5(4): 308-316 (2011) DOI: 10.3153/jfscom.2011035

Journal of FisheriesSciences.com

E-ISSN 1307-234X

RESEARCH ARTICLE ARAŞTIRMA MAKALESİ

THE CHEMICAL COMPOSITION OF SEXUALLY MATURE BLUE SWIMMER CRAB (*Portunus pelagicus*, Linnaeus 1758) IN THE MERSIN BAY

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Abstract: The objective of the present study was to determine chemical composition of carapace meat of male and female mature blue swimmer crabs, *Portunus pelagicus*, caught in the Mersin Bay. The levels of protein ranged from 20.75% to 23.44%, lipid from 1.13% to 1.43%, and water from 73.31% to 76.04%, total mineral substance (TMS) from 1.81% to 2.10% for blue swimmer crabs. Statistically, carapace meat of female blue swimmer crabs had higher protein level, and lower lipid, water and TMS levels than those of the male ($p<0.05$). In the present study, the major fatty acids found in blue swimmer crabs were palmitic acid (C16:0), stearic acid (C18:0), palmitoleic acid (C16:1), oleic acid (C18:1 *n*9), arachidonic acid (C20:4*n*6), eicosapentaenoic acid (EPA, C20:5*n*3) and docosahexaenoic acid (DHA, C22:6*n*3). Saturated fatty acid (SFA) level in the carapace meat of male blue swimmer crabs (24.94%) was similar female blue swimmer crabs (24.72%). Furthermore, the levels of monounsaturated fatty acids (MUFAs) changed from 23.69% to 26.52% and polyunsaturated fatty acids (PUFAs) from 43.19% to 45.98% for blue swimmer crabs. Statistically, there were no significant differences in palmitic acid and stearic acid levels in carapace meat of male and female blue swimmer crabs ($P>0.05$). Besides, statistically, there were significant differences in palmitoleic acid, oleic acid, arachidonic acid, EPA and DHA levels in carapace meat of male and female blue swimmer crabs ($P<0.05$). EPA levels of female blue swimmer crabs (21.09%) were higher than male blue swimmer crabs (20.56%). Furthermore, DHA levels of male blue swimmer crabs (14.57%) were higher than female blue swimmer crabs (12.41%). The PUFA/SFA and *n*-6/*n*-3 was detected as 1.77, 0.28 for female blue swimmer crabs whereas it was 1.82, 0.27 for male blue swimmer crabs, respectively. In the present study, it was observed that carapace meat of blue swimmer crabs were contaminated with Cu and Zn.

Keywords: Blue Swimmer Crab, *Portunus pelagicus*, Chemical Composition, Sexually mature

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Journal abbreviation: **J FisheriesSciences.com**

Özet: Eşeysel Olgunlaşmasını Tamamlamış Mavi Yüzücü Yengecin (*Portunus pelagicus* Linnaeus 1758) Kimyasal Kompozisyonu

Bu çalışmanın amacı Mersin Körfezi'nden yakalanan ergin dişi ve erkek mavi yüzücü yengeçlerin (*Portunus pelagicus*) karapaks eti kimyasal kompozisyonunun belirlenmesidir. Mavi yüzücü yengeçlerin protein düzeyi %20.75-%23.44, lipit düzeyi %1.13-%1.43, su düzeyi %73.31-%76.04 ve toplam mineral madde (TMM) düzeyi %1.81-%2.10 arasındadır. İstatistiksel olarak dişi mavi yüzücü yengeçlerin protein düzeyi erkeklerden yüksek lipit, su ve TMM düzeyi düşüktür ($p<0.05$). Çalışmada mavi yüzücü yengeçlerin temel yağ asitlerinin palmitik asit (C16:0), stearik asit (C18:0), palmitoleik asit (C16:1), oleik asit (C18:1*n*9), araşidonik asit (C20:4*n*6), eikosapentaenoik asit (EPA, C20:5*n*3) ve dokosaheksaenoik asit (DHA, C22:6*n*3) olduğu bulunmuştur. Erkek mavi yüzücü yengecin karapaks eti doymuş yağ asitleri (DYA) düzeyi (%24.94) dişilerinkine (%24.72) benzer bulunmuştur. Mavi yüzücü yengecin tekli doymamış yağ asitleri (TDYA) ve çoklu doymamış yağ asitleri (ÇDYA) sırasıyla %23.69-%26.52 ve %43.19-%45.98 arasında değişmektedir. Dişi ve erkek mavi yüzücü yengeçlerin karapaks eti palmitik ve stearik asit düzeyleri arasında istatistiksel bir farklılık bulunmamıştır ($p>0.05$). Bununla birlikte dişi ve erkek mavi yüzücü yengeçlerin karapaks eti palmitoleik asit, oleik asit, araşidonik asit, EPA ve DHA düzeyleri arasında istatistiksel bir ayrım bulunmaktadır ($p<0.05$). Dişi mavi yüzücü yengeçlerin EPA düzeyi (%21.09) erkek mavi yüzücü yengeçlerinkinden (%20.56) daha yüksektir. Erkek mavi yüzücü yengeçlerin DHA düzeyi (%14.57) ise dişilerinkinden (%12.41) yüksektir. Dişi mavi yüzücü yengeçlerin ÇDYA/DYA ve *n*-6/*n*-3 oranları sırasıyla 1.77, 0.28 olarak belirlenirken, bu oranlar erkekler için 1.82, 0.27 olarak belirlenmiştir. Bu çalışmada mavi yüzücü yengeçlerin karapaks etinin Cu ve Zn ile kontamine olduğu bulunmuştur.

