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SHORT COMMUNICATION KISA BİLGİLENDİRME

THE CHEMICAL COMPOSITION OF CARAPACE MEAT OF SEXUALLY MATURE BLUE CRAB (*Callinectes sapidus*, RATHBUN 1896) IN THE MERSIN BAY

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Abstract: Chemical composition of carapace meat from adult male and female blue crabs caught in the Mersin Bay, Northeastern Mediterranean, was investigated. The results of proximate analysis showed that carapace meat of female blue crabs had higher protein content and lower water content than those of the male. Moreover, there were variations in protein and water content of carapace meat of female and male crabs ($p<0.05$). Saturated fatty acid (SFA) content was detected as 24.76% for female crabs whereas it was 23.27% for male crabs. Monounsaturated fatty acid (MUFA) content in the meat of female blue crabs (29.57%) was higher than that of male blue crabs (26.63%). Besides, polyunsaturated fatty acid (PUFA) content of male crabs (42.80%) was higher than that of female crabs (39.15%). The dominant SFAs were palmitic acid (C16:0, 13.62%-14.23%) and stearic acid (C18:0, 6.42%-6.99%) for male and female crabs. The dominant MUFAs were palmitoleic acid (C16:1, 6.09%-8.65%) and oleic acid (C18:1, 14.66%-14.75%) in all samples. Statistically, there were no significant differences in eicosapentaenoic acid (EPA C20:5 n3) concentrations in carapace meat of male and female blue crabs ($P>0.05$). Besides, docosahexaenoic acid (DHA, C22:6 n3) concentrations in meat of male crabs were higher than those of the female ($p<0.05$).The total *n*-3 was detected as 29.70% for female crabs whereas it was 32.27% for male crabs. It was also found that crab meat was rich in terms of metal content, especially Cu, Zn, and Fe. Statistically, there were significant differences in Cd, Cr, Cu, Zn and Fe levels for carapace meat of male and female crabs ($p<0.05$). Cu, Zn, Fe content of female crabs was significantly higher ($p<0.05$) than male crabs.

Keywords: *Callinectes sapidus*, Chemical composition, Mersin bay

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Özet: Mersin Körfezi'nden Eşeysel Olgunlaşmasını Tamamlamış Mavi Yengeç (*Callinectes sapidus*, Rathbun 1896) Karapaks Etinin Kimyasal Kompozisyonu

Mersin Körfezi'nden yakalanan ergin dişi ve erkek mavi yengeçlerin kimyasal kompozisyonu araştırılmıştır. Dişi mavi yengeçlerin erkeklere göre protein düzeyi yüksek, su içeriği düşüktür. Dişi ve erkek yengeçlerin protein ve su düzeyi arasında istatistiksel farklılık vardır ($p<0.05$). Dişi yengeçlerin doymuş yağ asitleri (SFA) düzeyi %24.76, erkeklerin ise %23.27 olarak belirlenmiştir. Dişi yengeçlerin tekli doymamış yağ asitleri (MUFA) düzeyi (%29.57) erkeklerden (%26.63) yüksektir. Bunun yanı sıra erkek yengeçlerin çoklu doymamış yağ asitleri (PUFA) düzeyi (%42.80) dişilerden (%39.15) yüksektir. Mavi yengecin temel doymuş yağ asitleri palmitik asit (C16:0, %13.62-%14.23) ve stearik asit (C18:0, %6.42-%6.99) olarak belirlenmiştir. Temel tekli doymamış yağ asitleri palmitoleik asit (C16:1, %6.09-%8.65) ve oleik asit (C18:1, %14.66-%14.75) olarak saptanmıştır. Dişi ve erkek yengeçlerin eikosapentaenoik asit (EPA, C20:5 n3) düzeyleri arasında istatistiksel farklılık belirlenmemiştir ($p>0.05$). Bunun yanı sıra erkek yengeçlerin dokosaheksaenoik asit (DHA, C22:6 n3) düzeyi, dişilerden yüksektir ($p<0.05$). Dişi yengeçlerin toplam *n*-3 düzeyi %29.70 iken erkeklerin %32.27 olarak belirlenmiştir. Dişi ve erkek yengeç eti Cd, Cr, Cu, Zn ve Fe düzeyleri arasında istatistiksel farklılık bulunmaktadır ($p<0.05$). Dişi yengeçlerin Cu, Zn, Fe düzeyi erkeklerden önemli düzeyde yüksektir ($p<0.05$).

