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Research Article

Proximate Composition and Its Seasonality of the Mediterranean Green Crab: *Carcinus aestuarii* Nardo, 1847 (Brachyura, Portunidae), in Southern Tunisian Waters (Central Mediterranean)

Sonia Baklouti, Abdelkarim Derbali, Khalifa Dhieb, Wassim Kammoun, and Othman Jarboui

Institut National des Sciences et Technologies de la Mer (INSTM), BP 1035, 3018 Sfax, Tunisia

Correspondence should be addressed to Sonia Baklouti; sonia-baklouti@hotmail.fr

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The Mediterranean green crab *Carcinus aestuarii* was recorded in Tunisian waters several years ago. However, since its record in the Gulf of Gabes, no studies have been carried out about the spread of this crab. Because there is a lack of nutritional information concerning this species, this study aimed to characterize the chemical composition of hepatopancreas and gonads of *Carcinus aestuarii* in view of potential health implication for consumers and to determine the seasonal nutritional quality of females and males taken separately for various size groups. In this study, a total of 1399 individuals were collected along the Sfax coast. The nutritional value of various edible parts of *Carcinus aestuarii* was evaluated, and gender differences in terms of edible yield and proximate composition, protein, mineral, lipid, and water content, were compared for season, age, and sex. The biochemical compositions were strongly influenced by sex, age, and seasons. The highest protein and lipid contents were detected in gonads and hepatopancreas of females. Autumn was the season with the highest protein content and lowest fat content. Therefore, people with particular diets constrains should consume the ovaries of females in autumn and it should moderate in winter. The hepatopancreas and gonads from Tunisian waters can be a good source of proteins and mineral.

1. Introduction

It is generally accepted that seafood is important in a healthy, safe, nutritious, and balanced diet [1]. Seafood is an important source of valuable nutrients, like minerals (e.g., calcium, iron, zinc, iodine, selenium, and copper), vitamins, fatty acids (e.g., long chain n-3 polyunsaturated fatty acids) and high quality proteins with essential amino acids, and is low in saturated fats [2, 3]. Polyunsaturated n-3 fatty acids are known to decrease the risks of coronary heart disease and cancer and to improve the response to inflammatory diseases, like eczema, psoriasis, and rheumatoid arthritis [4–6]. However, seafood under certain circumstances poses risks to consumers as it can contain high levels of contaminants (e.g., As, Hg, Cd, and Pb) that either occur naturally or result anthropogenic sources [7].

Crustacean shellfish are also good sources of various minerals and high quality protein [8]. Although the nutritional composition of several commercially harvested species of crab has been partially characterized, shellfish vary widely in their nutrient content [9–11]. The biochemical compositions of different crab species have been reported in various parts of the world [9, 12–15]. Researchers have also reported differences in concentrations of moisture, fat, ash, protein, and various volatile compounds in meats from different body parts of the blue crab, *Callinectes sapidus* (Rathbun, 1896), and in the Southeast Asian crab, *Charybdis feriatus* (Linnaeus, 1758) [16–18]. The first step in exploring the economic potential of the green crab and reports on its proximate, amino acid, and fatty acid compositions was investigated [15]. However, no studies have targeted the proximate composition of the green crab *Carcinus aestuarii*

