

THE CHEMICAL COMPOSITION AND MEAT YIELD OF SEXUALLY MATURE CUTTLEFISH (*Sepia officinalis*)

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Abstract:

The objective of the present study was to determine the chemical composition and meat yield for both sexes of adult cuttlefish, *Sepia officinalis*, in the Mersin Bay, East Mediterranean. The results of meat yield showed that meat yield of adult male cuttlefish were higher than those of the female. The levels of protein ranged from 22.15% to 22.20%, lipid from 0.86% to 1.01%, and water from 74.97% to 75.30%, total mineral substance (TMS) from 1.68% to 1.69% for mantle of female and male cuttlefish. Moreover, there were not variations in protein, lipid, water and TMS content of mantle tissues of both adult females and males ($p>0.05$). The levels of saturated fatty acids (SFA) ranged from 29.49% to 29.88%, monounsaturated fatty acids (MUFAs) from 10.97% to 11.40%, and polyunsaturated fatty acids (PUFAs) from 52.27% to 53.42% for both of the sexes. In the present study, the major fatty acids found in *S. officinalis* were palmitic acid (C_{16:0}), stearic acid (C_{18:0}), eicosapentaenoic acid (EPA, C_{20:5 n-3}) and docosahexaenoic acid (DHA, C_{22:6 n-3}). Statistically, there were no significant differences in DHA concentrations in mantle tissue of male and female cuttlefish ($p>0.05$). Besides, EPA concentrations in mantle of female cuttlefish were higher than those of the male ($p<0.05$). It was also found that mantle of cuttlefish was rich in terms of mineral content, especially Cu, Zn, and Fe. Statistically, there were no significant differences in Cd, Cr, Pb, Zn and Fe levels in mantle tissue of male and female cuttlefish ($p>0.05$). Cu content of female cuttlefish was significantly higher ($p<0.05$) than that found in male cuttlefish.

Keywords: *Sepia officinalis*, Chemical Composition, Meat Yield

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Özet: Eşeyssel Olgunlaşmasını Tamamlamış Mürekkep Balıklarının (*Sepia officinalis*) Kimyasal kompozisyonu ve Et Verimi

Bu çalışmada Mersin Körfezi'nden yakalanan ergin dişi ve erkek mürekkep balıklarının kimyasal kompozisyonları ve et verimlerinin belirlenmesi amaçlanmıştır. Ergin erkek mürekkep balıklarının (*Sepia officinalis*) et verimlerinin dişilerden yüksek olduğu belirlenmiştir. Mürekkep balığının protein düzeyi %22.15-22.20, lipit düzeyi %0.86-1.01, su düzeyi %74.97-75.30 ve toplam mineral madde (TMM) düzeyi %1.68-1.69 arasında belirlenmiştir. Ergin dişi ve erkek mürekkep balıklarının protein, lipit, su ve TMM düzeyleri arasında istatistiksel bir ayrım yoktur ($p>0.05$). Mürekkep balığının doymuş yağ asitleri düzeyi (SFA) %29.49-29.88, tekli doymamış yağ asitleri düzeyi (MUFA) %10.97-11.40, çoklu doymamış yağ asitleri düzeyi (PUFA) %52.27-53.42 arasında belirlenmiştir. *S. officinalis*'in temel yağ asitleri palmitik asit ($C_{16:0}$), stearik asit ($C_{18:0}$), eikosapentaenoik asit (EPA, $C_{20:5}$ $n-3$), dokosaheksaenoik asit (DHA $C_{22:6}$ $n-3$) olarak tespit edilmiştir. Dişi ve erkek mürekkep balıklarının DHA düzeyi arasında istatistiksel bir farklılık yoktur ($p>0.05$). Dişi mürekkep balıklarının EPA düzeyi erkeklerden yüksektir ($p<0.05$). Mürekkep balığı manto dokusu özellikle Cu, Zn ve Fe düzeyleri yönünden zengindir. Dişi ve erkek mürekkep balıklarının manto dokusu Cd, Cr, Pb, Zn, Fe düzeyleri arasında istatistiksel farklılık bulunmamaktadır ($p>0.05$). Dişi mürekkep balığının Cu düzeyi erkeklerden yüksek bulunmuştur ($p<0.05$).

