International Journal of Life Sciences and Biotechnology
Bozkurt, et al., Determination of Fatty Acid Composition of *Silurus triostegus* Heckel, 1843 and *Arabibarbus grypus* (Heckel, 1843) Species Living in Ilısu Dam Lake (Batman/TÜRKİYE). International Journal of Life Sciences and Biotechnology, 2024 7(2): p. 74-79
https://doi.org/10.38001/ijlsb.1415281
Araştırma Makale/ Research article

Determination of Fatty Acid Composition of *Silurus triostegus* Heckel, 1843 and *Arabibarbus grypus* (Heckel, 1843) Species Living in Ilısu Dam Lake (Batman/TÜRKİYE)

Ramazan Bozkurt[1], Arslan Yusuf Yüksel[2], Muhammed Yaşar Dörtbudak[3], Arif Parmaksiz[4*]

ABSTRACT
In this study, fatty acid compounds in the muscle tissues of the economically important Mesopotamian catfish (*Silurus triostegus*, Heckel, 1843) and Shabut (*Arabibarbus grypus*, (Heckel, 1843)), which live in the Ilısu Dam Lake on the Tigris River, were investigated. For fatty acid analysis, muscle tissues were taken from the samples obtained from local fishermen, placed in tubes and lipids were obtained by applying chloroform/methanol method. The methylation steps of fatty acids in the samples were performed in accordance with TS EN ISO 12966:2 (TS EN ISO 12966-2., 2017) method. The total fatty acid content of saturated fatty acids (SFA) value was detected as 27,97 ± 0,26 in *A. grypus*, 32.46 ± 0.37 in *S. triostegus*, The value of Monounsaturated Fatty Acids (MUFA) varied between 42.63 ± 0.6% in *A. grypus* and 41.5 ± 0.51% in *S. triostegus*. Total polyunsaturated polyunsaturated acids (PUFA) ranged between 21.83 ± 1.49 for *A. grypus* and 25.82 ± 1.94 for *S. triostegus*. MUFA values in all samples were higher than SFA and PUFA values for both fish species. Docosa Hexaenoic Acid (DHA) and Eicosa Pentaenoic Acid (EPA) are commonly consumed omega-3 types. *A. grypus* and *S. triostegus* are within the recommended limits for EPA (C20:5n3) and DHA (C22:6n3). For *A. grypus*, ω3/ω6 values were (1,06); for *S. triostegus* ω3/ω6 values were (1.38). When the ω3/ω6 values of both fish species were analysed for human health, it was determined that the ω3/ω6 values of omega fatty acids *A. grypus* and *S. triostegus* were above 1. As a result information on the composition of 20 types of fatty acids and ω3/ω6 amounts were obtained in muscle tissue of *A. grypus* and *S. triostegus* species living in Ilısu Dam Lake and most preferred by local people. The levels of fat and its components in these species, which may cause different problems when accumulated in the body as a result of changing consumption habits, were indicated in the study.

ARTICLE HISTORY
Received
5 January 2024
Accepted
20 February 2024

KEYWORDS
Fatty acid composition,
Arabibarbus grypus,
Silurus triostegus,
Ilısu dam lake,
MUFA,
PUFA,
ω3/ω6

Introduction

The rapid increase in the world population leads to a continuous increase in food demand [1]. While terrestrial resources are insufficient with this increase, fish foods play an important role as an alternative food source [1]. With their high nutritional quality, fish are becoming an integral part of the human diet. Especially in developing countries, fisheries and aquaculture play a critical role in providing both food and income [1,2,3]. Fish is one of the most natural sources of protein, fatty acids, vitamins and minerals, which are essential components for the healthy growth and functioning of the body metabolism [4].
Omega-3 (ω-3) fatty acids are one of the important nutrients that should be taken into the body for a healthy life and protection against diseases. These are fatty acids that are essential for the body and cannot be produced in the human body. Therefore, fish is important to get omega-3 fatty acids [5]. However,