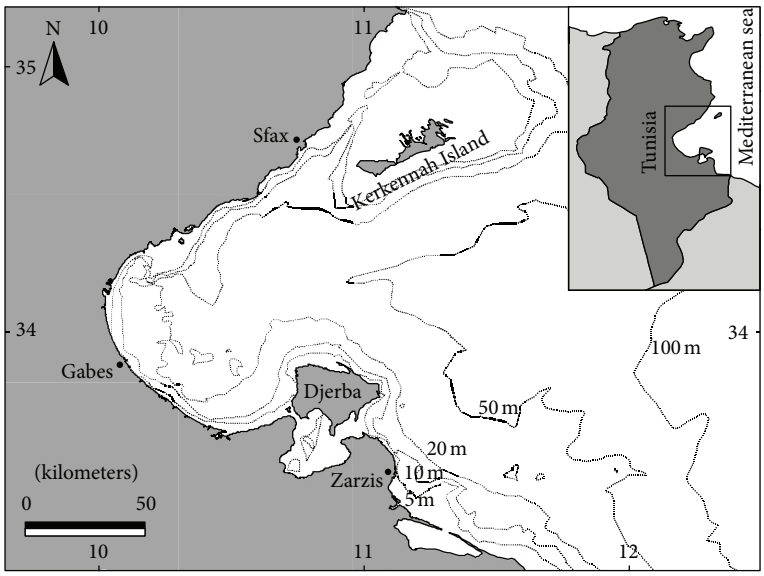

Figure 1: Map of the study area, indicating the sampling location (Gulf of Gabes, Tunisia).

(Nardo, 1847) along Tunisian coasts, but instead, findings focused on the fatty composition and nutritional properties of the green crab *Carcinus mediterraneus* (Czerniavsky, 1884) (= *Carcinus aestuarii*) [19].

Fundamental knowledge about the nutritional quality of crustaceans and human health implications of its consumption are still lacking, and these would be essential to facilitate the utilization and marketing of this seafood. The purpose of this study was to determine the seasonal nutritional quality of *C. aestuarii* (Nardo, 1847) in southern Tunisian waters by determining the proximate composition of protein, ash, lipid, carbohydrate, and water of males and females, juvenile and adult. Moreover, considering the controversy of the benefits related to shellfish consumption and the potential impact in consumer's food regarding the different edible tissues and consumption seasonality, samples were taken monthly during one-year period. Data were also analyzed to evaluate the nutritional quality in human consumption by determining the water content, the mineral content, the protein content, and the fat content. Additionally, the human health implications of consuming this species are also discussed.

2. Material and Methods

2.1. Study Area. The Gulf of Gabes is located in southern Tunisia and in southern Mediterranean Sea. It extends along 750 km from La Chebba to the Libyan border (Figure 1). This maritime zone, bathed by Atlantic water masses [20], includes large continental shelves characterized by the presence of large beds of *Posidonia oceanica* (Delile, 1813) [21–23]. Both wide and shallow continental shelves are topographically regular. The bottom slightly declines towards the sea and 60 m depth occurs at 110 km from the coast [22]. The area is locally the most important fishing area and comprises more than 50% of the Tunisian fishing fleet. The main characteristics of substrates in the Inshore and Midshore areas are muddy sand, being covered in some areas with the seagrass *Cymodocea nodosa* (Ascherson, 1870) and *Zostera noltii* (Hornemann, 1832) in the first sector and with high cover of seagrass *Posidonia oceanica* (Delile, 1813) in the second [23]. However, in the deeper waters, the substratum was dominated by coral reefs and dead shells.

2.2. Sampling and Data Analysis. The study involved 1399 individuals of *Carcinus aestuarii* (881 females and 518 males), collected in the North of Sfax in monthly intervals between September 2008 and August 2009 of total lengths between 22 and 64 mm. For each crab several parameters were recorded: sex, total weight, gonad and hepatopancreas weight, and carapace width and length.

The hepatopancreas and gonads (fresh weight) from each crab were subsequently weighed stored at 105°C for 24 h in an oven [24] and were placed in desiccators to obtain the dry weight for later biochemical analysis.

The moisture, ash, protein, and lipid contents were determined according to the AOAC methodologies [25].

The moisture content was determined by drying the sample in an oven at 105°C until a constant weight was obtained. The difference between fresh and dry weights represents the amount of water contained in the product. So this tenor was expressed in g of water per 100 g of fresh product by applying the following formula [25]:

$$\text{moisture content} = \frac{p_f - p_s}{p_f} \times 100, \quad (1)$$

where p_f is fresh weight of the sample and p_s is dry weight of the sample.

