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Determination of Seasonal Changes in the Fat and Fatty Acid Profiles of Saurida lessepsianus (Russell, Golani and Tikochinski, 2015) Caught from Mersin Bay

Mısra Bakan[1,a], Elif Ayşe Erdoğan Eliuz[2,b,*], Deniz Ayas[1,c]

[1]*Faculty of Fisheries, Mersin University, 33110 Yenişehir/Mersin, Turkey*
[2]*Department of Food technology, Vocational School of Technical Sciences, Mersin University, 33110 Yenişehir/Mersin, Turkey*
[*]*Corresponding author*

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A B S T R A C T

In this study, seasonal changes in the lipid and fatty acid profiles of *S. lessepsianus* caught from the Mersin Bay were investigated. The total lipid levels of *S. lessepsianus* were found to be 2.94%, 7.19%, 2.45%, 0.83%, in spring, summer, autumn and winter season, respectively. Major fatty acids in *S. lessepsianus* were palmitic acid, stearic acid, oleic acid, palmitoleic acid, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) in all seasons. The highest values of palmitic, palmitoleic and EPA were determined as 22.97%, 3.80% and 4.22% in spring, respectively. The highest values of stearic and oleic acid were determined as 15.93% and 7.84% in autumn, respectively. The highest value of DHA were also determined as 31.91% in winter season. The EPA level from polyunsaturated fatty acids was found in the range of 2.54-4.22% (23.09-195.62 mg/100g). The highest level of DHA were observed in the winter season and its levels changed in the range of 19.83-31.81% and was calculated as 201.29-1301.73 mg/100g. In addition, the highest level of the Σ*n*3, Σ*n*6, and Σ*n*9 were calculated in the summer season as 1516.39, 114.88, 399.77 mg/100g, respectively. This report showed that fat and fatty acid profiles of *S. lessepsianus* are quite influenced by seasonal factors.

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Mersin körfezi'nden avlanan *Saurida lessepsianus* (Russell, Golani ve Tikochinski, 2015) 'nin yağ ve yağ asitleri profilindeki mevsimsel değişimlerin belirlenmesi

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Ö Z

Bu çalışmada, Mersin Körfezi'nden avlanan *S. lessepsianus*'un lipid ve yağ asidi profillerindeki mevsimsel değişiklikler incelendi. *S. lessepsianus*'un toplam lipid düzeyleri ilkbahar, yaz, sonbahar ve kış mevsiminde sırasıyla %2,94; %7,19; %2,45; %0,83 olarak bulundu. *S. lessepsianus*'taki başlıca yağ asitleri, her mevsim palmitik asit, stearik asit, oleik asit, palmitoleik asit, eikosapentaenoik asit (EPA) ve dokosaheksaenoik asit (DHA)'ti. En yüksek palmitik, palmitoleik ve EPA değerleri sırasıyla %22,97, %3,80 ve %4,22 olarak ilkbahar ayında belirlendi. En yüksek stearik ve oleik asit değerleri sırasıyla %15,93 ve %7,84 olarak belirlendi. En yüksek DHA değeri ise %31,91 olarak kış ayında belirlendi. Çoklu doymamış yağ asitlerinden olan EPA seviyesi, %2,54-4,22 (23,09-195,62 mg/100g) arasında bulundu. En yüksek DHA seviyesi kış mevsiminde gözlendi ve seviyeleri %19,83-31,81 arasında değişti ve 201,29-1301,73 mg/100 g olarak hesaplandı. Ayrıca, Σ*n*3, Σ*n*6, ve Σ*n*9 seviyeleri en yüksek yaz mevsiminde 1516,39; 114,88; 399,77 mg/100g olarak hesaplandı. Bu rapor *S. lessepsianus* türünün besin içeriğinin mevsimsel faktörlerden oldukça etkilendiğini göstermiştir.

