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Fatty Acid Composition of Selected Tissues of *Unio elongatulus* (Bourguignat, 1860) (Mollusca: Bivalvia) Collected from Tigris River, Turkey

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Abstract

The total lipid, fatty acid content of some organs and whole specimen of freshwater mussel *Unio elongatulus* were investigated. The mussels were collected in July in 2007 from Tigris River, Turkey. Fatty acid content of selected tissues and whole mussel was analyzed by gas chromatography (GC) and gas chromatography-mass spectrometry (GC-MS). In the analyses, predominant fatty acids were C16:0, C16:1ω7, C18:1ω9, C20:1ω9, C20:4ω6 and C20:5ω3. Analyses of selected organs (mantle, gills, foot and whole body) presented different and characteristic fatty acids profiles. In the gills C16:1ω7 (30.2%), C16:0 (17.4%) acids; in the mantle C18:1ω9 (20.3%), C16:0 (25.4%) acids; in the foot C16:0 (20.8%), C16:1ω7 (15.9%), C18:1ω9 (15.4%) acids and in whole body C16:1ω7 (27.6%), C16:0 (23.6%) acids were the most abundant constituents. Also the percentages of C20:4ω6 and C20:5ω3 acids, precursors of eicosanoids, were apparently high in the gills and foot. It is presumed that the chief fatty acids present in a particular organ are related to specific functions of the organ. In all of the tissue analyses, ΣMUFA levels were higher than ΣPUFA and ΣSFA levels.

Keywords: Fatty acids, freshwater mussel, *Unio elongatulus*, Tigris River.

Türkiye, Dicle Nehri'den Toplanan *Unio elongatulus* (Bourguignat, 1860) (Mollusca: Bivalvia)'un Seçilmiş Dokularının Yağ Asiti Kompozisyonu

Özet

Tatlısu midyesi *Unio elongatulus*'un tüm vücut dokusu ile bazı organlarının total lipit yağ asidi içeriği araştırıldı. Midyeler Haziran 2007 tarihinde Türkiye Dicle Nehri'nden toplandı. Midyenin bütün vücut dokusu ile seçilmiş organlarının yağ asidi içeriği gaz kromatografi (GC) ve gaz kromatografi-kütle spektrometre (GC-MS) ile analiz edildi. Analizlerde, C16:0, C16:1ω7, C18:1ω9, C20:1ω9, C20:4ω6 ve C20:5ω3 asitler yoğunlukta bulunan bileşenlerdi. Analiz edilen organlar (manto, solungaç, ayak ve tüm vücut) farklı ve karakteristik yağ asidi profili gösterdi. Solungaçta C16:1ω7 (%30,2), C16:0 (%17,4) asitler; mantoda C18:1ω9 (%20,3), C16:0 (%25,4) asitler; ayakta C16:0 (%20,8), C16:1ω7 (%15,9), C18:1ω9 (%15,4) asitler ve tüm vücut dokusunda ise C16:1ω7 (%27,6), C16:0 (%23,6) asitler en çok bulunan bileşenlerdi. Ayrıca eikosanoidlerin öncül maddesi olan C20:4ω6 ve C20:5ω3 asitlerin yüzde oranları, solungaç ve ayakta önemli oranda yüksek bulundu. Belirli organlardaki temel yağ asitlerinin organların spesifik fonksiyonları ile bağlantılı olduğu sanılmaktadır. Tüm doku analizlerinde, ΣTDYA oranı, ΣDYA ve ΣÇDYA oranlarından daha yüksekti.

Anahtar Kelimeler: Yağ asitleri, tatlısu midyesi, *Unio elongatulus*, Dicle Nehri.

Introduction

Bivalve molluscs are very important for many reasons. Apart from their commercial value for use as a human foodstuff and in the feeding of several marine crustaceans (Deshimaru *et al*., 1979; Cotronea *et al*., 1980), the biological and pharmacological role of the polyunsaturated fatty acids (PUFAs) contained in them is of notable interest, above all since it was found that C20:5ω3 acid may be useful in the treatment of some cardiovascular diseases (Joseph, 1982). For these reasons, fatty acid composition of bivalves has been mostly studied (Beninger *et al*., 1985; Khardin *et al*., 2003; Milke *et al*., 2004, 2006; Alkanani *et al*., 2007; Ekin *et al*., 2008).

