Analysis of lipid classes and the fatty acid composition of fresh and the salted fish, *Alburnus tarichi*

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**Abstract:** This study was carried out to determine the distribution of total, phospholipid and triacylglycerol fatty acid composition in salted and fresh fish of pearl mullet. Fatty acid analyses were performed in muscle tissues of the fish samples. Eicosapentaenoic acid (EPA), Docosahexaenoic acid (DHA), Omega-3 (n-3), Omega-6 (n-6) which are important for health, were determined in the analyses. The distribution of total and TAG fatty acids in males and females was similar. It was determined that the changes were in the Phospholipid. N-3/n-6 ratio showed a similar distribution in both female and male individuals. In particular, the results obtained may benefit the fisheries industry, nutritionists and researchers, as the nutritional value of the fish is high.

**Subjects:** Substitutes - Food Chemistry; Food Analysis; Lipids; Preservation; Processing

**Keywords:** Fish and health; nutrition; phospholipid; triacylglycerol

1. Introduction

It is accepted that the consumption of seafood has advantages for humans in terms of nutrition and health. Fish and other seafood are considered good sources of essential amino acids, vitamins, minerals and polyunsaturated fatty acids (Corapci & Guneri, 2020). Since the nutritional composition of the fish affects both its quality and technological properties, it is important to process the fish correctly, and as a result of the process, the content of the fish must be preserved throughout the year. In general, different processing methods such as freezing, frying, boiling, and salting are used to provide a longer shelf life by giving the fish a fresh and attractive form for consumers.
These methods have significant effects on the chemical, physical, and nutritional composition of the fish. These effects cause physical and chemical changes (Aberoumand, 2020).

Salting has been used in human history long before other processes such as fumigation, drying, canning, and marinating. In particular, it is one of the oldest techniques known to man for the preservation and increase shelf life of fish (Hafez et al., 2019). Salted fish products have been shown to be safe for millennia, even in developed countries. Salting techniques are simple and are made with salt crystals or brine. Generally, dry salting, wet salting and a combination of the two methods are used. The length of the salting time and the salt concentration depend on the expected end product. Salt intake depends on many factors such as the quality and chemical composition of the raw material, type, muscle type, fish size, fillet thickness, weight, physiological condition, salting method, brine concentration, duration of the salting process, and fish/salt ratio (Hafez et al., 2019). Generally, sodium chloride (NaCl) is used in fish processing due to its protective feature. Salting in traditional fish products is carried out with 1.0–11.6% NaCl (w/w) or high sodium content (Guo et al., 2019). Salted fish is one of the most consumed fish products in the world and is considered a traditional food in many countries (Nikiforova et al., 2019). Fish is one of the most potential sources of animal protein and contains 66–84% water, 15–24% proteins, 0.1–22% lipids and is very close to animal foods in terms of basic components (El Bassir Arha et al., 2015). Omega-3, highly unsaturated fatty acids (HUFA), eicosapentaenoic (EPA), docosahexaenoic (DHA) acids and amino acids in fish help consumers to protect themselves from various diseases such as blood pressure, coronary heart disease, and cancer (Abroha et al., 2018). Recent epidemiological, clinical, and nutritional studies in animals and humans have shown that marine fish oils rich in polyunsaturated fatty acids of the omega-3 series are beneficial in preventing certain forms as well as reducing the risk of coronary heart disease and atherosclerosis (El Bassir Arha et al., 2015).

Pearl mullet (Alburnus tarichi), which is the only fish species that can live in Lake Van, accounts for 1/3 of the fish production in the region and inland waters of Turkey (Yellow, 1997), and consumed as an economically important food source in the Eastern Anatolia Region. Thus, in our study, total, PL, and TAG fatty acid analysis in muscle tissue of salt-dried and fresh fish of pearl mullet was carried out to give information about its fatty acid composition and nutritional quality. Considering the information about food composition and quality of the fish, which has an important place in our diet, these data will provide useful information about health and nutritional values.

2. Material and method

Fresh fish samples were caught by local fishermen using blind (towing) nets on Lake Van, which is located between Yeşilsu Village (38°46’ 51.30”N, 43°17’ 36.78”E, 1684 m) close to Van province. Salted fish samples were analyzed after they were taken from local markets in the region. The genders of fresh and salted fish were determined by dissection and examining the gonads under a light microscope.

