. The protein content pattern is similar to that of dry weight, with the maximum value (19.67%) in *T. carinifera* which indicates that the protein is of superior quality in this species. Both

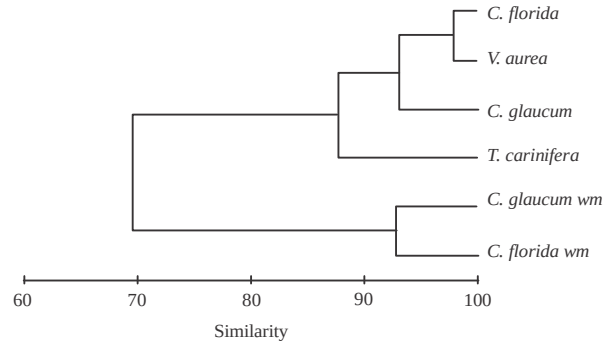


Fig. 9: Similarity dendrograms of the proximate components between the investigated species as fresh and whole mount (wm)

Table 3: Proximate composition (%) of some commercially important seafood

Species	Moisture	Crude protein	Carbohydrates	Lipid	Ash	References
<i>Meretrix casta</i>	77.50	13.74		2.00	1.50	Lakshmanan and Nambisan (1980)
<i>Villorita cyprinoides</i>	82.05	9.30		1.50	2.50	George and Gopakumar (1995)
<i>Perna viridis</i>	78.27	12.80		2.24	2.72	George (1985)
<i>Crassostrea madrasensis</i>	80.05	12.26			2.90	George (1985)
<i>Littorina quadricentus</i>			5.31			Thivakaran (1988)
<i>Nodilittorina pyramidalis</i>			4.69			Thivakaran (1988)
<i>Ruditapes decussatus</i>	83.98	9.56	1.14	0.98	3.30	Dincer (2006)
<i>Ruditapes philippinarum</i>	85.91	8.71	1.10	0.78	3.10	Dincer (2006)
<i>Anadara granosa</i>	81.30	11.70		1.10	2.40	Trung tam Tin hoc-Bo Thuy San (2007) cited in Laxmilatha (2009)
<i>A. subcrenulata</i>	83.80	8.80		0.40	4.00	Trung tam Tin hoc-Bo Thuy San (2007) cited in Laxmilatha (2009)
<i>Paphia undulata</i>	8.30	10.30		0.50	2.40	Trung tam Tin hoc-Bo Thuy San (2007) cited in Laxmilatha (2009)
<i>Meretrix lusoria</i>	83.10	11.20		1.10	2.60	Trung tam Tin hoc-Bo Thuy San (2007) cited in Laxmilatha (2009)
<i>Perna viridis</i>	85.40	9.30		0.90	2.40	Trung tam Tin hoc-Bo Thuy San (2007) cited in Laxmilatha (2009)
<i>Mactra violacea</i>	80.00	11.85		1.00	3.20	Laxmilatha (2009)
<i>Unio terminalis</i>	80.36	11.87		2.55	1.68	Ersoy and Sereflisan (2010)
<i>Potamida littoralis</i>	81.69	11.97		1.05	1.61	Ersoy and Sereflisan (2010)
<i>Crassostrea madrasensis</i>	82.64	9.41	3.20	3.25	1.01	Asha <i>et al.</i> (2014)
<i>Venerupis aurea</i>	78.95	11.43	5.50	0.94	3.18	Present study
<i>Callista florida</i>	79.84	9.49	6.65	1.09	2.92	Present study
<i>Cerastoderma glaucum</i>	86.94	5.89	3.17	0.54	3.47	Present study
<i>Thais carinifera</i>	63.89	19.67	8.66	2.40	5.38	Present study

of *V. aurea* and *C. florida* were well within the range reported in Table 3 for other seafood species v.z., *Ruditapes decussatus* and *Mactra violacea* (Dincer, 2006; Laxmilatha, 2009).