Lipid composition and storage strategy in molluscs, particularly of bivalves and gastropods, have been studied since lipids constitute a major fraction of molluscan tissues (Voogt, 1983). Almost all the data included in the molluscan lipid studies

concern the entire organism and only a few reports on the tissue distribution of fatty acids are available (Hagar and Dietz, 1986; Wenne and Polak, 1989).

Seasonal variations in lipid and fatty acid compositions have been reported for several marine bivalve molluscs, including *Pecten maximus, Crassostrea gigas, Tapes decussatus, Tapes philippinarum, Scapharea inaequivalvis* (Beninger and Stephan, 1985; Piretti *et al*., 1988; Pazos *et al*., 1996, 2003). Some of the other studies on bivalve fatty acids were concerned with analyses of whole animal (Watanabe and Ackman, 1974; Trider and Castell, 1980; Misra *et al*., 1985; Alkanani *et al*., 2007; Ekin *et al*., 2008). Furthermore, analyses on fatty acid composition of tissues were usually related to seasonal variations, sexual development and growth metabolism of marina bivalves.

Lipid composition and metabolism have been extensively studied in marine bivalves; a few investigations have been done on freshwater forms (Pollero *et al*., 1981, 1983; Dembitsky *et al*., 1992, 1993; Ekin *et al*., 2008) and even less on organs and tissues of freshwater species. As mentioned before, there were not much more studies on fatty acid composition of freshwater bivalve tissues. Among the known studies, only some of the freshwater bivalves, *Carunculina texasensis* (Hagar and Dietz, 1986), *Diplodom patagonicus* (Pollero *et al*., 1981), *Ligumia subrostrata* (Dietz and Graves, 1981), *Diplodon delodontus* (Pollero *et al*., 1983), *Dreissena polymorpha* and *Unio* sp. (Dembitsky *et al*., 1992) and *Dreissena siouffi* (Ekin *et al*., 2008) have been reported.

Up to now, lipid compositions of freshwater bivalves from Turkey have not been studied. *Unio elongatulus* mussels are densely distributed in Turkish rivers. Although not eaten by Turkish people, they have got important roles in food chain since they are consumed by fish, water birds, mammals and reptiles in the river. Sometimes, they are used as foodstuff for breeding some animals such as fish, chicken and pigs. For these reasons, every study on the mussels from Turkish freshwater gains importance. The primary goal of this study was to characterize the fatty acid composition of the total lipid in the mantle, gills, foot and whole body of freshwater bivalve mollusc *U. elongatulus* collected from Tigris River.

Materials and Methods

Mussels

U. elongatulus mussels were collected from Tigris River Bank (Altitude: 583 m, Coordinate: 37°55'02″ N, 40°13'08″ E) in Diyarbakır in the Southeast Anatolia Region of Turkey, in July 2007. Individually, three adult mussels of similar size (length: 9±1.50 cm, wet weight: 10±1.25 g) were sampled for each lipid analysis of the tissues. The temperature of the river water was 15°C in July. Adult animals were divided into four groups and their organs, i.e., mantle, gills, foot and whole body were dissected out. Samples were transferred into chloroform/methanol (2:1, v/v) and kept frozen (-80°C) until use.

Lipid Extraction

Three mussels of similar size were used for each individual analysis, totally twelve mussels. Samples (dissected tissues such as gills, foot, mantle and whole body) were homogenized in chloroform/methanol (2:1, v/v) solution in order to extract total lipids (Bligh and Dyer, 1959). Autoxidation of unsaturated components was minimized by adding 50 µl of 2% butylated hydroxytoluene in chloroform to each sample during the extraction process. Total lipid extracts were dried under a stream of N_2. Total lipids were put into reaction vials and the associated fatty acids were transmethylated by refluxing the fractions in acidified (sulfuric acid) methanol for 90 min at 85°C. The fatty acid methyl esters (FAMEs) of the tissues total lipids were extracted from the reaction vials three times with hexane and concentrated (Stanley-Samuelson and Dadd, 1983).