The lipid extraction in muscle tissue was performed according to chloroform-methanol (2:1 v/v) method of Folch et al. (1957). Fatty acid analysis of oil samples converted to methyl esters was analyzed using a SHIMADZU GC 2010 PLUS model Gas Chromatography device, flame ionization detector (FID) and DB-23 (Bonded 50 % cyanopropyl) (U & W Scientific, Folsom, CA, USA) capillary column (30 m x 0.25 mm inner diameter x 0.25 μm film thickness). Detector temperature: 250 °C; injector temperature: 250 °C; injection: Split-model 1/20. Gas flow rates: Carrier gas: helium 0.5 ml/min; hydrogen: 30 ml/min; dry air: 400 ml/min for 30 m column. Column (oven) temperature: standby time, 2 min at 170 °C; 2 °C/min until 210 °C, standby time 20 min; total analysis time: 42 min. Chromatograms of fatty acids methyl esters and total fatty acids amounts were obtained on the computer with GC Solution (Version 2.4) computer program. Fatty acid percentages were analyzed by one-way analysis of variance (ANOVA). Differences were determined by the TUKEY HSD test. As a result of the statistics, it was accepted that the differences were significant when the data were at the P < 0.05 level.
3. Results and discussion

When the individual fatty acids were considered in males, it was found that palmitic acid (16:0), palmitoleic acid (16:1 n-7), oleic acid (18:1 n-9), eicosapentaenoic acid (20:5 n-3), and docosahexaenoic acids (22:6 n-3) fatty acids were the major fatty acids (Table 1). Major fatty acids were found to be similar in females as in males (Table 2).

Palmitic acid, 16:1 n-7, 18:1 n-9 20:5 n-3, and 22:6 n-3 were major fatty acids in fresh and salted fish for *Pseudosciaena polyactis* (Cai et al., 2017); 16:0, 18:1 n-9, and 20:5 n-3 were major for *Alosa fallax lacustris* (Moretti et al., 2016); 16:0, 16:1 n-7, and 18:2 n-6 were major in mullet and sardine (Elshehawy et al., 2015); 16:0, 18:1 n-9, and 22:6 n-3 were major in lakerda fish (Ormanci et al., 2015); 16:0, 18:1 n-9, 20:5 n-3, and 22:6 n-3 were major in *Thunnus thynnus* L. (Garaffo et al., 2011); 16:0, stearic acid (18:0), 18:1 n-9, and 22:6 n-3 were major in *Thunnus albacares* (Guizani et al., 2011); 16:0, 16:1, 18:0, 18:1 were major in Golden Mullet; 16:0, 18:1 n-9 were major in both fresh and salted fish for 15:0 (Nikiforova et al., 2019); 16:0, 18:0, 18:1 n-9 were major in Grass carp dorsal and ventral (Guo et al., 2019). In our study, major fatty acids in both female and male individuals showed a similar distribution as in the study carried out by Cai et al. (2017). It was determined that our study contains more major fatty acids compared to other studies. This showed that the distribution of fatty acids among fish was different.

| Table 1. Variation of fatty acid percentages in fresh and salted muscle tissue of male *Alburnus tarichi* |
|-----------------------------------------------|-----|-----------------|-----------------|-----------------|-----------------|
| Fatty Acid | Total | Phospholipid | Triacylglycerol |
|------------|-------|--------------|----------------|----------------|----------------|
|            | Fresh | Salted       | Fresh | Salted | Fresh | Salted |
| 14:0* | 3.55±0.28a | 4.02±0.32a | 0.87±0.07a | 4.15±0.33b | 4.12±0.33a | 4.51±0.36a |
| 15:0 | 0.32±0.03a | 0.30±0.02a | 0.24±0.02a | 0.37±0.03b | 0.37±0.03a | 0.34±0.03a |
| 16:0 | 13.43±1.05a | 12.84±1.02a | 22.71±1.81a | 19.84±1.58a | 12.65±1.01a | 13.75±1.10a |
| 17:0 | 0.61±0.05a | 0.82±0.07a | 0.24±0.02a | 0.56±0.04b | 0.66±0.05a | 0.89±0.07a |
| 18:0 | 3.84±0.31a | 3.00±0.24a | 8.05±0.64a | 6.25±0.50a | 3.18±0.25a | 3.09±0.25a |
| ΣSFA | 21.75±1.74a | 20.98±1.67a | 32.11±2.56a | 31.17±2.49a | 20.98±1.67a | 22.59±1.80a |
| 16:1n-7 | 14.86±1.19a | 20.37±1.63a | 5.28±0.42a | 15.88±1.27b | 17.69±1.41a | 22.72±1.81a |
| 18:1n-9 | 25.70±2.05a | 25.04±2.00a | 14.66±1.17a | 28.64±2.28b | 29.88±2.38a | 27.31±2.18a |
| 20:1n-9 | 0.66±0.05a | 0.12±0.01b | 0.44±0.04a | 0.25±0.02b | 0.78±0.06a | 0.14±0.01b |
| ΣM.U.F.A | 41.22±3.29a | 45.54±3.63a | 20.38±1.63a | 44.76±3.57b | 48.35±3.86a | 50.16±4.00a |
| 18:2n-6 | 2.84±0.23a | 2.64±0.21a | 1.21±0.10a | 1.98±0.16b | 3.05±0.24a | 2.76±0.22a |
| 18:3n-3 | 1.74±0.14a | 0.17±0.01b | 0.63±0.05a | 0.18±0.01b | 1.86±0.15a | 0.20±0.02b |
| 20:2n-6 | 0.47±0.04a | 0.37±0.03a | 0.53±0.04a | 0.67±0.05a | 0.49±0.04a | 0.34±0.03a |
| 20:3n-3 | 0.74±0.06a | 0.71±0.06a | 0.59±0.05a | 0.58±0.05a | 0.75±0.06a | 0.69±0.06a |
| 20:4n-6 | 2.80±0.22a | 2.25±0.18a | 6.42±0.31a | 2.20±0.18b | 1.60±0.13a | 1.87±0.15a |
| 20:5n-3 | 10.19±0.81a | 13.65±1.09a | 10.81±0.86a | 7.41±0.59a | 8.85±0.71a | 11.42±0.91a |
| 22:5n-3 | 5.85±0.47a | 4.54±0.36a | 5.61±0.45a | 2.65±0.21b | 5.44±0.43a | 3.80±0.30a |
| 22:6n-3 | 12.40±0.99a | 9.15±0.73a | 21.72±1.73a | 8.39±0.67b | 8.56±0.68a | 6.18±0.49a |
| ΣP.U.F.A | 37.03±2.95a | 33.48±2.67a | 47.52±3.79a | 42.07±1.92b | 30.66±2.45a | 27.25±2.17a |
| n-3 | 30.18±2.41a | 27.51±2.19a | 38.77±3.09a | 18.63±1.49b | 24.71±1.97a | 21.60±1.72a |
| n-6 | 6.85±0.55a | 5.97±0.48a | 8.75±0.70a | 5.43±0.43b | 5.95±0.47a | 5.65±0.45a |
| n-3/n-6 | 4.41 | 4.61 | 4.43 | 3.43 | 4.15 | 3.82 |