[1] Harran University, Organized Industrial Zone Vocational School, Food Processing Department, 63100,Şanlıurfa, Türkiye
[2] Harran Unıversıty, Bozova Vocational School, Department of Fisheries and Aquaculture, 63850,Şanlıurfa, Türkiye
[3]Harran University, Faculty of Veterinary Medicine, Department of Fisheries and Diseases, 63200 Şanlıurfa, Türkiye
[4] Harran University, Faculty of Science-Literature, Department of Biology, 63100,Şanlıurfa, Türkiye
*Corresponding Author: Arif PARMAKSIZ e-mail: aprmksz@gmail.com

preferences and changes in dietary habits have increased the imbalance in the ratio of omega-6 to omega-3, especially by increasing the consumption of omega-6 fatty acids and decreasing the consumption of omega-3 [6]. Within the scope of the Southeastern Anatolia Project, a series of dams and hydroelectric power plants were built on the Tigris and Euphrates Rivers. Ilısu Dam is a part of Turkey's Southeastern Anatolia Project (GAP) and is a dam located on the Tigris River. There are many fish species in the Tigris River and the Ilısu Dam Lake built on it. It is located in the main river bed, 65 km above the border of Syria and Iraq. Among these species are Mesopotamian Catfish (*Silurus triostegus*) and Shabut (*Arabibarbus grypus*), which have high economic value and are frequently fishing by fishermen. Since these species are found in the Tigris and Euphrates basins, they contribute significantly to the local economy [7]. These two species belong to the Cyprinidae family and live in the Euphrates and Tigris river systems [8].

Fish play an important role in the human diet and nutrients, especially omega-3 fatty acids from seafood, are vital for our health. However, changes in dietary habits can lead to health problems by increasing the imbalance in the ratio of omega-6 to omega-3. Therefore, a more detailed evaluation of the nutritional quality of fish is needed, especially for species living in regions such as the Tigris River and Ilısu Dam Lake. Such research may help people to maintain a healthier and more balanced diet. In this study, it was aimed to determine the nutritional value in terms of fatty acid content by taking muscle samples of *S. triostegus* and *A. grypus* species living in Ilısu Dam Lake, fishing and trading by fishermen.

Material and Methods

The fish samples in the study were purchased by fishermen from fishermen fishing at the Ilisu Dam (Tigris) in February 2022. The fish caught were *A. grypus* (Shabut) and *S. triostegus* (Mesopotamian spring). Fish were taken randomly.

Material

The fish in the study were caught at the Ilısu Dam (Tigris) in February 2022 and purchased from fishermen in Hasankeyf (Batman). *A. grypus and S. triostegus* fishes in the study are economically important species that are consumed by the local people. Fish samples were selected randomly. For fatty acid analysis of the fish samples, muscle tissues were taken from each of the fish samples and placed in tubes.

Methods

Analysis of fatty acids

The lipids of each fish sample were extracted with chloroform/methanol (2:1 v/v) according to the method [9]. The methylation steps of fatty acids in the samples were carried out in accordance with the method of TS EN ISO 12966:2 [10]. For the analysis of fish samples, 100 mg of oil sample was weighed in a 10 ml screw cap test tube. Approximately 2 ml of isooctane and 100 µl of 0.2 M methanolic KOH solution were added. The solutions in the tubes were mixed using a vortex device. Mixing of the solutions in the tubes took 1 minute. 2 ml of 40% NaCl solution was added to the test tube and mixed with vortex again. The isooctane phase in the study was placed in a flask. Then approximately 1 g of sodium hydrogen sulphate was added and shaken and stirred. After a period of approximately 30 minutes, approximately 1 µL of the sample was taken from the top and syringed into gas chromatography (GC) kits.