Carbohydrates: Carbohydrates are major sources of energy in human diets. The ratio of carbohydrate was less when compared to the other nutrients such as proteins in animal tissues, especially in aquatic animals. In the present study, it was found to be the second major organic component in all investigated species. Similar finding was reported earlier by Salaskar and Nayak (2011) for *Perna viridis* and *Rapana venosa*. Carbohydrate content of *C. florida*, in the present study, was found to be significantly ($p < 0.05$) higher than the other investigated and comparable species. The greater level of carbohydrate make it sweeter than the other shellfishes that is because carbohydrate in the tissues exists as glycogen, free sugars and protein bound sugars (Vijayakumar *et al.*, 2014).

Generally, the sum of carbohydrate and protein (C+P) was the highest (27%) in the gastropod *T. carinifera* compared to the clams *V. aurea* and *C. florida* (~15%) and the cockle *C. glaucum* achieved also the lowest value (8%) on fresh basis. Whereas this sum was nearly similar (~80%) between species on dry basis except that of *C. glaucum* which also exhibited a lower value (69%). So, if we used it in animal feeding, the best quantity that would be added depends on the species as well as the matter of the flesh (dry or fresh).

Lipid: Aquatic animal fats are good sources of essential fatty acids that are not synthesized in the human body (Chedoloh *et al.*, 2011). In the present study, the gastropod *T. carinifera* recorded the highest lipid content (6.66 and 2.40% on fresh and dry basis, respectively). Meanwhile, minimum lipid level was found in *C. glaucum* (4.12 and 0.54%) followed by *V. aurea* (4.47 and 0.94%) on fresh and dry basis, respectively. Shellfish meat, particularly clam meat have been recommended in several dietary regimes for their high protein content, low calorific values, low fat/cholesterol profile and lower proportions of saturated fat, the presence of good lipids and several important minerals (Dong, 2001). Alternatively, the bivalves should be considered a low-fat, high-protein food-one that can be included in a low-fat diet (King *et al.*, 1990). The lipid content in the present species is comparatively low as against higher values recorded by *Crassostrea madrasensis* (Asha *et al.*, 2014) but similar to the other reported species (Table 3). Thus, the candidate species might be placed in a better quality food list for human beings.

Total calorific value: In the present investigation, *T. carinifera* showed the highest calorific value (16.07 and 5.80 kJ g⁻¹) followed by and *C. florida* (15.89 and 3.20 kJ g⁻¹) on dry and fresh basis, respectively. Meanwhile, *C. glaucum* was the lowest one (13.57 and 1.78 kJ g⁻¹). Generally, proteins are highly efficient as sources of energy in all investigated species as it exhibited high correlation with the total calories ($r = 0.98$). This means that protein of these species is of good quality. This agree with Albentosa *et al.* (2007), who reported that protein and total lipids contribute significantly to the total energy supply in *V. senegaleinsis*. On the other hand, our findings disagree with Okuzumi and Fujii (2000), who said that lipids are highly efficient as sources of energy and they contain more than twice the energy of carbohydrates and proteins. So, we can conclude that the contribution of the protein to the total energy vary between species.

Protein-energy ratio (PE ratio): The Protein-Energy ratio (PE ratio) is not a statement of requirements and is not intended to be used as such. Rather, the PE ratio is a descriptor of one aspect of the nutritional quality of foods or diets (Beaton and Swiss, 1974; Beaton, 1977). In current usage it is common to express the ratio as the proportional contribution of dietary protein to total dietary energy. It is possible, of course, also to describe the utilizable protein content of diets as in the calculation of net dietary protein as percentage of calories (NDPCals%) and indeed this type of presentation has some distinct advantages. Protein efficiency ratios of the present shellfishes were thus found to be the highest (2.34) in *C. glaucum* followed by *C. florida* (1.67). This means that *C. glaucum* and *C. florida* flesh are of high energy low protein diets which may be used for adult animals diets for maintenance and work. Also, it may be used for finishing meat type producing birds and fishes. On the other hand, both of *T. carinifera* and *V. aurea* flesh are high energy high protein food, when available with low price they may be used to push meat type producing animals especially poultry and fishes.

