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A comparison of the proximate compositions and fatty acid profiles of zander (*Sander lucioperca*) from two different regions and climatic conditions

Mehmet Çelik [a,*], Abdullah Diler [b], Aygül Küçükgülmez [a]

[a] *Department of Fishing and Fish Processing Technology, Faculty of Fisheries, University of Çukurova, Adana, Turkey*
[b] *Department of Aquaculture, Faculty of Fisheries, University of Suleyman Demirel, Eğirdir, Isparta, Turkey*

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Abstract

The proximate compositions and fatty acid profiles of the flesh of the fresh water fish zander (*Sander lucioperca*) obtained from Eğirdir Lake and from Seyhan Dam Lake were compared. The crude protein (18.8–18.1%), ash (1.37–0.75), and dry matter (20.67–20.09) contents of fish in Seyhan Dam Lake were observed to be higher than those in the other lake. Zander in Seyhan Dam Lake had a significantly ($p < 0.05$) higher lipid content than its Eğirdir counterpart. Differences were also observed in the fatty acid profiles. The percentages of total saturated fatty acids (SFA) and total monounsaturated fatty acids (MUFA) were higher in the zander in Seyhan Dam Lake than in Eğirdir Lake, whereas the corresponding total polyunsaturated fatty acids (PUFA) content was lower. Moreover, the fatty acid composition of these fish showed a relatively high ratio of PUFA/SFA (1.00). Both zanders showed palmitic acid, C16:0, to be predominant, (19.6–20.8%), followed by oleic acid, C 18:1 $n-9$, (19.2–13.4%).

The data obtained indicate that the % composition of $n-3$ PUFAs is greater in the flesh of zander in Eğirdir Lake. This finding is in compliance with the fact that $n-3$ fatty acids in fish living in cold climatic conditions have a higher % composition. It was concluded that the consumption of zander, widely found in Eğirdir Lake and having higher % composition of $n-3$ PUFAs than those caught from Seyhan Dam Lake, is more beneficial for human health.

Keywords: *Sander lucioperca*; Fatty acids; Proximate composition; PUFA

1. Introduction

The zander (*Sander lucioperca*) which is distributed abundantly in fresh water in Turkey and has commercial value in both domestic and foreign markets, is a neutral-tasting, lean fresh water fish.

Nowadays, it is known that fatty acids of fish flesh are the most beneficial for human health. Because, animal fats contain a high proportion of glycerides of saturated fatty acids and tend to be solids whilst those from fish contain predominantly unsaturated fatty acid esters and tend to be liquids. Fish lipids are well known to be rich in long chain $n-3$ polyunsaturated fatty acid (PUFA), especially eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). These fatty acids play a vital role in human nutrition, disease prevention, and health promotion. Long chain $n-3$ PUFAs cannot be synthesised by humans and must be obtained through the diet. Scientific data indicate that the consumption of fish oil containing $n-3$ PUFAs reduces the risk of coronary heart disease, decreases mild hypertension, prevents certain cardiac arrhythmias and sudden death, lowers the incidence of diabetes, and appears to alleviate symptoms of rheumatoid arthritis. Besides, it appears

* Corresponding author. Tel.: +90 322 338 66 46; fax: +90 322 338 64 39.
E-mail address: mcelik@cu.edu.tr (M. Çelik).

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that $n-3$ PUFAs play a vital role in the development and function of the nervous system (brain), photoreception (vision), and the reproductive system (Alasalvar, Taylor, Zubcov, Shahidi, & Alexis, 2002; Conner, 1997; Dyeberg, 1986; Leaf & Weber, 1988; Sidhu, 2003; Skonberg & Perkins, 2002; Tapiero, Nguyen Ba, Couvreur, & Tew, 2002).

Considering all these facts, and the lower the risk of cardiovascular diseases in particular, the importance of consuming fish rich in $n-3$ PUFAs can hardly be neglected.

Research indicates that fresh water fish generally have lower levels of $n-3$ PUFA than marine fish. Fish need PUFA to provide the lower water temperature adaptation. Fatty acids of cold and deep sea fish are abundant and the melting temperatures of $n-3$ fatty acids are lower than $n-6$ fatty acids (Chanmugam, Boudreau, & Hwanm, 1986; Kayam, 1977; Rahman, Huah, Hassan, & Daud, 1995). Therefore, it is estimated that $n-3$ PUFA contents of fish in warm regions are lower.

