Acta Nat. Sci. (2020) 1(1): 12-23

e-ISSN: 2718-0638

Original Research Paper

info@actanatsci.com

www.actanatsci.com

ACTA NATURA ET SCIENTIA

Seasonal Changes in the Lipid and Fatty Acid Profile of *Pomadasys stridens* (Forsskål, 1775) Caught from Mersin Bay

Mısra Bakan[1] • Nuray Çiftçi[1]✉ • Deniz Ayas[1]

[1] Mersin University, Faculty of Fisheries, Mersin, Turkey. misrabakann@gmail.com; nciftci@mersin.edu.tr; ayasdeniz@mersin.edu.tr

✉ Corresponding Author: misrabakann@gmail.com

Please cite this paper as follows:

Bakan, M., Çiftçi, N., Ayas, D. (2020). Seasonal Changes in the Lipid and Fatty Acid Profile of *Pomadasys stridens* (Forsskål, 1775) Caught from Mersin Bay. *Acta Natura et Scientia*, 1(1): 12-23.

ARTICLE INFO

Received: 19.08.2020

Accepted: 13.10.2020

Keywords

Mersin Bay

Pomadasys stridens

Lipid

Fatty acids

ABSTRACT

The seasonal changes in the total lipid and fatty acid profile of *Pomadasys stridens*, which were caught from Mersin Bay, were examined. Total lipid changes were found as 4.09%, 7.54%, 2.56%, and 1.81% in spring, summer, autumn, and winter seasons, respectively. A total of 30 fatty acids were defined in the muscle tissue by GC analysis. Among these, the major fatty acids are saturated fatty acids such as (SFA) palmitic acid (C16:0) and stearic acid (C18:0), monounsaturated fatty acids as oleic acid (C18:1*n*9*c*) and 11-docosenoic acid (C22:1*n*11), and polyunsaturated fatty acids as eicosapentaenoic acid (C20:5*n*3), and docosahexaenoic acid (C22:6*n*3). Palmitic acid and stearic acid varied in the range of 16.92-22.74%, and 8.06-13.86%; and they were found at the level of 297.82-1567.14 mg/100g and 182.49-555.46 mg/100g, respectively. Oleic acid and 11-docosenoic acid varied in the range11.54-21.32% and 2.99-4.98%, and they were determined to range 251.20-1436.89 mg/100g and 72.56-206.06 mg/100g, respectively. Eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) varied in the range of 3.58-5.45% and 5.57-13.42%; the levels of EPA and DHA were found 55.27-324.59 mg/100g and 153.12-492.90 mg/100g, respectively. The$\Sigma n3$, $\Sigma n6$, $\Sigma n9$ fatty acid levels of *P. stridens* changed between 10.65-19.41%, 3.45-4.50%, 12.59-22.72%; and they were found 233.75-733.95 mg/100g, 68.40-237.76 mg/100g, 271.12-1531.99 mg/100g respectively. The change intervals of the atherogenicity index (Ai) and thrombogenicity index (Ti) levels during the year were determined as 0.32-0.42% and 0.39-0.51%, respectively.

INTRODUCTION

Since the Suez Canal opened in 1869, numerous aquatic organisms from various taxonomic groups have migrated from the Red Sea to the Mediterranean Sea. Although the Suez Canal allows for a two-way passage, more species have migrated from the Red Sea to the Mediterranean (Bentur, 2008). The first record of non-native fish from Turkey's Mediterranean coast is given in the Iskenderun Bay in 1943. Many non-native species have been recorded in the Eastern Mediterranean to date. The settlement of non-native species on our coasts and other parts of the Eastern Mediterranean caused changes in some indigenous species' stock and habitat. Lessepsian migration has adverse effects on the Mediterranean Sea as well as positive effects. The evaluation of ecological niches that cannot be evaluated adequately in the Mediterranean by some non-native species can be interpreted as an ecologically positive result. The fact that consumable species find buyers at high prices in the market contributes to the national economy. However, it is known that some non-native species negatively affect fishing activities (Avşar & Mavruk, 2009). *P. stridens* is one of the economically important species that joins the Mediterranean with the Lessepsian migration and shows the distribution in Indo-Pacific, Red Sea and East Africa, New Guinea, and Arafura Sea (Por, 1978; Russell, 1989). Its maximum length is 30 cm (Sommer et al., 1996). Generally, there are 4-6 black colored lines horizontally in silver color (Heemstra, et al., 1986).

Lipids are essential structural organic compounds for animals. The physical and chemical properties of them determine the ratio and composition of the fatty acids they contain. The lipid quality is closely related to the distribution and position of fatty acids in it. Different types of lipids are formed with the composition of fatty acids that have other properties.

ω-3 fatty acids, which are of great importance for human health, are not synthesized in the body. Therefore, they should be taken from the outside with nutrients (Leaf and weber 1988). It has been reported that the primary sources of the essential-3 fatty acids EPA and DHA are seafood (Gordon et al., 1992). It has been found that these fatty acids have an essential effect in protecting against many diseases such as heart attack, cardiovascular diseases, depression, migraine headaches, joint rheumatism, diabetes, high cholesterol, and blood pressure, some types of allergies, and cancer (Gorga, 1988). Long-chain, ω-3 polyunsaturated fatty acids (PUFAs) have been highlighted by in vitro studies showing that eicosapentaenoic acid (EPA, 20:5ω-3) and docosahexaenoic acid (DHA, 22:6ω-3) suppress the development of cancers (Karmalli et al., 1984; Lindner, 1991; Rose et al., 1991; Tsai et al., 1998; Boudreau et al., 2001; Narayanan et al., 2001).

