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Food Chemistry 95 (2006) 382–385

Food Chemistry

www.elsevier.com/locate/foodchem

Seasonal changes of fatty acids of cuttlefish *Sepia officinalis* L. (Mollusca: Cephalopoda) in the north eastern Mediterranean sea

Gulsun Özyurt *, Önder Duysak, Erhan Akamca, Canan Tureli

Department of Fishing and Fish Processing, Faculty of Fisheries, University of Cukurova, 01330 Balcalı, Adana, Turkey

Received 25 October 2004; received in revised form 13 December 2004; accepted 13 December 2004

Abstract

The total lipids and seasonal variations in the fatty acids of the mantle of cuttlefish (*Sepia officinalis*) captured in the north eastern Mediterranean were investigated and the mantle was found to be a good source of polyunsaturated fatty acids (ω3 PUFAs, in particular). In all seasons, the major fatty acids in the cuttlefish mantle were observed to be palmitic acid (16:0), stearic acid (18:0), eicosapentaenoic acid (EPA, 20:5ω3) and docosahexaenoic acid (DHA, 22:6ω3). A comparison of the saturated fatty acid (29.5–36.8%), monounsaturated fatty acids (7.81–9.84%) and polyunsaturated fatty acids (43.7–49.6%) of the cuttlefish mantle revealed that polyunsaturated fatty acids (PUFA) constituted the highest proportion. The levels of DHA in the cuttlefish mantle in autumn, winter, spring and summer were 27.6%, 28.5%, 29.5% and 23.9%, while those of EPA were 16.8%, 15.4%, 14.7% and 13.9%, respectively.

Keywords: Cuttlefish; *Sepia officinalis*; Fatty acid composition; Seasonal changes

1. Introduction

Cephalopoda, one of the most important groups of marine invertebrates, are consumed throughout the world, both as food and as feed supplement. Cuttlefish, which has recently been captured in various amounts ranging from 11,000 to 15,000 tons annually throughout the world, occupies an important place among cephalopoda (FGIS, 2004). Known as common cuttlefish or European cuttlefish, *Sepia officinalis* belongs to the Sepiidae family. There exist 100 cuttlefish species throughout the world (Okutani, 1990). Of these, *S. officinalis* is one of the best known and is easily cultivated (Forsythe, DeRusha, & Hanlon, 1994). Highly preferred by consumers, this species is distributed from the Baltic and northern sea in the east Atlantic to Africa, and the Mediterranean (Roper et al., 1984). The muscle of the cuttlefish, whose connective tissues are highly developed compared to fish in general, is white in colour and hard. The fatty acids are generally low, but ω3 polyunsaturated fatty acids constitute the majority of the total lipids (Sinanoglou & Miniadis-Meimaroglou, 1998). These fatty acids have an essential role in human diet in preventing diseases and lead to a healthy life (Horrocks & Yeo, 1999; Kromhout, Bosschieter, & Coulander, 1985; Siscovick et al., 1995).

It is known that the biochemical contents of marine organisms undergo changes due to seasonal changes (Ackman, 1995; Gamez-Meza et al., 1999; Orban et al., 2002a; Vlieg & Body, 1988). Though very limited, studies have been conducted on the nutrient value and fatty acid composition of cuttlefish (Shchenikova, Pavlycheva, Davydova, Isa, & Sokolova, 1987; Sinanoglou & Miniadis-Meimaroglou, 1998; Soriguer et al., 1997), but these studies do not give any insight of the seasonal changes in fatty acids. For this reason, an investigation of the fatty acids composition of the cuttlefish in all seasons was aimed at in this study. It is anticipated that the

* Corresponding author. Tel.: +90 322 3386084x2961; fax: +90 322 3386439.

E-mail address: beklevik@cu.edu.tr (G. Özyurt).

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doi:10.1016/j.foodchem.2004.12.044

determination of the fatty acid composition of cuttlefish will provide necessary information of the nutrient value of this food for both consumers and researchers working on nutrient tables, and guide the farmers, cultivating this species, on its feeding requirements.

2. Materials and methods

Cuttlefish used in this study were captured, with trawl, by academic staff of Fisheries Faculty in the Iskenderun bay, north eastern Mediterranean in February, April, July and November, 2003. The samples were kept in ice after capturing and transferred to the laboratory. Mantle which is the main edible portion of cuttlefish was homogenized and chemical analyses were done on this part of fresh samples. The analyses were performed at least in triplicate.