Gas Chromatography (GC)

Fatty acid methyl esters were separated and quantified by capillary gas chromatography. The chromatography system consisted of a Hewlett Packard (Wilmington, DE) gas chromatograph (model 6890), a DB-23 capillary column (60 m x 0.25 mm i.d. x 0.250 µm film thickness and Bonded 50% cyanopropyl) (J & W Scientific, Folsom, CA), a flame ionization detector, and Hewlett-Packard ChemStation software. The injection port and the detector temperatures were 270°C and 280°C, respectively. The split ratio was 1:20. The flow rates of compressed air and hydrogen were 300 ml/min, 30 ml/min, respectively. Helium was used as carrier gas (2.8 ml/min). The oven temperature was programmed at a rate of 6.5°C/min from 130°C (1 min hold) to 170°C, then increased at a rate of 2.75°C/min to a 215°C, then again increased at a rate of 40°C/min to 230°C, was held for 12 minutes. Total fatty acids levels and spectra of FAMEs are obtained by HP 3365 ChemStation computer program (Ekin *et al*., 2008). FAMEs existence and retention times were determined by comparing the spectra of authentic standards (Sigma-Aldrich Chemicals). Individual FAMEs were identified by comparisons with the chromatographic behaviors of authentic standards.

Gas Chromatography-Mass Spectrometry (GC-MS)

The chemical structures of the FAMEs (especially highly unsaturated fatty acids and odd numbered fatty acids) were confirmed by capillary

gas chromatography-mass spectrometry (GC-MS). GC-MS analyses were made using a GC-MS equipment (HP 5890-E series GC-System, Hewlett-Packard, Palo Alto, CA, USA) with mass-selective detection. An Innowax column (30 m x 0.25 mm i.d., 0.25 μm film thickness) was used, and the temperature was programmed from 150 to 230°C at a 2°C/min increase with an initial hold of 6 min. The carrier gas was helium (1 ml/min) and the split ratio was 1:50. The injection port and the detector temperatures were 250 and 300°C, respectively. The mass spectrometer was operated in the electron impact ionization mode (70 eV). Chemical structures of the FAMEs were identified by comparison with the Wiley 275 and Nist 98 library. Chemical structures of the FAMEs were determined by analysis of spectra and by comparing obtained spectra with the spectra of authentic standards.

Statistical Analyses

Statistical analyses were done by SPSS (12.0) computer programme. The percentages of fatty acids were tested by analyses of variance (ANOVA) and comparisons between means were performed with TUKEY test. Differences between means were evaluated as significant if $P<0.05$.

Results

The total lipid fatty acid compositions of some selected tissues of *U. elongatulus* are presented in Table 1. In the mixture of methyl esters obtained from the total lipids extracted from the mantle, gills, foot and whole body of the mussel, following principal constituents were identified C12:0, C14:0, C15:0, C16:0, C17:0, C18:0 as saturated fatty acids (SFA); C16:1ω7, C18:1ω9, C20:1ω9 as monounsaturated fatty acids (MUFA) and C18:2ω6, C18:3ω3, C20:2ω6, C20:4ω6, C20:5ω3 as polyunsaturated fatty acids.

In the gills analyses C16:1ω7 (30.2%), C16:0 (17.4%), C20:1ω9 (10.9%); in the mantle C16:0 (25.4%), C18:1ω9 (20.3%), C16:1ω7 (14.4%); in the foot C16:0 (20.8%), C16:1ω7 (15.9%), C18:1ω9 (15.4%) and in whole body C16:1ω7 (27.6%), C16:0 (23.6%), C18:1ω9 (10.2%) acids were most abundant components (Figure 1). In all of the tissues, C12:0, C15:0, C17:0 and C20:2ω6 acids were always less than 1%. The proportion of C14:0 acid was more than twice as high as in the mantle in comparison to the foot and whole body. The percentage of this component in the gills was slightly lower than in the mantle. There was not important proportional difference in C18:0 acid levels among tissues. Its percentage varied from 5% to 7%. The highest value of C18:2ω6 acid was found in the mantle (9.5%); the lowest value was in whole body (3.5%). However, in the analyses, the level of C18:3ω3 acid did not exceed 3.2%.

There were statistically important findings in ΣSFA, ΣMUFA and ΣPUFA levels. For example, in all of the tissue analyses, ΣMUFA levels were higher than ΣSFA and ΣPUFA levels. ΣSFA levels ranged from 28.9% to 35.4%, ΣMUFA levels ranged from 40.2% to 48.1% and ΣPUFA levels were between 21.0% and 27.5%. The maximum ΣMUFA amount was found in the gills (48.1%), the maximum amount of SFA was found in the mantle (35.4%) and the maximum amount of ΣPUFA was in the foot (27.5%).

