THE CHEMICAL COMPOSITION AND MEAT YIELD OF MATURE BLUE SWIMMER CRAB (*Portunus pelagicus*, Linnaeus 1758) IN MERSIN BAY, NORTHEASTERN MEDITERRANEAN, TURKEY

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ABSTRACT

The objective of the present study was to determine meat yield and chemical composition of lump crabmeat (LCM) and chela crabmeat (CCM) of male and female adult blue swimmer crabs, *Portunus pelagicus*, caught in the Mersin Bay. Total meat yield of adult male blue swimmer crabs (37.67%) was higher than that of female (29.50%). Lipid levels of LCM (1.18-1.39%) were significantly higher ($P<0.05$) than those found in CCM (0.86-0.88%) while total mineral substance (TMS) levels (2.12-2.15%) were lower ($P<0.05$) in LCM than CCM (2.30-2.36%). The highest proportions of fatty acids found in blue swimmer crabs were myristic acid (C14:0, 0.84-1.06%), palmitic acid (C16:0, 10.81-12.82%), heptadecanoic acid (C17:0, 1.08-1.15%), stearic acid (C18:0, 8.60-10.04%), arachidic acid (C20:0, 0.56-1.07%), palmitoleic acid (C16:1, 4.93-6.89%), heptadecenoic acid (C17:1, 0.83-1.22%), oleic acid (C18:1*n*-9, 12.36-15.50%), octadecenoic acid (C18:1*n*-7, 2.71-3.14%), linoleic acid (C18:2 *n*-6, 2.04-3.04%), arachidonic acid (C20:4 *n*-6, 6.41-8.31%), cis-5,8,11,14, 17-eicosapentaenoic acid (EPA, C20:5 *n*-3, 18.04-20.81%) and cis-4,7,10,13,16,19-docosahexaenoic acid (DHA, C22:6 *n*-3, 12.45-14.43%). In the present study, it was observed that LCM and CCM of female and male blue swimmer crabs contained high levels of Cu, Zn, and Fe.

KEYWORDS: Blue swimmer crab, *Portunus pelagicus*, meat yield, chemical composition

1. INTRODUCTION

Blue swimmer crab, *Portunus pelagicus*, is an Indio-Pacific species. This exotic portunid crab species came to the Mediterranean waters after the opening of Suez Canal. Blue swimmer crabs are commonly distributed in the Northeastern Mediterranean shores of Turkey.

Blue swimmer crab is one of crab species which have economic value. Thus, this species is caught both in the world and our country. According to Fishstat plus report [1], 55 and 95 tons of blue swimmer crabs were caught in 2003 and 2007, respectively, in Turkey.

Blue swimmer crabs mature at the early stage of their life period. Razek [2] reported that male and female blue swimmer crabs with carapace width (CW) over 90-100 mm were accepted as adults on the coast of Egypt. In a similar study, carried out in Kakinada region of India, Devi [3] accepted male and female blue swimmer crabs with CW >95 mm as adults. Meat yield of male portunid crabs is usually higher than that of females, and Türeli *et al.* [4] reported that meat yields of males were higher than those of females.

While blue swimmer crabs contain low levels of lipids, they are rich in proteins [5-7]. Many studies have been done to determine fatty acid composition of portunid crabs [8-13]. Hall *et al.* [11] reported that EPA and DHA levels were approximately 30% of the total lipids for blue swimmer crabs. Among the polyunsaturated fatty acids, EPA and DHA are the dominant *n*-3 fatty acids. These fatty acids have been reported to have preventive effects on cancers, brain disorders, rheumatoid arthritis, multiple sclerosis, autoimmune disorders, coronary heart and inflammatory bowel diseases, inflammation and arrhythmias [14-19], and to decrease the risk of sudden death among men without evidence of prior cardiovascular disease [11, 20]. Besides, as high level of EPA can cause bleeding, the low content of EPA has been recommended for pregnant and nursing mothers by Ward and Singh [21]. For this reason, investigation of the fatty acid compositions of big sea crab species has great importance in terms of human health. Blue swimmer crabmeat contains high levels of Cu, Zn, and Fe [6, 22]. Although there are many studies on the chemical composition of blue swimmer crabs, there is hardly any available information about chemical composition in blue swimmer crabs living in Mersin Bay. Thus, the objective of this study was to determine and compare chemical compositions in LCM and CCM of male and female blue swimmer crabs in Mersin Bay.