Furthermore, the fatty acid composition of fish muscle is clearly influenced by fish and diet. The lipids of fresh water feeds are characterized by linoleic (C18:2*n*6) and linolenic (C18:3*n*3) acids and EPA. Hence, the fatty acid composition of fresh water fish is characterized by high contents of $n-6$ PUFA. On the other hand, the plankton of marine feeds present low levels of $n-6$ PUFA, of which EPA and DHA are the predominant acids (Justi, Hayashi, Visentainer, de Souza, & Matsushita, 2003). Because zander is a carnivorous fish, it generally feeds on other fish species rich in fatty acid (Ekmekçi, Erkakan, & Bayrak, 1991).

Eğirdir Lake is the second biggest natural fresh water lake in Turkey. Zander was implanted into Eğirdir Lake in 1955. Other carp species evidently decreased and some species became extinct while zander population increased in subsequent years. Eventually, only carp, zander, and crayfish fishing in the lake had commercial value. At the same time, *Carassius auratus*, implanted in lake in the 1990s, had a big population because of fast reproduction and became a commercial fish in the lake (Erk'akan, Bayrak, & Ekmekçi, 1992). Currently, carp, zander, *Carassius auratus* and crayfish are caught in Eğirdir Lake and, according to Fisheries Statistics (2001), the total catches of these species are 60.4; 100.8; 334.25 and 797.95 tons, respectively.

Research on zander in Eğirdir Lake, has focussed on its stock determination (Ekmekçi et al., 1991; Erk'akan et al., 1992), population (Sarıhan, Erdem, & Erdemli, 1988), feeding (Campbell, 1992), reproduction (Sarmaşık, 1992), catching (Balık, 1992) and bacterial flora (Diler & Diler, 1998). But, no information is available on the chemical composition and fatty acids of zander living in the fresh waters of Turkey.

Because of its high commercial value, most of the fish caught is made into frozen fillets at processing factories in the local region. These processed products are mainly exported to European countries (Austria, Italy, Germany and France) and less to the USA and Canada. Few of these products are marketed in domestic markets as fresh products.

Seyhan Dam Lake is situated to the north of Adana. The lake area changes, depending on the season, from 6000 to 9000 ha. and it is one of the most the important fresh water reservoirs in the south eastern Mediterranean. The most important fish population of the lake is carp and, at the same time, there are a lot of fish species of no commercial value. With this aim, zander, transported from Eğirdir Lake, were implanted into Seyhan Dam Lake in 1971 and 1972 (Karakoç, 1987).

When the geographical areas of Seyhan Dam Lake and Eğirdir Lake are taken into consideration, Eğirdir Lake is situated at an altitude of 925 m above sea level and in a cool terrestrial climate region while Seyhan Dam Lake is situated in a hot climate region.

The primary aim of this work was to identify how the proximate compositions and total fatty acid profiles of zander varied between the two different regions with different climatic conditions.

2. Materials and methods

2.1. Materials

Zander, *S. lucioperca*, (average weight 150 ± 15 g) used in this study, were caught by using a galsame net from the Seyhan Dam Lake, which is in a hot climate region, and from Eğirdir Lake, which is relatively colder than Seyhan Dam Lake in Turkey in October, 2002. The average temperatures of these lakes are given Table 1. After being caught, they were transferred to the laboratories, filleted, and then frozen. Frozen fillets were dispatched (packed into a sterefor box with ice) to the

Table 1
Average water temperature values of Seyhan Dam Lake and Eğirdir Lake (°C) (Anonymous, 2001a,b)

Months	Seyhan Dam Lake	Eğirdir Lake
January	10.80	Lake froze
February	11.20	4
March	15.50	11
April	24.50	12.5
May	28.80	14.5
June	29	24
July	30.40	24
August	29.20	24
September	26	21
October	22	18
November	15	10
December	14	5

Faculty of Fisheries, University of Çukurova, Turkey, for the analyses.

2.2. Proximate composition analysis

The flesh of zander from Eğirdir Lake and from Seyhan Dam Lake was analysed for proximate composition. After the samples were defrosted, they were homogenized. Crude protein content was determined by the Kjeldahl method (Matissek, Schnepel, & Steiner, 1989). Lipid was determined by the method described by Bligh and Dyer (1959). The dry matter content of fish was determined by drying the meat in an oven at 104 °C for 4 h. Ash content was determined by dry ashing in a furnace oven at 550 °C for 4 h.