The total of ω6 (Σω6) fatty acids was higher than total of ω3 (Σω3) fatty acids. Σω6 / Σω3 ratio was defined the highest in the gills tissue (1.46) and the lowest was in whole body (1.03). On the other

Table 1. Fatty acid composition (%) of total lipids in selected tissues of *U. elongatulus*

Fatty Acids	Gills (mean*±S.E.)**	Mantle (mean*±S.E.)**	Foot (mean*±S.E.)**	Whole body (mean*±S.E.)**
C12:0	0.61±0.05^{a}	0.15±0.02^{b}	0.08±0.01^{b}	0.23±0.01^{d}
C14:0	1.32±0.12^{a}	1.80±0.14^{a}	0.97±0.07^{b}	0.77±0.05^{b}
C15:0	1.01±0.08^{a}	0.53±0.05^{b}	0.68±0.05^{b}	0.69±0.04^{b}
C16:0	17.49±1.26^{a}	25.45±1.37^{b}	20.83±1.32^{c}	23.66±1.40^{b}
C17:0	1.35±0.13^{a}	1.23±0.10^{a}	1.28±0.10^{a}	1.20±0.10^{a}
C18:0	7.15±0.65^{a}	6.27±0.62^{b}	7.26±0.65^{a}	5.18±0.47^{c}
ΣSFA	28.93±1.44^{a}	35.43±1.74^{b}	31.10±1.49^{a}	31.73±1.40^{c}
C16:1ω7	30.27±1.47^{a}	14.40±1.12^{b}	15.90±1.11^{b}	27.64±1.42^{c}
C18:1ω9	6.89±0.71^{a}	20.30±1.35^{b}	15.40±1.10^{c}	10.23±0.65^{d}
C20:1ω9	10.99±1.03^{a}	5.58±0.63^{b}	10.18±0.93^{a}	9.27±0.85^{a}
ΣMUFA	48.15±2.18^{a}	40.28±2.02^{b}	41.48±2.08^{b}	47.14±2.12^{a}
C18:2ω6	4.87±0.36^{a}	9.56±0.97^{b}	6.82±0.57^{c}	3.50±0.24^{d}
C18:3ω3	0.62±0.04^{a}	2.47±0.19^{b}	1.87±0.13^{c}	3.16±1.11^{d}
C20:2ω6	0.95±0.08^{a}	0.30±0.04^{b}	0.37±0.02^{b}	0.23±0.01^{b}
C20:4ω6	8.33±0.87^{a}	3.34±0.42^{b}	8.37±0.72^{a}	6.97±0.54^{c}
C20:5ω3	9.04±0.91^{a}	8.82±0.75^{a}	10.16±0.93^{a}	7.21±0.63^{b}
Σω6/Σω3	1.46	1.17	1.29	1.03
ΣPUFA	23.81±1.37^{a}	24.49±1.42^{a}	27.59±1.52^{b}	21.07±1.43^{c}

* Means are the averages of three replicates. The values are shown as mean±S.E

** Means followed by different letters in the same line are significantly different ($P<0.05$) by Tukey's test.

SFA: Saturated Fatty Acids, MUFA: Monounsaturated Fatty Acids, PUFA: Polyunsaturated Fatty Acids

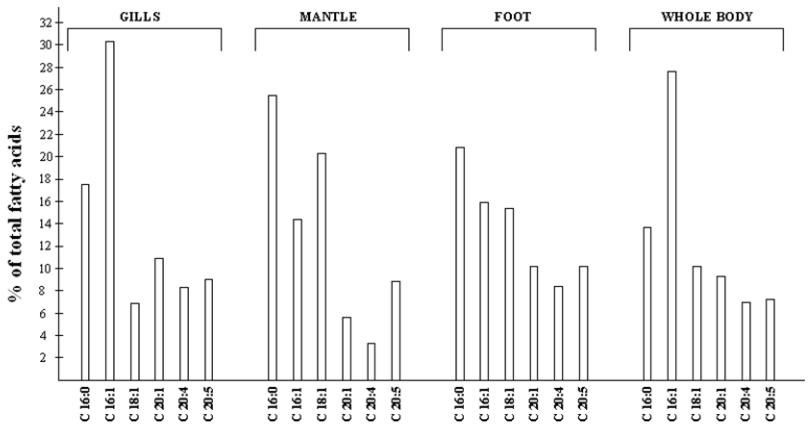

Figure 1. Distribution of major fatty acids percentages in the gills, mantle, foot and whole body of *U. elongatulus.*