[a] *mbakan@gmail.com* *https://orcid.org/0000-0002-0107-4349*
[c] *ayasdeniz@mersin.edu.tr* *https://orcid.org/0000-0001-6762-6284*
[b] *eliferdogan81@gmail.com* *https://orcid.org/0000-0003-4317-3000*

Introduction

Fish are quite important nutrient because of their high levels of protein, mineral and lipid, which are vital for humans. Especially, they are rich in energy due to lipids in their structures. The most important of those are EPA and DHA known as polyunsaturated fatty acids (PUFAs). EPA and DHA are two important fatty acids which are abundant in seafood but not in other foods. These fatty acids in fish change depending on the environmental and water temperature, sex, age and maturity of fish, biological and developmental status of fish, and many factors such as nutrition and reproduction (Turan et al., 2006; Friedland, 2003; Morris et al., 2003; Kalogeropoulos et al., 2004, Bourre, 2007). Studies on the benefits of fatty acids in fish showed that EPA and DHA have significant effect on protection from heart attack, cardiovascular diseases, depression, migraine type headaches, rheumatism, diabetes, high cholesterol and blood pressure (Nettleton, 2000; Golani and Sonin, 2006; Mairesse et al., 2006).

Lessepsian *S. undosquamis* (brushtooth lizardfish) is recently called as *S. lessepsianus*, a new taxon, characterized based on external characteristic properties of Mediterranean and Red Sea populations (Russel et al., 2015). It is located in East Indian Ocean, Malaya Peninsula, South Philippines, Northern Cava Island, Southwest Australia and known as amphidromous fish and live in shallow rocky areas, between 1 m and 350 m depth (Russel, 1999). *S. lessepsianus* is a demersal immigrant species that passes through the Suez Canal to the Mediterranean from Indo-Pacific, it is usually in 20-30 cm size. It is a commercially important deep marine resource, which could be benefit economically, and every year tons of it are consumed mainly in fast food industries such as fish cakes and fish burgers (Başusta and Erdem, 2000; Mahmoudzadeh et al., 2010). A few studies have been found on fat and fatty acids profiles due to seasonal changes of Lessepsian fish species which have increasing numbers in Mediterranean coasts (Küçükgülmez et al., 2008).

The aim of this study was to determine the influence of seasons (spring, summer, autumn and winter) the total lipid levels and fatty acid profiles of *S. lessepsianus*, which is the new elements of the Mediterranean Sea originated from Indo-Pacific.

Materials and Methods

S. lessepsianus (Richardson, 1848) was caught from Mersin Bay on March-2016, September-2016, December-2016, and June-2016 by trawler boat. In every season, 30 individuals were sampled, and the study was conducted with 120 individuals in total. The average total length and weight of the sampled individuals were taken.

The seasonal length change of *S. lessepsianus* were noted as 19.43-22.28 cm and they varied between 53.67-95.94 g (Table 1).

Fat and Fatty Acids Analyses

Lipid content was measured by the method of Bligh and Dyer (1959). In extracted lipids, fatty acid methyl esters were obtained using the Ichibara et al., (1996) method. Fatty acid composition was analysed using a Gas Chromatography (GC) Clarus 500 device (Perkin–Elmer, USA), one flame ionization detector (FID) and SGE (60 m×0.32 mm ID BPX70×0.25 µm, USA or Australia) column. Injector and detector temperatures were set as 260°C and 230°C respectively. During this time, the furnace temperature was kept at 140°C for 8 minutes. After that, it was increased by 4°C per minute until 220°C, and from 220°C to 230°C by increasing the temperature 1°C per minute. It was kept at 230°C for 15 minutes to complete analysis. Sample scale was 1 µl and carrier gas was controlled at 16 ps. For split flow 40, 0 mL/minute (1:40) level was used. Fatty acids were determined using a comparison to the exit times of the FAME mix that contains 37 standard components.

Table 1 Total length and weight of *S. lessepsianus*

Season	N	Mean TL (cm) $\bar{X} \pm S_x$	Mean Weight (g) $\bar{X} \pm S_x$
Spring	30	22.28±0.10^x	95.94±1.67^b
Summer	30	19.43±0.24^x	53.67±2.22^a
Autumn	30	19.74±1.30^x	67.44±12.49^a
Winter	30	19.48±1.01^x	64.72±10.07^a

The values on the same line, shown in different letters, are statistically different (P<0.05), TL: total length, W: weight $\bar{X}$±S_x mean±Standart deviation

Conversion Factor

Triplicate GC analyses were performed and the results were converted to mg fatty acid per 100 g total lipid using lipid conversion factors and then to mg fatty acid per 100 g edible portion of food using the total lipid content. Details of the derivation of lipid conversion factors were published by Weihrauch et al., (1975).