Ash content: Ash content exhibited complete reversely correlation with the total calories as well as with the proximate components. Ash content of the cockle *C. glaucum* (3.47) was compared with other cockles. It was higher than the cockle *Anadara granosa* (2.4%) but lower than *A. subcrenulata* (4%) as reported in literature. On the other hand, clams of the present study had ash content ranged from 2.92 (*C. florida*) to 3.48% (*V. aurea*). It was obvious that their ash contents were nearly within the same range as the other clams (Dincer, 2006; Laxmilatha, 2009) but clearly higher than *Meretrix casta* (1.5%, Lakshmanan and Nambisan, 1980). Meanwhile, the gastropod *T. carinifera* exhibited the highest ash content (5.38%) when compared with the other species.

Whole mount: Shells of molluscs were added to animal feeds as energy source. The mollusc shells have high carbohydrate content. This is not surprising as the organic constituents of mollusc shell are polysaccharides and glycoproteins (Hodasi, 1982). Jatto *et al.* (2010) reported that snail shells have also high carbohydrate content. Clam shells were used also as a source of calcium supplements for lactating cows (Finkelstein *et al.*, 1993). Active ingredients of the shells can be used in the feed industries, too (Ademolu *et al.*, 2015). Malu *et al.* (2009) stated that, after consuming the soft-flesh, the empty shells are constantly thrown away as waste; but results of analysis of these shells show that they contain a high percentage (95.54%) of calcium oxide (CaO), 2.52% of magnesium oxide (MgO) and trace amount of other oxides which make them suitable source raw materials for the production of calcium supplements by food industry. Moreover, the seafood flesh contains betaines, beside the proximate components. Many naturally occurring betaines serve as organicosmolytes, substances synthesized or taken up from the environment by cells for protection against osmotic stress, drought, high salinity or high temperature. Intracellular accumulation of betaines permits water retention in cells, thus protecting from the effects of dehydration. Betaine which is abundant in marine animals, such as mussels, clams and cockles (Carlberg *et al.*, 2015; Liu *et al.*, 2011), is a known attractant for many fish species.

Nowadays, the cockle *C. glaucum* is not commercially exploited. These cockles are upwelled and beached in large quantities along Timsah Lake. The local people collect them for domestic consumption. In view of their nutritive value, attempts may be made to encourage targeted exploitation of these cheap shellfish in animal feeding as their flesh was not very easy to digest for human being (Voultsiadou *et al.*, 2010). Additionally, the clam *C. florida* had large meat and its shell was easily broken according to our laboratory devices potential rather than the other species. The whole mounts (shell+flesh) of these two species in the present study are prospective valuable feed for fish and animals due to many advantages: 1- they are very cheap, 2- they have great potential as mineral sources (ash content was 78.47 and 50.87% for *C. florida* and 90.05 and 58.11% for *C. glaucum* on dry and fresh basis, respectively). Generally, the higher the ash content, the higher the calcium, phosphorus and magnesium content which are predominantly from their shells, 3- in addition to their nutrients value on dry and fresh basis: *C. florida* had 5.74 and 3.72% crude protein, 13.49 and 8.74% carbohydrates and 2.30 and 1.49% lipid, respectively. *Cerastoderma glaucum* had also similar but slightly lower values except ash content which was very high. From this investigation it is obvious that *C. florida* and *C. glaucum* might be used as alternative cheap sources of fish meal. Fish meal manufacture is worldwide mainly used in aquaculture feeds (Pike, 1990). It is a high quality protein feedstuff as an excellent source of essential amino acids according to Hertrampf and Piedad-Pascual (2000). Although, the protein digestibility of fish meal is the highest for aquaculture and poultry production, it is the most

expensive protein source. So, efforts are made by nutritionists to reduce the expenses of its production by many ways, including how to reduce fish meal by a suitable source of high replacement value. Here, chemical analyses support the first step to use an alternative for fish meal. The whole mounts of *C. florida* is easy to dry and grind with high protein and energy content, so we recommend it for further experiments in poultry and fish diets.

CONCLUSION

In the light of these findings, it may be concluded that the investigated species are suitable items for the human diet. Nutritional quality of meat in the investigated species was high. Protein was the major organic constituent and carbohydrate was the second major organic component. Due to their low lipid and adequate mineral, the health benefit to the consumers may be ascertained. So, this seafood could be a source of alternative human diet to the ordinary high fat meat as chicken and red meat. The whole mount may also be used as a cheap alternative for fish meal by the aqua-culturists, for formulating feed, as well as concentrates for other animals as poultry.

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