In this study, the investigation of the seasonal changes in the lipid and fatty acid profile of *P.*

stridens, caught from the Mersin Bay, was aimed.

MATERIAL AND METHODS

The individuals of *P. stridens* were obtained from trawlers in Mersin Bay in March-2016, September-2016, December-2016, and caught in overtime networks in June-2016. In each season, 30 individuals were sampled, and a total of 120 individuals were used during the study. The average height and weight of the individuals were taken and shown in Table 1. The sampling region was shown in Figure 1.

Table 1. The average length and weight of *P. stridens* in four seasons

Season	N	Mean TL (cm) $\bar{X} \pm S_x$	Mean Weight (g) $\bar{X} \pm S_x$
Spring	30	13.00±0.41^{x}	42.44±4.00^{a}
Summer	30	14.01±0.33^{x}	48.69±3.01^{b}
Autumn	30	14.00±0.20^{x}	40.31±1.56^{a}
Winter	30	13.48±0.12^{x}	41.13±.20^{a}

Note: $\bar{X} \pm S_x$: mean±standart deviation The levels on the same line, shown in different letters, are statistically different ($p<0.05$). TL: total length, W: weight

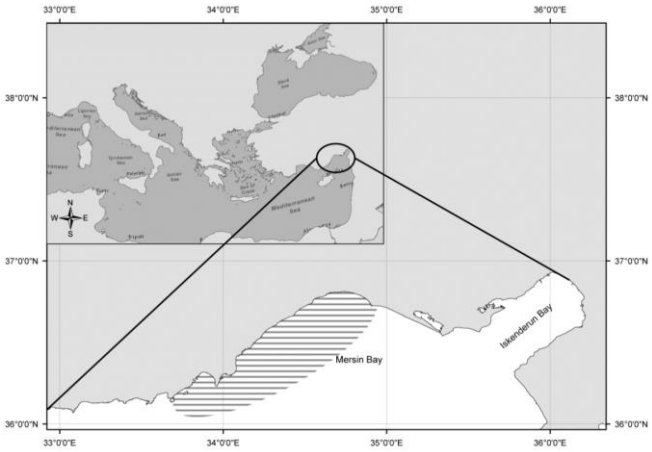

Figure 1. Sampling location map. The shaded region (Mersin Bay) is the sampling area

Lipid and Fatty Acids Analyses

Lipid analysis was performed using the Bligh & Dyer (1959) method. In extracted lipids, fatty acid methyl esters were obtained using the Ichibara et al. (1996) method. The fatty acid composition was analyzed 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 the analysis. The 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.

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).

$$Factor\ (Fish) = \frac{0.956 - 0.143.}{total\ lipid}$$

$$Fatty\ acid\ \left(\frac{mg}{1llg}\right) = Factor \times FAME(\%) \times lipid\ level(\%) \times 10$$

$$Atherogenicity\ index(AI)$$

Atherogenicity Index (AI) and Thrombogenicity Index (TI)

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

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

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

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

Statistical Analysis

Prior to the analyses, all data were checked for outliers, and homogeneity of variance was also tested. Statistical analysis of data was carried out with the SPSS statistical program. ANOVA (Analysis of Variance) was used to evaluate the effect of season on the metals levels.

RESULTS AND DISCUSSION

Results

It was found that the total lipid level of *P. stridens* has been indicated a seasonal statistical difference (p<0.05) (Table 2).

Fatty Acid Levels (%)

A total of 30 fatty acids constituted the total fatty acid composition. These are lauric acid (C12:0), myristic acid (C14:0), pentadecanoic acid (C15:0), palmitic acid (C16:0), heptadeconoic acid (C17:0), stearic acid (C18:0) arachidic acid (C20:0), behenic acid (C22:0), trichosanoic acid (C23:0), lignosuric acid (C24:0), myristoleic acid (C14:1), pentadecenoic acid (C15:1), palmitoleic acid (C16:1), heptadecenoic acid (C17: 1), oleic acid (C18: 1n9t), oleic acid (C18:1*n*9c), vaccenic acid (C18:1*n*7), gadoleic acid (C20:1*n*9), cetoloic acid (C22:1*n*11), nervonic acid (C24:1*n*9), linoleic acid (C18:2*n*6t), linoleic acid (C18:2*n*6c), alpha linolenic (C18:3*n*3), gamma linolenic (C18:3*n*6), eicosatrienoic acid (C20:3*n*3), eicosatrienoic acid (C20:3*n*6), arachidonic acid (C20:4*n*6), eicosapentaenoic acid (C20:5*n*3), docosahexaenoic acid (C22:6*n*3), docosadienoic acid (C22:2cis). The seasonal changes of fatty acid profiles (%) of *P. stridens* was shown in Table 3.