Anahtar Kelimeler: *Callinectes sapidus*, Kimyasal kompozisyon, Mersin körfezi

Introduction

Poturnid crabs, big sea crabs, are the most important members of the sea food chain. While they feed on detritus, fish, alga, plant, cephalopods, decapods and annelids, they serve as preys to mammals, birds and fishes (Hall *et al*. 2006). Poturnid crabs play an important role in the carriage of fatty acids to mammals.

Blue crab, *Callinectes sapidus*, is an important species of big sea crabs consumed both in the world and our country. According to Fisheries Statistics (2010) report, 17 and 77 tons of blue crab were caught in 2008 and 2009, respectively in Turkey.

Blue crabs mature at the early stage of their life period. Fischer and Wolf (2006) reported that male and female blue crabs (*Callinectes arcuatus*) with the carapace width (CW) over 95 mm were accepted as adults on the coast of Nicoya Gulf in Costa Rica.

Seafood, including crustacean shellfish, is recommended for human diet due to their health-promoting characteristics (Skonberg and Perkins 2002). Seafood lipids are rich in *n*-3 PUFAs such as EPA and DHA. These fatty acids have a variety of health benefits, including prevention of sudden cardiac death (Leaf *et al*. 2003) and chemopreventive effects of cancer (Akihisa *et al*. 2004).

The fat and fatty acid compositions of seafood can vary depending on species, diet, gender, location and season of capture (Ayas *et al*. 2005, Özogul *et al*. 2007). Gökoğlu and Yerlikaya (2003) indicated that blue crabs had high protein and trace elements and low fat contents. Küley *et al*. (2007) reported that *n*-3 PUFAs, such as EPA and DHA, corresponded to approximately 25% of the total lipid in blue crabs.

Although the studies have been carried out on the fatty acid, metal and proximate composition of blue crabs (Türeli *et al*. 2002, Gökoğlu and Yerlikaya 2003, Çelik *et al*. 2004, Küçükgülmez *et al*. 2006, Türkmen *et al*. 2006, Küley *et al*. 2007), there is hardly any available information about metal, proximate and fatty acid composition in blue crabs living in Mersin Bay. Thus, this study aimed to determine and compare metal, fatty acid and proximate compositions of male and female blue crabs in Mersin Bay.

Materials and Methods

Materials

C. sapidus was caught by dip net from Mersin Bay, the coast of Northeastern Mediterranean, in March, 2008 (Figure I). In the fishing procedure, dip net which had mesh size of 32 mm was used. 30 male and 30 female individuals of every species were caught and kept in polystyrene boxes

with ice. They were still alive when they were brought to the laboratory.

Sample preparation

Some morphometric measurements [carapace length (CL), carapace width (CW)] and weight of all samples were recorded (Table I). The morphometric measurements of crab carapace were done using a caliper. After that, carapace meats of each sex group including 30 individuals were taken out by hand. All assays were conducted on triplicate samples of the homogenates. Metal, fatty acid and proximate composition analyses were done on these muscle tissue samples.

Proximate analysis

Crab samples were analyzed in triplicate for proximate composition. The following methods were used: Bligh and Dyer (1959) method for lipid content, AOAC (1998a) method for water content, Kjeldahl method (AOAC, 1998a) for total crude protein and AOAC (1998b) method for total mineral substance (TMS) content.

