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RESEARCH ARTICLE

Biochemical composition of different sex and body parts of blue crabs (*Callinectes sapidus*) caught from the middle Black Sea coast

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ABSTRACT

This study was carried out to determine the nutritional composition of blue crabs (*Callinectes sapidus*) caught on the Fatsa (Ordu) coasts of the Middle Black Sea of Türkiye. The nutritional value of various edible body parts (carapace, right and left claw, and legs) of the blue crabs were evaluated, and the proximal biochemical compositions of crabs belonging to different sexes were compared. The average protein content in male and female blue crabs was 18.79% and 19.11%, respectively. The highest amount of protein in female crabs was determined in the carapace, while the highest amount in males was determined in the legs. The quantity of fat in male crabs ranged from 0.46 to 0.69%, whereas the amount in female crabs ranged from 0.63 to 0.92%. The mean fat in female crabs was higher than in male crabs ($p<0.05$). The moisture and ash content in all of the body parts of male and female crabs varied between 78.62-76.73% and 2.29-2.39%, respectively; however, the difference between these values was statistically insignificant. The lowest and highest energy values for 100 g of crab meat were determined to be 78.27 kcal and 88.00 kcal, respectively. This study suggests that the blue crab, with its high protein and low-fat content, may be an alternative nutrient-dense species for the rural population.

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Introduction

This study was carried out to determine the nutritional composition of blue crabs (*Callinectes sapidus*) caught on the Fatsa (Ordu) coasts of the middle Black Sea of Türkiye. The nutritional value of various edible body parts (carapace, right and left claw, and legs) of the blue crabs were evaluated, and the proximal biochemical compositions of crabs belonging to different sexes were compared. The average protein content in male and female blue crabs was 18.79% and 19.11%, respectively. The highest amount of protein in female crabs was determined in the carapace, while the highest amount in males

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As a result of population growth in the world, people's food requirements are increasing day by day. Effective use of currently available food sources and the availability of substitute food sources are required to meet these demands.

When used effectively, seafood contains many nutritional sources in terms of human health. However, the availability of these resources is prone to decline owing to climate change, inappropriate human overuse, and poor policy. These consumption patterns led to a decline in endemic species and an increase in the alien invasive species (AIS) population. Although this condition may initially seem alarming, it has been shown that invasive edible species may be used to acquire nutritional and economic advantages, at least in part (Piras et al., 2019). The increased water temperature due to deep water currents and climate change makes the environmental conditions more suitable for Mediterranean-origin species in the Black Sea. In addition, increased human activities and maritime transport play a critical role in the transferring species to other regions. For these reasons, it was recently discovered that the Black Sea has a large number of AIS (Shefer et al., 2004; Şahin et al., 2009; Sağlam et al., 2011; Turan et al., 2016, Ceylan, 2020). One of these invasive edible alien species is the blue crab, first discovered in Europe in the early 20th century and the Mediterranean in 1949. The blue crab is thought to have originated in the western Atlantic (Enzenroß et al., 1997) and is processed locally in the Mediterranean region and exported to European countries with a high economic return (Türeli et al., 2000). It was initially recorded in 2017 in Ordu province in the Middle Black Sea area of Türkiye (Aydın, 2017). Numerous studies have been undertaken on the nutritional profile of different species of crab across the world (Tsai et al., 1984; Siddiquie et al., 1987; Barrento et al., 2010; Bayraklı, 2021; Shaeik et al, 2021; Tufan, 2022). Although there are certain studies on the nutritional composition of different crab species including blue crab in Mediterranean coasts of Türkiye (Türeli et al., 2000; Gökoglu & Yerlikaya, 2003; Çelik et al., 2004), no such study has been conducted on blue crabs in the Middle Black Sea coast. For this purpose, this aimed to determine the nutritional compositions such as protein, fat and mineral content among the sex and different body parts of the blue crab.