2. MATERIALS AND METHODS

2.1. Materials

Blue swimmer crabs, *P. pelagicus*, were caught by dip net from Mersin Bay, the coast of Northeastern Mediterranean, in May 2009 (Fig. 1). In the fishing procedure, a dip net (mesh size of 32 mm) was used and 30 individuals of each sex were caught and kept in polystyrene boxes with ice. When they were brought to the laboratory, they were still alive.

2.2. Sample preparation

Some morphometric measurements [carapace length (CL), carapace width (CW)] and weight of all samples were carried out by the use of a scale (0.01 g) and a caliper (0.1 cm) (Table 1). After that, muscle tissues of each sex group including 30 individuals were taken out by hand. Meat yield of crabs was determined by including lump, chela and flake meats. All assays were conducted on triplicate samples of the homogenates, and chemical composition was analyzed in tissue samples.

2.3. Proximate analysis

Blue swimmer crab samples were analyzed in triplicate for proximate composition. The following methods were used: Lipid level by the Bligh and Dyer [23] method, water level by AOAC [24] method, total crude protein by the Kjeldahl method [24], and TMS (total mineral substance) level by the AOAC [25] method.

2.4. Fatty acid analysis

Fatty acid profiles of fat extracted from blue swimmer 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*. [26], 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.

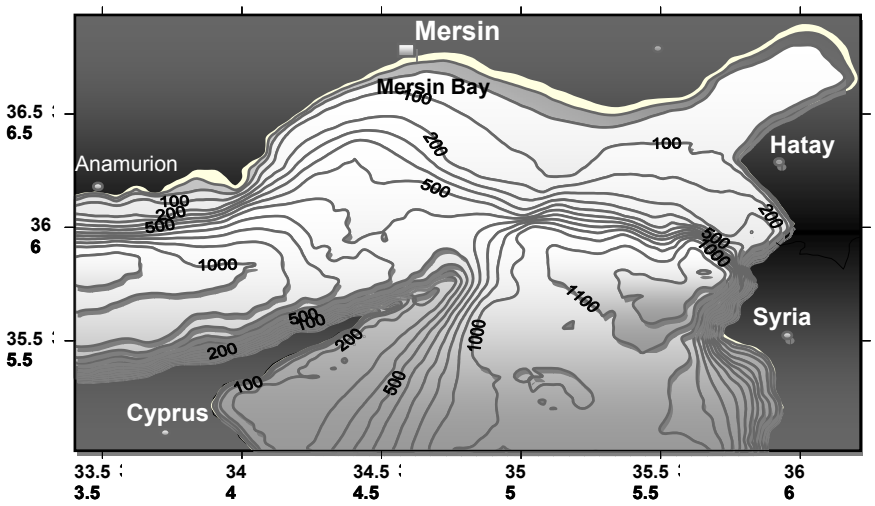

FIGURE 1 - Mersin Bay (sampling zone map).

TABLE 1 - Some morphological measurements and meat yield of female and male blue swimmer crab

	♀ $\bar{X} \pm S_{\bar{x}}$	Min-max	♂ $\bar{X} \pm S_{\bar{x}}$	Min-max
Carapace Length (mm)	77.10±0.35	73.5-81.5	69.7±0.47	63.5-76.0
Carapace Width (mm)	147.80±0.67	142.0-156.0	138.80±0.74	130.5-151.0
Weight (g)	207.05±23.65	187.7-240.45	203.65±38.92	154.6-257.35
Chela meat weight (g)	20.61±4.81	16.45-26.77	28.46±5.82	21.98-37.25
Lump meat weight (g)	21.98±2.20	19.91-24.9	21.16±2.22	18.01-24.01
Flake meat weight (g)	19.24±7.43	12.99-28.64	27.22±7.74	19.36-39.32
Chela meat yield (%)	9.83±1.17	8.71-11.28	13.95±0.35	13.62-14.47
Lump meat yield (%)	10.63±0.25	10.36-11.1	10.55±0.90	9.33-11.65
Flake meat yield (%)	9.03±2.46	6.87-12	13.17±1.25	11.93-15.28
Total carapace meat yield (%)	19.66±2.34	17.41-22.56	23.72±0.59	23.15-24.61
Total meat yield (%)	29.50±3.51	26.12-33.84	37.67±0.94	36.77-39.08