Fatty acid analysis

Fatty acid profiles of fat extracted from the blue crab samples were determined by gas chromatography (GC) of methyl esters. Methyl esters were prepared by transmethylation using 2 M KOH in methanol and *n*-heptane according to the method described by Ichibara *et al*. (1996) with minor modification. Extracted lipids (10 mg) were dissolved in 2 mL n-heptane followed by 4 mL of 2 M methanolic KOH. The tube was then vortexed for 2 min at room temperature. After centrifugation at 4,000 rpm for 10 min, the heptane layer was taken for GC analyses.

The fatty acid composition was analyzed by the GC Clarus 500 with autosampler (Perkin Elmer, Shelton, CT, USA) equipped with a flame ionization detector and a fused silica capillary SGE column (30 m 0.32 mm, ID 0.25 mm, BP20 0.25 UM; SGE Analitic Science Pty Ltd, Victoria, Australia). The oven temperature was 140 ^{o}C, held for 5 min, raised to 200 ^{o}C at a rate of 4 ^{o}C/min and to 220 ^{o}C at a rate of 1 ^{o}C/min, while the injector and the detector temperature were set at 220 ^{o}C and 280 ^{o}C, respectively. The sample size was 1 µL and the carrier gas was controlled at 16 ps. The split used was 1:50. Fatty acids were identified by comparing the retention times of fatty acid methyl esters with a standard 37-component fatty acid methyl ester mixture (catalog no 18919; Supelco). Tri replicate GC analyses were performed and the results were expressed in GC area % as the mean value±standard deviation.

Metal analysis

The crab carapace meat samples used for metal analysis were dried at 105°C to reach constant weights, and then concentrated nitric acid and percholoric acid (2:1 v/v) were added to the samples, and they were put on a hot plate set to 150°C until all tissues were dissolved. All crab meat samples were analyzed with ICP-AES (Varian model-Liberty Series II). The analyses were performed at least in triplicate.

Statistical analysis

Statistical analysis of data was carried out with the SPSS 16.0. T-test was used to evaluate the effects of sex on the chemical compositions of blue crab.

Figure 1. Sampling zone map (Mersin Bay)

Table 1. Some morphological measurements of male and female blue crabs

Sex	NS	CL (mm)		CW (mm)		Weight (g)	
		$\overline{X} \pm S_{\overline{X}}$	Min-max	$\overline{X} \pm S_{\overline{X}}$	Min-max	$\overline{X} \pm S_{\overline{X}}$	Min-max
♀	30	78.95±8.34	64.5-93.5	183.40±21.30	140.0-215.0	180.79±47.56	92-253
♂	30	95.63±16.96	68.5-127.0	214.00±35.00	155.0-280.0	238.60±99.95	93-438

NS-Number of specimens, CL: Carapace Length, CW: Carapace Width

Results and Discussion

In this study, average carapace widths of female and male blue crabs were 183.40 mm and 214.00 mm, respectively (Table 1). In a study carried out by Fisher and Wolff (2006) in Nicoya Bay, male and female with the carapace width over 95 mm accepted as adults. Thus, according to the results of this study, male and female blue crabs used in our study were adults.

Proximate composition

The protein and water contents of female and male blue crabs were significantly ($P<0.05$) different. The lipid and TMS contents of female and male crabs were not significantly ($P>0.05$) different. Protein contents of female blue crabs were significantly higher ($P<0.05$) than those found in male blue crabs. Water contents of male blue crabs were significantly higher ($P<0.05$) than those found in female blue crabs (Table 2).

This study shows that carapace meat of blue crabs caught from the Gulf of Mersin have high protein (21.40% for males-22.45% for females) and low fat contents (0.96% for females–1.11% for males). Some researchers support the result obtained in our study. Gökoğlu and Yerlikaya (2003) reported that protein contents were 14.71%-15.0% for blue crabs caught from the Gulf of Antalya. In our study, it was found out that these protein values for blue crabs were higher than those reported by Gökoğlu and Yerlikaya (2003). Gökoğlu and Yerlikaya (2003) reported average lipid contents were 0.64%-0.79% for blue crabs caught from the Gulf of Antalya. In our study, these lipid values were higher than those reported by Gökoğlu and Yerlikaya (2003). This difference was caused by the fact that individual crabs used in the study of Gökoğlu and Yerlikaya (2003) were smaller than those used in the present study. Besides, the crab samples used in these two studies were caught in different sea-