hand, surprisingly the percentage of C20:5ω3 (ω3) acid in all of the tissues was slightly higher than C20:4ω6 acid (ω6). Its proportion was between 7.2% and 10.1% and it was major fatty acid among PUFAs, however C20:4ω6 acid was the second major PUFA. The sum of C20:4ω6 and C20:5ω3 acids was 18.4% in the foot, 17.4% in the gills, 14.2% in whole body and 12.2% in the mantle.

Discussion

U. elongatulus mussel was examined in order to get more detailed fatty acid variations of its some selected tissues such as gills, mantle, foot and whole body. There are not much more studies on fatty acid composition of freshwater bivalve organs. Among the investigations studied on freshwater bivalves; gills fatty acid composition of *C. texasensis* (Hagar and Dietz, 1986) and fatty acid composition of female gonad tissues of *D. delodontus* (Pollero *et al*., 1983) are known. Most of the researches are about marine bivalves (Klingensmith and Stillway, 1982; Piretti *et al*., 1988; Pazos *et al*., 2003) and marine gastropods (Rakshit *et al*., 1997). The most detailed study is about fatty acid composition of some selected tissues (whole body, hepatopancreas, mantle, gills and male and female gonads) of *Macoma balthica* brackish water mussel (Wenne and Polak, 1989).

In the selected tissues of *M. balthica* (Wenne and Polak, 1989) C16:1ω7, C18:1ω9, C20:1ω9 and C20:5ω3 acids were found abundantly. On the other hand, in the analyses of *C. texasensis* gills (Hagar and Dietz, 1986), C20:1ω9 (between 7.9-18.4%) and C20:4ω6 (between 15.1-17.7%) acids were found higher than other fatty acids. In *D. delodontus* (Pollero *et al*., 1983) mussel, the proportions of ΣSFA in the gonads were low and unsaturation was scattered mostly in C16:1ω7, C18:1ω9 and C20:1ω9 acids. In a study on gastropod organs, Rakshit *et al*. (1997) were reported that among SFAs C16:0, C18:0, C20:0; among MUFAs C18:1ω9, C16:1ω7, C20:1ω9 and among PUFAs C22:5ω6, C20:5ω3, C18:2ω6 and C20:4ω6 acids were major constituents in *Telescopium telescopium* organs such as foot, mantle and digestive gland.

In *U. elongatulus*, tissues presented different and characteristic fatty acid profiles quantitatively. For instance, in the gills C16:1ω7 (30.2%), C16:0 (17.4%), C20:1ω9 (10.9%) acids; in the mantle C16:0 (25.4%), C18:1ω9 (20.3%), C16:1ω7 (14.4%) acids; in the foot C16:0 (20.8%), C16:1ω7 (15.9%), C18:1ω9 (15.4%) acids and in whole body C16:1ω7 (27.6%), C16:0 (23.6%), C18:1ω9 (10.2%) acids were found at high percentages (Figure 1). These fatty acids are familiar and mostly found at high percentages in most of mussels, especially in freshwater representatives such as *C. texasensis*, *D. patagonicus*, *L. subrostrata*, *D. delodontus*, *D. polymorpha, Unio* sp. and *D. siouffi.* Predominant MUFAs such as C16:1ω7 and C18:1ω9 acids of *U. elongatulus* tissues may have two origins: exogenous from the diets or endogenous by desaturation of C16:0 and C18:0 acids, respectively. Also, it is accepted that the fatty acid composition of an organ is dictated by organ's metabolic activities.

In the present work, in all of the tissues, ΣMUFA levels were found higher than ΣPUFA and ΣSFA levels. ΣPUFA levels were found the lowest in all of the tissues analyses. However, there were also some similarities between *U. elongatulus* and some of the other mollusc. For instance, as in the mantle and foot of *U. elongatulus*, the levels of ΣSFA and ΣPUFA in the mantle and foot of *T. telescopium* were also found at high percentages. In addition, ΣMUFA level in *U. elongatulus* gills, not studied by Rakshit *et al*. (1999) in *T. telescopium*, was found at high percentage. The occurrence of fatty acids classes in different organs of *T. telescopium* marine gastropod exhibited a unique pattern of variation. Digestive gland possessed a maximum amount of ΣMUFA and minimum amount of ΣSFA; the mantle contained a maximum level of ΣSFA and minimum level of ΣPUFA; whereas in the foot ΣPUFA were maximum and ΣMUFA minimum. According to the organwise distribution, maximum ΣSFA was found in the mantle, maximum ΣMUFA was in the digestive gland

and maximum ΣPUFA was obtained in the foot (Rakshit *et al*., 1997).