Factor (Fish) = 0.956-0.143/total lipid

Fatty acid (mg/100g) = Factor × FAME (%) × lipid level (%) × 10

Atherogenicity Index (AI) and Thrombogenicity Index (TI)

The AI and TI linked to the fatty acid composition were calculated according to Ulbricht and Southgate, (1991).

$$AI = \frac{[(a\times 12{:}0)+(b\times 14{:}0)+(c\times 16{:}0)]}{[d\times(PUFA\ n-6+n-3)+e\times(MUFA)+f\times\ (MUFA-18{:}1)]}$$

$$TI = \frac{[g\times(14{:}0+16{:}0+(18{:}0)]}{[(h\times MUFA)+i\times\ (MUFA-18{:}1)+(m\times n-6)+(n\times n-3)+(n-3/n-6)]}$$

a, c, d, e, f=1, b=4, g=1, h, i, m=0.5 n=3

Result and Discussion

Lipid (%)

The lipid levels of *S. lessepsianus* was 0.83%-7.19% and the highest total lipid level was determined in summer (Table 2). In present study, the lowest lipid content was in winter (0.83%) whereas the highest level of lipid were found in summer (7.19%). Furthermore, lipid levels of the fish in autumn and spring were 2.45% and 2.94%, respectively (P<0.05). In present study, the lipid change of *S. lessepsianus* researched in four seasons can be determined as: winter (0.83%), < autumn (2.45%) < spring (2.94%), < summer (7.19%). Lipid content of fish has increased with the spring and summer season. Many researchers attributed this result to the abundance of nutrients and reproductive cycle in the summer (Sargent et al., 1995). In a similar study, the lipid content of *S. lessepsianus* was observed to increase in spring (1.46%) and winter (1.64%) (Özoğul et al., 2011). In another study, it was noted the lipid level as 1.08% in *S. lessepsianus* caught from Mediterranean (Özoğul et al., 2009). The findings of this study are in parallel with the literature.

Fatty acid Levels (%)

Total fatty acid composition consisted of 30 fatty acids (Table 3). The major fatty acids of *S. lessepsianus* were determined palmitic acid and stearic acid from saturated fatty acids, oleic acid, 11-docosenoic acid and palmitoleic acid from monounsaturated fatty acids, EPA and DHA from polyunsaturated fatty acids.

Table 2 Lipid changes of different season of *S. lessepsianus* (%), $\overline{X} \pm S_x$

	Spring	Summer	Autumn	Winter
% lipid	2.94±0.40^{b}	7.19±0.75^{c}	2.45±0.43^{b}	0.83±0.05^{a}

The values on the same line, shown in different letters, are statistically different (P<0.05), $\overline{X}$±S_x: mean±Standart deviation

Table 3 Fatty acids profiles of different season of *S. lessepsianus* (%), $\overline{X} \pm S_x$

