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The Chemical Composition of the Lionfish (*Pterois miles*, Bennett 1828), the New Invasive Species of the Mediterranean Sea

Deniz Ayas[1*], Gulsemin Sen Agılkaya[1], Ali Rıza Kosker[2], Mustafa Durmus[2], Yılmaz Ucar[2], Mısra Bakan[1]

[1]Faculty of Fisheries, Mersin University, Mersin, Turkey
[2]Faculty of Fisheries, Çukurova University, Adana, Turkey

Abstract

In this study, the proximate composition of muscle tissue was investigated in lion fish (*P. miles*), which has a high invasion potency in the Mediterranean. At the same time, the potentials of accumulation of essential and toxic metals in brain, gill, muscle and liver tissues have been examined. The study was carried out with 4 lion fish individuals (1st individual 278 g, 28 cm, 2nd individual 55 g, 19 cm, 3rd individual 68 g, 20 cm, 4th individual 92 g, 22 cm) caught from the Yeşilovacık Bay in 2016. Water, crude protein, total lipid, total mineral substance (TMS) percentages were found to be 75.68-77.62%, 20.05-21.08%, 1.11-1.84%, 1.22-1.54 in *P. miles*, respectively. The percentage of fatty acids in lionfish ranged from 34.26% to 37.57% saturated fatty acids (SFAs), from 24.99% to 27.99 % monounsaturated fatty acids (MUFAs), and from 20.49% to 49.31% polyunsaturated fatty acids (PUFAs). Dominant fatty acids are palmitic acid and stearic acid from SFAs, palmitoleic acid, oleic acid, cetoleic acid from MUFAs, EPA and DHA from PUFAs. The accumulation levels of heavy metals in the tissues were found as Fe> Zn> As> Cu> Cr> Pb, respectively. The accumulation levels of each metal in the tissues were determined as follows: liver>gill>brain>muscle (29.19-384.43 µg g^{-1}dw) for Fe, gill>brain>liver>muscle (16.08-56.68 µg g^{-1}dw) for Zn, muscle>brain>gill>liver (2.69-7.88 µg g^{-1}dw) for As, liver> brain>gill>muscle (0.74-7.05 µg g^{-1}dw) for Cu, brain>gill>muscle>liver (0.35-2.67 µg g^{-1}dw) for Cr, brain>gill>muscle>liver (0.26-2.11 µg g^{-1}dw) for Pb. As a result; while lionfish muscle tissue contains high levels of protein, unsaturated fatty acids, minerals and trace elements, it has been determined that levels of heavy metals in this consumable tissue are not at levels that could threaten human health.

Keywords:

Mersin Bay, *Pterois miles*, Lionfish, Chemical Composition

Article history:

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[*] *Corresponding Author: Deniz Ayas, e-mail: ayasdeniz@mersin.edu.tr*

Introduction

After the opening of the Suez Canal, the Mediterranean Sea has been heavily exposed to Indo-Pacific species for a long time (Zenetos et al., 2012; Katsanevakis et al. 2014). With the impact of climate change, the ever-increasing sea water temperature in the Mediterranean Sea leads to the transition of tropical marine species to the Mediterranean Sea, the establishment of populations and the expansion of their distribution: Tropicalisation of the Mediterranean Sea (Kletou & Hall-Spencer 2012; Lejeusne et al. 2010; Montefalcone et al. 2015). One of the last species of this tropic process is the lion fish that recently passed to the Mediterranean Sea. *P. miles* is currently among the most successful marine invaders on the history of underwater invasions (Bariche et al., 2013). The entry of this species into the Mediterranean Sea has posed a potential threat to local species. *P. miles* has recently started to be seen in the Mediterranean Sea (Golani & Sonini, 1992; Bariche et al., 2013; Evripidou, 2013; Turan & Öztürk, 2015; Kletou et al., 2016), which increases the concern that this species will affect the structure and function of local ecosystems in a negative way.

Lion fish is hunter-predator species fed with small fishes, invertebrates and crustaceans. Lion fish is a venomous species that transmit their poison to a victim with a needle (Gallagher, 2001) and, they do not have poisonous in their tissues such as balloon fishes (Mosher & Fuhrmann, 1984). For this reason, its consumption is suitable for human nutrition. Johnston & Purkis (2014) stated that the occupation pressure from the Red Sea in the Mediterranean Sea was clearly high. While this species is a risk for other species in the Mediterranean Sea, it can be considered as an opportunity because of the consumption as human food. For this purpose, lion fish hunting is encouraged and its flesh is consumed in many countries to prevent damage created in the ecosystem (Gallagher, 2013; Lund, 2015; Morris, 2012).