Anahtar Kelimeler: *Sepia officinalis*, Kimyasal Kompozisyon, Et verimi

Introduction

Cuttlefish is an important species of marine invertebrates consumed both in the world and our country. According to Fisheries Statistics (2008) report, 1.288 and 1.502 tons of cuttlefish were caught in 2007 and 2008, respectively in Turkey. According to Fisheries Report (2010), 17 and 77 tons of cuttlefish were caught in 2008 and 2009, respectively in Turkey. Meat yield of cuttlefish has been reported to change due to sexual differences (Erdilal et al., 2007). While cuttlefish contain low levels of lipid, it is rich for protein level (Reale et al. 2006, Ozogul et al. 2008). Lipids of cuttlefish contain high levels of long-chain $n-3$ polyunsaturated fatty acids. The dominant long-chain $n-3$ fatty acids of cuttlefish are EPA and DHA (Thanonkaew et al. 2006, Ozyurt et al. 2006, Zlatanov et al. 2006). These fatty acids are of great importance to humans for the prevention of coronary heart disease (Tavani et al. 2001). Mantle of cuttlefish was rich in terms of Cu, Zn, Fe (Miramand and Bently, 1992, Raimundo et al. 2005, Miramand et al. 2006, Laourenço et al. 2009, Pereira et al. 2009). In this study, chemical composition and meat yield of mantle of adult female and male cuttlefish (*Sepia officinalis*) were investigated.

Materials and Methods**Materials**

The common cuttlefish is generally caught in the Mediterranean and Aegean Seas in Turkey. This species used in this study was caught in Mersin Bay with net in spring season in 2008 (Figure 1). In the fishing procedure, dip net which had mesh size of 32 mm was used. 20 male and 20 female individuals of this species were caught and kept in polystyrene boxes with ice.

Sample preparation

Some morphometric measurements [mantle length (ML) and total length (TL)] of all samples (male and female) were carried out with a ruler (Table 1). Mantle which is the main edible portion of cuttlefish was homogenized and chemical analyses were done on this part of fresh samples.

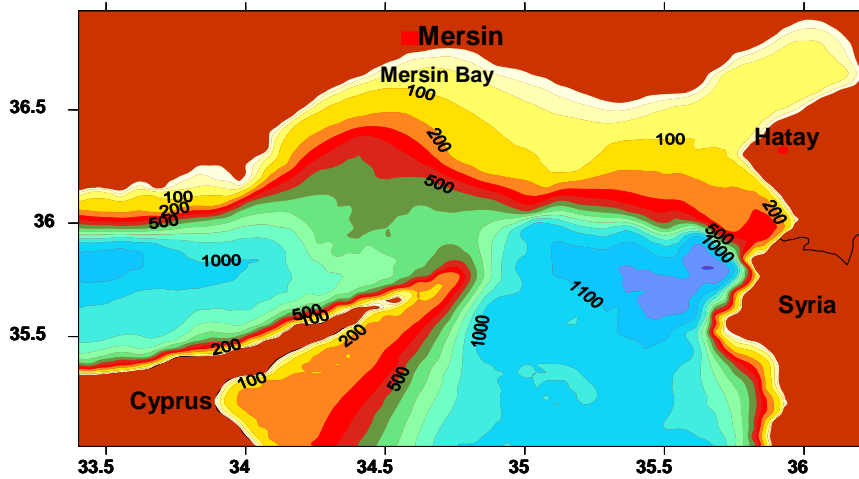


Figure1. Sampling zone map (Mersin Bay)

Proximate analysis

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

Fatty acid analysis

Fatty acid profiles of fat extracted from the cuttlefish 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 μ m; SGE Analytic 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 to 220 °C at a rate of 1 °C/min, while the injector and the detector temperature were set at 220 °C and 280 °C, respectively. The sample

size was 1 μ L 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). Triplicate GC analyses were performed and the results were expressed in GC area % as the mean value \pm standard deviation.

Mineral analysis

The mantle tissue samples used for mineral analysis were dried at 105 °C to reach constant weights, and then concentrated nitric acid and perchloric 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 mantle tissue 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 cuttlefish.