Gas chromatography

After the necessary laboratory procedures, the samples taken from the dorsal muscles of the fish were syringed into the GC (Thermo type Trace GC form Gas Cromatography) device for analysis. The fatty acids in the fish samples were analysed by Thermo type Trace GC model with FID sensor. A 60 m HP-88 capillary column was used to analyse the samples. The sensor and injection block temperatures were regulated at 280 °C and 250 °C. The column was subjected to alternating temperatures. Firstly, it was kept at a temperature of 50 ºC for about 2 minutes. Then it was increased to 180 ºC with an increase of 20 ºC/min. It was then immediately increased to 230 ºC with an increase of 5 ºC/min. This temperature programme was maintained for approximately 5,5 min. The amount of syringing (injection) in the experiment was 1 µL and the division scale was programmed as 1/50.

Analysing the data

Twenty types of fatty acids were analysed in Ilısu Dam Lake. In the calculations made in the studies, "mean ± standard error" values are used only to determine certain characteristics of a group (such as age, height, length, weight); if it is desired to learn the difference in a relationship between different groups, the "mean ± standard error" form of calculation of the values obtained becomes more meaningful [11]. The data obtained from the study were transferred to the table as the mean ± standard error of the gas chromatographic assay data in the form of percentage area (%). The determination of the differences between the data between the

fish groups was determined by statistical evaluation (One-Way ANOVA- SPSS) at significance levels of $p<0,05$ according to the significance level of 0,05 (Table 2).

Table 1 Mean weight (g)±SD and mean length (mm)±SD values of the two fish species examined in the study (SE: Standart Error).

Species	**Species name**	**Number of samples**	**Mean weight (g) ± SE**	**Average standard length (cm)± SE**
Shabut	*A. grypus*	12	520.67± 367	420±95,54
Mesopotamian catfish	*S. triostegus*	12	605.17±436.62	472.31±135

Results

Fish meat, which has an important place in the human diet, is a good source of fatty acids. Fatty acid composition of fish may vary depending on many reasons such as fish species and geographical conditions. In this study, fatty acid types and ratios of the two fish species living in Ilısu Dam Lake and consumed most by people were determined and shown in (Table 2).

In terms of total fatty acids in the fish samples, the fatty acid ratio in S. triostegus (Catfish) species (99.78 %) was higher than *A. grypus* (Shabut) species (92.43 %). When A. grypus iω3/ω6 ratios in Ilısu Dam Lake and Atatürk Dam Lake [12]. Were compared, they were between 2.4± 0.1 - 4.8± 0.1. Since Ilısu Dam Lake has just started to fill up, these values were found to be low. When the proportional amounts of lipid values in fish are compared with each other, ω-3/ω-6 ratio is preferred. The ω-3/ω-6 ratios of fatty acids in fish vary between 1-5. Considering the WHO/FAO recommendation, the most realistic diet and ω3/ω6 ratio should be 5:1 or slightly less [12,13]. SFA, MUFA and PUFA fatty acid values (%) of *A. grypus* are shown in (Figure 1).

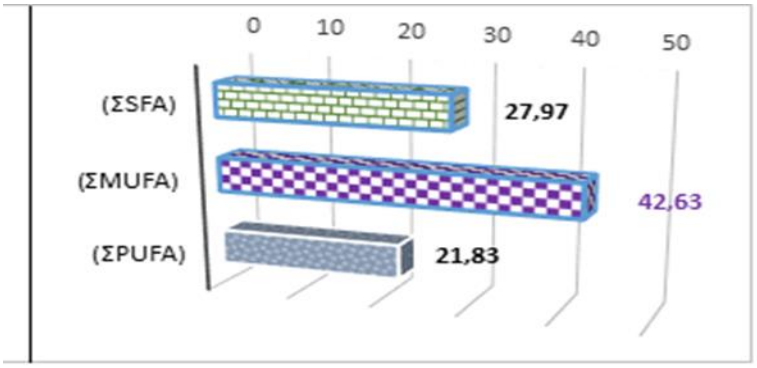

Fig 1 Total fatty acid values of *A. grypus* (%)

When total fatty acid values of *A. grypus* were analysed, the highest value was found in total MUFAs (42,63 %) and the lowest value was found in total PUFAs (21,83 %). SFA, MUFA and PUFA fatty acid values (%) of *S. triostegus* are given in (Figure 2).