2.3. Fatty acid analysis

The lipids were saponified and esterified for fatty acid analysis by the method of Metcalfe, Schmitz, and Pelka (1966). The fatty acid methyl esters (FAMEs) were analysed on a Hewlett–Packard (HP) 5880 gas chromatograph (GC) with a flame ionisation detector (FID). The esters were separated on a 50 m × 0.20 mm i.d. wall-coated open tubular fused silica capillary column coated with Carbowax 20 M. Column injector, and detector temperatures were 200, and 300 °C, respectively. Carrier gas was helium; split ratio was 100:1. Identification was achieved by comparison to retention times of authentic standards, argentation TLC followed by GC of the bands separated by degree of unsaturation, and mass spectrometry.

2.4. Statistical analysis

The data on proximate and fatty acid composition were subjected to analyses of variance at the 5% level using SPSS 12.0 (2003) and the *t*-test was performed to separate differences among means.

3. Results and discussion

3.1. Proximate composition

The results of proximate analysis of zander from Seyhan Dam Lake and from Eğirdir Lake are shown in Table 2. In the present study, protein, lipid, ash and dry matter contents of zander in Seyhan Dam Lake were found to be higher than in zander from Eğirdir Lake. While crude protein, lipid, ash and dry matter of zander caught from Seyhan Dam Lake are 18.8 ± 0.12, 0.12 ± 0.00, 1.37 ± 0.02, 20.67 ± 0.02%, respectively, those values in zander caught from Eğirdir Lake were 18.1 ± 0.10, 0.10 ± 0.00, 0.75 ± 0.02 and 20.09 ± 0.07 %, respectively. Current results showed that all chemical compositions of zander in Seyhan Dam Lake were higher than those of the other group. Jankowska, Zakes, Zmijewski, and Szczepkowski (2003) reported similar results (protein % 18.0, lipid % 0.96) in the *S. lucioperca*.

Table 2
Proximate compositions of zander from Seyhan Dam Lake and from Eğirdir Lake (%)

Component	Seyhan Dam Lake	Eğirdir Lake	Significance of differences
Protein	18.8 ± 0.12*	18.1 ± 0.10	S
Lipid	0.12 ± 0.00**	0.10 ± 0.00	S
Ash	1.37 ± 0.02**	0.75 ± 0.02	S
Dry matter	20.67 ± 0.02**	20.09 ± 0.07	S

Note. S indicates a significant difference between two groups.
* The values are significantly different at $p < 0.05$.
** The values are significantly different at $p < 0.01$.

3.2. Fatty acid composition

The fatty acid profiles of zander in Seyhan Dam Lake and Eğirdir Lake are listed in Table 3. When fatty acids were investigated, it was observed that the % composition of PUFA was higher while those of saturated and MUFA were lower in zander caught from Eğirdir Lake. The PUFA/SFA ratio of zander in Eğirdir Lake (1.00) was higher than that in Seyhan Dam Lake (0.63). Total $n-3$ and $n-6$ fatty acid % compositions were found to be higher in zander caught from Eğirdir Lake (Table 3). Fish living in cold waters need more $n-3$ PUFAs to respond to their physiological requirements (Kayam, 1977). According to the results of this study, the PUFA levels of zander in Eğirdir Lake, that is situated 925 m above the sea level, were higher than those in zander in Seyhan Dam Lake situated at sea level.

The total saturated fatty acid content of lipids was 329% in zander caught from Seyhan Dam Lake and 30.5% in zander caught off Eğirdir Lake. Thus, the remaining fatty acids found in both species (about 70%) were mono and polyunsaturated fatty acids (MUFA + PUFA). These values are higher than the reported values (15.7) in silver carp (*Hypopthalmiehthys molitrix*) (Rahman et al., 1995). In general, fish are relatively low in saturated fatty acid (<30%), except for certain species (Neltleton & Exler, 1992).

The major fatty acids identified in both fish were 16:0, 18:0, 18:1 $n-9$, 18:2 $n-6$, 22:2 $n-9$, 20:5 $n-3$ (EPA) and 22:6 $n-3$ (DHA). Total $n-3$ fatty acids levels were significantly higher in zander caught from Eğirdir Lake than the other group.

Palmitic acid was the primary saturated fatty acid, contributing approximately 65% to the total saturated fatty acid content of the lipids for both zanders. Similar results for wild zander (Jankowska et al., 2003) and other freshwater fish have also been reported in the literature (Haliloğlu, 2002; Rahman et al., 1995).