The fatty acid composition was analyzed with a Clarus 500 GC, equipped with autosampler (Perkin Elmer, Shelton, CT, USA), flame ionization detector and a fused silica capillary column (30 m x 0.32 mm, film thickness 0.25 µm; BP20 0.25 UM; SGE Analytical Science Pty Ltd, Victoria, Australia). The oven temperature was 140 °C, held for 5 min, raised to 200 °C at a rate of 4 °C/min, and then to 220 °C at a rate of 1 °C/min, while injector and detector temperature were set at 220 and 280 °C, respectively. The sample size was 1 µL and the carrier gas was controlled at 16 psi. The split ratio 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). Triplicate GC analyses were performed and the results were expressed in GC area % as mean values ± standard deviation.

2.5. Metal analysis

The LCM and CCM samples used for metal analysis were dried at 105 °C to reach constant weights, and then concentrated with nitric/percholoric acid (2:1, v/v) added to the samples, and put onto a hot plate (150 °C) until all tissues were dissolved. All blue swimmer crabmeat samples (LCM and CCM) were analyzed with inductively coupled plasma atomic emission (ICP-AES, Varian model, Liberty series II, Sydney, Australia). The analyses were performed at least in triplicate.

2.6. Statistical analysis

Statistical analysis of data was carried out with the SPSS 16.0 software package. Duncan test was used to evaluate the effects of sex and different tissues (LCM and CCM) on the chemical compositions of blue swimmer crabs.

3. RESULTS AND DISCUSSION

The mean carapace width (CW) was 138.8-147.8 mm for blue swimmer crabs (Table 1). In a study carried out by Razek [2] at the coast of Egypt, male and female blue swimmer crabs with CW >90-100 mm were accepted as adults. In a similar study carried out in Kakinada region of India, Devi [3] accepted male and female blue swimmer crabs with CW >95 mm as adults. Thus, according to the results of these studies, male and female blue swimmer crabs used in our study were adults.

The chela meat yield, lump meat yield, flake meat yield, total carapace meat yield and total meat yield of males were 13.95, 10.55, 13.17, 23.72 and 37.67%, respectively, while these values were 9.83, 10.63, 9.03, 19.66 and 29.50%, respectively, for females. Total meat yield of adult male blue swimmer crabs was higher than that of females, according to Türeli *et al.* [4] reporting that meat yields of males (41.99%) were higher than of females (28.23%). Similar results were also found for blue crabs (*Callinectes bocourti*) [27], and results of both studies support our findings. The levels obtained for lump meat yield of both sexes were similar. Additionally chela, flake, total carapace and total meat yield of male blue swimmer crabs were higher than those of females.

3.1. Proximate composition

Protein levels of adult female blue swimmer crabs were higher than those of males ($p<0.05$). However, water levels of males were found to be higher than those of females ($p<0.05$). Lipid levels of LCM were significantly higher ($p<0.05$) than those found in CCM while TMS levels were lower ($p<0.05$) in LCM than CCM. Additionally, according to our findings, blue swimmer crabs caught from the Gulf of Mersin have high protein and low fat levels. These results are supported by findings of other researchers [5-7]. In this study, it was found out that protein and lipid levels of blue swimmer crabs were 21.66-23.55% and 0.86-1.39%, respectively. Musaiger and Al-Rumaidh [7] indicated that protein and lipid levels were 19.80 and 0.60-0.80% for blue swimmer crabs, respectively. In a similar study, Gökoğlu and Yerlikaya [6] reported that protein and lipid levels were 21.5-22.6% and 0.8-1.2% for blue swimmer crabs caught from the Gulf of Antalya, respectively. Musaiger and Al-Rumaidh [7] as well as Gökoğlu and Yerlikaya [6] also found levels of proteins and lipids in blue swimmer crabmeat which were similar to our study. Herein, lipid levels of LCM (1.18-1.39%) were significantly higher ($p<0.05$) than those found in CCM (0.86-0.88%). Gökoğlu and Yerlikaya [6] reported that lipid levels of LCM (1.21%) were higher than that of CCM (0.81%), as well found for blue crabs (*Callinectes sapidus*) [13]. TMS levels of CCM (2.30-2.36%) were significantly higher ($p<0.05$) than those found in LCM (2.12-2.15%), similar to results of Kuley *et*