Fatty acid (%)	Spring	Summer	Autumn	Winter
Lauric acid (C12:0)	0.23±0.01^{a}	0.24±0.01^{a}	0.33±0.06^{b}	0.33±0.02^{b}
Myristic acid (C14:0)	3.00±0.18^{c}	1.58±0.04^{b}	1.07±0.38^{a}	1.20±0.08^{ab}
Pentadecylic acid (C15:0)	0.67±0.04^{a}	0.51±0.03^{a}	0.51±0.21^{a}	0.45±0.00^{a}
Palmitic acid (C16:0)	22.97±0.85^{c}	17.40±1.24^{a}	19.36±6.89^{abc}	21.60±2.12^{bc}
Margaric acid (C17:0)	0.80±0.04^{a}	0.69±0.04^{a}	0.82±0.29^{a}	0.71±0.01^{a}
Stearic acid (C18:0)	11.30±0.52^{ab}	9.99±1.76^{a}	15.93±5.17^{c}	13.50±1.15^{bc}
Arachidic acid (C20:0)	0.30±0.04^{ab}	0.23±0.06^{a}	0.36±0.17^{b}	0.27±0.04^{ab}
Behenic acid (C22:0)	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}
Lignoceric acid (C24:0)	2.11±0.01^{bc}	1.54±0.06^{a}	1.83±0.16^{ab}	2.26±0.11^{c}
ΣSFA	41.38	32.18	40.21	40.32
Myristoleic acid (C14:1)	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}
Pentadecenoic (C15:1)	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}
Palmitoleic acid (C16:1)	3.80±0.23^{b}	2.23±0.08^{a}	2.09±0.73^{a}	2.39±0.15^{a}
Heptadecenoic acid (C17:1)	0.34±0.02^{a}	0.30±0.03^{a}	0.39±0.14^{a}	0.37±0.01^{a}
Trans oleic acid (C18:1*n*9t)	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}
Oleic acid (C18:1*n*9c)	7.33±0.49^{ab}	5.54±0.21^{a}	7.84±2.79^{b}	7.33±0.38^{ab}
Vaccenic acid (C18:1*n*7)	2.16±0.07^{b}	1.56±0.06^{a}	1.87±0.64^{ab}	1.88±0.01^{ab}
Gadoleic acid (C20:1*n*9)	0.53±0.05^{c}	0.27±0.00^{a}	0.37±0.15^{ab}	0.46±0.01^{bc}
Cetoleic acid (C22:1*n*11)	2.69±0.02^{ab}	2.20±0.18^{a}	2.86±0.25^{abc}	3.48±0.25^{c}
Nervonic acid (C24:1*n*9)	0.29±0.01^{a}	0.28±0.01^{a}	0.18±0.25^{a}	0.50±0.01^{b}
ΣMUFA	17.14	12.38	15.60	16.41
Linolelaidic Acid (C18:2*n*6t)	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}
Linoleic acid (C18:2*n*6c)	1.13±0.01^{a}	0.91±0.01^{a}	1.03±0.32^{a}	1.00±0.02^{a}
α-Linolenic acid (C18:3*n*3)	0.24±0.00^{c}	0.16±0.01^{b}	0.00±0.00^{a}	0.00±0.00^{a}
Gamma linolenic acid (C18:3*n*6)	0.13±0.00^{b}	0.08±0.11^{a}	0.00±0.00^{a}	0.00±0.00^{a}
Eicosatrienoic acid (C20:3*n*3)	0.15±0.00^{b}	0.13±0.01^{b}	0.00±0.00^{a}	0.00±0.00^{a}
Dihomo-γ-linolenic acid (C20:3*n*6)	0.29±0.01^{c}	0.18±0.01^{b}	0.00±0.00^{a}	0.21±0.00^{b}
Arachidonic acid (C20:4*n*6)	0.24±0.01^{a}	0.22±0.01^{a}	0.17±0.23^{a}	0.24±0.00^{a}
Eicosapentaenoic acid (C20:5*n*3)	4.22±0.11^{b}	2.98±0.15^{a}	2.54±0.09^{a}	3.66±0.12^{b}
Adrenic acid (C22:4*n*6)	0.45±0.02^{ab}	0.36±0.05^{a}	0.47±0.08^{ab}	0.63±0.05^{b}
Docosahexaenoic acid (C22:6*n*3)	29.02±0.34^{b}	19.83±0.88^{a}	21.71±2.01^{a}	31.91±0.91^{b}
Docosadienoic acid (C22:2*n*6)	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}
ΣPUFA	35.87	24.67	25.92	37.65
SFA/PUFA	1.15	1.30	1.5	1.07
Σ*n*7	2.16	1.56	1.87	1.88
Σ*n*6	2.24	1.75	1.67	2.08
Σ*n*3	33.63	23.10	24.25	35.57
Σ*n*9	8.15	6.09	8.39	8.29
Σ*n*11	2.69	2.20	2.86	3.48
*n*6/*n*3	0.07	0.08	0.07	0.06
*n*3/ *n*6	15.01	13.20	14.52	17.10
DHA/EPA	6.87	6.65	8.54	8.71
AI	0.47	0.56	0.51	0.44
TI	0.24	0.31	0.36	0.26
Unidentified	5.61	30.77	18.27	5.62

The values on the same line, shown in different letters, are statistically different (P<0.05), $\overline{X}$±S_x: mean±Standart deviation