For mineral content, the ash contained in mineral matter was obtained by calcination of weight dry at 650°C for one hour in an oven until all the organic materials were burned and eliminated in volatile form. The ash content was

expressed in g of mineral matter per 100 g of fresh product by applying the following formula [25]:

$$\text{mineral content} = \frac{p_1 - p_0}{p_e} \times 100, \quad (2)$$

where p_0 represents the weight after calcinations, p_1 the dry weight of the sample, and p_e is the taken fresh test.

The protein content was determined by the Kjeldahl method [25], and a conversion factor of 6.25 was used to convert total nitrogen to crude protein. This technique has three essential steps that are the mineralization, distillation and dosage

$$\text{Nitrogen rate} = \frac{14 \times 0.1 \times V}{p_e} \times 100, \quad (3)$$

where 14 represents the molecular weight of nitrogen, 0.1 the normality of the sulphuric acid, V the volume paid in mL acid, and p_e is the mg test.

The fat content was determined by using the Soxhlet extraction method [25], with chloroform as solvent. Indeed, the chloroform compared to petroleum ether and hexane gives the best performance for the extraction of fishery products lipids [25]. This content was expressed in g of fat per 100 g of fresh product. It was calculated by the following formula:

$$\text{Fat content} = \frac{p_1 - p_0}{p_f} \times 100, \quad (4)$$

where p_0 represents the weight of the empty beaker, p_1 the weight of beaker containing fat, and p_f is the fresh weight of the sample.

2.3. Statistical Analyses. All analyses were repeated three times. Results were expressed as mean values ± standard deviation (SD). The differences were calculated using one-way analysis of variance ANOVA, and statistically significant differences were reported at $P < 0.05$.

3. Results and Discussion

Biochemical studies are very important from the nutritional point of view. The biochemical constituents in animals are known to vary with season, size of the animal, stage of maturity, temperature, and availability of food, and so forth [26].

In the present study, all examples were captured on the preselected seasons to determine the most appropriate season for utilization. For hepatopancreas and gonads together, the moisture, ash, protein, and fat contents of average were 74.082 ± 2.709%, 14.254 ± 0.15%, 11.514 ± 0.637%, and 3.548±0.847%, respectively (Figure 2). The results of moisture analysis of European green crab ranged from 79.1 ± 0.4% to 82.30 ± 0.5%. In the crab *Carcinus maenas* (Linnaeus, 1758), the moisture value was 79.0 ± 0.7% [13]. These values are close to findings of the present study. The measures of Blue crab's (*Callinectes sapidus*, Rathbun, 1896) and sand crab's (*Portunus pelagicus*, Linnaeus, 1758) breast meat fat contents

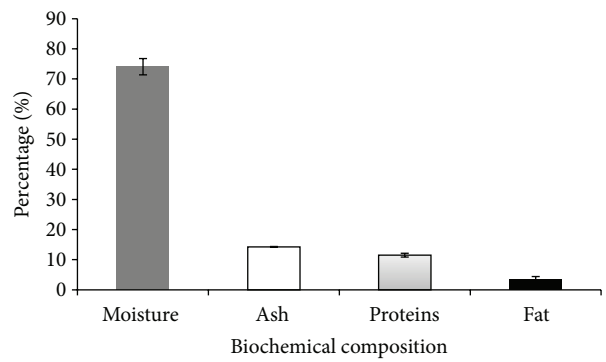

Figure 2: The percentage of biochemical composition of hepatopancreas and gonads in *Carcinus aestuarii* (Nardo, 1847) from the Gulf of Gabes (Tunisia).

were 1.51 ± 0.01 and 1.53 ± 0.01%, respectively [27]. In Northern Canada, the European green crab samples taken from 4 different stations had protein contents of 13%-14% [15].