One of the principal problems faced by freshwater animals is the maintenance of ionic balance. In freshwater mussels, the primary site of Na uptake is gills (Dietz and Graves, 1981). In addition to being the primary site of ion transport, gills also involved in food procurement and gas exchange and serve as a brooding chamber for larval glochidia in females. Thus, gills serve many different functions the relative importance of which may vary during the year (Hagar and Dietz, 1986). C20:4ω6 acid is the substrate for production of the prostaglandins involved in regulating Na uptake and its content is relatively high in whole body lipids of freshwater bivalves as well as in gill lipids e.g. in the mussel *C. texasensis* (Hagar and Dietz, 1986). The increased proportion of the C20:4ω6 acid in the gills and, to some extent, in the mantle of *M. balthica* (Wenne and Polak, 1989) suggests an adaptation to brackish-water conditions in the Gulf of Gdansk. This is confirmed by the low content of C20:4ω6 acid in *Mytilus edulis* gills from the typical sea-water (Morris *et al*., 1983). While marine molluscs possessed little C20:4ω6 acid, some freshwater bivalves investigated contained relatively high levels of this component. C20:4ω6 acid was also found to be the most abundant fatty acid in a total lipid extract of *L. subrostrata* gills (Saintsing *et al*., 1983) and was reported to be major component of a whole animal extract of the South American freshwater mussel *D. patagonicus* (Pollero *et al*., 1981). As in most of other freshwater bivalves, we found C20:4ω6 acid in high percent (8.3%) in *U. elongatulus* gills and foot. For this reason, it was showed that *U. elongatulus* gills contained an abundant supply of substrate for the production of prostaglandins. C20:4ω6 acid concentration in the gills was also higher than those in the mantle and whole body lipids of *U. elongatulus*. This highest quantity is probably related to prostaglandin synthesizing in the gills to regulate Na uptake.

The diet composition of *U. elongatulus* was mostly containing *Amphora, Cocconeis*, *Cymbella, Cyclotella*, *Gomphonema*, *Synedra*, *Navicula, Rhoicosphenia*, *Nitzschia, Meridion, Bacillaria, Spirogyra*, *Oscillatoria* and *Lyngbya* algae. It is mostly similar to other bivalve filter feeding molluscs diets which consist of diatoms, dinoflagellates, bacteria as well as dissolved and particulate organic material. In general terms, diatoms are distinguished by high concentration of C20:5ω3 acid and low concentration of C22:6ω3 acid, whereas dinoflagellates are rich in C22:6ω3 acid (Ackman *et al*., 1968; Chuecas and Riley, 1969; Parrish *et al*., 1991; Alkanani *et al*., 2007). Most of the lipid and considerable amount of C20:5ω3 and C22:6ω3 acids are provided by diatoms and dinoflagellates, respectively, while small amounts of lipids, SFAs and MUFAs of 14 to 18 carbons are provided by detritus (Williams, 1965; Ackman *et al*., 1968; Chuecas and Riley, 1969). By bivalve molluscs, C16:0 and C16:1ω7 acids are easily synthesized *de novo*, whereas PUFAs of 20 and 22 carbons are only provided by diet and can be synthesized from corresponding dietary precursors (De Moreno *et al*., 1977). In the analyses of *U. elongatulus* tissues, C20:5ω3 acid proportion was varied from 7.2% to 10.1%. These high proportions probably come from diatoms mostly found in filtered Tigris River water. To be mentioned that *U. elongatulus* mussels were collected at the beginning of summer (in July). It is known that planktonic bloom takes place during spring and goes on until autumn. For this reason, at the beginning of summer the water must be rich with planktons. It is wise to express that the reproduction season of the mussel was spring and in the current study the mussels were harvested from the river in July not far from breeding season. Therefore, there was probably relation between reproduction and fatty acid profiles. Alkanani *et al*. (2007) suggested that C20:4ω6 is mostly associated with the reproductive processes and not with growth. Maybe, the high proportion of C20:4ω6 acid in all of the fractions of *U. elongatulus* was attributed to reproduction processes. However, it remains difficult to correlate fatty acid composition of algae with the fatty acid composition of the mussel since it is impossible to take all the interspecific differences between different algal diets and metabolic activities into account. Furthermore, certain minor components such as vitamins and minerals may play an important role on fatty acid composition of bivalves (Caers *et al*., 1998).