When the total fatty acid values of *S.triostegus* were analysed in Figure 2, the highest value was recorded as total MUFA (41,5 %) and the lowest value was recorded as total PUFA (25,82 %). For fish samples, monounsaturated fatty acids (MUFA) were the highest fatty acid group in all samples analysed, followed by saturated fatty acids (SFA) and polyunsaturated fatty acids (PUFA). It is that people's own bodies cannot produce and must obtain from outside Omega-3 fatty acids in the form of alpha-linolenic acid (C18:3n3; ALA), eicosapentaenoic acid (C20:5n3; EPA) and docosahexaenoic acid (C22:6n3; DHA) are called essential or basic fatty acids (TYAs). ALA (C18:3n3), one of the Omega-3 fatty acids taken from outside with food, is then converted into EPA and DHA by our body [15]. It is beneficial for people to consume Omega-3 oils in order to lead a healthier life. Vigorous and adult people can get at least 0.5-1 g of omega-3 per day by consuming fish at least twice a week [16]. Total saturated fatty acid (ΣSFA) values in *A. grypus*

(Shabut) were found to be 27.97 ± 0.26 in our study in the Ilısu Dam Lake. These data were found as 31.07±0.70 in Atatürk Dam Lake [17].

Table 2 Fatty acid ratios (%) in muscle tissues of *A. grypus* and *S. triostegus* individuals*

Fatty Acids	***A. grypus, Mean ± S.E***	***S. triostegus, Mean ± S.E***
(C12:0) Lauric Acid	0,16 ± 0,1[a]	0,44 ± 0,13[a]
(C14:0) Myristic Acid	2,35 ± 0,46[a]	2,11 ± 0,21[a]
(C15:0) Pentadecanoic Acid	0,35 ± 0,4[a]	0,67 ± 0,06[b]
(C16:0) Palmitic Acid	19,61 ± 0,59 [a]	20,21 ± 1,36[b]
(C17:0) Heptadecanoic Acid	0,47 ± 0,51[a]	0,82 ± 0,10[b]
(C18:0) Stearic Acid	4,29 ± 0,74[a]	7,05 ± 0,37[b]
(C20:0) Arachidic Acid	0,39 ± 0,2[a]	0,5 ± 0,07[b]
(C22:0) Behenic Acid	0,35 ± 0,21[a]	0,66 ± 0,09[b]
Total Saturated Fatty Acid (ΣSFA)**	27,97 ± 0,26	32,46 ± 0,37
(C14:1) Myristoleic Acid	0,23 ± 0,16[a]	0,31 ± 0,06[b]
(C16:1) Palmitoleic Acid	5,29 ± 0,93[a]	6,69 ± 0,74[b]
(C17:1) cis-10-Heptadecenoic Acid	0,5 ± 0,64[a]	0,73 ± 0,06[b]
(C18:1n9c) Oleic Acid	35,5 ± 0,94[a]	32,1 ± 1,26[b]
(C20:1n9) cis-11-Eicosenoic Acid	0,76 ± 0,34[a]	0,9 ± 0,08[a]
(C24:1n9 Nervonic Acid)	0,35 ± 0,43[a]	0,77 ± 0,06[b]
Total Monounsaturated Fatty Acid (ΣMUFA)**	**42,63 ± 0,6**	41,5 ± **0,51**
(C18:3n3) A-Linolenic Acid	3,01 ± 0,79[a]	4,27 ± 1,01[b]
(C20:5n3) cis-5,8,11,14,17-Eicosapentaenoic Acid (EPA)	2,37 ± 0,7[a]	3,24 ± 0,26[b]
(C22:6n3) cis-4,7,10,13,16,19-Docosahexaenoic Acid (DHA)	5,85 ± 1,42[a]	7,42 ± 0,71[b]
Σ ω-3	**11,23** ± 1,13	**14,93** ± 1,31
(C18:2n6c) Linoleic Acid	8,15 ± 0,7[a]	7,01 ± 0,83[b]
(C20:2) cis-11,14-Eicosadienoic Acid	0,25 ± 0,14[a]	0,37 ± 0,50[b]
(C20:4n6) Arachidonic Acid	2,2 ± 0,85[a]	3,51 ± 0,23[b]
Σ ω-6	10,6 ± 0,57[a]	10,89 ± 0,37[a]
Total Polyunsaturated Fatty Acid (ΣPUFA)**	21,83 ± 1,50	25,82 ± 1,95
ω-3/ω-6	1,06	1,38
EPA+ DHA	8,22	10,66
PUFA/SFA	**0,79**	0,80
Σ Fatty Acid	92,43	99,78