Material and Method

Captured individuals were sampled at 2-10 m depths in a Trammel net with 48 mm mesh set up close to the creek mouth for demersal fish sampling (Aydın, 2017).

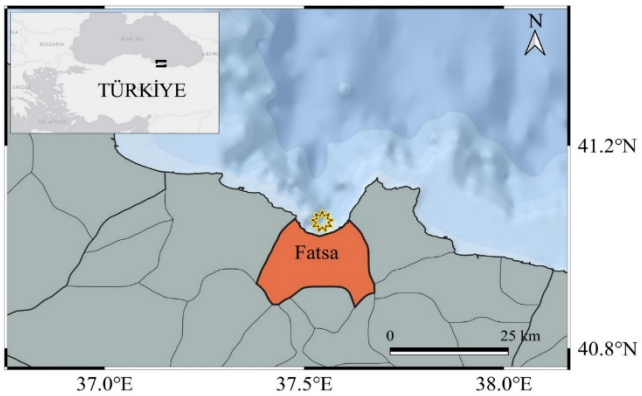

Figure 1. Sampling area of blue crab (Fatsa, Ordu, Türkiye)

After the captured samples (n_{male}:9, n_{female}:8) were frozen at -18°C, they were brought to Sürmene Faculty of Marine Sciences by the cold chain in a styrofoam box. The sampled individuals were taken to the laboratory and their height and weight measurements were performed. The carapace width of the female individual sampled with one claw missing was 19.6±0.6 cm, the carapace length was 7.83±0.7 cm, and the total weight was 269.39±14.22 g. The carapace width of the male individual was 19.4 cm, carapace length was 8.40 cm and the total weight was determined as 449.19±17.32 g. After length and weight measurement, sex was determined in blue crabs (Figure 3; Millikin & Williams, 1984, as male and female). After sex determination, the flesh meat on the carapace, right claw, left claw and legs of female and male crabs were removed and prepared for analysis separately (Figure 4). The removed flesh meats obtained from the same sex and the same body part representing the same season were mixed with a homogenizer (Arçelik; K-1631 P Valso Plus, 2.2 L capacity, Türkiye).

Analysis of Proximate Composition

Moisture analyses were conducted according to the oven drying method. 5 g wet sample was taken from each blue crab body part sample, and the moisture content was determined by removing the water content between 14-16 hours at 105°C (AOAC, 1995, Method 985.14). The total ash amount was

determined with the gradual combustion method, with the final temperature in the muffle furnace at 540-560°C (AOAC, 2005a). Crude fat analyses were carried out on dry matter using the Soxhlet method (Velp SER 148/6, Velp Scientifica, Milano, Italy) by petroleum ether and hot oil extraction method (130°C), and the results were calculated as g/100 g by converting to wet sample amount. The crude protein amount (nitrogen content) was determined according to AOAC Method 2.507. The analysis was made on dry matter, and the protein amount was calculated by converting to the amount of wet-weight samples as a result of the analysis (AOAC, 2005b). The Atwater method was applied to calculate the total energy value of the soup (Merrill & Watt, 1973).