Fish is a nutritional and very useful food because it is a source of high protein, essential elements and especially n-3 polyunsaturated fatty acids (n-3 PUFAs) (Daviglus et al., 2002; Michael & Butler, 2005). These nutrients, especially docosahexaenoic acid, are beneficial to the development of the brain and visual system in infants and reduce the incidence of paralysis and cholesterol levels in adults and reduce the risk of some heart diseases (Oken, 2012; Mahaffey, 2011; Bouzan et al., 2005). For this reason, the Nutrition Committee of the American Heart Association recommends eating fish of any kind two or three times a week (Kris-Etherton et al., 2003). In addition, fish consumption is an important way of exposing many environmental pollutants, including heavy metals. For this reason, consumers can accumulate environmental pollutants at considerable levels in their bodies. Since muscle tissue is the edible part of fish, the level of exposure to these toxic elements is important.

Mercury (Hg), cadmium (Cd) and lead (Pb), which are known to have no function in metabolic events, are also found in aquatic environments, while heavy metals such as copper (Cu), zinc (Zn) and iron (Fe) are used by organisms at certain levels for metabolic events. In this study, the chemical composition of muscle tissue was investigated in lion fish (*P. miles*), which has a high invasion potency in the Mediterranean Sea. At the same time, the potentials of accumulation of essential and toxic metals in brain, gill, muscle and liver tissues have been examined.

Materials and Methods

Fish collection, identification and measurements

Four specimens of the common lionfish *P. miles* were caught alive by a commercial trawl fishing boat in the North-Eastern Mediterranean (Yeşilovacık Bay) (36°06'37"N 33°40'04"E to 36°06'27"N 33°40'41"E) in 2016 (Fig. 1). Taxonomic identification was based on diagnostic characters provided by Turan et al. (2017). Their size (cm) and weight (g) were measured (Table 1).