TABLE 2 - Proximate compositions of LCM and CCM of male and female blue swimmer crab (%)

	♀ $\bar{X} \pm S_x$		♂ $\bar{X} \pm S_x$	
	LCM	CCM	LCM	CCM
Protein	23.20±0.23[b]	23.55±0.12[c]	21.93±0.06[a]	21.66±0.23[a]
Lipid	1.18±0.15[b]	0.86±0.09[a]	1.39±0.07[c]	0.88±0.11[a]
Water	73.07±0.32[a]	73.03±0.45[a]	74.22±0.30[b]	74.82±0.24[b]
TMS	2.15±0.07[a]	2.30±0.03[b]	2.12±0.07[a]	2.36±0.08[b]

Within the rows values with different letters are significantly different (P<0.05); $\bar{X} \pm S_x$: Mean ± Standard Deviation; LCM: lump crabmeat, CCM: chela crabmeat.

TABLE 3 - Fatty acid compositions of LCM and CCM of female and male blue swimmer crab (%).

Fatty acids	♀ $\bar{X} \pm S_{\bar{X}}$		♂ $\bar{X} \pm S_{\bar{X}}$	
	LCM	CCM	LCM	CCM
C12:0	0.03±0.01[a]	0.03±0.00[ab]	0.03±0.00[ab]	0.04±0.01[b]
C14:0	0.84±0.04[a]	0.86±0.04[a]	1.06±0.10[b]	0.87±0.07[a]
C15:0	0.57±0.03[a]	0.62±0.06[a]	0.57±0.07[a]	0.64±0.04[a]
C16:0	11.67±0.10[c]	11.30±0.10[b]	12.82±0.28[d]	10.81±0.23[a]
C17:0	1.08±0.13[a]	1.09±0.14[a]	1.13±0.02[a]	1.15±0.08[a]
C18:0	9.15±0.26[ab]	8.60±0.35[a]	10.04±0.28[c]	9.67±0.29[bc]
C20:0	0.56±0.11[a]	0.66±0.12[a]	1.07±0.11[b]	0.65±0.09[a]
C22:0	0.12±0.02[a]	0.13±0.02[a]	0.44±0.11[b]	0.22±0.02[a]
ΣSFA	24.02	23.29	27.16	24.05
C14:1	0.04±0.00[a]	0.04±0.01[a]	0.04±0.01[a]	0.04±0.00[a]
C15:1	0.14±0.01[a]	0.15±0.01[a]	0.15±0.02[a]	0.15±0.01[a]
C16:1	6.56±0.17[d]	6.89±0.10[c]	4.93±0.06[a]	5.65±0.11[b]
C17:1	0.88±0.11[a]	1.19±0.04[b]	0.83±0.05[a]	1.22±0.01[b]
C18:1*n*9	12.36±0.13[a]	15.50±0.15[c]	15.18±0.18[b]	15.15±0.16[b]
C18:1*n*7	3.11±0.11[b]	2.74±0.16[a]	3.14±0.15[b]	2.71±0.17[a]
C20:1	0.17±0.01[a]	0.17±0.00[a]	0.17±0.02[a]	0.17±0.01[a]
C22:1*n*9	0.05±0.01[ab]	0.05±0.01[b]	0.04±0.00[a]	0.04±0.01[a]
ΣMUFA	23.31	26.73	24.48	25.13
C18:2*n*6	2.04±0.17[a]	3.04±0.06[c]	2.29±0.13[b]	2.32±0.10[b]
C18:3*n*6	0.25±0.01[a]	0.24±0.01[a]	0.25±0.01[a]	0.25±0.02[a]
C18:3*n*3	0.57±0.03[b]	0.58±0.03[b]	0.51±0.02[a]	0.52±0.03[a]
C20:2 cis	0.06±0.01[a]	0.05±0.01[a]	0.05±0.01[a]	0.06±0.01[a]
C20:3*n*6	0.12±0.01[ab]	0.13±0.00[b]	0.12±0.01[a]	0.12±0.01[ab]
C20:3*n*3	0.00±0.00[a]	0.00±0.00[a]	0.00±0.00[a]	0.00±0.00[a]
C20:4*n*6	6.41±0.09[a]	7.44±0.11[b]	6.42±0.08[a]	8.31±0.13[c]
C20:5*n*3	20.81±0.23[d]	18.69±0.09[b]	18.04±0.06[a]	18.96±0.06[c]
C22:2 cis	0.24±0.01[a]	0.25±0.02[a]	0.24±0.03[a]	0.23±0.01[a]
C22:6*n*3	14.01±0.04[c]	12.45±0.09[a]	14.43±0.08[d]	13.23±0.22[b]
ΣPUFA	44.51	42.87	42.35	44.00
PUFA/SFA	1.85	1.84	1.56	1.83
Σ*n*6	8.82	10.85	9.08	11.00
Σ*n*3	35.39	31.72	32.98	32.71
*n*6/*n*3	0.25	0.34	0.28	0.34
Unidentified	8.16	7.11	6.01	6.42