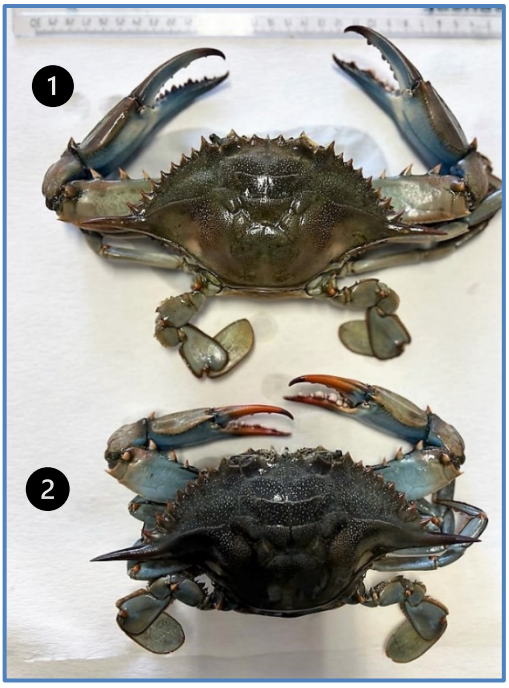

Figure 2. Male (1) and female (2) blue crab

Statistical Analysis

The data obtained were analyzed by analysis of variance (One-Way ANOVA) and when significant differences were found, comparisons among means were further analyzed by using a TUKEY and Mann-Whitney U test (data not provided in the normality of assumptions) under the JMP 5.0.1 program (SAS Institute. Inc. USA) and SPSS (SPSS Inc., Chicago, IL) (Sokal & Rohlf, 1987). A significance level of 95% ($p<0.05$) was used throughout the analysis.

Results

The nutritional composition of the analyzed blue crab meat is given in Table 1. According to these results, protein values in body parts (carapace, right claw, left claw and legs) of male individuals were found to be 18.26-19.22%. The amount of protein in female crabs was found to be the highest (19.93%) in carapace and the lowest in right claw (18.05%). The total crude fat in the body parts of male crabs was found to be in the range of 0.46-0.69%. The amount of fat in female crabs was found to be the highest in carapace (0.92%) and the lowest in legs (0.63%). It was determined that the lowest and highest moisture content in female (in carapace) and male (in right claw) crabs varied between 76.73-78.58%, respectively. The lowest amount of ash was determined in the carapace of female crabs (2.29%), while the highest in the carapace of male crabs (2.39%). When the energy amounts in 100 g crab meat were calculated, the highest amount was found as 88.00 kcal/100 g in the carapace of female crabs, and the lowest was found as 78.27 kcal/100 g in the right claw of male crabs.

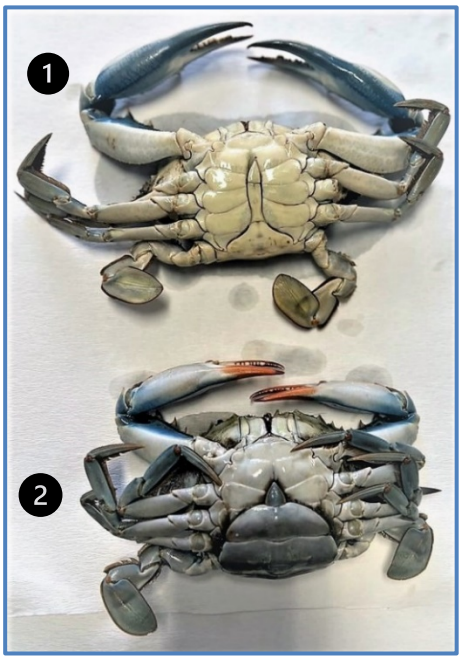

Figure 3. Male (1) and female (2) blue crab bottom view

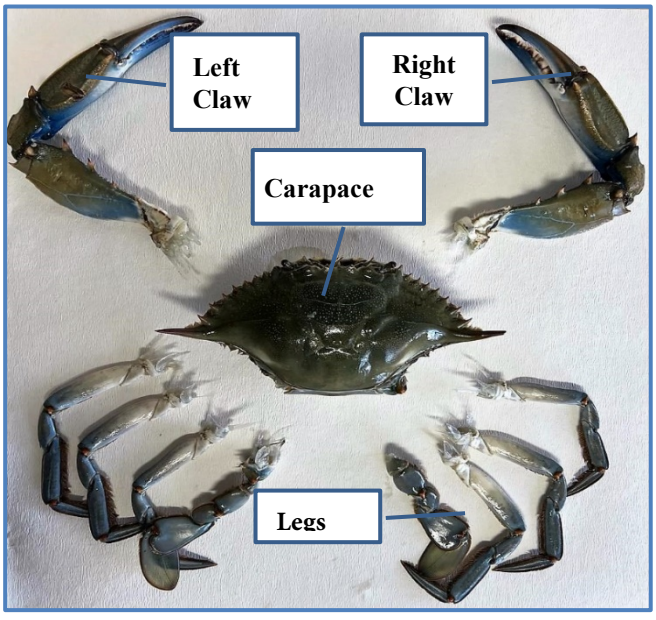

Figure 4. Analyzed body parts of blue crab

Table 1. Proximate composition in body parts of male and female blue crabs (*Callinectes sapidus*) (g/100 g)