Table 2. The seasonal changes of total lipid level (%) of *P. stridens*

	Spring $\bar{X} \pm S_x$*	Summer $\bar{X} \pm S_x$*	Autumn $\bar{X} \pm S_x$*	Winter $\bar{X} \pm S_x$*
Lipid (%)	4.09±0.95^{c}	7.54±0.47^{d}	2.56±0.16^{b}	1.81±0.18^{a}

Note: $\bar{X} \pm S_x$: mean±standard deviation.

* The values on the same line, shown in different letters, are statistically different (p<0.05).

The primary fatty acids of *P. stridens* were palmitic acid and stearic acid from SFAs, oleic acid (C18: 1*n*9c), palmitoleic acid, and cetoloic acid from MUFAs, EPA, and DHA from PUFAs (Table 3).

Among the SFAs, the highest level of myristic acid was found in the spring (2.60%), the lowest level was in the winter (1.80%) (p<0.05). The palmitic acid was found at the highest level in the summer and autumn seasons (22.74%) and the lowest level in the spring season (16.92%) (p<0.05). The highest stearic acid level was

Table 3. The seasonal changes of fatty acid profiles of *P. stridens* (%)

Fatty acids (%)	Spring $\bar{X} \pm S_x^*$	Summer $\bar{X} \pm S_x^*$	Autumn $\bar{X} \pm S_x^*$	Winter $\bar{X} \pm S_x^*$
Lauric acid (C12:0)	0.26±0.02^{b}	0.09±0.00^{a}	0.09±0.00^{a}	0.06±0.00^{a}
Myristic acid (C14:0)	2.60±0.42^{b}	2.18±0.04^{ab}	2.23±0.04^{ab}	1.80±0.05^{a}
Pentadecylic acid (C15:0)	0.63±0.01^{a}	0.78±0.01^{a}	0.80±0.02^{a}	0.77±0.01^{a}
Palmitic acid (C16:0)	16.92±0.65^{a}	22.74±0.12^{b}	22.74±0.25^{b}	19.29±0.17^{ab}
Margaric acid (C17:0)	0.93±0.02^{a}	1.05±0.01^{a}	1.04±0.02^{a}	1.02±0.01^{a}
Stearic acid (C18:0)	13.86±0.55^{b}	8.06±0.04^{a}	9.28±0.04^{a}	11.82±1.10^{ab}
Arachidic acid (C20:0)	0.63±0.01^{bc}	0.48±0.01^{a}	0.60±0.01^{abc}	0.67±0.04^{c}
Behenic acid (C22:0)	0.24±0.01^{a}	0.23±0.00^{a}	0.31±0.01^{b}	0.29±0.01^{b}
Lignoceric acid (C24:0)	1.89±0.30^{b}	0.74±0.01^{a}	1.04±0.09^{a}	1.55±0.21^{b}
ΣSFA	**37.96**	**36.35**	**38.13**	**37.27**
Myristoleic acid (C14:1)	0.26±0.07^{a}	0.35±0.01^{b}	0.34±0.01^{b}	0.27±0.01^{a}
Pentadecenoic (C15:1)	0.18±0.01^{a}	0.29±0.01^{d}	0.25±0.00^{c}	0.20±0.00^{b}
Palmitoleic acid (C16:1)	4.35±0.47^{b}	4.99±0.09^{b}	4.40±0.09^{b}	3.02±0.08^{a}
Heptadecenoic acid (C17:1)	0.41±0.01^{a}	0.58±0.04^{b}	0.52±0.01^{b}	0.48±0.01^{ab}
Trans oleic acid (C18:1*n*9t)	0.23±0.02^{a}	0.35±0.01^{b}	0.32±0.01^{ab}	0.25±0.01^{a}
Oleic acid (C18:1*n*9c)	11.54±0.71^{a}	20.85±1.20^{c}	21.32±0.46^{c}	16.27±0.13^{b}
Vaccenic acid (C18:1*n*7)	3.63±0.10^{bc}	3.89±0.04^{c}	3.35±0.04^{ab}	2.89±0.01^{a}
Gadoleic acid (C20:1*n*9)	0.63±0.01^{a}	0.96±0.04^{b}	1.01±0.00^{b}	0.94±0.04^{b}
Cetoloic acid (C22:1n11)	4.98±0.62^{b}	2.99±0.00^{a}	3.45±0.18^{a}	4.70±0.37^{b}
Nervonic acid (C24:1*n*9)	0.19±0.01^{a}	0.07±0.01^{a}	0.07±0.01^{a}	0.10±0.01^{a}
ΣMUFA	**26.40**	**35.32**	**35.03**	**29.12**
Linolelaidic Acid (C18:2*n*6t)	0.11±0.01^{a}	0.19±0.01^{b}	0.15±0.01^{ab}	0.12±0.00^{a}
Linoleic acid (C18:2*n*6c)	1.29±0.01^{b}	0.70±0.01^{a}	0.78±0.00^{a}	1.07±0.08^{b}
α-Linolenic acid (C18:3*n*3)	0.23±0.05^{b}	0.14±0.00^{a}	0.10±0.00^{a}	0.11±0.01^{a}
Gamma linolenic acid (C18:3*n*6)	0.26±0.00^{a}	0.32±0.00^{a}	0.27±0.01^{a}	0.27±0.00^{a}
Eicosatrienoic acid (C20:3*n*3)	0.31±0.01^{a}	0.23±0.00^{a}	0.26±0.00^{a}	0.30±0.01^{a}
Dihomo-γ-linolenic acid (C20:3*n*6)	0.58±0.04^{b}	0.49±0.01^{a}	0.48±0.01^{a}	0.48±0.02^{a}
Arachidonic acid (C20:4*n*6)	0.55±0.03^{a}	0.47±0.01^{a}	0.56±0.01^{a}	0.58±0.01^{a}
Eicosapentaenoic acid (C20:5*n*3)	5.45±0.01^{c}	4.71±0.12^{b}	3.63±0.08^{a}	3.58±0.08^{a}
Adrenic acid (C22:4*n*6)	1.71±0.21^{bc}	1.28±0.03^{a}	1.64±0.03^{b}	1.91±0.13^{c}
Docosahexaenoic acid (C22:6*n*3)	13.42±1.58^{b}	5.57±0.16^{a}	6.82±0.77^{a}	11.15±1.58^{b}
Docosadienoic acid (C22:2cis)	0.29±0.04^{b}	0.14±0.00^{a}	0.16±0.01^{a}	0.23±0.12^{ab}
ΣPUFA	**24.20**	**14.24**	**14.85**	**19.80**
PUFA/ SFA	0.64	0.39	0.39	0.53
Σ*n*7	3.63	3.89	3.45	4.70
Σ*n*6	4.50	3.45	3.88	4.43
Σ*n*3	19.41	10.65	10.81	15.14
Σ*n*9	12.59	22.23	22.72	17.56
Σ*n*11	4.98	2.99	3.45	4.70
*n*6/*n*3	0.23	0.32	0.36	0.29
*n*3/*n*6	4.31	3.09	2.79	3.42
DHA/EPA	2.46	1.18	1.88	3.11
AI	0.32	0.42	0.42	0.36
TI	0.39	0.49	0.51	0.44
Unidentified	11.44	14.09	11.99	13.62