Lipid content was analyzed according to the procedure of Bligh and Dyer (1959). The lipids were saponified and esterified for fatty acid analysis by the method of Metcalfe, Schmitz, and Pelka (1966). The fatty acid methyl esters (FAMEs) were separated and quantified with a Hewlett-Packard 5880 gas–liquid chromatograph (GC) using a capillary column equipped with flame ionization detector (FID). Separation was achieved on a 50-m × 0.20-mm i.d. wall-coated open tubular fused silica capillary column coated with Carbowax 20M. The column, injector and detector temperatures were maintained at 200 and 300 °C, respectively. The carrier gas was helium with a split ratio of 1:100. Identification was achieved by comparison to retention times of authentic standards, argentation TLC, followed by GC, of the bands separated by degree of unsaturation and mass spectrometry. All data, obtained separately for each sampling season, were subjected to analysis of variance (one-way ANOVA) at 5% confidence level using Duncan (1955) multiple range test.

3. Results and discussion

The total lipid content determined in the cuttlefish mantle throughout the four seasons can be seen in Fig. 1. For this species, Sinanoglou and Miniadis-Meimaroglou (1998) and, for several other cephalopoda, De Koning (1993) reported similar total lipid contents. No significant seasonal changes were observed in cuttlefish mantle in terms of lipid content ($p > 0.05$). Fatty acid composition of the mantle of the cuttlefish, which is captured in different seasons, is given in Table 1. At the end of the study, it was determined that the major fatty acids in the cuttlefish mantle were palmitic acid (16:0), stearic acid (18:0), eicosapentaenoic acid (EPA, 20:5ω3) and docosahexaenoic acid (DHA, 22:6ω3). Similarly, Sinanoglou and Miniadis-Meimaroglou (1998) also reported that these fatty acids constituted the major constituents of the fatty acids in the cuttlefish mantle.

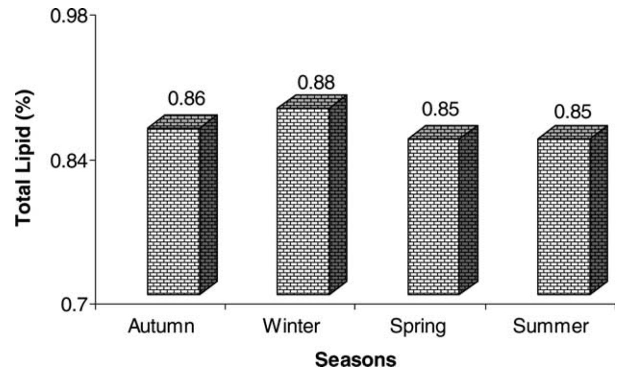

Fig. 1. Total lipid content of the cuttlefish mantle captured in different seasons.

Culkin and Morris (1970) recorded that, in some cephalopoda species in the north Atlantic, the levels of the saturated, monounsaturated and polyunsaturated fatty acids were 32–38%, 14–18% and 44–45%, respectively, while Gibson (1983) reported these levels to be 30.5–37.9%, 12.2–25.2% and 44.3–52.3% for some cephalopoda species in southern Australia. Similarly, in the current work, the level of saturated fatty acids was determined to be 29.5–36.8% and that of polyunsaturated fatty acids to be 43.7–49.6% in the mantle of the cuttlefish captured in the north eastern Mediterranean, while the 7.81–9.85% level recorded for monounsaturated fatty acids was found to display differences from those of the cephalopoda studies.

Palmitic acid (17.0–21.1%) and stearic acid (7.47–8.77%) in the cuttlefish mantle were found to be present at the highest levels through all seasons among the saturated fatty acids. The level of the monounsaturated fatty acid is highly dependent on the level of oleic acid, since the primary constituent of this group is oleic acid. In this study, oleic acid was identified as the dominant monounsaturated fatty acid among monounsaturated fatty acids, but, compared to fish in general, was observed to be in remarkably low levels (3.56–4.88%). Shchenikova et al. (1987) reported that the level for the 16:1 of the monounsaturated fatty acids captured is the Far East basin (Russia) was 10.5% and that of the 22:1 was 13.6%. The reason for the remarkable difference between the data of Shchenikova et al. (1987) and both the results in our study and those in Sinanoglou and Miniadis-Meimaroglou (1998) is likely to be related to the geographical region where fishing was conducted. The decrease in the saturated fatty acid level in the cuttlefish mantle in autumn and winter is thought to have resulted from its catabolization in order to compensate for the metabolic energy.