*The data determined with the same letters in each row are not different from each other at the probability level of P > 0.05.*

*Each data is the average of 3 replicates. 3 injections were given in each repetition.*

*Values are provided as mean ± SE of three replicate samples; values with different letters in one line are significantly different (ANCOVA, Tukey HSD test, P < 0.05); SFA saturated fatty acid, MUFA monounsaturated fatty acid, PUFA polyunsaturated fatty acid.*
Table 2. Variation of fatty acid percentages in fresh and salted muscle tissue of female Alburnus tarichi

| Fatty Acid   | Fresh* | Salted | Phospholipid | Triacylglycerol |
|--------------|--------|--------|--------------|-----------------|
| 14:0         | 3.10±0.25a | 3.62±0.29a | 0.92±0.07a | 2.66±0.21b | 4.24±0.34a | 3.68±0.29a |
| 15:0         | 0.32±0.03a | 0.30±0.02a | 0.24±0.02a | 0.31±0.02a | 0.38±0.03a | 0.34±0.03a |
| 16:0         | 13.48±1.08a | 12.75±1.02a | 22.35±1.78a | 20.64±1.65a | 12.48±1.00a | 13.31±1.06a |
| 17:0         | 0.60±0.05a | 0.87±0.07a | 0.21±0.02a | 0.43±0.03b | 0.71±0.06a | 0.83±0.07a |
| 18:0         | 3.96±0.32a | 4.06±0.32a | 7.65±0.61a | 8.69±0.69a | 3.17±0.25a | 3.62±0.29a |
| ΣS.F.A       | 21.46±1.71a | 21.61±1.72a | 31.37±2.50a | 32.71±2.61a | 20.98±1.67a | 21.77±1.74a |
| 16:1n-7      | 13.31±1.06a | 16.57±1.32a | 5.12±0.41a | 11.11±0.89b | 17.14±1.37a | 19.74±1.43a |
| 18:1n-9      | 23.30±1.86a | 27.50±2.19a | 16.97±1.35a | 26.18±2.09b | 28.17±2.25a | 29.06±2.32a |
| 20:1n-9      | 0.69±0.06a | 0.18±0.01b | 0.38±0.03a | 0.22±0.02b | 0.77±0.06a | 0.14±0.01b |
| ΣM.U.F.A     | 37.30±2.98a | 44.24±3.53a | 22.47±1.79a | 37.50±2.99b | 60.08±3.68a | 47.14±3.76a |
| 18:2n-6      | 2.74±0.22a | 2.92±0.23a | 1.71±0.14a | 1.58±0.13a | 3.25±0.26a | 2.98±0.24a |
| 18:3n-3      | 1.56±0.12a | 0.16±0.01b | 0.56±0.04a | 0.19±0.02b | 1.84±0.15a | 0.23±0.02b |
| 20:2n-6      | 0.54±0.04a | 0.58±0.05a | 0.55±0.04a | 0.80±0.06a | 0.52±0.04a | 0.54±0.04a |
| 20:3n-6      | 0.77±0.06a | 0.86±0.07a | 0.68±0.05a | 0.56±0.04a | 0.79±0.06a | 0.86±0.07a |
| 20:4n-6      | 3.10±0.25a | 1.93±0.15b | 6.16±0.49a | 2.84±0.23b | 1.74±0.14a | 1.93±0.15b |
| 20:5n-3      | 12.53±1.00a | 12.36±0.99a | 10.51±0.84a | 8.43±0.67a | 10.32±0.82a | 11.44±0.91a |
| 22:5n-3      | 6.03±0.48a | 5.46±0.44a | 5.44±0.43a | 3.57±0.28b | 5.85±0.47a | 4.81±0.38a |
| 22:6n-3      | 13.98±1.12a | 9.87±0.79a | 20.55±1.64a | 11.81±0.94b | 6.83±0.69a | 8.29±0.66a |
| ΣP.U.F.A     | 41.25±3.29a | 34.15±2.72a | 46.16±3.68a | 29.79±2.38b | 32.94±2.63a | 31.09±2.48a |
| n-3          | 34.10±2.72a | 27.85±2.22a | 37.06±2.96a | 24.00±1.91b | 26.64±2.13a | 24.77±1.98a |
| n-6          | 7.15±0.57a | 6.30±0.50a | 9.10±0.73a | 5.79±0.46b | 6.30±0.50a | 6.32±0.50a |
| n-3/n-6      | 4.77      | 4.62      | 4.07      | 4.15      | 4.23      | 3.92      |