* The data identified with the same letters in each row are not different from each other at the P>0.05 probability level.
** (ΣSFA): Total Saturated Fatty Acid; ΣMUFA: Total Monounsaturated Fatty Acid; ΣPUFA: Total Polyunsaturated Fatty Acid

Total monounsaturated fatty acids (ΣMUFA) data in *S. triostegus* were found as 32.46 ± 0.37. These data were found as 21,86 in Tigris River [17].The total monounsaturated fatty acid (ΣMUFA) data of *A. grypus* and *S. triostegus* were 42.63 + 0.6 and 41.5 + 0.51, respectively. In this study in Ilısu Reservoir, total monounsaturated was detected in *A. grypus* and *S. triostegus*. The total monounsaturated fatty acids (ΣMUFA) data for *A. grypus* (Shabut) were 42.63 + 0.6 and 41.5 + 0.51 for *S. triostegus*. The ΣMUFA values for *A. grypus* were found to be 39.96±0.18 in Atatürk Reservoir [17]. In another study in Ataturk Reservoir, it was found between 35.2±0.2 - 44.2±0.0, The (ΣMUFA) values in *S. triostegus* were 41.5 ± 0.51. [12]. In a study in Tigris River, they found between 37 - 38.71 [18]; in a study in Atatürk Dam Lake, they found between 23.01 ± 1.2 - 37.21 ± 1.43 [7].

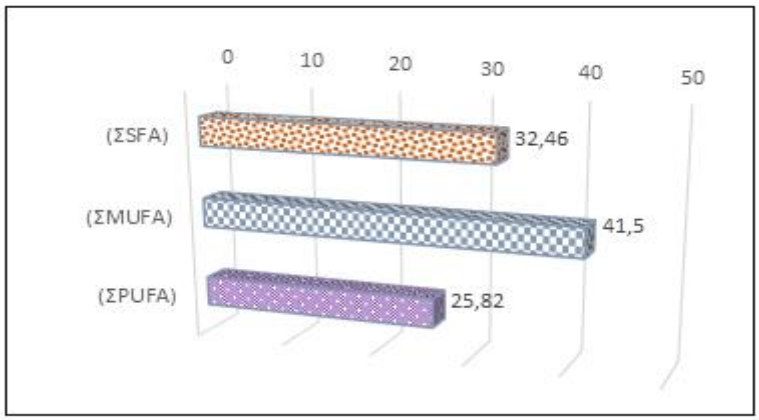

Fig 2 Total fatty acid values (%) of *S. triostegus*

The Σ PUFA values of polyunsaturated fatty acids were determined as 21.83 ± 1.50 for *A. grypus* and 25.82 ± 1.95 for *S. triostegus*, respectively. Σ PUFA values for *A. grypus* were found as 28,85 ± 0,68 in Atatürk Dam Lake [7]. Σ PUFA data for *S. triostegus* were found as 16, 94 in Tigris River [19].