sons. The crab samples used in this study were caught in March whereas the samples used in Gökoğlu and Yerlikaya (2003) study was caught in July. Türeli *et al.* (2000) reported that protein contents were 14.3-16.8% for blue crabs caught from the Gulf of İskenderun. In our study, it was found out that these protein values for blue crabs were higher than those reported by Türeli *et al*. (2000). This difference might have been caused by the fact that the sizes of the individuals used in these two studies were different from each other. Küley *et al*. (2007) reported that protein and lipid contents were 26.5-31.0%, and 1.12-1.64% for blue crab meat, respectively. In a similar study, Küçükgülmez *et al.* (2008) also reported the contents of protein and lipid as 18.8-20.0%, 0.4%, respectively. Both of the studies present the similar findings to those obtained in our study.

Fatty acids profiles

Fatty acids, SFAs, MUFAs, PUFAs, PUFA/SFA, *n*-3 acids, *n*-6 acids and the *n*-6/*n*-3 ratio of male and female blue crabs' meat are presented in Tables III. The dominant SFAs were palmitic acid (13.62%-14.23%) and stearic acid (6.42%-6.99%) for both of the sexes. The highest total SFA values were found in the meat of female crabs. Çelik *et al*. (2004) reported that the amount of palmitic acid and stearic acid contents in blue crabs changed between 13.5%-15.0 and 5.56%-6.29, respectively. Çelik *et al*. (2004) also reported that the values of palmitic acid in crab meat were similar to our study while these values were found to be different for stearic acid.

The total MUFA percentage was the highest in meat of female blue crabs. Oleic acid (14.66%-14.75%) was the major MUFA in all crab carapace meats, followed by palmitoleic acid (6.09%-8.65%) and octadecenoic acid (4.28%-4.38%). Significant differences were observed in terms of palmitoleic acid between female and male crabs ($P<0.05$) (Table III). Küley *et al*. (2004) reported that the amounts of oleic acid and palmitoleic acid contents in blue crabs changed between 3.4%-17.1% and 3.0%-3.3%, respectively. Küley *et al*. (2007) also reported the values of oleic acid in crab meat were similar to our study while these values were different for palmitoleic acid.

The total PUFA levels in meat of male crabs (42.80%) were higher than in meat of female blue crabs (39.15%). EPA (20:5) and DHA (22:6) were PUFAs having maximal values. Statistically, there were no significant differences in EPA concentrations in carapace meat of male and female blue crabs ($P>0.05$). EPA content of blue crabs was reported to be 13.6%-16.3% by Küley *et al*. (2007). In our study, these values were found to be higher. It was assumed that this stemmed from the differences in the sizes of individuals and local area. Besides, DHA concentrations in carapace meat of male crabs were higher than those of the females ($p<0.05$). Küley *et al*. (2007) also reported this result regarding DHA contents.

The UK Department of Health recommends a maximum ratio of *n*-6/*n*-3 of 4.0 (HMSO 1994). Values higher than the maximum value are harmful to health and may promote cardiovascular diseases (Moreira *et al*., 2001). In this study, the ratio *n*-6/*n*-3 was found to range from 0.30 to 0.31. A minimum value of PUFA/SFA ratio recommended is 0.45 (HMSO 1994), which was lower than those obtained in the present study.