Anahtar Kelimeler: Mavi Yüzücü Yengeç, *Portunus pelagicus*, Kimyasal Kompozisyon, Eşeysel Olgunlaşmasını Tamamlamış

Introduction

Blue swimmer crab, *Portunus pelagicus*, is a large crab found on the coasts of the Indian, Pacific and Mediterranean Seas (Razek 1988, Shields and Wood 1993, Gökoğlu and Yerlikaya 2003). This big sea crab is an Indio-Pacific species. This exotic species came to the Mediterranean waters after the opening of Suez Canal. Blue swimmer crabs are commonly distributed in the Northeastern Mediterranean shores in Turkey.

Blue swimmer crab is one of crab species which have economic value. Thus, this species is caught both in the world and in Turkey. According to Fishstat plus (2010) report, 55 and 95 tons of blue swimmer crabs were caught in 2003 and 2007, respectively in Turkey. On the coasts of Northeastern Mediterranean Sea in Turkey, common big sea crab is the most largely caught species of the Decapods. Although there is a significant amount of big sea crabs in the Mediterranean, in Turkey, the consumption of crab meat is very low but they are generally consumed by European countries.

There are many articles related to the chemical composition of big sea crabs in the various regions of the world (Badawi 1971, Türeli *et al.* 2000, Al-Mohanna and Subrahmanyam 2001, Skonberg and Perkins 2002, Türeli *et al.* 2002, Gökoğlu and Yerlikaya 2003, Çelik *et al.* 2004, Naczk *et al.* 2004, Musaiger and Al-Rumaidh 2005, Hall *et al.* 2006, Chen *et al.* 2007, Sudhakar *et al.* 2009). While blue swimmer crabs contain low levels of lipid, they are rich for protein levels (Türeli *et al.* 2000, Gökoğlu and Yerlikaya 2003, Musaiger and Al-Rumaidh 2005). Gökoğlu and Yerlikaya (2003) reported that lipid levels of blue swimmer crabs were less than 1%. In a similar study, Musaiger and Al-Rumaidh (2005) indicated that protein levels of blue swimmer crabs were approximately 20%. Many studies have been done to determine fatty acid composition of big sea crabs (Skonberg and Perkins 2002, Çelik *et al.* 2004, Naczk *et al.* 2004, Hall *et al.* 2006, Chen *et al.* 2007, Küley *et al.* 2007). These studies generally have focused on poly-unsaturated fatty acids. Hall *et al.* (2006) reported that EPA and DHA levels were approximately 30% of the total lipid for blue

swimmer crabs. In a similar study, Küley *et al*., (2007) indicated that PUFAs were 40-45% of the total lipid for Atlantic blue crabs.

Blue swimmer crab meat contains high levels of Cu, Zn, and Fe (Al-Mohanna and Subrahmanyam 2001, Gökoğlu and Yerlikaya 2003). Gökoğlu and Yerlikaya (2003) reported that the levels of Cu and Zn of blue swimmer crabs which were caught from Antalya Bay reached to nearly contamination levels. Metal contamination levels for edible tissue of big sea crabs are: The U.S. Food and Drug Administration (USFDA, 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}.