Table 1. The weight and length of the specimens

Specimen	Weight (g)	Length (cm)
1.	278	28
2.	55	19
3.	68	20
4.	92	22

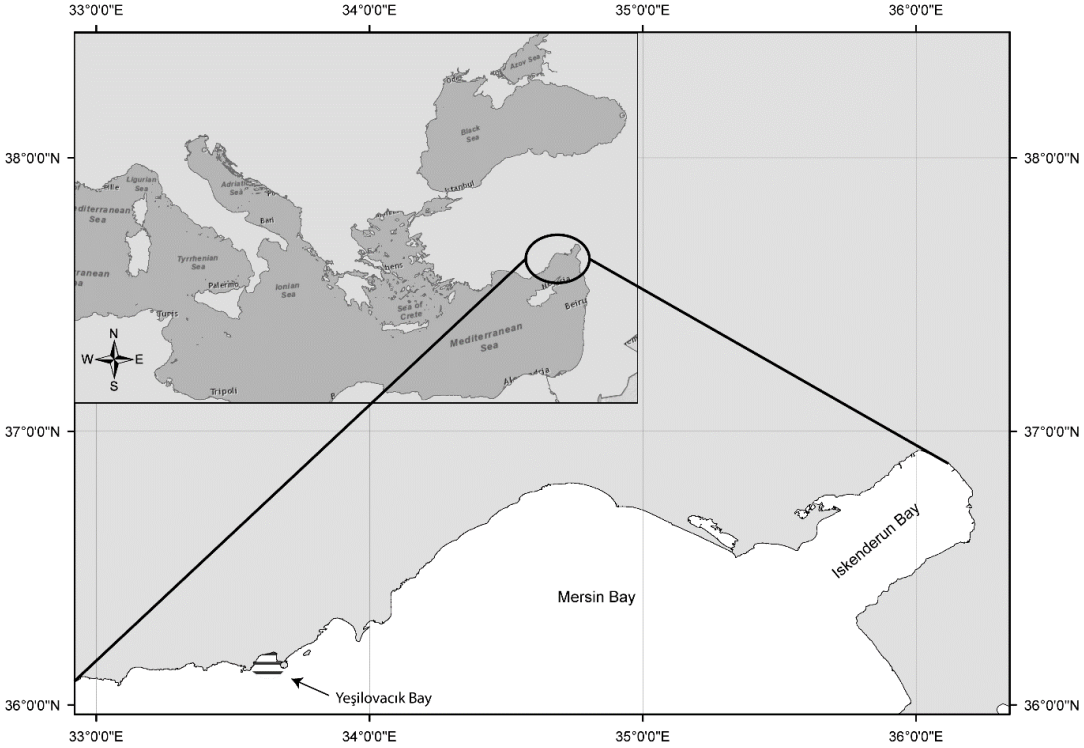

Figure 1: Sampling location map. (The shaded region (Yeşilovacık Bay) is the sampling area)

Proximate Analyses

AOAC (935.47, 1998) method was used for the TMS (total mineral substance) measurements, AOAC (1990) method was used for water measurements. Total protein measurement was taken using Kjeldahl method (AOAC 981.10, 1998), and lipid analysis was performed using Bligh & Dyer (1959) method.

Fatty Acids Analyses

Total lipids extracted by Bligh & Dyer (1959) method and fatty acid methyl esters were obtained using the Ichibara *et al.* (1996) method. 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 x 0.32 mm ID BPX70 x 0.25 μm, USA or Australia) column. Injector and detector temperatures were set as 260 ^{o}C and 230 ^{o}C respectively. During this time, the furnace temperature was kept at 140 ^{o}C for 8 minutes. After that, it was increased by 4 ^{o}C per minute until 220 ^{o}C, and from 220 ^{o}C to 230 ^{o}C by increasing the temperature 1^{o}C per minute. It was kept at 230 ^{o}C for 15 minutes to complete analysis. Sample scale was 1 μl and carrier gas was controlled at 16 ps. For split flow 40, 0 mL/minute (1:40) level was used. Fatty acids were determined using a comparison to the exit times of the FAME mix that contains 37 standard components (Fatty acid methyl ester, Supelco, PA, USA).

Atherogenicity index (AI) and thrombogenicity index (TI)

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

AI = [(a*12:0)+(b*14:0)+(c*16:0)] / [d*(PUFA n-6+n-3)+e*(MUFA)+f*(MUFA-18:1)]
TI = [g*(14:0+16:0+(18:0)] / [(h *MUFA)+i*(MUFA-18:1)+(m*n-6)+(n*n-3)+(n-3/n-6)]
a, c, d, e, f=1, b=4, g=1, h, i, m=0.5 n=3

Analyses of Elements

The samples (0.1 g dry weight) used for element analysis were dried at 105°C to reach constant weights, and then concentrated with nitric acid (4 mL, Merck, Darmstadt, Germany) and percholoric acid (2 mL, Merck, Darmstadt, Germany) were added to the samples, and they were heat up to 150°C on a hot plate heater. The process was run until all tissues were dissolved in acid solution (Canli & Atli, 2003).

Inductively coupled plasma mass spectrometer (ICP-MS) (Agilent, 7500ce Model, Japan) was used to determine elements in samples. ICP-MS operating conditions were the following: radio frequency (RF) (W),1500; plasma gas flow rate (L min-1),15; auxiliary gas flow rate (L min-1), 1; carrier gas flow rate (L min-1),1.1; spray chamber T (°C), 2; sample depth (mm), 8.6; sample introduction flow rate (mL min-1), 1; nebuliser pump (rps), 0.1; extract lens (V), 1.5 (mention the detection limits for the ICP/MS). The levels of trace element (Fe, Cu, Zn) and potential toxic metal (Cr, As, Pb) in samples were detected as μg metal g-1 dry weight. High Purity Multi Standard (Charleston, SC 29423) was used for determination of the metal analyses. Standard solutions for calibration curves were prepared by dilutions of the trace elements and

potential heavy metals. Solutions have prepared for the toxic metals had a content of lead, arsenic and chromium in the range of 1-50 ppb (0.001 to 0.050 mg/L), for the trace elements had a content of copper, iron, and zinc in the range of 1-50 ppm (1 to 50 mg/L).

Metal analysis were conducted with stable samples with fixed weighing (dw). Mathematical transformation of wet weight (in muscle tissue) was carried out by using the percent dry matter value in order to compare the levels of potential toxic metals with the toxic limits of food codex.