Note: $\bar{X} \pm S_x$: mean ± standard deviation

*The values on the same line, shown in different letters, are statistically different ($p<0.05$).

found in the spring (13.86%) and the lowest in the summer (8.06%).

Among the MUFAs, the highest level of palmitoleic acid was found at the highest level in summer (4.99%) and the lowest in winter (3.02%). The lowest level of trans oleic acid (C18: 1*n*9*t*) was found in spring (0.23%) and the highest level in summer (0.35%). The highest level of oleic acid (C18:1*n*9*c*) was found in the autumn (21.32%), and the lowest level was in the spring (11.54%). The lowest vaccenic acid level was found in the winter season (2.89%) and the highest in the summer season (3.89%). The lowest cetoloic acid level was found in the summer (2.99%) and the highest in the spring (4.98%).

Among the PUFAs, the highest level (1.29%) of linoleic acid (C18: 2*n*6*c*) was found in the summer (0.70%). The lowest EPA level was found in autumn (3.63%) and the highest in the spring (5.45%). The highest level of DHA was found in spring (13.42%) and the lowest level in summer (5.57%).

The Σ*n*3, Σ*n*6, Σ*n*9 fatty acid levels of *P. stridens* varied between 10.65-19.41%, 3.45-4.50%, 12.59-22.72%, respectively. The highest level of Σ*n*3 and Σ*n*6 level was found in spring, and the Σ*n*9 level was found in autumn.

The change intervals of AI and TI values during the year were found to be 0.32-0.42% and 0.39-0.51%, respectively. The highest value of AI was found in summer and autumn, while TI's highest value was autumn.

Table 4. The seasonal changes of fatty acid profiles of *P. stridens* (mg/100g)