	Body Parts	Protein	Fat	Moisture	Ash	Energy (kcal/100 g)
MALE	Carapace	$18.97\pm0.09^{a}{}_{A}$	$0.69\pm0.03^{a}{}_{A}$	$77.69\pm1.23^{a}{}_{A}$	$2.39\pm0.21^{a}{}_{A}$	$82.08\pm1.23^{ab}{}_{A}$
	Left Claw	$18.69\pm0.07^{a}{}_{A}$	$0.59\pm0.02^{a}{}_{A}$	$78.32\pm0.96^{a}{}_{A}$	$2.38\pm0.15^{a}{}_{A}$	$80.10\pm1.41^{ab}{}_{A}$
	Right Claw	$18.26\pm0.05^{a}{}_{A}$	$0.58\pm0.03^{a}{}_{A}$	$78.58\pm1.14^{a}{}_{A}$	$2.35\pm0.18^{a}{}_{A}$	$78.27\pm0.85^{bc}{}_{A}$
	Legs	$19.22\pm0.06^{b}{}_{A}$	$0.46\pm0.04^{b}{}_{A}$	$77.49\pm0.84^{a}{}_{A}$	$2.34\pm0.21^{a}{}_{A}$	$81.03\pm0.96^{a}{}_{A}$
	Mean	$18.79\pm0.23_{A}$	$0.58\pm0.06_{A}$	$78.02\pm0.68_{A}$	$2.37\pm0.14_{A}$	$80.37\pm0.77_{A}$
FEMALE	Carapace	$19.93\pm0.15^{a}{}_{B}$	$0.92\pm0.04^{a}{}_{B}$	$76.73\pm0.97^{a}{}_{A}$	$2.29\pm0.28^{a}{}_{A}$	$88.00\pm0.69^{a}{}_{B}$
	Left Claw	$18.75\pm0.31^{b}{}_{A}$	$0.79\pm0.08^{b}{}_{B}$	$77.85\pm0.45^{a}{}_{A}$	$2.32\pm0.36^{a}{}_{A}$	$82.14\pm0.48^{b}{}_{B}$
	Right Claw	$18.05\pm0.45^{b}{}_{A}$	$0.77\pm0.06^{b}{}_{B}$	$78.62\pm1.01^{a}{}_{A}$	$2.31\pm0.21^{a}{}_{A}$	$79.17\pm0.98^{d}{}_{A}$
	Legs	$19.72\pm0.09^{a}{}_{B}$	$0.63\pm0.02^{c}{}_{B}$	$76.98\pm1.12^{a}{}_{A}$	$2.30\pm0.11^{a}{}_{A}$	$84.51\pm1.32^{bc}{}_{B}$
	Mean	$19.11\pm0.14_{A}$	$0.78\pm0.07_{B}$	$77.54\pm0.89_{A}$	$2.31\pm0.17_{A}$	$83.45\pm1.04_{B}$

Note: n=3, ±: standard deviation (SD). Different superscript letters in the same column (a, b, c and d) indicate significant differences amongst different body parts of the same sex ($p<0.05$). Different subscript letters (A and B) in the same column indicate significant differences between the same body parts of different sexes (male and female) ($p<0.05$).