A statistical difference was found between the spring and summer season of lauric acid and the autumn and winter season ($P<0.05$). The lowest level of this fatty acid was found in the spring season (0.23%) and the highest level (0.33%) in autumn and winter season. There were the differences between all seasons in myristic acid levels ($P<0.05$). The lowest level of this fatty acid was found in the autumn season (1.07%) while the highest level was in the spring season (3.00%). There were no differences the levels of pentadecylic acid between seasons ($P>0.05$). The variation of this fatty acid was in the range of 0.45-0.67. There was a difference for the levels of palmitic acid between seasons ($P<0.05$). The lowest level of this fatty acid was found in the summer season (17.40%), the highest value was found in the spring season (22.97%). There was no statistical difference between the seasons at the margaric acid level ($P>0.05$). The variation of this fatty acid was in the range of 0.69-0.82%. In the stearic acid level differences were found between the seasons ($P<0.05$). The lowest value in this fatty acid was found in the summer season (9.99%), the highest value in the autumn season (15.93%). A statistical difference was found between the summer season and the autumn season with arachidic acid level ($P<0.05$). The highest value of this fatty acid was found in the autumn season (0.36%) and the lowest value in the summer season (0.23%). The level of behenic acid was below the detection limit in all seasons. A statistical difference was found between the level of lignoceric acid in the summer and the winter seasons ($P<0.05$). The highest value of this fatty acid was found in the winter season (2.26%) and the lowest value in summer (1.54%).

In monounsaturated fatty acids, the levels of myristoleic acid and pentadecenoic acid were below the detection limit in all seasons. There was a statistically significant difference between palmitoleic acid levels in spring and other seasons ($P<0.05$). The lowest value of this fatty acid was found in the autumn season (2.09%), the highest value in the spring season (3.80%). There was no statistically significant difference between heptadecenoic acid levels ($P>0.05$). The variation of this fatty acid is in the range of 0.30-0.39%. Trans oleic acid (C18:1*n*9t) level was below the detection limit in all seasons. Oleic acid (C18:1*n*9c) has shown a statistical difference between the summer and autumn season ($P<0.05$). The highest level of the oleic acid was found in the autumn season (7.84%), the lowest value in the summer season (5.54%). The levels of vaccenic acid varied between spring and summer season ($P<0.05$). The highest value of this fatty acid was found in the spring (2.16%) and the lowest value in the summer season (1.56%). The levels of gadoleic acid have a statistical difference between the spring season and the summer and autumn season ($P<0.05$). Similarly, there is a statistical difference between the summer and spring and winter seasons ($P<0.05$). The highest value of this fatty acid was found in the spring season (0.53%) and the lowest value in the summer season (0.27%). In terms of the level of ceteloic acid, the winter season has shown a statistical difference ($P<0.05$) according to the seasons of spring and summer. The highest value of this fatty acid was found in the winter season (3.48%) and the lowest value in the summer season (2.20%). The level of nervonic acid in the winter season was found to differ from the other seasons ($P<0.05$). The highest of nervonic acid was determined in the winter season (0.50%), while the lowest value was found in the autumn season (0.18%).

In polyunsaturated fatty acids, the levels of linolelaidic acid (C18:2*n*6t) were below the detection limit in all seasons. Seasonal differences were not detected at the levels of linoleic acid (C18:2*n*6c) ($P>0.05$). The variation of this fatty acid is in the range of 0.91-1.13%. The α-linolenic acid level is below the detection limit in autumn and winter seasons. A statistical difference was found between the spring and summer seasons ($P<0.05$). The level of the spring was highest (0.24%) and the level in the summer season was the smallest (0.16%). The γ-linolenic acid levels in the autumn and winter season are below the detection limit. The γ-linolenic level in the spring season is 0.13%, and the level in the autumn season is 0.08%. The level of eicosatrienoic acid is below the detection limit in autumn and winter. The level in the spring was 0.15% and the level in the summer season was 0.13%. The levels of Dihomo-γ-linolenic acid showed a statistical difference between the seasons ($P<0.05$). The highest level of this fatty acid was found in the spring (0.29%), in the lowest summer season (0.18%). The level of arachidonic acid did not differ between the seasons ($P>0.05$). The variation of this fatty acid is in the range of 0.17-0.24%. The level of eicosapentaenoic acid showed a statistical difference between the summer and autumn season and spring and winter seasons ($P<0.05$). The highest level of this fatty acid was found in the spring season (4.22%) and the lowest level in autumn (2.54%). There were statistical differences between summer and winter in terms of the adrenic acid level ($P<0.05$). The lowest value of this fatty acid was found in the summer season (0.36%) and the highest value in the winter season (0.63%). The level of docosahexaenoic acid showed a statistical difference between the summer and autumn season and spring and winter seasons ($P<0.05$). The highest value was found in the winter season (31.91%), in the lowest summer season (19.83%). The level of docosadienoic acid is below the detection limit in all seasons.