	Spring	**Summer**	**Autumn**	**Winter**
Lipid (%)	4.09	7.54	2.56	1.81
Factor	0.898	0.914	0.877	0.853
Fatty acids (mg/100g)	Spring	Summer	Autumn	Winter
Lauric acid (C12:0)	9.55	6.20	2.02	0.93
Myristic acid (C14:0)	95.49	150.24	50.07	27.79
Pentadecylic acid (C15:0)	23.14	53.75	17.96	11.89
Palmitic acid (C16:0)	621.44	1567.14	510.54	297.82
Margaric acid (C17:0)	34.16	72.36	23.35	15.75
Stearic acid (C18:0)	509.05	555.46	208.35	182.49
Arachidic acid (C20:0)	23.14	33.08	13.47	10.34
Behenic acid (C22:0)	8.81	15.85	6.96	4.48
Lignoceric acid (C24:0)	69.42	51.00	23.35	23.93
ΣSFA	1394.20	2505.08	856.06	575.42
Myristoleic acid (C14:1)	9.55	24.12	7.63	4.17
Pentadecenoic (C15:1)	6.61	19.99	5.61	3.09
Palmitoleic acid (C16:1)	159.77	343.89	98.79	46.63
Heptadecenoic acid (C17:1)	15.06	39.97	11.67	7.41
Trans oleic acid (C18:1*n*9*t*)	8.45	24.12	7.18	3.86
Oleic acid (C18:1*n*9*c*)	423.84	1436.89	478.66	251.20
Vaccenic acid (C18:1*n*7)	133.32	268.08	75.21	44.62
Gadoleic acid (C20:1*n*9)	23.14	66.16	22.68	14.51
Cetoloic acid (C22:1*n*11)	182.91	206.06	77.46	72.56
Nervonic acid (C24:1*n*9)	6.98	4.82	1.57	1.54
ΣMUFA	969.62	2434.09	786.47	449.59
Linolelaidic Acid (C18:2*n*6*t*)	4.04	13.09	3.36	1.85
Linoleic acid (C18:2*n*6*c*)	47.38	48.24	17.51	16.52
a-Linolenic acid (C18:3*n*3)	8.45	9.65	2.25	1.70
Gamma linolenic acid (C18:3*n*6)	9.55	22.05	6.06	4.17
Eicosatrienoic acid (C20:3*n*3)	11.39	15.85	5.83	4.63
Dihomo-γ-linolenic acid (C20:3*n*6)	21.30	33.77	10.78	7.41
Arachidonic acid (C20:4*n*6)	20.20	32.39	12.57	8.95
Eicosapentaenoic acid (C20:5*n*3)	200.17	324.59	81.50	55.27
Adrenic acid (C22:4*n*6)	62.81	88.21	36.82	29.49
Docosahexaenoic acid (C22:6*n*3)	492.90	383.86	153.12	172.15
Docosadienoic acid (C22:2*n*6)	10.65	9.65	3.59	3.55
ΣPUFA	888.82	981.36	333.40	305.70
Σ*n*6	165.28	237.76	87.11	68.40
Σ*n*3	712.89	733.95	242.70	233.75
Σ*n*9	462.24	1531.99	510.09	271.12
Σ*n*11	182.91	206.06	77.46	72,56
Σ*n*7	133.32	268.08	77.46	72.56
Unidentified	420.17	971.02	269.20	210.28

The level of ΣSFA of *P. stridens* was found to be 1394.20 mg/100g, 2505.08 mg/100g, 856.06 mg/100g, and 575.42 mg/100g respectively in the spring, summer, autumn, and winter seasons. The highest level of palmitic acid was determined as 1567.14 mg/100g in summer, and the lowest level was 297.82 mg/100g in winter. Likewise, the highest level of stearic acid was 555.46 mg/100g in summer, and the lowest level was 182.49mg/100g in winter.

The levels of fatty acid in MUFAs, were determined as 46.63-343.89 mg/100g, 251.20-1436.89 mg/100g, 44.66-268.08 mg/100g, 77.46-206.06 mg/100g in palmitoleic acid, oleic acid (C18:1*n*9c), vaccenic acid, and cetoloic acid, respectively. The heptadecenoic acid, oleic acid (C18:1*n*9*t*), gadoleic acid, nervonic acid were at low levels in all seasons.

The EPA level was found to be between 55.27-324.59 mg/100g while the highest level was measured in summer; the lowest level was in winter. DHA level was in the range of 153.12-492.90 mg/100g, the highest level was calculated in the spring, and the lowest level was calculated in the autumn. Low-level fatty acids were determined as linoleic acid (C18:2*n*6*t*) 1.85-13.09 mg/100g, linoleic acid (C18:2*n*6*c*) 16.52-48.24 mg/100g, alpha-linolenic acid 1.70-9.65 mg/100g, gamma-linolenic 4.17-22.05 mg/100g, eicosatrienoic acid (C20:3*n*3) 4.63-15.85 mg/100g, Dihomo-γ-linolenic acid (C20:3*n*6) 7.41-33.77 mg/100g, docosadienoic acid (C22:2cis) 3.55-10.65 mg/100g. The level of the arachidonic acid was found in the range of 8.95-32.39 mg/100g. The ΣPUFAs levels were found to be 888.82 mg/100g, 981.36 mg/100g, 333.40 mg/100g, 305.70 mg/100g in the spring, summer, autumn, and winter seasons, respectively (Table 4).

The Σ*n*3, Σ*n*6, Σ*n*9 fatty acid levels of *P. stridens* ranged from 233.75-712.89 mg/100g, 68.40-237.76 mg/100g, 271.12-1531.99 mg/100g, respectively.

Discussion

The lipid content and composition of fish is influenced by species, age, sex, reproductive cycle, season, feeding preference, living habits, and so all (Ross, 1977; Montevechhi & Piatt, 1984; Saoud et al. 2007). The total lipid (%) level in *P. stridens* caught from Mersin Bay was higher in summer and spring than in autumn and winter. The total lipid level of *Saurida lesepsianus*, a non-native fish, was found higher in summer (7.19%) (Bakan et al., 2019). In similar research indicated that the total lipid level of *Scomber japonicus* and *Trachurus trachurus* sampled from Iskenderun Bay was high in spring (Çelik, 2008). The lower total lipid level in autumn and winter can be explained by the reproductive period of this species. Karimi et al. (2019) reported that *P. stridens* breed in November and December. During this period, egg-filled gonads (Safi et al., 2014) limit the digestive system, and the number of consumption decreases. At the same time, however, energy is spent on reproduction rather than lipid production. Towards the spring and summer seasons, the number of nutrition increases, and lipid storage begins to prepare for the new breeding season.