Metal contents

It was also found that they were rich in terms of metal content, especially Cu, Zn, and Fe. Pb values in meat of female and male blue crabs were not significantly different ($P>0.05$). Cu, Zn, Fe contents of female blue crabs were significantly higher ($P<0.05$) than those found in male blue crabs while Cd, Cr level were lower ($p<0.05$) (Table IV). Gökoğlu and Yerlikaya (2003) found out that Zn, Fe and Cu levels of blue crabs were 40.7-60.9 μg g^{-1}, 10.4-11.3 μg g^{-1}, and 25.3-31.3 μg g^{-1}, respectively in the Gulf of Antalya. Metal levels of blue crab species found in this study were lower than those found in our study. This difference was caused by the fact that individual crabs (carapace width, 96.2 mm) used in the study of Gökoğlu and Yerlikaya (2003) were smaller than those used in the present study. Besides, metal pollution levels in the Gulf of Mersin and Antalya might have affected these values. Pb, Cr and Cd levels of *Patella caerulea* and *Patella rustica* were determined by Ayas *et al.* (2009) in Mersin Bay. Cd, Cr, Pb levels of *Patella* species were found as 0.11-4.08 μg g^{-1}, 0.01-7.35 μg g^{-1}, 0.00-3.74 μg g^{-1} respectively. These levels obtained in the study of Ayas *et al*. (2009) were higher to those found in the present study. These differences may be caused by different species used in these two studies. In a similar study, Türkmen *et al.* (2006) reported Cd, Cr, Pb levels of *C. sapidus* as 1.77 μg g^{-1}, 4.53μg g^{-1}, 3.51μg g^{-1}, respectively in the Gulf of İskende-

run. There are differences between the study of Türkmen *et al.* (2006) and the present study in terms of the findings. The differences in the metal levels in the studies mentioned above may have stemmed from contamination levels of capture area and season of capture.

Table 2. Proximate compositions of carapace meat of female and male blue crabs (%)

	♀		♂	
	$\overline{X} \pm S_x$	Min-max	$\overline{X} \pm S_x$	Min-max
Protein	22.45±0.08[b]	22.37-22.55	21.40±0.23[a]	21.12-21.64
Lipid	0.96±0.16[a]	0.84-1.16	1.11±0.05[a]	1.06-1.17
Water	74.30±0.25[a]	73.88-74.57	75.47±0.15[b]	75.17-75.59
TMS	2.00±0.23[a]	1.77-2.32	1.85±0.24[a]	1.61-2.24

Within the rows values with different letters are significantly different (P<0.05). $\overline{X} \pm S_x$: Mean±Standart Deviation

Table 3. Fatty acid compositions of carapace meat of female and male blue crabs (%)