Within the rows values with different letters are significantly different (P<0.05); $\bar{X} \pm S_{\bar{X}}$: Mean ± Standard Deviation; LCM: lump crabmeat; CCM: chela crabmeat.

al. [13] for blue crabs. Gökoğlu and Yerlikaya [6] also reported that TMS levels of CCM (2.52%) were higher than TMS levels of LCM (2.24%).

3.2. Fatty acids composition

Statistically, palmitoleic and linolenic acid (C18:3 *n*-3) levels of female blue swimmer crabs were higher than those of the male (p<0.05). Palmitic acid, octadecenoic acid, and DHA levels of LCM were significantly higher (p<0.05) than those found in CCM while heptadecenoic and arachidonic acid levels were lower (p<0.05) in LCM.

In the present study, the highest proportions of fatty acids found in blue swimmer crabs were myristic acid (C14:0, 0.84-1.06%), palmitic acid (C16:0, 10.81-12.82%), heptadecanoic acid (C17:0, 1.08-1.15%), stearic acid (C18:0, 8.60-10.04%), arachidic acid (C20:0, 0.56-1.07%), palmitoleic acid (C16:1, 4.93-6.89%), heptadecenoic acid (C17:1, 0.83-1.22%), oleic acid (C18:1*n*-9, 12.36-15.50%), octadecenoic acid (C18:1*n*-7, 2.71-3.14%), linoleic acid (C18:2 *n*-6, 2.04-3.04%), arachidonic acid (C20:4 *n*-6, 6.41-8.31%), cis-5,8,11,14, 17-eicosapentaenoic acid (EPA, C20:5 *n*-3, 18.04-20.81%) and cis-4,7,10,13,16,19-docosahexaenoic acid (DHA, C22:6 *n*-3, 12.45-14.43%). These results are supported by the findings of Hall *et al*. [11].

SFA, MUFA and PUFA levels were found to be 23.29-27.16%, 23.31-26.73% and 42.35-44.51%, respectively. The major saturated fatty acids were palmitic acid (11.67-12.82% for LCM, 10.81-11.30% for CCM) and stearic acid (9.15-10.04% for LCM, 8.60-9.67% for CCM). Palmitoleic acid (6.56-6.89% for female, 4.93-5.65% for male) and oleic acid (12.36-15.50% for female, 15.15-15.18% for male) were the major MUFAs in blue swimmer crabs, followed by cis-7-octadecenoic acid (3.11-3.14% for LCM, 2.71-2.74% for CCM). The results of fatty acid composition indicated that LCM and CCM of blue swimmer crabs were very rich in *n*-3 fatty acids (EPA and DHA). Total *n*-3 was detected as 32.98-35.39% for LCM whereas it was 31.72-32.71% in CCM. Total *n*-3 levels of LCM were higher than those of CCM. The levels of *n*-3 PUFAs (ranging from 31.72 to 35.39%) were higher than those of *n*-6 PUFAs (ranging from 8.82 to 11.00%). The PUFA/SFA and *n*-6/*n*-3 were detected as 1.56-1.85 and 0.25-0.28 in LCM of blue swimmer crabs whereas these levels were 1.83-1.84 and 0.34 in CCM of blue swimmer crabs, respec-