Although there are studies on the chemical composition of blue swimmer crabs caught in Antalya and İskenderun Bays, there is hardly any available information about chemical composition of blue swimmer crabs living in Mersin Bay. Thus, the objective of this study was to determine and compare chemical compositions of male and female sexually mature blue swimmer crabs in Mersin Bay.

Materials and Methods

Materials

Blue swimmer crabs, *P. pelagicus*, were caught by dip net from Mersin Bay, the coast of Northeastern Mediterranean, in March, 2008 (Figure 1). In the fishing procedure, dip net which had mesh size of 32 mm was used. 30 male and 30 female individuals were caught and kept in polystyrene boxes with ice. When they were brought to the laboratory, they were still alive.

Figure 1. Sampling zone map (Mersin Bay)

Sample preparation

Some morphometric measurements [carapace length (CL), carapace width (CW)] and weight of all samples were done (Table 1). The morphometric measurements of crab carapace were done using a calliper. After that, muscle tissues of each sex group including 30 individuals were taken out by hand. All assays were conducted on triplicate samples of the homogenates. Chemical composition analyses were done on these muscle tissue samples.

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 (1959) method, water level by AOAC (1998a) method, total crude protein by the Kjeldahl method (AOAC, 1998a) and total mineral substance (TMS) level by the AOAC (1998b) method.

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*. (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 analysed 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 (Canlı and Atlı 2003). All blue swimmer crab meat samples were analyzed with ICP-AES. 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 carapace meat of blue swimmer crabs.

Results and Discussion

Table 1 shows some morphological measurements of male and female blue swimmer crabs.

The mean carapace width (CW) was 172.8-183.0 mm for blue swimmer crabs (Table 1). In a study carried out by Razek (1988) in coast of Egypt, male and female blue swimmer crabs (*P.pelagicus*) with the CW over 90-100 mm were accepted as adults. In a similar study carried out in Kakinada region of India, Devi (1985) accepted male and female blue swimmer crabs (*P.pelagicus*) with the CW over 95 mm as adults. Thus, according to the results of these studies, male and female blue swimmer crabs used in our study were adults.

Table 1. Some morphological measurements of male and female blue swimmer 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	90.25±6.38	78.0-107.0	183.0±14.9	160.0-220.0	177.76±32.60	124.0-289.0
♂	30	111.03±16.24	87.5-142.5	172.8±21.8	130.0-200.0	174.25±53.21	102.0-285.0

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

Table 2. Proximate compositions in carapace meat of male and female blue swimmer crab (%)

	♀		♂	
	$\overline{X} \pm S_{x}$	Min-max	$\overline{X} \pm S_{x}$	Min-max
Protein	23.23±0.22[b]	22.96-**23.44**	20.92±0.20[a]	**20.75**-21.17
Lipid	1.19±0.05[a]	**1.13**-1.24	1.34±0.08[b]	1.24-**1.43**
Water	73.60±0.27[a]	**73.31**-74.12	75.43±0.65[b]	74.49-**76.04**
TMS	1.89±0.08[a]	**1.81**-2.04	2.04±0.04[b]	2.00-**2.10**

Within the rows values with different letters are significantly different (P<0.05).

$\overline{X} \pm S_{x}$: Mean±Standart Deviation

Proximate composition

Table 2 shows sexual variation in the proximate composition of carapace meat of blue swimmer crabs.

Protein levels of female blue swimmer crabs were significantly higher (P<0.05) than those found in male blue swimmer crabs. Lipid, water, and TMS levels of male blue swimmer crabs were significantly higher (P<0.05) than those found in female blue swimmer crabs.

The results indicate that, blue swimmer crabs caught from the Gulf of Mersin have high protein and low lipid levels. These results are supported by findings of the other researchers (Türeli *et al.* 2000, Gökoğlu and Yerlikaya 2003, Musaiger and Al-Rumaidh 2005). In this study, it was found out that protein and lipid levels of blue swimmer crabs were 20.75%-23.44% and 1.13%-1.43%, respectively. Musaiger and Al-Rumaidh (2005) indicate that protein and lipid levels were 19.80%, 0.60%-0.80% in carapace meat of blue swimmer crabs, respectively. In a similar study, Gökoğlu and Yerlikaya (2003) reported that protein and lipid levels were 21.5%-22.6%, 0.8%-1.2% for blue swimmer crabs caught from the Gulf of Antalya, respectively. Musaiger and Al-Rumaidh (2005), Gökoğlu and Yerlikaya (2004) also reported that the values of protein and lipid in carapace meat of blue swimmer crabs were similar to our study.