Table 3
Fatty acid profiles (% total fatty acids) of zander caught from Seyhan Dam Lake and Eğirdir Lake

Fatty acids	Seyhan Dam Lake	Eğirdir Lake	Significance of differences
C12:0	0.21 ± 0.00	0.52 ± 0.02**	S
C14:0	2.74 ± 0.02**	1.34 ± 0.02	S
C16:0	19.6 ± 0.15	20.8 ± 0.47	NS
C18:0	9.23 ± 0.02**	6.77 ± 0.01	S
C20:0	0.30 ± 0.01	0.31 ± 0.01	NS
C22:0	0.26 ± 0.01	0.24 ± 0.01	NS
C24:0	0.55 ± 0.02	0.56 ± 0.01	NS
∑SFA	32.9	30.5	
C14:1	0.30 ± 0.02	0.31 ± 0.02	NS
C16:1	4.96 ± 0.06**	1.88 ± 0.09	S
C17:1	0.69 ± 0.03**	0.20 ± 0.00	S
C18:1 $n-9$	19.2 ± 0.20**	13.4 ± 0.05	S
C20:1 $n-9$	0.44 ± 0.02	0.35 ± 0.02	NS
C22:1 $n-9$	0.18 ± 0.01	0.38 ± 0.02**	S
C24:1 $n-9$	2.27 ± 0.16	3.78 ± 0.06	NS
∑MUFA	28.0	20.3	
C18:2 $n-6$	4.12 ± 0.01	9.08 ± 0.11**	S
C22:2 $n-9$	4.32 ± 0.05	4.83 ± 0.09*	S
C18:3 $n-3$	1.45 ± 0.02**0.49 ± 0.04	S	
C20:5 $n-3$	3.52 ± 0.02	3.73 ± 0.03*	S
C22:6 $n-3$	7.37 ± 0.17	12.41 ± 0.10**	S
∑PUFA	20.8	30.5	
$\sum n-3$	12.3	16.6	
$\sum n-6$	4.12	9.08	
PUFA/SFA	0.63	1.00	
Unknown	18.3	18.6	

Note. SFA, saturated fatty acid; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; PUFA/SFA, ratio of polyunsaturated to saturated fatty acids; S indicates a significant difference between two groups; NS, no significant difference. Values without letters within a row are not significantly different.

* The values are significantly different at $p < 0.05$.

** The values are significantly different at $p < 0.01$.

Oleic acid was identified as the primary monounsaturated fatty acid in both fish and was significantly ($p < 0.05$) higher in zander from Seyhan Dam Lake than in zander from Eğirdir Lake. Kinsella, Shimp, Mai, and Weihrauch (1977) found similar results in *Stizostedion lucius* and other fresh water fish. Among the $n-3$ series, both fish are good sources of EPA (3.52–3.73 %) and DHA (7.37–12.4%).

Freshwater fish normally contain more $n-6$ PUFAs, whereas marine fish are rich in $n-3$ fatty acids, especially DHA and EPA (Wang, Miller, Perren, & Addis, 1990). Likewise, Alasalvar et al. (2002) determined that wild sea bass (*Dicentrarchus labrax*) had higher total $n-3$ quantity than in the results of this study. Total saturated contents were found equal while MUFA contents were higher than in the present study. On the other hand, Osman, Suriah, and Law (2001) found higher $n-3$ PUFA concentrations in different marine fish than in the present study.

It has been reported that the types and amounts of fatty acids in fish tissues vary with the geographic location, size, age, what the fish eat, reproductive status and seasons (Bandarra, Batista, Nunes, Empis, & Christie, 1997; Leger, Bergot, Lukuet, Flanzy, & Meurot, 1977; Wodtke, 1981).

4. Conclusions

Seafood-origin proteins and fatty acids play an important part in the human diet. The fatty acids PUFAs and HUFAs are crucial in terms of human feeding physiology. These fatty acids contain five or six double bonds in their body. The most important of HUFAs and PUFAs are $n-3$ fatty acids and are particularly found in cold water and deep sea fish (Dyeberg, 1986; Neuringer & Conner, 1986; Pigott & Tucker, 1987). This condition can be regarded as an explanation for the fact that the zander in Eğirdir Lake are richer in $n-3$ fatty acids, taking into consideration the fatty acid profile of the fish.

In the light of the literature and all of these findings, it may be concluded that the zander from Eğirdir is more beneficial for human health than that from Seyhan Dam Lake due to the richer $n-3$ fatty acid % composition.

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