Results and Discussion

Meat yield

Table 1 shows some morphological measurements and meat yield of adult male and female cuttlefish. In this study, average mantle lengths of female and male cuttlefish were 140 mm and 163 mm, respectively (Table 1). In a study carried out by Erdilal et al. (2007) in Antalya Bay, males with the mantle length over 87 mm and females with the mantle length over 100 mm were accepted as adults. Thus, according to the results of

this study, male and female cuttlefish used in our study were adults.

In this study, while meat yield was found to be almost 30.18% for females, it was 35.23% for males (Table 1). Erdilal et al. (2007) reported meat yield as % 30.64 for females and as 35.20 for males.

Proximate compositions

Table 2 gives the proximate compositions of mantle of female and male cuttlefish. Statistically, there were not variations in protein, lipid, water and TMS content of mantle tissues of both adult females and males ($p > 0.05$).

The levels of protein ranged from 22.15% to 22.20%, lipid from 0.86% to 1.01%, and water from 74.97% to 75.30%, total mineral substance (TMS) from 1.68% to 1.69% for the mantle of cuttlefish (Table 2). Reale et al. (2006) reported that protein, lipid, water and TMS contents were 18.32%, 2.38%, 78.68% and 1.51% for mantle of cuttlefish, respectively. In a similar study, Ozogul et al. (2008) also reported the contents of protein, lipid, water and TMS as 16.91%, 1.01%, 81.02%, 1.12%, respectively. The current study also showed that mantle of cuttlefish caught from the Gulf of Mersin had high protein (22.20% for female and 22.15% for male) and low fat contents (0.86% for female and 1.01% for male).

Fatty acids profiles

Fatty acids (SFAs, MUFAs, PUFAs) in *S. officinalis* are presented in Table 3. In the present study, the major fatty acids found in *S. officinalis* were palmitic acid (C16:0), stearic acid (C18:0), eicosapentaenoic acid (EPA, 20:5n3) and docosahexaenoic acid (DHA, 22:6n3). These results correspond to previous studies on fatty acids of cuttlefish (Hayashi and Bower 2004, Ozyurt et al., 2006; Reale et al., 2006; Zlatanov et al., 2006; Ozogul et al., 2008).

The levels of saturated fatty acids (SFA) ranged from 29.49% to 29.88%, monounsaturated fatty acids (MUFAs) from 10.97% to 11.40%, and polyunsaturated fatty acids (PUFAs) from 52.27% to 53.42% for cuttlefish. Ozyurt et al. (2006) reported that SFA, MUFAs and PUFAs levels were 29.5-36.8%, 7.8-9.8%, 43.7-49.6% for mantle of cuttlefish, respectively. In a similar study, Ozogul et al. (2008) also reported the contents of SFA, MUFAs and PUFAs as 29.8-31.3%, 6.9-8.3%, 53.1-56.3%, respectively. Thanonkaew et al. (2006) reported that SFA,

MUFAs and PUFAs levels were 35.1%, 11%, 50.3% for mantle of cuttlefish, respectively.

The dominant SFAs were palmitic acid (16.52%-17.74%), and stearic acid (8.18%-8.94%) for both of the sexes. The highest total SFA levels were found in the mantle of male cuttlefish. Statistically, there were significant differences in palmitic acid and stearic acid levels in mantle tissue of male and female cuttlefish ($p < 0.05$). Zlatanov et al. (2006) reported that the amount of palmitic acid and stearic acid contents in cuttlefish 23.3% and 8.5%, respectively. Ozyurt et al. (2006) reported that palmitic acid and stearic acid levels were 17.0-21.0%, 7.5-8.8% for mantle of cuttlefish, respectively. In a similar study, Ozogul et al. (2008) also reported the contents of palmitic acid and stearic acid as 17.6-19.0%, 7.9-8.2%, respectively.

The total MUFA percentage was the highest in mantle of male cuttlefish. Significant differences were not observed in terms of oleic acid between females and males ($P > 0.05$). Statistically, there were significant differences in cis-11 eicosenoic acid levels (C_{20:1}) in mantle tissue of male and female cuttlefish ($p < 0.05$). Cis-11 eicosenoic acid (C_{20:1}, 4.23-4.84%) was the major MUFA in all samples, followed by oleic acid (C_{18:1 n-9}, 3.38-3.87%). Ozogul et al. (2008) reported that the amounts of cis-11 eicosenoic acid (C_{20:1}) and oleic acid (C_{18:1 n-9}) contents in cuttlefish 3.71% and 3.48%, respectively.