A comparison of saturated, monounsaturated and polyunsaturated, fatty acids of the cuttlefish mantle suggests that polyunsaturated fatty acids constitute the

Table 1
The fatty acid composition of the mantle of cuttlefish captured in different seasons

(%)	Autumn	Winter	Spring	Summer
12:0	0.05 ± 0.00^{a}	0.03 ± 0.00^{a}	0.05 ± 0.00^{a}	0.46 ± 0.00^{b}
14:0	2.36 ± 0.05^{b}	1.85 ± 0.12^{a}	1.85 ± 0.00^{a}	2.56 ± 0.03^{c}
15:0	0.82 ± 0.01^{a}	0.84 ± 0.04^{ab}	0.84 ± 0.00^{ab}	0.89 ± 0.01^{b}
16:0	18.2 ± 0.29^{b}	17.0 ± 0.20^{a}	18.8 ± 0.03^{c}	21 ± 0.08^{d}
17:0	1.43 ± 0.02^{a}	1.51 ± 0.03^{b}	1.63 ± 0.00^{c}	1.48 ± 0.00^{ab}
18:0	7.47 ± 0.07^{a}	7.49 ± 0.06^{a}	8.41 ± 0.02^{b}	8.77 ± 0.01^{c}
20:0	0.20 ± 0.02^{a}	0.32 ± 0.00^{b}	0.41 ± 0.00^{c}	0.64 ± 0.00^{d}
21:0	0.03 ± 0.01^{a}	0.06 ± 0.02^{ab}	0.07 ± 0.01^{b}	0.09 ± 0.01^{b}
22:0	0.07 ± 0.01^{a}	0.07 ± 0.00^{a}	0.27 ± 0.01^{b}	0.40 ± 0.01^{c}
23:0	0.12 ± 0.02^{c}	0.11 ± 0.01^{bc}	0.06 ± 0.01^{a}	0.09 ± 0.01^{ab}
24:0	0.27 ± 0.00^{ab}	0.24 ± 0.03^{a}	0.30 ± 0.00^{bc}	0.34 ± 0.02^{c}
∑ SFA	31.0	29.5	32.7	36.8
14:1	0.09 ± 0.00^{c}	0.07 ± 0.00^{ab}	0.06 ± 0.00^{a}	0.08 ± 0.00^{bc}
15:1	0.12 ± 0.00^{a}	0.12 ± 0.00^{a}	0.15 ± 0.01^{b}	0.12 ± 0.01^{a}
16:1	1.01 ± 0.02^{c}	0.94 ± 0.02^{b}	0.82 ± 0.02^{a}	0.83 ± 0.00^{a}
17:1	1.34 ± 0.00^{c}	1.10 ± 0.03^{b}	0.04 ± 0.00^{a}	0.05 ± 0.00^{a}
18:1	3.69 ± 0.04^{b}	3.59 ± 0.01^{a}	3.56 ± 0.01^{a}	4.88 ± 0.01^{c}
20:1	2.81 ± 0.07^{b}	3.31 ± 0.02^{c}	2.87 ± 0.01^{b}	2.18 ± 0.03^{a}
22:1	0.07 ± 0.02^{ab}	0.04 ± 0.00^{a}	0.09 ± 0.02^{b}	0.14 ± 0.00^{c}
24:1	0.71 ± 0.00^{d}	0.65 ± 0.02^{c}	0.22 ± 0.00^{a}	0.27 ± 0.00^{b}
∑ MUFA	9.84	9.82	7.81	8.55
18:2ω6	0.75 ± 0.01^{a}	0.94 ± 0.01^{b}	1.03 ± 0.01^{c}	1.35 ± 0.06^{d}
18:3ω6	0.05 ± 0.01^{a}	0.11 ± 0.03^{b}	0.03 ± 0.00^{a}	0.03 ± 0.00^{a}
20:2ω6	0.33 ± 0.00^{a}	0.38 ± 0.02^{b}	0.37 ± 0.00^{b}	0.32 ± 0.01^{a}
20:4ω6	0.03 ± 0.01^{a}	0.02 ± 0.00^{a}	3.70 ± 0.02^{b}	3.91 ± 0.09^{c}
22:2ω6	3.10 ± 0.01^{b}	3.23 ± 0.06^{c}	0.15 ± 0.04^{a}	0.21 ± 0.01^{a}
18:3ω3	0.07 ± 0.01^{a}	0.14 ± 0.01^{b}	0.08 ± 0.00^{a}	0.08 ± 0.00^{a}
20:3ω3	0.03 ± 0.00	0.02 ± 0.00	0.02 ± 0.00	0.02 ± 0.00
20:5ω3	16.8 ± 0.07^{d}	15.4 ± 0.26^{c}	14.7 ± 0.12^{b}	13.9 ± 0.03^{a}
22:6ω3	27.6 ± 0.24^{b}	28.5 ± 0.15^{c}	29.5 ± 0.07^{d}	23.9 ± 0.08^{a}
∑ PUFA	48.7	48.8	49.6	43.7
Unknown	10.4	11.9	9.85	11.0