*The data determined with the same letters in each row are not different from each other at the probability level of P > 0.05.

*Each data is the average of 3 replicates. 3 injections were given in each repetition.

Values are provided as mean ± SE of three replicate samples; values with different letters in one line are significantly different (ANOVA, Tukey HSD test, P < 0.05); SFA saturated fatty acid, MUFA monounsaturated fatty acid, PUFA polyunsaturated fatty acid

There are also studies in which the fatty acid compositions of male and female fish are quantitatively different. For example, (Görgün & Akpinar, 2007) investigated the muscle fatty acid composition of Oncorhynchus mykiss and male and female Salmo trutta macrostigma living in Tohma River. Quantitative differences were found in individual fatty acids in tissues depending on gender. The most abundant fatty acids in muscle tissue of both genders of S. t. macrostigma were established as 16:0 (21.6%), 18:0 (11.3%), 18:1 n-9 (22.4%), 20:5 n-3 (7.88%), and 22:6 n-3 (15.6%); Akpinar et al. 2009). In our study, when male and female individuals were considered, other major fatty acids were similar except for 18:0, 16:1 n-7. As a result of the data obtained in the analysis, percentages of 16:0 (13.43–13.48%) and 22:6 n-3 (12.40–13.98%) were lower, whereas that of 20:5 n-3 (10.19–12.53%) was higher. In addition, the distributions of fatty acids between genders were close to each other.

When the fatty acid distribution of fresh and salted fish was considered, it was seen that distribution of 16:0, 20:5 n-3 was similar in the fresh and the salted fish for P. polyactis, while 16:1 n-7 (9.87%), 18:1 n-9 (2.89%), and 22:6 n-3 (7.71%) were lower in the salted fish (Cai et al., 2017); 16:0 (5.45%) was lower in the salted fish for A. fallax lacustris, while 18:1 n-9 (1.38%) and 20:5 n-3 (6.5%) were higher (Moretti et al., 2016); the salted decreased 26.75% in Mullet, while
there was an increase of 99.51% in sardine, 16:0 decreased 1.01% in Mullet, while it increased 8.29% in sardine. Furthermore, 18:1 n-9 was 34.29% lower in the salted one in mullet, 98.48% lower in sardine; eicosenoic acid (20:1 n-9) was found to be 41.46% lower in mullet, 172.94% lower in sardine. It was stated that 18:2 n-6 increased in both mullet (35.38%) and sardine (34.94%) in salty fish (Eishehawy et al., 2015). They determined that 16:0 (20.37%) and 22:6 (19.85%) decreased in salted lakefish. 18:1 n-9 was reported to increase by 12.13%. Other fatty acids have been reported to have close to each other or similar results (Ormanci et al., 2015). 16:0 (5.67%), 18:1 (43.20%), and 22:6 (23.78%) were higher in salty bottarga than fresh one. In the same fish, 20:5 was 80.45% lower (Garaffo et al., 2011). When the 5% salinity was taken into account, 16:0 (23.22%), 18:0 (22.93%), and 18:1 n-9 (19.27%) were higher in the salted T. albacares, while 22:6 n-3 (5.54%) was lower. When the contents of different concentrations were compared, it was observed that the percentages of 16:0, 18:0, 18:1, 22:6 decreased (Guizani et al., 2011). 16:0 (48.87%) and 18:1 (16.91%) showed a decrease, whereas 16:1 (36.88%), 20:5 (55.25%), and 22:6 (52.91%) increased in salted Golden Mullet fish (Hedayatifard & Yousefian, 2010). In Grass carp salted fish, 16:0 was 7.81% higher in dorsal and 4.92% higher in ventral; 18:1 was 10.86% higher in dorsal and 11.45% higher in ventral, while 18:0 was 18% lower in dorsal and 11.99% lower in ventral (Guo et al., 2019). In our study, when the distribution of total and TAG fatty acids in male individuals was considered, it was found that 18:3 n-3 was 923.53% lower in total fatty acid and 830% lower in TAG in salted fish compared to fresh one. While high or low levels of other fatty acids were detected in previous studies, the distribution of other fatty acids was similar in our study. When the total fatty acid distribution in the female individual was considered, 18:3 n-3 was 875% lower and 20:4 n-6 was 60.62% lower in salted fish compared to fresh one. Other fatty acid distributions were similar.