Lipids are highly efficient as sources of energy and they contain more than twice the energy of carbohydrates and proteins [28]. In *Podophthalmus vigil* (Fabricius, 1798) the lipid values were assessed from 15.13% to 9.73% [29]. However, the lipid values recorded in *Charybdis smithii* (MacLeay, 1838) varied from 6.2% to 7.6% [30]. In *Chaceon affinis* (Milne-Edwards & Bouvier, 1894) the lipid value was 0.7% [31]; in blue crab it was 1.5% [32]. On other hand, the lipid content in *Scylla serrata* (Forsskal, 1775) from body meat was 1.65% and claw meat was 2.01% [33]. The lipid values in *S. serrata* (Forsskal, 1775) from body meat (1.07%) and claw meat (1%) were assessed by George and Gopakumar [34]. In *Portunus pelagicus* (Linnaeus, 1758) the lipid value ranged from 3.3% to 5.6%, and in *Portunus sanguinolentus* (Herbst, 1783) it was 3.8% to 5.5% [35]. The lipid content in *Scylla tranquebarica* (Fabricius, 1798) of the body meat (0.9% to 1.6%), claw meat (1.83% to 2.06%) and leg meat (1.58% to 2.08%) was estimated by Thirunavukkarasu [36]. In comparison, the lipid content of hard shell crabs *Charybdis lucifera* (Fabricius, 1758) (1.65%) was found to be a little bit lower than eyestalk ablated crabs (1.85%) [37]. In crustaceans, lipids are not only the principal organic reserve and source of metabolic energy, but also indispensable in maintaining cellular integrity. Lipids as a general rule act as major food reserve along with protein and are subject to periodic fluctuations influenced by environmental variables like temperature [38].

According to proximate chemical composition analysis, there were significant differences in the moisture, protein, ash and fat contents in terms of seasons, ages, and sexes ($P < 0.05$). In the whole, female gonads and hepatopancreas were rich in protein and fat. They showed significantly lower ash and moisture than males (Figure 3). In particular, between adults and juveniles, the moisture and ash contents had no significant differences ($P > 0.05$), but instead the fat and the protein contents were low among adults than juveniles ($P < 0.05$) (Figure 4).

It has been reported that freshwater crab is a good source of protein on different regions of the world [39]. The meat

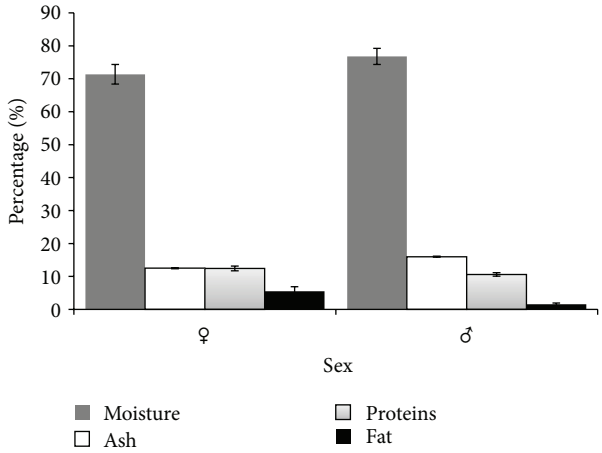

Figure 3: Variations of biochemical composition of hepatopancreas and gonads in function of sex in *Carcinus aestuarii* (Nardo, 1847) from the Gulf of Gabes (Tunisia).

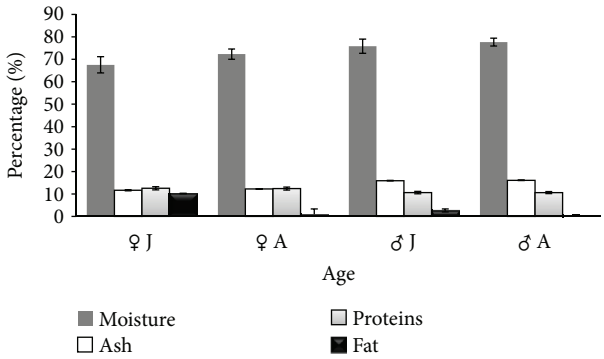

Figure 4: Variations of biochemical composition of hepatopancreas and gonads in function of age in *Carcinus aestuarii* (Nardo, 1847) from the Gulf of Gabes (Tunisia).