Lipids of cuttlefish contain high levels of long-chain n-3 polyunsaturated fatty acids (nearly 50-52%). The total PUFA value in mantle of female was higher than that of the male. DHA (32.55-33.12%) was the major PUFA in all samples, followed by EPA (15.77-17.91%). The dominant long-chain n-3 fatty acids of cuttlefish are EPA and DHA (Thanonkaew et al. 2006, Ozyurt et al. 2006, Zlatanov et al. 2006). Statistically, there were no significant differences in DHA levels in mantle tissue of male and female cuttlefish ($p > 0.05$). Besides, EPA levels in mantle of female cuttlefish were higher than those of the male ($p < 0.05$).

Mineral contents

Mineral contents of mantle tissue of female and male cuttlefish are presented in Table 4. It was found that this species was rich in terms of mineral content, especially Cu, Zn, and Fe.

Cd, Cr, Pb, Zn and Fe levels in mantle tissue of female and male cuttlefish were not significantly different ($p>0.05$). Cu contents of female mantle tissue were significantly higher ($p<0.05$) than those found in male mantle tissue. In this study, mineral levels of mantle tissue of cuttlefish were 3.31-3.52 $\mu\text{g Cd g}^{-1}$, 0.49-0.50 $\mu\text{g Cr g}^{-1}$, 0.33-0.51 $\mu\text{g Pb g}^{-1}$, 5.51-7.63 $\mu\text{g Cu g}^{-1}$, 50.37-50.73 $\mu\text{g Zn g}^{-1}$, 8.56-10.07 $\mu\text{g Fe g}^{-1}$, respectively. Raimundo *et al.* (2005) found out that Zn, Fe, Cu, and Cd levels of mantle tissue of cuttlefish were 79-88 $\mu\text{g g}^{-1}$, 10-12 $\mu\text{g g}^{-1}$, 8.6-12 $\mu\text{g g}^{-1}$,

0.03-0.16 $\mu\text{g g}^{-1}$ respectively. In present study, Cd levels were found to be higher than those found by other researchers. This was could be the differences in Cd contamination in catching areas. In a similar study, Lourenço *et al.* (2009) found out that mineral levels of mantle tissue of cuttlefish were 4.50 $\mu\text{g Cu g}^{-1}$, 1.40 $\mu\text{g Fe g}^{-1}$, 17.70 $\mu\text{g Zn g}^{-1}$, 0.31 $\mu\text{g Cd g}^{-1}$, 0.04 $\mu\text{g Pb g}^{-1}$, respectively. These values were lower than those obtained in this study. This difference might have been caused by the regional differences, sexual maturation and size of individuals.

Table 1. Some morphological measurements and meat yield of cuttlefish for different sexes.

Sex	NS	ML (mm)	TL (mm)	TW (g)	MW (g)	Meat Yield (%)
		$\bar{X} \pm S_x$	$\bar{X} \pm S_x$	$\bar{X} \pm S_x$	$\bar{X} \pm S_x$	$\bar{X} \pm S_x$
♀	20	140.00±7.87 (130-151)	467.30±35.85 (420-515.5)	333.30±46.35 (253.13-384.64)	101.19±17.87 (69.46-119.29)	30.18±1.44 (27.44-31.31)
♂	20	163.10±13.53 (145-180)	519.20±46.82 (465-575)	344.27±80.61 (260.92-474.74)	121.68±30.86 (87.85-173.92)	35.23±1.21 (33.67-36.64)

NS: Number of specimens, ML: Mantle length, TL: Total length, TW: Total weight, MW: Mantle weight

Table 2. The proximate compositions of the mantle cuttlefish for different sexes (%).

	♀		♂	
	$\bar{X} \pm S_x$	Min-max	$\bar{X} \pm S_x$	Min-max
Protein	22.20±0.26 ^a	21.97-22.49	22.15±0.17 ^a	22.01-22.34
Lipid	0.86±0.10 ^a	0.79-0.97	1.01±0.04 ^a	0.97-1.05
Water	74.97±0.13 ^a	74.87-75.12	75.30±0.17 ^a	75.11-75.45
TMS	1.69±0.14 ^a	1.55-1.82	1.68±0.07 ^a	1.61-1.74

*Different letters in the same row indicate significant differences ($p<0.05$).