Order of fatty acids was ΣPUFA>ΣMUFA>ΣSFA in fresh P. polyactis and in fresh Laker, while the order was ΣMUFA>ΣPUFA>ΣSFA in salted Lake fish and in fresh and salted A. fallax lacustris, it was ΣPUFA>ΣSFA>ΣMUFA in P. polyactis, fresh and salted Thunnus thynnus L., Baikal omul in Bottarga (Cai et al., 2017; Garaffo et al., 2011; Guizani et al., 2011; Moretti et al., 2016; Nikiforova et al., 2019; Ormanci et al., 2015). The order was found to be ΣPUFA>ΣSFA>ΣMUFA in Mullet in both fresh and salted fish, while the order was ΣSFA = ΣMUFA>ΣPUFA in fresh sardine and ΣSFA>ΣMUFA>ΣPUFA in salted one (Eishehawy et al., 2015). The order was ΣMUFA>ΣSFA>ΣPUFA in both fresh and salted Golden Mullet (Hedayatifard & Yousefian, 2010). In Grass carp fish, ΣSFA was similar in dorsal and ventral of fresh and salted fish, MUFA was similar in ventral, while it was 8.89% higher in dorsal of the salted fish. Total PUFA in both dorsal (25.69%) and ventral (30.71%) was lower in salted fish. In fresh and salted fish, the order was ΣSFA>ΣMUFA>ΣPUFA in the dorsal, while ΣSFA = ΣMUFA>ΣPUFA in the ventral (Guo et al., 2019). Total SFA in muscle phospholipids of the five carp species in India ranged from 31.1% to 35.7% in four species. It was detected at a rate of 63.5% due to 16:0 found around 50% in only Catla catla. The rate of ΣMUFA in four species was found to be 15.1–21.3%, and ΣPUFA was between 33–56% (Ackman 2002). In our study, when the fatty acid distribution as total and TAG in both salted and fresh fish in male individuals was considered, it was ΣSFA<ΣPUFA<ΣMUFA; in fresh fish, it was ΣPUFA>ΣSFA>ΣMUFA for PL, in salted fish, it was ΣMUFA<ΣSFA<ΣPUFA (Table 1). The highest percentage of ΣSFA was found in PL, ΣMUFA in TAG, and ΣPUFA in PL in fresh fish and in total in salted fish. In terms of ΣMUFA, while the percentage of phospholipids in fresh fish (20.38%) was the lowest, it showed a similar percentage distribution in salted fish as in total and triacylglycerol. It showed a distribution as ΣPUFA>ΣMUFA>ΣSFA in fresh fish and as ΣMUFA>ΣPUFA>ΣSFA in salted fish in female individuals. When the triacylglycerol distribution was considered, the percentage of 18:3 n-3 was found to be 700% lower in salted fish than that in fresh fish. The other distributions were similar. Distribution was in the order of ΣMUFA<ΣPUFA<ΣSFA in fresh and salted fish. When the fatty acid distributions in the phospholipid were considered, it was observed that 14:0 was 189.14%, 16:1 n-7 was 116.99%, 18:1 n-9 was 54.28%, and ΣMUFA was 66.89% higher in the salted fish than those in the fresh fish. In the case of polyunsaturated fatty acids, 20:4 n-6 (116.91%), 22:5 n-3 (52.39%), 22:6 n-3 (74.01%), ΣPUFA (54.96%), n-3 (54.42%), and n-6 (57.17%) were found to be lower as
a percentage in salted fish compared to fresh one. The distribution was ΣMUFA<ΣSFA<ΣPUFA in fresh fish, while it was ΣPUFA<ΣSFA<ΣMUFA in salted one (Table 2).