tively. The UK Department of Health recommends an ideal ratio of *n*-6/*n*-3 of 4.0 as maximum value [28]. Values higher than that are harmful to health and may promote cardiovascular diseases [29]. In this study, the ratio *n*-6/*n*-3 was found to range from 0.25 to 0.34. A minimum value of PUFA/SFA ratio recommended is 0.45 [28], being lower than values obtained from this study.

3.3. Metal contents

Table 4 shows sexual variation in metal levels of LCM and CCM of female and male blue swimmer crabs.

It was also found out that they were rich in terms of metal content, especially Cu, Zn, and Fe. Cd, Cu, Zn contents in CCM of blue swimmer crabs were significantly higher ($p<0.05$) than those found in LCM of blue swimmer crabs. However, Fe levels of CCM were lower ($p<0.05$) than those of LCM.

TABLE 4 - Metal compositions of LCM and CCM of female and male blue swimmer crab (µg g^{-1})

Metals	♀ $\overline{X} \pm S_{\overline{X}}$		♂ $\overline{X} \pm S_{\overline{X}}$	
	LCM	CCM	LCM	CCM
Cd	1.08±0.07^{a}	1.39±0.07^{b}	1.02±0.04^{a}	1.37±0.07^{b}
Cr	0.45±0.04^{a}	0.41±0.04^{a}	0.41±0.04^{a}	0.42±0.05^{a}
Pb	0.32±0.03^{a}	0.29±0.02^{a}	0.30±0.02^{a}	0.40±0.03^{b}
Cu	31.13±0.27^{a}	51.13±0.38^{b}	30.30±0.19^{a}	50.28±0.26^{b}
Zn	71.13±0.65^{a}	161.12±0.88^{b}	70.25±0.27^{a}	160.69±0.55^{b}
Fe	26.10±0.19^{b}	20.64±0.58^{a}	25.27±0.24^{b}	20.38±0.27^{a}

Within the rows values with different letters are significantly different ($P<0.05$); $\overline{X} \pm S_{\overline{X}}$: Mean ± Standard Error; LCM: lump crabmeat; CCM: chela crabmeat.

Herein, metal levels of blue swimmer crab were 1.02-1.39 µg Cd g^{-1}, 0.41-0.45 µg Cr g^{-1}, 0.29-0.40 µg Pb g^{-1}, 30.30-51.13 µg Cu g^{-1}, 70.25-161.12 µg Zn g^{-1}, 20.38-26.10 µg Fe g^{-1}, respectively. Gökoğlu and Yerlikaya [6] found out that Zn, Fe and Cu levels of blue swimmer crabs were 37.2-46.8 µg g^{-1}, 4.5-6.8 µg g^{-1}, and 14.9-20.8 µg g^{-1}, respectively. The metal levels reported earlier were lower than those obtained in our study. This might have been caused by regional differences, sexual maturation and size of individuals. In a similar study, Al-Mohanna and Subrahmanyam [22] indicated that Cr, Cu, Pb and Zn levels of female and male blue swimmer crabs were 0.15-0.62 µg g^{-1}, 110.15-142.80 µg g^{-1}, 1.72-2.08 µg g^{-1} and 188.69-228.68 µg g^{-1}, respectively, being higher than those found in our study. Metal pollution levels in the Gulf of Mersin and Kuwait Bay might have affected these values.

The U.S. Food and Drug Administration [30] has set 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 corresponding levels presented by the Turkish Food Codex [31] were 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 excessive copper and zinc could be cumulated in the food chain and carried to the upper trophic levels, they might create important ecological problems.

In our study, it was found that the blue swimmer crab, *Portunus pelagicus*, is contaminated with Cu and Zn, but the meat of male and female crabs is also an important *n*-3 fatty acids and protein source.

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