$\Sigma n3$, $\Sigma n6$, $\Sigma n9$ fatty acids of *S. lessepsianus* changed in the range of 23.10-35.57%, 1.67-2.24%, and 6.09-8.39%, respectively. The highest level of total omega-3 fatty acids is in the winter season, the highest level of omega-6 fatty acids is in the spring season, the highest level of $\Sigma n9$ was found in the winter season. The change intervals of AI and TI levels in the year were found as 0.44-0.56, 0.26-0.36%, respectively. The highest level of the AI was found in the autumn season while the highest level of the TI was in the spring season.

The lipids of marine fish have raised interest because they are rich in beneficial fatty acids for human healthy such as EPA and DHA (Öksüz et al., 2011). Among results in fatty acids profiles of different season of *S. lessepsianus*, those occurring in the highest proportions were palmitic acid (16:0; 17.40-22.97%), stearic acid (18:0; 9.99-15.93%), oleic (18:1*n*9 5.54-7.84%), palmitoleic acid (16:1 2.09–3.80%), EPA (20:5*n*3; 2.54-4.22%) and DHA (22:6*n*3; 19.83–31.91%). We can noted that the relative amount of these major acids change significantly between seasons. Aberoumand et al., (2017) were reported that the major elements of total FA in *S. lessepsianus* were to be palmitic acid (between 38.64% and 48.98%), stearic acid (between 11.35% and 19.50%) and oleic acid (between 12.15% and 27.48%).

Fatty Acid Levels (mg/100g)

The ΣSFAs were calculated as 1072.44 mg/100g, 2112.45 mg/100g, 861.02 mg/100g and 254.34 mg/100g, in the spring, summer, autumn and winter season, respectively. The lowest value of ΣSFAs was found in the winter season. The highest values from the saturated fatty acids were calculated in palmitic acid and stearic acids. The highest value of palmitic acid was in summer 1142.22 mg/100g, the lowest value was in winter 136.25 mg/100g. The highest value of stearic acid value was 655.79 mg/100g in summer; the lowest value was 85.16 mg/100g in winter.

The ΣMUFAs were determined in spring, summer, autumn, winter season as 445.46 mg/100g, 812.68 mg/100g, 334.04 mg/100g, and 103.51 mg/100g respectively. The major fatty acids of MUFAs are palmitoleic acid, oleic acid (C18:1n9c), vaccenic acid, ceteloic acid and their values were calculated as between 15.08-146.38 mg/100g, 46.24-363.67 mg/100g, 11.86-102.41 mg/100g, 21.95-144.42 mg/100g, respectively. The heptadecenoic acid, gadoleic acid, nervonic acid values were found 2.33-19.69 mg/100g, 2.90-17.72 mg/100g, and 3.15-18.38 mg/100g respectively.

The ΣPUFAs were calculated in spring, summer, autumn, winter season as 932.24 mg/100g, 1631.27 mg/100g, 555.02 mg/100g, and 237.49 mg/100g, respectively. The levels of linoleic acid (C18:2*n*6c), α-linoleic acid (C18:3*n*3), gamma linoleic acid (C18:3*n*6), eicosatrienoic acid (C20:3n3), dihomo-γ-linolenic acid (C20:3n6) from the PUFAs were 6.01-59.74 mg/100g, 0.00-10.50 mg/100g, 0.00-29.37 mg/100g, 0.00-8.53 mg/100g, 0.00-11.82 mg/100g, respectively. The lowest level of arachidonic acid in the winter season was found to be 1.51 mg/100g, and the highest level was 14.44 mg/100g in the summer season.

The EPA's highest level was 195.62 mg/100g in summer and the lowest level was 23.09 mg/100g in winter season. The DHA level was in the range of 201.29-1.301.73 mg/100g. The highest value was determined in summer and the lowest value in the winter season (Table 4).