$\bar{X} \pm S_x$: Average±standart deviation

Table 3. The fatty acids composition of the mantle cuttlefish for different sexes (%).

Fatty Acid	♀		♂	
	$\bar{X} \pm S_x$	Min-max	$\bar{X} \pm S_x$	Min-max
C _{14:0}	1.65±0.09 ^a	1.55-1.71	1.67±0.10 ^a	1.59-1.78
C _{15:0}	0.78±0.02 ^a	0.77-0.80	0.81±0.06 ^a	0.77-0.88
C _{16:0}	16.52±0.46 ^a	16.09-17.01	17.74±0.23 ^b	17.57-18.00
C _{17:0}	1.60±0.11 ^a	1.49-1.70	1.48±0.16 ^a	1.34-1.66
C _{18:0}	8.94±0.22 ^b	8.70-9.12	8.18±0.16 ^a	8.00-8.31
ΣSFA	29.49	28.60-30.34	29.88	29.27-30.63
C _{16:1}	0.89±0.11 ^a	0.78-1.00	1.08±0.07 ^a	1.00-1.12
C _{18:1 n9}	3.38±0.35 ^a	3.00-3.69	3.87±0.24 ^a	3.59-4.01
C _{18:1 n7}	1.86±0.12 ^a	1.78-2.00	2.22±0.12 ^b	2.11-2.34
C _{20:1}	4.84±0.18 ^b	4.65-4.99	4.23±0.29 ^a	4.00-4.56
ΣMUFA	10.97	10.21-11.68	11.40	10.70-12.03
C _{20:4 n6}	2.96±0.17 ^a	2.78-3.11	3.38±0.22 ^a	3.13-3.55
C _{20:5 n3}	17.91±0.30 ^b	17.57-18.15	15.77±0.09 ^a	15.67-15.85
C _{22:6 n3}	32.55±0.41 ^a	32.21-33.00	33.12±0.12 ^a	33.00-33.24
ΣPUFA	53.42	52.56-54.26	52.27	51.80-52.64
Unidentified	6.12	3.72-8.63	6.45	4.70-8.23

*Different letters in the same row indicate significant differences ($p < 0.05$).

$\bar{X} \pm S_x$: Average ± standart deviation

Table 4. The mineral compositions of the mantle cuttlefish for different sexes ($\mu\text{g g}^{-1}$).

Mineral	♀		♂	
	$\bar{X} \pm S_x$	Min-max	$\bar{X} \pm S_x$	Min-max
Cd	3.52±0.50 ^a	3.00-4.00	3.31±0.27 ^a	3.00-3.51
Cr	0.50±0.12 ^a	0.39-0.62	0.49±0.08 ^a	0.40-0.55
Pb	0.33±0.09 ^a	0.27-0.43	0.51±0.09 ^a	0.43-0.61
Cu	7.63±0.55 ^b	7.00-8.00	5.51±0.50 ^a	5.00-6.00
Zn	50.73±1.08 ^a	50.00-51.97	50.37±1.10 ^a	49.27-51.47
Fe	8.56±0.56 ^a	8.00-9.01	10.07±0.79 ^a	9.31-10.89

$\bar{X} \pm S_x$: Average ± standart error

Conclusion

The Official Journal of European Commission (2001) sets food contamination levels for mantle tissue of cephalopods as $1 \mu\text{g Cd g}^{-1}$, $1 \mu\text{g Pb g}^{-1}$. For Turkish Food Codex (2005), these levels are presented as $1 \mu\text{g Cd g}^{-1}$, $1 \mu\text{g Pb g}^{-1}$, $20 \mu\text{g Cu g}^{-1}$ and $50 \mu\text{g Zn g}^{-1}$. However, the present study reveals that Cd and Zn levels are higher than those given above. Although high levels of these minerals do not directly affect human health, the excess cadmium and zinc could be accumulated in the food chain and by being carried to the upper trophic levels, they might create important ecological problems.

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