In the most of studies on vertebrates and invertebrates, C16:1ω7 acid usually found in low percentages. This component was only found in high percentages in diptera (Thompson, 1973), some heteroptera (Spike *et al*., 1991; Bashan *et al*., 2002) and in diatoms (Kharlamenko *et al*., 1995). We obtained C16:1ω7 acid 30.2% in the gills and 27.6% in whole body of *U. elongatulus*. Also the percentages of this component in the foot (15.9%) and mantle (14.4%) were not low. Probably the accumulation of C16:1ω7 acid in the gills was related to physiological activities in the organs. The mussel likely provided C16:1ω7 acid both by synthesizing from C16:0 acid and taking from diatoms.

The data on freshwater mussels differ considerably from those of marine molluscs. C20:4ω6 acid accounted for only 0-5% of the total fatty acids in marine bivalves (Gardner and Riley, 1972; Watanabe and Ackman, 1974; Paradis and Ackman, 1977; Joseph, 1982) and 5-10% in marine gastropods (Paradis and Ackman, 1977; Johns *et al*., 1980; Joseph, 1982). Marine molluscs are generally rich in fatty acids of ω3 (especially C18:3ω3, C20:5ω3 and C22:6ω3). Freshwater mussels, however, contain a greater proportion of fatty acids of ω6 (especially C18:2ω6 and C20:4ω6). While freshwater mussels have Σω6 / Σω3 ratios of 2-4, marine molluscs have ratios of 0.1-1.0 (Hagar and Dietz, 1986). In the

present study, Σω6 / Σω3 ratios in *U. elongatulus* were 1.46, 1.29, 1.17 and 1.03 in the gills, foot, mantle and whole body, respectively. The findings were similar to freshwater mussels. The differences in the fatty acid profiles of marine and freshwater molluscs may be due to dietary differences since marine plankton are rich in ω3 acids, while ω6 acids predominate in terrestrial and freshwater plants (Sargent, 1976).

Non-methylene-interrupted dienoic (NMID) fatty acids have been reported in both marine (Paradis and Ackman 1975) and freshwater (Pollero *et al*., 1981) bivalves. Their structures were established as $C20{:}2\Delta^{5\text{-}11}$, $C20{:}2\Delta^{5\text{-}13}$, $C22{:}2\Delta^{7\text{-}13}$ and $C22{:}2\Delta^{7\text{-}15}$. It was suggested that these fatty acids in animals are derived almost exclusively from food sources and are biochemically inert (Paradis and Ackman, 1977). On the other hand, some authors suppose that these in aquatic invertebrates have an endogenous origin (Joseph, 1982; Zhukova, 1986, 1991). As it has been mentioned in most of the other freshwater mollusc studies, in the analyses, none of the tissues of *U. elongatulus* contained NMID fatty acids which are mostly indicated as constituents of the polar lipids of marine molluscs (Pollero *et al*., 1981, 1983; Dembitsky *et al*., 1992; Fried *et al*., 1993).

In conclusion, the results obtained in the present work reveal that the quantitatively most important fatty acids of selected tissues (mantle, gills, foot and whole body) are C16:0, C16:1ω7, C18:1ω9, C20:1ω9, C20:4ω6 and C20:5ω3. Analyses of selected organs presented different and characteristic fatty acids profiles. Also the percentages of C20:4ω6 and C20:5ω3 acids, precursors of eicosanoids, were apparently high in the gills and foot. In all of tissue analyses, ΣMUFA levels were higher than ΣPUFA and ΣSFA levels. In the light of these results, *U. elongatulus* mussels are good source for some important fatty acids mentioned above. For breeding and manufacturing animal foodstuff, the mussels may be significant resource. Even, they may be eaten as edible freshwater food after studying pathologically.

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