Fatty acids	♀		♂	
	$\overline{X} \pm S_x$	Min-max	$\overline{X} \pm S_x$	Min-max
C12:0	0.04±0.00[a]	0.04	0.05±0.00[b]	0.05
C14:0	0.83±0.10[a]	0.73-0.93	0.78±0.04[a]	0.75-0.82
C15:0	0.65±0.04[a]	0.60-0.68	0.58±0.02[a]	0.56-0.60
C16:0	14.23±0.10[b]	14.14-14.33	13.62±0.25[a]	13.43-13.90
C17:0	1.17±0.06[a]	1.12-1.23	1.11±0.04[a]	1.06-1.13
C18:0	6.99±0.04[b]	6.95-7.03	6.42±0.34[a]	6.03-6.65
C20:0	0.84±0.04[b]	0.80-0.88	0.72±0.02[a]	0.71-0.74
C22:0	0.08±0.00[b]	0.08	0.00±0.00[a]	0.00
ΣSFA	24.76	24.46-25.20	23.27	22.59-23.89
C14:1	0.03±0.01[a]	0.02-0.03	0.04±0.00[b]	0.04
C15:1	0.16±0.01[b]	0.15-0.16	0.13±0.01[a]	0.12-0.14
C16:1	8.65±0.13[b]	8.57-8.80	6.09±0.23[a]	5.96-6.36
C17:1	1.20±0.03[a]	1.17-1.22	1.13±0.03[a]	1.11-1.17
C18:1*n*9	14.75±0.24[a]	14.50-14.97	14.66±0.30[a]	14.43-15.00
C18:1*n*7	4.38±0.05[a]	4.27-4.44	4.28±0.03[a]	4.24-4.32
C20:1	0.37±0.01[b]	0.36-0.38	0.26±0.01[a]	0.25-0.27
C22:1*n*9	0.04±0.01[b]	0.04-0.05	0.03±0.00[a]	0.03
ΣMUFA	29.57	29.08-30.05	26.63	26.18-27.33
C18:2*n*6	2.83±0.16[a]	2.69-3.00	3.09±0.08[a]	3.02-3.17
C18:3*n*6	0.13±0.03[a]	0.11-0.16	0.11±0.01[a]	0.10-0.12
C18:3*n*3	0.88±0.02[a]	0.86-0.89	0.95±0.05[a]	0.90-1.00
C20:2 cis	0.27±0.02[a]	0.26-0.29	26±0.02[a]	0.24-0.28
C20:3*n*6	0.26±0.04[a]	0.23-0.30	0.38±0.04[b]	0.34-0.40
C20:3*n*3	ND	-	ND	-
C20:4*n*6	5.73±0.29[a]	5.42-6.00	6.51±0.15[b]	6.34-6.60
C20:5*n*3	17.51±0.09[a]	17.40-17.56	17.72±0.13[a]	17.57-17.81
C22:2 cis	0.24±0.01[a]	0.23-0.25	0.22±0.01[a]	0.21-0.23
C22:6*n*3	11.31±0.09[a]	11.21-11.37	13.59±0.25[b]	13.31-13.80
ΣPUFA	39.15	38.41-39.82	42.80	42.03-43.41
PUFA/SFA	1.58	1.52-1.63	1.84	1.76-1.92
Σ*n*6	8.95	8.45-9.46	10.06	9.80-10.29
Σ*n*3	29.70	29.47-29.82	32.27	31.78-32.61
*n*6/*n*3	0.30	0.28-0.32	0.31	0.30-0.32
Unidentified	6.52	4.93-8.05	7.30	5.37-9.20

Within the rows values with different letters are significantly different (P<0.05). $\overline{X} \pm S_{\overline{x}}$: Mean±Standart Deviation

Table IV. The metal compositions of carapace meat of female and male blue crabs (µg g^{-1})

Metal	♀ $\overline{X} \pm S_{\overline{x}}$	♀ Min-max	♂ $\overline{X} \pm S_{\overline{x}}$	♂ Min-max
Cd	0.24±0.01[a]	0.22-0.25	0.42±0.01[b]	0.39-0.44
Cr	0.43±0.01[a]	0.40-0.46	0.58±0.04[b]	0.50-0.69
Pb	0.24±0.03[a]	0.17-0.31	0.19±0.01[a]	0.17-0.21
Cu	29.48±0.56[b]	27.59-30.74	21.55±0.31[a]	20.67-22.50
Zn	127.84±1.13[b]	125.28-130.67	113.35±1.66[a]	110.54-119.66
Fe	24.10±0.38[b]	23.03-24.99	22.61±0.39[a]	21.77-23.92

Within the rows values with different letters are significantly different (P<0.05). $\overline{X} \pm S_{\overline{x}}$: Mean±Standart Eror

The U.S. Food and Drug Administration (2005) sets food contamination levels for crabs (for edible tissue) as 3 µg Cd g^{-1}, 1.5 µg Pb g^{-1}, 12 µg Cr g^{-1}, and these levels are presented as in the following by the Turkish Food Codex (2005): 0.5 µg Cd g^{-1}, 0.5 µg Pb g^{-1}, 20 µg Cu g^{-1} and 50 µg Zn g^{-1}. However, our study reveals that Cu and Zn levels are higher than those given above. As crabs are not consumed much in our country, these metals do not pose any serious threats for public health. However, although high levels of these metals do not directly affect human health, the excess copper and zinc could be cumulated in the food chain and by being carried to the upper trophic levels, they might create important ecological problems.

Conclusions

In our study, although it was found out that the carapace meat of big sea crab, *Callinectes sapidus*, were contaminated with Cu and Zn, the results obtained from the study showed that the carapace meat of male and female crabs was an important fatty acid and protein source.

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