In P. polyactis, there were n-3 (fresh 30.26, salted 29.62), n-6 (fresh 3.88, salted 6.09) and n-3/n-6 (fresh 7.80, salted 4.86); in A. fallax lacustris, there were n-3 (fresh 25.98, salted 26.50), n-6 (fresh 8.82, salted 8.58) and n-3/n-6 (fresh 2.95, salted 3.09); in Lakerda, there were n-3 (fresh 30.81, salted 26.89), n-6 (fresh 9.14, salted 9.49) and n-3/n-6 (fresh 3.38, salted 2.83); in T. thynnus L., there were n-3 (fresh 33.02, salted 32.73), n-6 (fresh 3.89, salted 3.89) and n-3/n-6 (fresh 8.48, salted 8.41) and in Golden Mullet, n-3 was 6.62 in fresh fish and 14.57 in salted one (Cai et al., 2017; Garaffo et al., 2011; Hedayatifard & YOUSEFIAN, 2010; Moretti et al., 2016; Ormanci et al., 2015). In our study, in total fatty acids, n-3 was (fresh 30.18, salted 27.51) in males, (fresh 34.10, salted 27.85) in females, n-6 was (6.85 fresh, salted 5.97) in males, (fresh 7.15, salted 6.30) in females and n-3/n-6 ratio was (4.41 fresh, salted 4.61) in males, (4.77 fresh, salted 4.42) in females. Our n-3/n-6 ratio was lower than that of P. polyactis and T. thynnus L. and higher than A. fallax lacustris and Lakerda fish. In Baikal omul fish, n-3 was (fresh 28.9, salted 26.7), n-6 was (fresh 11.4, salted 11.6) and n-3/n-6 was (fresh and salted 2.3; Nikiforova et al., 2019). The ratio of n-3 fatty acids in muscles was found to be higher than that of n-6 fatty acids in male and female individuals of zander fish. Fatty acids ratio and fatty acid classes (ΣSFA, ΣPUFA, ΣMUFA, n-3 and n-6) did not show much difference between genders (Uysal & Aksoylar, 2005). Similarly, in our analyses, a similar distribution was found between males and females. The n-3/n-6 ratio in Pearl Mullet was found to be 3.70 (Balikçik Misir et al., 2013) and 4.0 (Kizmaz et al., 2021). This ratio was determined as 3.15 in Liza carinata, a mullet species collected from the Mediterranean (Küçükgülmez et al., 2011) and 8.22 in Mugil cephalus (Özogul & Özogul, 2007). In our study, average ratio in male fish was (fresh 4.33, salted 3.95) and in female was (fresh 4.36, salted 4.16).