Discussion

In the study conducted by Gökoğlu & Yerlikaya (2003) on the blue crabs (*C. sapidus*) caught from the Mediterranean region, the protein, fat and ash amount in claw meat were found to be 15.00, 0.64, 1.39, and 14.71, 0.79, 1.89 g/100g in carapace meat respectively. Oramadike & Kolade (2015) examined the proximate composition of blue crabs they bought from the local fish market in Nigeria, and they reported that. The study's results reported that the protein, fat and ash values, respectively, were 19.18, 0.43, and 2.18%, in male crabs, and 20.21, 0.72, and 2.30% in female crabs. In another study, the protein and fat contents of male blue crabs obtained from Akyatan Lagoon in the Mediterranean were 30.31% and 1.64% in carapace, respectively, and 31.03-1.22% in claws. In female crabs, the amount of protein in carapace and claw was 26.51-29.59% and, the amount of fat was 1.62-1.12%, respectively (Kuley et al., 2008). It was concluded from the findings of previous studies that the nutritional composition analysis results of crabs were roughly in agreement with our study data. However, certain differences were identified between the sexes. These differences are thought to be due to the height and weight differences (male and female) and reproductive period of the crabs (Balogun & Talabi, 1985; Nettleton et al., 1990; Silva & Chamul, 2000; Baklouti et al., 2013). In the present study, the lowest amount of protein (18.05%) in both male and female crabs was found in the right claw; however, the highest amount of protein (19.93%) was determined in the carapace. While the amount of protein in the carapace of female crabs was similar to that in the legs, significant differences were found among other body parts ($p<0.05$). The amount of protein in the carapace of female individuals was statistically different from both among other body parts of the same sex (except legs) and from the carapaces of male crabs ($p<0.05$). Also, statistical differences were found between the amount of protein in the legs and other body parts of male blue crabs ($p<0.05$).

The low fat content of crabs (Table 1) is a feature of carapace, reported as <2% in several studies (Gökoğlu & Yerlikaya, 2003; Kuley et al., 2008; Ayas, 2011). The lowest and highest amount of fat in male blue crabs was found in the legs (0.46%) and carapace (0.69%), respectively. Statistically significant differences were found between the amount of fat in the legs and other organs ($p<0.05$). The amount of crude fat in the body organs of female crabs was found to be between 0.63% and 0.92%. The lowest fat was found in the legs, while the highest was in the carapace like in male crabs. While the amount of fat in the right claw and left claw of female crabs is similar, the amount of fat among the other body parts was significantly different ($p<0.05$). In addition, statistically significant differences were found between the amount of fat in all body part of male and female crabs ($p<0.05$). The lowest moisture content in the male and female crab species was 76.73% in the carapace of females and the highest was in the right claw of female crabs. In addition, there was no statistical difference between both the body parts and sexes. The highest amount of ash in female and male crabs was determined as 2.39% in the carapace of male crabs and the lowest (2.29%) was in carapace of female crabs.

On the other hand, like the amount of moisture, there were no significant differences between the different body parts and sexes. The energy values of crab meat were in the range of 78.27

and 88.00 kcal/100 g. The highest energy value was found in carapace of female crabs, while the lowest was found in the right claw of male crabs. In addition, the average amount of energy in the meat of female crabs was statistically different from that of male crabs ($p<0.05$).

Conclusion

The nutritional values of the edible meat of the blue crab caught in the middle Black Sea coast of Türkiye were analyzed and it was determined that both male and female individuals of this species have a high protein and low-fat content. Thanks to this feature of blue crabs, it can be beneficial for the people of the region as an alternative aquatic product. It has been observed that invasive species can migrate to different regions such as the middle Black Sea due to changing climatic conditions, so this study raises awareness of the existence of this species in the Black Sea region. It is believed that the use of foreign invasive species such as blue crabs as food will partially prevent the over-spreading of the species.

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Compliance With Ethical Standards

Conflict of Interest

The author declares that they have no conflict of interest.

Ethical Approval

For this study, all applicable international, national, and/or institutional guidelines for the care and use of animals were followed.

Data Availability Statements

The data that support the findings of this study are available from the author upon reasonable request.

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