The values are expressed as means±standard deviation, $n = 3$.
[*] Means followed by different letters are significantly different ($p < 0.05$).

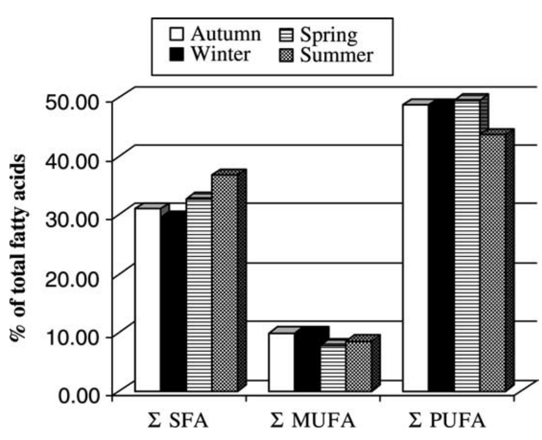

Fig. 2. Total SFA, MUFA and PUFA contents of the cuttlefish mantle captured in different seasons.

highest proportion (Fig. 2). This finding of a high PUFA level is similar to the literature data (Ackman, 1995; Forneris, Guidetti, & Sarra, 1981; Joseph, 1982; Shchenikova et al., 1987; Sinanoglou & Miniadis-Meimaroglou, 1998; Soriguer et al., 1997). Numerous researchers have reported that the major polyunsaturated fatty acids of cephalopoda were EPA and DHA (De Koning, 1972; Forneris et al., 1981; Joseph, 1982). In this study, DHA, which was recorded in autumn, winter, spring and summer to be 27.6%, 28.5%, 29.5% and 23.9%, respectively, was observed to be the major polyunsaturated fatty acid. The EPA level in cuttlefish mantle was found to be 16.8%, 15.4%, 14.7% and 13.9% in autumn, winter, spring and summer, respectively.

Water temperature has a remarkable influence on the polyunsaturated fatty acids of lipids. It has long been known that, as the polyunsaturated fatty acid level increases in phospholipids, an important constituent of cell membranes, the melting point of the lipid mixture decreases and, therefore, the flexibility and permeability of the cell increases (Love, 1992). As can be observed in the Table 1, the DHA and EPA levels of cuttlefish mantle were significantly low ($p < 0.05$) in summer when water temperature was high. Parallel to the findings in this study, many other researchers have reported that the amount and type of fatty acids in most marine organisms were influenced by seasonal changes (Aro et al., 2000; Luzia, Sampaio, Castellucci, & Torres, 2003; Montaño & Navarro, 1996; Orban et al., 2002b; Soriguer et al., 1997; Vlieg & Body, 1988).

It was determined, at the end of the study, that PUFAs constituted the 43.8–49.6% of the total lipids of cuttlefish whose lipid content ranged from 0.85% to 0.88%. The fact that the total lipid content is remarkably low and that the EPA and DHA levels of the total lipids it contains are high seems to be a significant factor that might positively influence the preference of those who are on a diet. In animal feeding, the procedure followed in developing feed for certain species involves the identification of the food that of the animal to be raised naturally eats and, depending on analysis of its body composition, determining what kind of nutrients it will need. In this respect, this study can also guide farmers cultivating this species on its feeding requirements.

Acknowledgements

The authors are grateful to the Scientific Research Project Fund of Cukurova University for financial support of this research project.

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