Fatty acids composition

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 swimmer crabs' meat are presented in Tables 3.

The highest proportions of fatty acids in blue swimmer crabs' carapace meat were palmitic acid (C16:0), heptadecanoic acid (C17:0), stearic acid (C18:0), palmitoleic (C16:1), oleic acid (C18:1 *n*-9, cis-9-octadecenoic acid), cis-7-octadecenoic acid, (C18:1 *n*-7), linoleic acid (C18:2 *n*-6), arachidonic acid (C20:4 *n*-6), cis-5,8,11,14,17-eicosapentaenoic acid (EPA, C20:5 *n*-3) and cis-4,7,10,13,16,19-docosahexaenoic acid (DHA, C22:6 *n*-3). These results are supported by the findings of Hall *et al*. (2006).

The results of fatty acid composition indicated that blue swimmer crabs' carapace meat is very rich in *n*-3 fatty acids (EPA and DHA). SFAs, MUFAs, PUFAs levels were found as 24.01%-25.30%, 23.69%-26.52% and 43.19-45.98%, respectively. The major saturated fatty acids were palmitic acid (12.81% for female, 12.82% for male) and stearic acid (8.64% for female, 9.05% for male). Statically, there were no significant differences in these saturated fatty acids levels in carapace meat of female and male blue swimmer crabs (p>0.05). Palmitoleic acid (4.84%-6.82%) and oleic acid (13.15%-14.05%) were the major MUFAs in blue swimmer crabs' carapace meat, followed by cis-7-octadecenoic acid (4.00%-

4.93%). Significant differences were indicated in terms of palmitoleic acid, oleic acid, and cis-7-octadecenoic acid between female and male blue swimmer crabs' carapace meat ($p<0.05$). There were statistically significant differences ($p<0.05$) in EPA and DHA -the major PUFAs- levels in female and male blue swimmer crabs' carapace meat. The proportions of *n*-3 PUFAs (ranging from 33.68% to 36.01%) were higher than those of *n*-6 PUFAs (ranging from 9.18% to 9.74%). The UK Department of Health recommends an ideal ratio of *n*-6/*n*-3 of 4.0 as a maximum (HMSO 1994) value. 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 0.26 to 0.29. A minimum value of PUFA/SFA ratio recommended is 0.45 (HMSO 1994), which was lower than those obtained from this study.