Conclusion and Discussion

In the study, total monounsaturated fatty acids (MUFA) values in the muscle tissues of both fish samples were the highest. These fatty acids were followed by saturated (SFA) and polyunsaturated fatty acids (PUFA) values, respectively. The EPA value (C20:5n3) in *A. grypus* was 2.37 ± 0.7 and 3.24 ± 0.26 in *S. triostegus*. The DHA value (C22:6n3) in *A. grypus* was 5.85 ± 1.42 and 7.42 ± 0.71 in *S. triostegus*.
Oleic acid values in both fish (C18:1n9c) were the highest (*A. grypus*: 35,5 ± 0,94; *S. triostegus* 32,1 ± 1,26). The highest values (C16:0) of palmitic acid (*A. grypus*: 19,61 ± 0,59; *S. triostegus* 20,21 ± 1,36) followed the Oleic acid data in *A. grypus* and *S. triostegus* species. PUFA/SFA ratios were 0.79 for *A. grypus* and 0.80 for *S. triostegus.*
Total Σ ω3 values were 11.23 ± 1.13 in *A. grypus*, 14.93 ± 1.31 in *S. triostegus*; Σ ω6 values were 10.6 ± 0.57 (*A. grypus*), 10.89 ± 0.37 (*S. triostegus*). Total fatty acids (Σ Fatty Acid) values in the samples were 2.43 in *A. grypus* and 99.78 in *S. triostegus*. The ω3/ω6 values were 1,06 in *A. grypus* and 1,38 in *S. triostegus*. In terms of ω3/ω6, *A. grypus* and *S. triostegus* were 1.06 and 1.38, respectively. When the ω3/ω6 data of both fishes were analysed, it was seen that *S. triostegus* Omega-3 fatty acid ratio was slightly higher than *A. grypus*. Although the ratio of ω3/ω6 Omega-3 fatty acids in both samples was slightly above 1, both fish (*A. grypus* and *S. triostegus*) species can be recommended as an important food source for human nutrition.
The DHA and EPA amounts of both species in this study in Ilısu Dam Lake were found to be close to each other. The amount of PUFA in S. triostegus was higher than *A. grypus.* According to these results, S.triostegus is a better source of Omega-3 than *A. grypus* species in terms of ω3. Polyunsaturated fatty acids (PUFA) constitute the ω3 sources of seafood and especially fish. Although the amounts of alpha-linolenic acid (ALA), eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) in this group vary among fish species, they are still the most important sources of human nutrition. Alpha-linolenic acid (ALA) is a plant-based essential omega-3 source that should be consumed with food. In addition, EPA and DHA, which humans cannot synthesise, are easier to meet from fish. Omega-3, which the body cannot get enough and has many health benefits, should be taken in sufficient amounts in the form of some plants, fish, some algae varieties and fish oils [20,21,22].
As a result of this study, information on the composition of 20 types of fatty acids and ω3/ω6 amounts of *Arabibarbus grypus* and *Silurus triostegus*, which live in Ilısu Reservoir and are consumed in the region, were determined.

Funding
The author did not receive support from any organization for the submitted work.

Data Availability statement
The author confirms that the data supporting this study are cited in the article.

Compliance with ethical standards

Conflict of interest / Çıkar çatışması
The author declare no conflict of interest.

Ethical standards
The study is proper with ethical standards.

Authors' contributions
During the study, The formulation of the idea or hypothesis for the manuscript, the supervision and responsibility for the organisation and progress of the manuscript was carried out by Ramazan Bozkurt, the organisation and reporting of the data by Arif Parmaksız, the explanation and presentation of the findings by Muhammed Yaşar Dörtbudak, the drafting of the manuscript by Arslan Yusuf Yüksel and the evaluation of the manuscript before submission not only in terms of spelling and grammar but also in terms of intellectual content by all authors.

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