The major fatty acid profiles of *P. stridens* were determined that palmitic acid (16:0 16.92-22.74%) and stearic acid (18:0 8.06-13.86%) in saturated, oleic acid (C18:1*n*9*c* 11.54-21.32%), palmitoleic acid (16:1 3.02-4.99%), and cetoloic acid (22:1*n*11 2.99-4.98%) in monounsaturated fatty acids, docosahexaenoic acid (22:6*n*3 5.57-13.42%) and eicosapentaenoic acid (20:5*n*3 3.58-5.45%) in polyunsaturated fatty acids in the present study. Compared to a similar study, it can be stated that the MUFA and PUFA group fatty acids of *P. stridens* are higher than those of *S. lesepsianus* (Bakan et al., 2019). It has been reported that palmitic acid, stearic acid, EPA, and DHA were the primary fatty acids of *Dicentrarchus labrax*, an endemic fish in the Mediterranean Sea. It has been reported in the same study that n-3 PUFA in wild *D. labrax* was found higher than cultured fish due to the commercial fish food, which is rich in SFA and MUFA while lacking in PUFA (Alasalvar et al., 2002). This indicates that nutrition affects the change in the fatty acid profile of fish. *n*3 PUFA fatty acids are critical structural components of the phospholipid membranes of tissues in fish, and it is known that especially docosahexaenoic acid (DHA; 22:6*n*3) constitutes ≤36.4 of the total fatty acids (Connor, 2000). The high MUFA and PUFA levels in *P. stridens* raise the nutritional quality of this species for human consumption.

The seasonal changes were detected in the fatty acid profiles of *P. stridens* in the present study. The highest amount of major SFA (14:0, 16:0, 18:0), MUFA (16:1, 18:1*n*9*t*, 18:1*n*7, 22:1*n*11) except (18:1*n*9*c*) and PUFA (18:2*n*6*c*, 20:5*n*3, 22:6*n*3) were found in spring and summer in *P. stridens*. Similar results were found in *S. lesepsianus*. Unlike *P. stridens*, stearic acid was detected mostly in autumn and cetoloic acid in winter in *S. lesepsianus* (Bakan et al., 2019). The MUFA level in *S. japonicus* and *T. trachurus* were higher in spring and autumn than in winter, while PUFA level was higher in spring and winter than in autumn was noticed by Çelik (2008). It was known that MUFA in muscle has been to increase or decrease in direct proportion to the lipid contents. However, the PUFA level can be decreased after the reproduction period. In the present study, the seasonal changes of total lipid level and fatty acid profiles in *P. stridens* was found similar. It can be associated with the biological properties of *P. stridens,* such as the tolerance of temperate water, nutritional preference, reproductive cycle.

One of the essential functions of PUFA is related to its enzymatic conversion. Eicosanoids are hormone-like lipids with 20 carbon atoms and are useful in cellular growth and cell differentiation in the inflammatory and immune system. Arachidonic acid and EPA in the cell membrane are responsible for the formation of eicosanoids. Eicosanoids produced from arachidonic acid have been shown to promote adhesion of tumor cells to endothelial cells (Honn et al., 1992; Lipkin et al., 1999). The effect that *n*3 fatty acids can reduce the risk of cancer is the suppressive effect on Arachidonic acid biosynthesis of eicosanoids. In terms of nutritional impact, the potency of EPA and DHA

is estimated to be approximately five times the a-Linolenicacid for suppression of Arachidonic acid eicosanoids (Okuyama et al., 1996). In our study, EPA (3.58-5.45%) and DHA (5.57-13.42%) ratios were more than five times compared to the recommended levels of a-Linolenic acid (0.10-0.23) and arachidonic acid (0.47-0.58%) levels.

Fish or fish oil consumption has been shown to have anti-inflammatory properties (Barber, 2001) and also improve lipid profile (Schmidt et al., 1990). Various molecular mechanisms have been proposed, in which *n*3 PUFAs potentially affect carcinogenesis. This effect firstly causes them to participate in membrane phospholipids in which they replace a certain percentage of arachidonic acid with high *n*3 fatty acid intake (Crawford et al., 2000). Consequently, by incorporating *n*3 fatty acids into the diet, it will be produced less than prostaglandin E2, which produces inflammation in normal and tumor tissues and promotes growth (Hardman, 2004).

The data show that the most crucial aspect of PUFA in breast cancer prevention is the ratio*n*3/*n*6 (PUFA) rather than the absolute concentration of both. Studies show that ~1:1–1:2 ratio has the most protective effect against the development and growth of breast cancers (Cowing be Saker 2001). In this study, the *n*3/*n*6 ratio of *P. stridens* sampled in four seasons ranged from 2.79 to 4.31. It has been reported in previous research that the *n*3/*n*6 ratio of *S. lesepsianus* was found 13.20-17.10 (Bakan et al., 2019).

Consumption of foods rich in PUFA is effective in preventing heart problems. The minimum recommended PUFA/SFA level for humans is 0.45 (HMSO, 1994). In our study, the PUFA/SFA rate in muscle tissue of *P. stridens* was found to be 0.64 in spring and 0.53 in winter.

CONCLUSION

Due to the fact that the Mediterranean has created a suitable feeding, shelter, and spawning area for non-native fish, many of them have formed populations. Apart from putting pressure on endemic species and negatively affecting fishing activities, some species create consumable species with high nutritional quality and contribute to the economy. In the present study, the lipid and fatty acid profiles determined in *P. stridens* indicate that the species has nutritional quality so that it can be consumed by humans.