Table 4 Fatty acids profiles of different season of *S. lessepsianus* (mg/100g)

Lipid %	2.94	7.19	2.45	0.83
Factor	0.884	0.913	0.874	0.760
Fatty acid (mg/100g)	Spring	Summer	Autumn	Winter
Lauric acid (C12:0)	5.98	15.75	7.07	2.08
Myristic acid (C14:0)	77.97	103.72	22.91	7.57
Pentadecylic acid (C15:0)	14.41	33.48	10.92	2.84
Palmitic acid (C16:0)	596.98	1142.22	414.56	136.25
Margaric acid (C17:0)	20.79	45.29	17.56	4.48
Stearic acid (C18:0)	293.68	655.79	341.11	85.16
Arachidic acid (C20:0)	7.80	15.10	7.71	1.70
Behenic acid (C22:0)	0.00	0.00	0.00	0.00
Lignoceric acid (C24:0)	54.83	101.09	39.19	14.26
ΣSFA	1072.44	2112.45	861.02	254.34
Myristoleic acid (C14:1)	0.00	0.00	0.00	0.00
Pentadecenoic (C15:1)	0.00	0.00	0.00	0.00
Palmitoleic acid (C16:1)	98.76	146.38	44.75	15.08
Heptadecenoic acid (C17:1)	8.84	19.69	8.35	2.33
Trans oleic acid (C18:1*n*9t)	0.00	0.00	0.00	0.00
Oleic acid (C18:1*n*9c)	190.50	363.67	167.88	46.24
Vaccenic acid (C18:1*n*7)	56.14	102.41	40.04	11.86
Gadoleic acid (C20:1*n*9)	13.77	17.72	7.92	2.90
Ceteloic acid (C22:1*n*11)	69.91	144.42	61.24	21.95
Nervonic acid (C24:1*n*9)	7.54	18.38	3.85	3.15
ΣMUFA	445.46	812.68	334.04	103.51
Linolelaidic Acid (C18:2*n*6t)	0.00	0.00	0.00	0.00
Linoleic acid (C18:2*n*6c)	29.37	59.74	22.06	6.01
α-Linolenic acid (C18:3*n*3)	6.24	10.50	0.00	0.00
Gamma linolenic acid (C18:3*n*6)	29.37	5.25	0.00	0.00
Eicosatrienoic acid (C20:3*n*3)	3.90	8.53	0.00	0.00
Dihomo-γ-linolenic acid (C20:3*n*6)	7.54	11.82	0.00	1.32
Arachidonic acid (C20:4*n*6)	6.24	14.44	3.64	1.51
Eicosapentaenoic acid (C20:5*n*3)	109.68	195.62	54.39	23.09
Adrenic acid (C22:4*n*6)	11.69	23.63	10.06	3.97
Docosahexaenoic acid (C22:6*n*3)	754.22	1301.73	464.88	201.29
Docosadienoic acid (C22:2*n*6)	0.00	0.00	0.00	0.00
ΣPUFA	932.24	1631.27	555.02	237.49
Σ*n*6	58.22	114.88	35.76	13.12
Σ*n*3	874.03	1516.39	519.27	224.38
Σ*n*9	211.82	399.77	179.66	52.30
Σ*n*11	69.91	144.42	61.24	21.95
Σ*n*7	56.13	102.41	40.04	11.86
Unidentified	143.20	2008.07	391.22	35.45

Σ*n*3, Σ*n*6, Σ*n*9 fatty acids of *S. lessepsianus* have changed in the range of 224.38-1.516.39 mg/100g, 13.12-114.88 mg/100g, 52.30-399.77 mg/100g, respectively. The highest value of the level Σ*n*3, Σ*n*6, and Σ*n*9 were found in the summer season. Although according to our study, *n*6/*n3* fatty acids of *S. lessepsianus* was found to be 0.07 in autumn, Özogul and et al. (2019) were reported that *n*6/*n3* ratio in *Saurida undosquamis* were calculated as 0.60 from Bligh and Dyer method in december, 2018. In a similar study, the ratio of n-6/n-3 were found to be 0.06-0.07 for *Pterois miles* (Ayas et al., 2018).

Fatty Acid Levels (%) (mg/100 g)