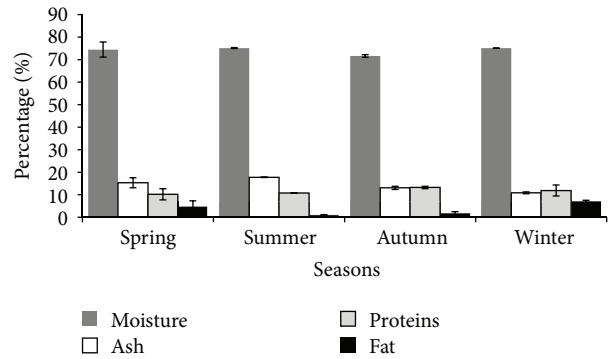

Figure 5: Variations of biochemical composition of hepatopancreas and gonads in function of seasons in *Carcinus aestuarii* (Nardo, 1847) from the Gulf of Gabes (Tunisia).

protein contents of *P. pelagicus* (Linnaeus, 1758), reported by Türeli et al. [27], were 18.83 ± 0.23% and 17.55 ± 0.23% in males and females, respectively. In another study, the protein value in *P. vigil* (Fabricius, 1798) was 15.75% to 20.16% [29], and in *C. affinins* (Milne-Edwards & Bouvier, 1894) was 17.8% [31]. In *S. serrata* (Forsskal, 1775), the protein contents of the body meat and claw meat were 20.11% and 18.54%, respectively [33]. In blue crab, the protein value was 17.17% [32]. Indeed, the protein content varied from 0.47% to 15.91% in *P. pelagicus* (Linnaeus, 1758) and from 12.81% to 13.6% in *P. sanguinolentus* (Herbst, 1783) [35]. Other studies reported that the protein values in *S. serrata* (Forsskal, 1775) were 17.69% and 19.39% for males and females, respectively [40]. Further investigations reported 11.60% protein in body meat of males and 19.92% protein in females body meat of *S. serrata* (Forsskal, 1775) [41]. The chemical composition had variations through seasons (Figure 5). For female juveniles, the highest protein values were shown in autumn and the highest fat values were obtained in winter. Moreover, the lowest protein values were measured during spring while in males the protein values did not vary through seasons (Figures 4 and 5). In *Potamon potamios* (Olivier, 1804) the lowest protein values (13.94 ± 0.228%) were measured in females during spring while in males (18.35 ± 0.202%) during summer [42].

The highest fat values for female and male juveniles showed in winter and spring (Figures 4 and 5). The chemical composition analysis of crab gonads and hepatopancreas revealed variable moisture contents ranging from 60.134 ± 2.174 to 78.998 ± 4.054% according to the season, and there was no significant difference between sexes ($P > 0.05$). The highest fat values for females and males juveniles were showed in winter (10.497 ± 0.457% and 3.638 ± 0.535%, resp.).

Autumn is the best season to eat crab, especially due to the lower fat content and the higher protein content in females adults' gonads and hepatopancreas. Previous findings indicated clearly that *C. aestuarii* (Nardo, 1847) was beneficial for human health and nutrition, and a preparation of green crab lipids was efficiently hydrolysed by human pancreatic juice in vitro, suggesting a good digestibility of these lipids in vivo [19]. Other studies showed that the protein is essential for the sustenance of life and accordingly exists in the largest quantity of all nutrients as a component of the human body [28].

The present study showed that green crab gonads and hepatopancreas were rich in proteins and poor in fat. Both tissues can be a good source of low fat content. These results are in agreement with those found in the literature for other crustaceans, like blue crab, Swimmer crab, and Chinese mitten crab though generally lower fat in hepatopancreas has been reported.

In conclusion, this study is the first report investigating the nutrient composition of the green crab *Carcinus aestuarii* in the Gulf of Gabes. The biochemical compositions were strongly influenced by sex, age and seasons. The hepatopancreas and gonads of green crab from Tunisian waters are a good source of proteins and mineral. From the present study, findings may help to determine future quantitative changes indicating trends in the southern Tunisian waters that are exposed to various factors of environmental conditions and human activities.

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