ACKNOWLEDGEMENTS

This study was supported by the Research Fund of Mersin University in Turkey with Project Number: 2017-1-TP2-2185.

COMPLIANCE WITH ETHICAL STANDARDS

Authors' Contributions

All authors contributed equally to this paper.

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethical Approval

For this type of study, formal consent is not required.

REFERENCES

Alasalvar, C., Taylor, K. D. A., Zubcov, E., Shadidi, F., & Alexis, M. (2002). Differentiation of cultured and wild sea bass (*Dicentrarchus labrax*): total lipid content, fatty acid and trace mineral composition. *Food Chemistry*, *79(2),* 145–150. https://doi.org/10.1016/S0308-8146(02)00122-X

Bakan, M., Erdoğan-Eliuz, E. A., & Ayas, D. (2019). Determination of seasonal changes in the fat and fatty acid profiles of *Saurida lessepsianus* (Russell, Golani and Tikochinski, 2015) caught from Mersin Bay. *Turkish Journal of Agriculture - Food Science and Technology*, *7*(9), 1483-1489. https://doi.org/10.24925/turjaf.v7i9.1483-1489.2535

Barber, M. D. (2001). *Cancer cachexia* and its treatment with fish-oil-enriched nutritional supplementation. *Nutrition, 17*(9), 751-755. https://doi.org/10.1016/s0899-9007(01)00631-1

Bentur, Y., Ashkar, J., Lurie, Y., Levy, Y., Azzam, Z. S., Litmanovich, M., Golik, M., Gurevych, B., Golani, D., & Eisenman, A. (2008). Lessepsian migration and tetrodotoxin poisoning due to *Lagocephaluss celeratus* in the eastern Mediterranean. *Toxicon*, *52*(8), 964–968. https://doi.org/10.1016/j.toxicon.2008.10.001

Bligh, E. G., & Dyer, W. J. (1959). A rapid method of total lipid extraction and purification. *Canadian Journal of Biochemistry and Physiology, 37(8),* 911-917. https://doi.org/10.1139/o59-099

Boudreau, M. D., Sohn, K. H., Rhee, S. H., Lee, S. W., Hunt, J. D., & Hwang, D. H. (2001). Suppression of tumor cell growth both in nude mice and in culture by n−3 polyunsaturated fatty acids: mediation-through cyclooxygenase-independent pathway *Cancer Research*, *61*(4), 1386–1391. https://doi.org/10.1158/0008-5472.CAN-19-2362

Çelik, M. (2008). Seasonal changes in the proximate chemical compositions and fatty acids of chub mackerel (*Scomber japonicus*) and horse mackerel (*Trachurus trachurus*) from the northeastern Mediterranean Sea. *International Journal of Food Science and Technology*, *43*(5), 933-938. https://doi.org/10.1111/j.1365-2621.2007.01549.x

Connor, W. E. (2000). Importance of n-3 fatty acids in health and disease. *The American Journal of Clinical Nutrition, 71*(Suppl.), 171S–175S. https://doi.org/10.1093/ajcn/71.1.171S

Cowing B. E., & Saker, K. E. (2001). Polyunsaturated fatty acids and epidermal growth factor receptor/mitogen-activated protein kinase signaling in mammary cancer. *Journal of Nutrition*, *131*(4), 1125–1128. https://doi.org/10.1093/jn/131.4.1125

Crawford, M., Galli, C., Visioli, F., Renaud, S., Simopoulos, A. P., & Spector, A. A. (2000). Role of plant-derived omega-3 fatty acids in human nutrition. *Annals of Nutrition and Metabolism*, *44*(5-6), 263–265. https://doi.org/10.1159/000046694

Ghaeni, M., Ghahfarokhi, K. N., & Zaheri, L. (2013). Fatty acids profile, atherogenic (IA) and thrombogenic (IT) health lipid indices in *Leiognathus bindus* and *Upeneus sulphureus*, *Journal of Marine Science: Research & Development*, *3*, 138. https://doi.org/10.4172/2155-9910.1000138

Gordon, D. T., & Ratliff, V. (1992). The implications of omega-3 fatty acids in human health. In G. E. Flick, R. E. Martin (Eds.), *Advances in seafood biochemistry: Composition and quality*. CRC Press.

Gorga, C. (1998). A new selected comments on lipids, *Quality Assurance of Seafood Appendix 1*, 245p.

Hardman, W. E. (2004). (*n*-3) fatty acids and cancer therapy. *Journal of Nutrition*, *134*(12 Suppl.), 3427S–3430S. https://doi.org/10.1093/jn/134.12.3427s

Heemstra, P. C. (1986). Teraponidae (pp. 543-546). In M. M. Smith, P. C. Heemstra (Eds.), *Smiths' sea fishes*. Springer-Verlag, Berlin.

HMSO UK. (1994). Nutritional aspects of cardiovascular disease (report on health and social subjects no. 46), London.