In order to understand the changes in the fat content of the muscle and to determine the nutritional value of the fish, it is necessary to reveal the fatty acid composition of the PL and TAG fractions, which are the main lipid classes (Shirai et al., 2002). In muscle PL analysis of four fish species, 16:0 was 11.8–15.1%, 18:0 was 8.5–10.7%, 18:1 was 5.9–10.7%, 16:1 n-7 was 2.2–3.1%, 18:2 n-6 was 2.8–6.4%, 18:3 n-3 was 2.8–3.5%, 20:4 n-6 was 5.7–10.6%, 20:5 n-3 was 3.0–4.5%, 22:6 n-3 was 9.6–16.1%; in C. cattia fish, 16:0 was 54.5%, 18:0 was 5.4%, 18:1 was 3.7%, 16:1 was 1.5%, 18:2 n-6 was 1.0%, 18:3 was 0.4%, 20:4 n-6 was 2.8%, 20:5 n-3 was 2.0%, and 22:6 n-3 was 6.4% (Ackman 2002). Values of major components in muscle PL lipid in Vimba vimba were as follows: 16:0 was 17.85%, 18:0 was 10.74%, total SFA was 33.70%, 16:1 n-7 was 3.23%, 18:1 n-9 was 11.12%, total MUFA was 18.55%, 18:2 n-6 was 1.28%, 18:3 n-3 was 0.60%, 20:4 n-6 was 12.11%, 20:5 n-3 was 7.12%, 22:6 n-3 was 17.37%, total PUFA was 47.16%, total n-3 PUFA was 29.55%, total n-6 PUFA was 17.61%, n-3/n-6 was 1.68% (Görgün et al., 2013). Among the tissues examined in V. vimba fish, the highest n-3/n-6 ratio was determined as 1.68 in muscle PL (Kalyoncu et al., 2009). 16:0 (7.41%) and 22:6 n-3 (12.36%) were higher in salted fish for Baikal omul, while 18:0 (24.42%) and 18:1 n-9 (32.91%) was found to be lower. They determined as ΣPUFA>ΣSFA>ΣMUFA in both fresh and salted fish. n-3 was (fresh 32.5, salted 37.7), n-6 was (fresh 9, salted 8.6), and n-3/n-6 was (fresh 3.61, salted 4.38; Nikiforova et al., 2019). In our study, out of phospholipids, 14:0 was 377.02%, 16:1 n-7 was 200.76%, 18:1 n-9 was 95.37%, and 18:2 n-6 was 63.64% higher in salted fish compared to fresh fish. It was observed that 20:4 n-6 decreased 191.82%, 20:5 n-3 decreased 45.89%, 22:6 n-3 decreased 158.88%, n-3 decreased 108.11%, and n-6 decreased 61.15% in the salted fish. Out of PL in both salted and fresh fish, the order was ΣPUFA>ΣSFA>ΣMUFA in fresh fish, and it was ΣSFA>ΣSA>ΣPUFA in salted one (Table 1). SFA (fresh 32.11, salted 31.17) and ΣPUFA (47.52 fresh) were also found in PL with the highest percentage. In terms of ΣMUFA, the percentage of phospholipids in fresh fish was determined to be the lowest with (20.38%). In terms of 20:4 n-6 in phospholipid, while it was 191.82% higher in fresh fish compared to salted one, it was similar and lower in total and triacylglycerol distribution in salted fish (Table 1). Furthermore, it was observed that the percentage of total and
triaclylglycerol in 20:4 n-6 and 22:6 n-3 in phospholipids was higher. In terms of omega-3, phospholipids were found to be 108.11% higher in fresh fish than in salted one. Although the distribution in individual fatty acids fluctuated, the n-3/n-6 ratio showed a similar distribution. When the fatty acid distributions in phospholipids were considered in females, it was determined that 14:0 was 189.14%, 16:1 n-7 was 117%, 18:1 n-9 was 54.28%, ΣMUFA was 66.89% higher in the salted fish than the fresh one. When considered in terms of polyunsaturated fatty acids, 20:4 n-6 (116.91%), 22:5 n-3 (52.39%), 22:6 n-3 (74.01%), ΣPUFA (54.96%), n-3 (54.42%), n-6 (57.17%) were lower as a percentage in the salted fish compared to fresh one. While the order was ΣMUFA<ΣSFA<ΣPUFA in fresh fish, it was ΣPUFA<ΣSFA<ΣMUFA in salted one. In terms of omega-3/n-6, it showed a similar distribution with the male individual (Table 2).

In the neutral lipid of Petromyzon marinus, a marine fish species, ΣMUFA was the most, followed by ΣSFA, and ΣPUFA the least. Based on this, it was determined that fish species mainly accumulate ΣSFA and ΣMUFA as storage lipids (Pinella et al., 2009). The amount of ΣPUFA was found to be high in the neutral lipid of three trout species. 18:2 n-6 was dominant in total and neutral lipids of fish (Bayir et al., 2010). The n-3/n-6 ratio in TAGs of freshwater fish is higher than that of marine fish and ranges from 1 to 3 (Steffens & Wirth, 2005). Total SFA was (31.59%–40.07%), total MUFA was (30.17–44.62%), and total PUFA was (18.38–31.86%) in muscle TAG content of five fish species (Squaliobarbus curriculus, Erythroculter ilishaeformis, Pseudobagrus fulvidraco, Bostrichthys sinensis, and Siniperca kneri Garman) collected from Lake Poyand, China's largest freshwater lake. 160, which was the major one in ΣSFA was determined in the range of 16.29–21.10%. Total MUFA was found to be 29.34% in S. kneri garman and 43.9% in S. curriculus. The most abundant component was 18:1 n-9. It has been suggested that the ratios of 18:2 n-6 (9.18%) and 18:3 n-3 (5.77%) are higher in B. sinensis than those in the other fish species. 20:5 n-3 (3.26%) and 22:6 n-3 (6.01%) were detected most in E. ilishaeformis, while 20:4 n-6 (5.51%) was detected most in S. kneri garman. In the analyzed fish, n-6 was 8.78%—17.54%, and n-3 was determined as 9.59%—13.59% (Lei et al., 2012).