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

Fatty acids	♀		♂	
	$\overline{X} \pm S_x$	Min-max	$\overline{X} \pm S_x$	Min-max
C12:0	0.03±0.00[a]	0.03	0.03±0.00[a]	0.03
C14:0	0.80±0.04[b]	0.76-0.83	0.65±0.02[a]	0.63-0.67
C15:0	0.66±0.04[a]	0.63-0.70	0.62±0.01[a]	0.61-0.63
C16:0	12.81±0.23[a]	12.55-13.00	12.82±0.16[a]	12.64-12.93
C17:0	1.31±0.06[a]	1.25-1.37	1.31±0.04[a]	1.28-1.35
C18:0	8.64±0.27[a]	8.38-8.91	9.05±0.04[a]	9.02-9.10
C20:0	0.43±0.03[a]	0.41-0.46	0.45±0.01[a]	0.44-0.46
C22:0	0.00±0.00[a]	0.00	0.0±0.00[a]	0.00
ΣSFA	24.72	24.01-25.30	24.94	24.65-25.17
C14:1	0.03±0.00[a]	0.03	0.04±0.00[b]	0.04
C15:1	0.18±0.00[a]	0.18	0.18±0.00[a]	0.18
C16:1	6.66±0.20[b]	6.44-6.82	5.00±0.16[a]	4.84-5.15
C17:1	0.94±0.08[a]	0.89-1.03	0.93±0.03[a]	0.90-0.95
C18:1*n*9	13.25±0.09[a]	13.15-13.33	13.81±0.23[b]	13.60-14.05
C18:1*n*7	4.65±0.26[b]	4.44-4.93	4.01±0.01[a]	4.00-4.01
C20:1	0.15±0.04[a]	0.10-0.18	0.13±0.01[a]	0.13-0.14
C22:1*n*9	0.02±0.00[b]	0.02	0.00±0.00[a]	0.00
ΣMUFA	25.88	25.25-26.52	24.10	23.69-24.52
C18:2*n*6	2.62±0.06[b]	2.57-2.68	2.24±0.18[a]	2.10-2.44
C18:3*n*6	0.21±0.03[b]	0.19-0.24	0.15±0.03[a]	0.12-0.17
C18:3*n*3	0.47±0.05[b]	0.43-0.52	0.39±0.01[a]	0.38-0.39
C20:2 cis	0.16±0.01[b]	0.16-0.17	0.00±0.00[a]	0.00
C20:3*n*6	0.10±0.02[a]	0.08-0.12	0.08±0.01[a]	0.08-0.09
C20:3*n*3	0.00±0.00[a]	0.00	0.00±0.00[a]	0.00
C20:4*n*6	6.50±0.18[a]	6.34-6.70	7.03±0.04[b]	7.00-7.08
C20:5*n*3	21.09±0.17[b]	20.98-21.29	20.56±0.05[a]	20.53-20.62
C22:2 cis	0.18±0.01[a]	0.17-0.19	0.18±0.01[a]	0.17-0.19
C22:6*n*3	12.41±0.15[a]	12.27-12.56	14.57±0.39[b]	14.23-15.00
ΣPUFA	43.75	43.19-44.47	45.32	44.61-45.98
PUFA/SFA	1.77	1.71-1.85	1.82	1.77-1.87
Σ*n*6	9.43	9.18-9.74	9.63	9.30-9.73
Σ*n*3	33.97	33.68-34.37	35.52	35.14-36.01
*n*6/*n*3	0.28	0.27-0.29	0.27	0.26-0.28
Unidentified	5.66	3.71-7.55	5.64	4.33-7.05

Within the rows values with different letters are significantly different ($P<0.05$).

$\overline{X} \pm S_x$: Mean±Standart Deviation

Metal contents

Table 4 shows sexual variation in metal levels of carapace meat of blue swimmer crab.

It was also found out that they were rich in metal content, especially Cu and Zn. Cr, Cu, Fe contents of male blue swimmer crabs' carapace meat were significantly higher ($p<0.05$) than those found in female blue swimmer crabs' carapace meat while Cd, Pb, and Zn levels were lower ($p<0.05$). Gökoğlu and Yerlikaya (2003) 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 by the researchers were lower than those obtained in our study. This difference might have been caused by the regional differences, sexual maturation and size of individuals. In a similar study, Al-Mohanna and Subrahmanyam (2001) indicated that Cr, Cu, Pb, Zn, levels of female and male blue swimmer crabs' carapace meat 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. Metal levels of blue swimmer crab species found in this study were 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 (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.

Conclusion

In this study, the results showed that the carapace meat of male and female crabs were rich in fatty acid (especially EPA and DHA), protein and trace metals. The results also indicated that the blue swimmer crabs, *Portunus pelagicus*, caught from Mersin Bay, were contaminated with Cu and Zn metals.

Table 4. Metal compositions in carapace meat of female and male blue swimmer crab (µg g^{-1})

Metals	♀		♂	
	$\bar{X} \pm S_{\bar{x}}$	Min-max	$\bar{X} \pm S_{\bar{x}}$	Min-max
Cd	1.11 ± 0.02^{b}	1.05-1.17	0.88 ± 0.01^{a}	0.84-0.91
Cr	0.40 ± 0.04^{a}	0.30-0.52	0.55 ± 0.02^{b}	0.50-0.61
Pb	0.33 ± 0.04^{b}	0.22-0.43	0.21 ± 0.02^{a}	0.19-0.23
Cu	26.92 ± 0.50^{a}	25.39-28.20	29.98 ± 0.32^{b}	29.29-31.05
Zn	107.27 ± 0.45^{b}	106.13-108.64	102.51 ± 0.53^{a}	101.40-104.13
Fe	15.21 ± 0.61^{a}	13.15-16.53	22.64 ± 0.39^{b}	21.92-23.90

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

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