Honn, K V., Nelson, K. K., Renaud, C., Bazaz, R., Diglio, C. A., & Timar, J. (1992). Fatty acid modulation of tumor cell adhesion to micro vessel endothelium and experimental metastasis. *Prostaglandins*, *44*(5), 413–429. https://doi.org/10.1016/0090-6980(92)90137-I

Ichibara, K., Shibahara, A., Yamamoto, K., & Nakayama, T. (1996). An improved method for rapid analysis of the fatty acids of glycerolipids. *Lipids*, *31*, 535-539. https://doi.org/10.1007/BF02522648

Karimi, S., Katiraei, E., Soofiani, N. M., Taghavimotlagh, S. A., & Vazirizadeh, A. (2019). Feeding habits of striped piggy, *Pomadasys stridens* (Forsskal, 1775) (Haemulidae) in the northern part of the Persian Gulf. *International Journal of Aquatic Biology*, *7*(2), 85-92. https://doi.org/10.22034/ijab.v7i2.477

Karmali, R. A., Marsh, J., & Fuchs, C. (1984). Effect of omega-3 fatty acids on growth of a rat mammary tumor. *Journal of the National Cancer Institute*, *73*(2), 457–461. https://doi.org/10.1093/jnci/ 73.2.457

Leaf, A., & Weber, P. C. (1988). Cardiovascular effects of n-3 fatty acids, *The New England Journal of Medicine*, *318*, 549-557. https://doi.org/10.1056/NEJM198803033180905

Lindner, M. A. (1991). A fish oil diet inhibits colon cancer in mice. *Nutrition and Cancer*, *15*(1), 1–11. https://doi.org/10.1080/01635589109514105

Lipkin, M., Reddy, B., Newmark, H., & Lamprecht, S. A. (1999). Dietary factors in human colorectal cancer. *Annual Review of Nutrition*, 19, 545–586. https://doi.org/10.1146/annurev.nutr.19.1.545

Mavruk, S., & Avşar, D. (2008). Non-native fishes in the Mediterranean from the Red Sea, by way of the Suez Canal. *Reviews in Fish Biology and Fisheries*, *3*, 251-262. https://doi.org/10.1007/s11160-007-9073-7

Montevechhi, W. A., & Piatt, J. (1984). Composition and energy content of mature inshore spawning capelin (*Mallotus villosus*): implications for sea bird predators. *Comparative Biochemistry and Physiology*, *78*(1), 15–20. https://doi.org/10.1016/0300-9629(84)90084-7

Narayanan, B. A., Narayanan, N. K. & Reddy, B. S. (2001). Docosahexaenoic acid regulated genes and transcription factors inducing apoptosis in human colon cancer cells. *International Journal of Oncology*, *19*(6), 1255–1262. https://doi.org/10.3892/ijo.19.6.1255

Okuyama, H., Kobayashi, T., & Watanabe, S. (1996). Dietary fatty acids–the *n*−6/*n*−3 balance and chronic elderly diseases. Excess linoleic acid and relative *n*−3 deficiency syndrome seen in Japan. *Progress in Lipid Research*, *35*(4), 409–457. https://doi.org/10.1016/s0163-7827(96)00012-4

Rose, D. P., Connolly, J. M., & Meschter, C. L. (1991). Effect of dietary fat on human breast cancer growth and lung metastasis in nude mice. *Journal of the National Cancer Institute*, *83*(20), 1491–1495. https://doi.org/10.1093/jnci/83.20.1491

Safi, A., Khan, M. A., Hashmi, M. U. A., & Khan, Z. (2014). Studies on gonadosomatic index & stages of gonadal development of striped piggy fish, *Pomadasys stridens* (Forsskal, 1775) (Family; Pomadasyidae) of Karachi coast, Pakistan. *Journal of Entomology and Zoology Studies*, *2*(5), 28-31.

Saoud, I. P., Batal, M., & Lebbos, G .N. (2007). Seasonal variation in highly unsaturated fatty acid composition of muscle tissue of two fishes endemic to the eastern Mediterranean. *Ecology of Food and Nutrition*, *46*(2), 77–89. https://doi.org/10.1080/03670240701282456

Schmidt, E. B., Varming, K., Ernst, E., Madsen, P., & Dyeberg, J. (1990). Dose-response studies on the effect of n-3 polyunsaturated fatty acids on lipids and haemostasis. *Thrombosis and Haemostasis*, *63*(1), 1-5.

Sommer, C., Schneider W., & Poutiers J. M. (1996). FAO species identification field guide for fishery purposes, Rome. The living marine resources of Somalia. , FAO.

Tsai, W. S., Nagawa, H., Kaizaki, S., Tsuruo, T., Muto, T. (1998). Inhibitory effects of n-3 polyunsaturated fatty acids on sigmoid colon cancer transformants. *Journal of Gastroenterology*, *33*, 206–212. https://doi.org/10.1007/s005350050071

Ulbricht, T. L. V., Southgate, D A. T. (1991). Coronary heart disease: seven dietary factors. *Lancet*, *338*(8773), 985-992. https://doi.org/10.1016/0140-6736(91)91846-m

Weihrauch, J. L., Posati, L. P., Anderson, B. A., & Exler, J. (1975). Lipid conversion factors for calculating fatty acid contents of foods. *Journal of the American Oil Chemists' Society*, *54*, 36-40. https://doi.org/10.1007/BF02671370