Values of major components in muscle neutral lipid in V. vimba were as follows; 16:0 was 20.31%, 18:0 was 2.60%, total SFA was 27.90%, 16:1 n-7 was 15.70%, 18:1 n-9 was 30.56%, total MUFA was 52.82%, 18:2 n-6 was 2.85%, 18:3 n-3 was 1.23%, 20:4 n-6 was 3.24%, 20:5 n-3 was 4.65%, 22:6 n-3 was 3.5%, total PUFA was 19.24%, total n-3 PUFA was 11.73%, total n-6 PUFA was 7.50%, n-3/n-6 was 1.56% (Görgün et al., 2013). They found that percentages of 16:0 (17.45%), 18:1 n-9 (27.62%), ΣSFA (15.49%) and ΣMUFA (6.94%) were lower in salted Baikal omul. It was also stated that ΣPUFA was 12.92% higher in the salted fish than in the fresh one. It was reported that the other fatty acids were similar and close to each other. They found that while the order of fatty acids was ΣSFA>ΣMUFA>ΣPUFA in fresh fish, it was ΣPUFA>ΣMUFA>ΣSFA in salted one. N-3 was (20.1, 27.4 salted), n-6 was (11.4 fresh, 10.7 salted), and n-3/n-6 was (1.76 fresh, 2.56 salted; Nikiforova et al., 2019). When the TAG fatty acid distribution was considered in our study, it was determined that 18:3 n-3 was 830% lower in salted fish compared to fresh one. When the other fatty acid distribution was studied, it was observed that there was no difference. When the fatty acid distribution in TAG was investigated in both salted and fresh fish, it was determined that the order was ΣSFA<ΣMUFA<ΣPUFA (Table 1). Although the distribution in individual fatty acids fluctuated, the n-3/n-6 ratio showed a similar distribution. When the triacylglycerol distribution in females was explored, it was found that the percentage of 18:3 n-3 was 700% lower in salted fish than in fresh one. The other distributions were similar. The distribution was ΣMUFA<ΣPUFA<ΣSFA in both fresh and salted fish (Table 2).

The percentage of n-3 (18.63) in phospholipid in salted fish was lower than total (27.51) and triacylglycerol (21.60). Although the distribution in individual fatty acids fluctuated, the omega-3/omega-6 (n-3/n-6) ratio showed a similar distribution (Table 1).

DHA and AA are precursors of many bioactive lipid mediators which are actively involved in the regulatory responses and resolution of inflammation. Especially in the brain, DHA is involved in neuronal growth, neuronal migration, synaptogenesis, synaptic plasticity and gene expression. Regarding synaptic
function, studies on mice indicate that dietary AA has positive impacts on cognition and synaptic plasticity in aging animals. Especially in recent years, important studies have been carried out in understanding the cellular and molecular mechanisms underlying the neuroprotective effect of DHA and AA in the extreme stages of life (Sambra et al., 2021). In another study, it was reported that EPA and DHA have beneficial effects in many diseases, including cardiovascular disease, metabolic syndrome and chronic inflammatory diseases, as well as brain and liver protection. Especially in studies on respiratory diseases, it was reported that n-3 PUFA in fish oil alleviates allergic asthma. It was stated that this effect is due to the higher content of n-3 PUFA in erythrocytes. From the point of view of N-3 PUFA, it was shown that it is an interesting approach in terms of chronic obstructive pulmonary disease (COPD) and Asthma treatments (Zúñiga-Hernández et al., 2022). It is rich in AA, EPA, and DHA values in our study, indicating the importance of this fish.

It has been shown that the n-6/n-3 ratio in the foods should be 3/1. However, in modern diets, this ratio is expressed as 15/1. A study on biopsy specimens, especially in fatty liver patients (NAFLD), indicated that the n-6/n-3 ratio was significantly correlated with the TAG content of the liver. In a study on rats, it was reported that liver damage was prevented as a result of feeding a diet rich in fish oil (Valenzuela et al., 2020). In our research data, it can be seen that it should be consumed in terms of health, since n-6/n-3 is parallel to the rate that should be taken with the diet.

4. Conclusions
Consumption of fish and fish derivatives is recommended by health authorities, not only because of its high-quality protein content, but also because it is a source of fatty acids that are shown to be extremely beneficial for human health (Garaffo et al., 2011). It has been shown that especially the n-3/n-6 fatty acid distributions in fish are useful for comparing nutritional values. World Health Organization (WHO) states that the daily n-3/n-6 ratio should not be less than 1:5 in a balanced diet (Ormanci et al., 2015). The n-3/n-6 ratio in pearl mullet is within the recommended values, which is important in terms of nutrition. In addition to this value, it is stated that EPA + DHA in a balanced diet is 0.65 g/100 g for daily nutrition. In our study, this value was determined at a similar rate. In this regard, pearl mullet seems to be a valuable food in terms of EPA+DHA intake. Hence, the results obtained in this study can benefit researchers who study the nutritional value of fish, the fishing industry, nutritionists.

Funding
The author received no direct funding for this research.

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Disclosure statement
No potential conflict of interest was reported by the author(s).

Citation information
Cite this article as: Analysis of lipid classes and the fatty acid composition of fresh and the salted fish, Alburnus tarichi, Veysi Kizmaz, Cogent Food & Agriculture (2022), 8: 2126052.

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