The highest ∑SFAs and ∑MUFAs was measured in spring season (41.83% and 17.14%, respectively) and the lowest ∑SFAs and ∑MUFAs in summer season (32.54% and 12.38%, respectively). In contrast, in the study made by Küçükgülmez vd. (2008), the lowest ∑SFA value was measured in spring season (34.30%) and the highest value in autumn season (42.58%), while the lowest ∑MUFA was detected in winter season (15.44%) and the highest value in autumn season (18.98%) for *S. undosquamis*. In addition, the percentages of ∑PUFAs were noted with lowest value in winter (13.39%), with highest value in spring (16.79%) (Küçükgülmez et al., 2008). Furthermore, Özogul et al. (2011) conducted that the highest ∑SFAs was measured in summer (38.70%), the lowest ∑SFAs was in Autumn season (32.18%) while the lowest ∑MUFAs level was measured in spring (14.72%), the highest ∑MUFAs was in summer (16.73%) for *S. undosquamis* (Özoğul et al., 2011). Rahayu et al. (2014) showed that the percentages of ∑SFAs, ∑MUFAs and ∑PUFAs in *Saurida tumbil* were to be 27.74%, 7.70%, 11.92%, respectively. The researchers reported that the ∑SFAs ranged from 258.31 to 2.136,08 mg/100g saturated fatty acids (SFA), the ∑MUFAs ranged from 103.51 to 812.68 mg/100g and ∑PUFAs ranged from 233.52 to 1.607,64 mg/100g in *S. tumbil*. Some studies showed that unsaturated fatty acids increased in lipid molecules along with the reduce of water temperature (Shirai et al., 2002; Çelik et al.2005; Yildiz et al., 2006).

Results of pharmacological research suggest that EPA and DHA found in fish abundantly, have immensely beneficial properties for the protection of cardiovascular health (Weber and Sellmayer, 2011). According to our study, the EPA and DHA levels detected in four seasons can be presented as: summer (195.62 and 1.301.73 mg/100 g) > spring (109.68 and 754.22 mg/100 g) > autumn (54.39 and 464.88 mg/100 g) > winter (23.09 and 201.29 mg/100 g) for *S. lessepsianus,* respectively. The Mediterranean has abundant fish, which is rich in terms of EPA and DHA in all seasons. Plenty EPA and DHA were found 0.9-3.5 g/100g and 2.0-4.5 g/100g, respectively for *Siganus rivulatus* while they were calculated as 1.7-4.6 g/100g and 1.1-14.6 g/100g, respectively for *Diplodus sargus* for all seasons (Saoud et al., 2007). *N. randalli*, which is a lessepsian species, contained EPA between 3.75 and 5.49 mg/100 g and DHA between 20.16 and 22.02 mg/100 g in winter (Göçmen et al., 2018). Samples of *Lagocephalus sceleratus* caught in Mediterranean were detected to include <0.01 g/100 g EPA and 46.8 g/100 g DHA in winter (Kırımer et al., 2016). Although DHA/EPA fatty acids of *S. lessepsianus* was found to be ranged from 6.65-8.71% during the four seasons in our study, Ozyilmaz et al. (2017), were reported that DHA/EPA ratio in *Echeneis naucrates* caught from northeastern Mediterranean were calculated as 0.15-5.31 in April 2011.

∑*n*-3/∑*n*-6 ratio is an important indicator for evaluating the nutritional value of fish lipid and lizard fish from the northeastern Mediterranean Sea are rich in these elements (Kinsella et al., 1990). Current studies showed that high quantities of *n*-6 and a deficit in *n*-3 is associated with the increase of various chronic diseases Hence, fish and shellfish were noted to be nutritionally high quality food because of their meat are to be a unique source of *n*-3 PUFA (Simopoulos, 2002; Gebauer et al., 2006; Wijendran et al., 2004). The last report published by Dietary Guidelines for Americans (2005) have indicated that the best way to insert PUFA and MUFA into our daily diets was to eat fish. Our results showed that the ∑*n*3/∑*n*6 ratios of *S. lessepsianus* vary in each season, being lower in summer (16.61%) and raising up to 24.53% in winter.

In this study, the related health lipid indices (IA, atherogenic and IT thrombogenic) were studied in four seasons in *S. lessepsianus* originated from Mediterranean. AI and TI were measured between 0.26% and 0.67 for *S. lessepsianus*. The highest AI and TI were noted in spring (0.67%) and in autumn (0.36%), respectively. From these results, we could noted that fatty acids of *S. lessepsianus* had greatly potential in health.

Conclusion

This study demonstrated that the quantitative and qualitative composition of fatty acids in *S. lessepsianus* affected by different seasonal conditions. The highest lipid contents in the fish were found analyzed in summer, followed by spring. As regards PUFAs (∑n3/∑n6) contents, *S. lessepsianus* collected during winter showed the highest value, followed by autumn. Hence, the *S. lessepsianus* proved to be quite proper to a fish-based diet due to its lipid and EPA/DHA contents.

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