Daily and weekly metal intake are calculated using the following formulas:

EWI (mg/week/70 kg body weight): c £ FIR £ 7
EDI (mg/day/70 kg body weight): c £ FIR £ 1

Concentration (c): mean metal level in the tissue (mg kg^{-1}).

Consumption Rate (FIR): Daily amount of fish consumed in Turkey is 0.017 kg/person/ day according to Turkish Statistical Institute (TURKSTAT, 2016). Yearly amount of fish consumed in Turkey is 6.2 kg/person/year in 2015 according to Turkish Statistical Institute (TURKSTAT, 2016).

Statistical analysis

Prior to the analyses, all data were checked for outliers and Levene's homogeneity of variance was also applied for variance homogeneity. Statistical analysis of data was carried out with the IBM SPSS STATISTICS 22 statistical program. ANOVA (Analysis of Variance) was used to evaluate the differences of metals levels of the tissues (Gündoğdu, 2014).

Results

Water, crude protein, total lipid, total mineral substance (TMS) levels were found to be 75.68-77.62%, 20.05-21.08%, 1.11-1.84%, 1.22-1.54 in *P. miles*, respectively (Table 2). The fatty acids of lionfish ranged from 34.26% to 37.57% saturated fatty acids (SFAs), from 24.99% to 27.99 % monounsaturated fatty acids (MUFAs) and from 20.49% to 49.31% PUFAs (Table 3).

Table 2. The proximate composition of the *P. miles* (%)

Component	Specimen (1) $\overline{X} \pm S_X$	Specimen (2) $\overline{X} \pm S_X$	Specimen (3) $\overline{X} \pm S_X$	Specimen (4) $\overline{X} \pm S_X$
Water	77.62 ± 0.10^{b}	77.11 ± 0.24^{b}	77.06 ± 0.08^{b}	75.68 ± 0.60^{a}
Protein	20.07 ± 0.68^{a}	20.16 ± 0.21^{a}	20.05 ± 0.06^{a}	21.08 ± 0.46^{a}
Lipid	1.11 ± 0.13^{a}	1.21 ± 0.19^{a}	1.84 ± 0.02^{b}	1.54 ± 0.05^{b}
TMS	1.22 ± 0.04^{a}	1.54 ± 0.04^{b}	1.30 ± 0.01^{a}	1.50 ± 0.12^{b}

Uppercases in same lines indicates difference ($p<0.05$). $\overline{X} \pm S_X$: Average±Standard deviation

It was determined that the fatty acid profile was composed of 25 fatty acids. These fatty acids are lauric acid (C12: 0), myristic acid (C14: 0), pentadecanoic acid (C15: 0), palmitic acid (C16: 0), heptadecanoic acid (C17: 0), stearic acid (C18: 0), arachidic acid (C20: 0), behenic acid (C22: 0), myristoleic acid (C14: 1), pentadecenoic acid (C15:1), palmitoleic acid (C16: 1), heptadecenoic acid (C17: 1), oleic acid (C18:1*n*9), vacceneic acid (C18:1*n*7), gadoleic acid

(C20:1*n*9), cetoleic acid (C22:1n11), nervonic acid (C24:1n9), linoleic acid (C18:2*n*6), alfa linolenic (C18:3*n*3), eicosadienoic acid (C20:2cis), eicosatrienoic acid (C20:3n6), arachidonic acid (C20:4*n*6), eikosapentaenoic acid (C20:5*n*3), docosahexaenoic acid (C22:6*n*3), docosadienoic acid (C22:2cis) (Table 3).

Dominant fatty acids are palmitic acid and stearic acid in SFAs, palmitoleic acid, oleic acid, cetoleic acid in MUFAs, EPA and DHA in PUFAs. Palmitic acid and stearic acid levels ranged from 20.60% to 23.50% and from 9.32% to 12.32%, respectively. Palmitoleic acid, oleic acid and cetoleic acid levels from the MUFAs were found to be between 3.05% and 6.21%, 10.83% and 12.23%, and 2.85% and 4.46%, respectively. EPA levels were found to be between 3.21% and 5.07% and DHA levels between 18.77% and 20.74% (Table 3).

Table 3. The fatty acid profile of the *P. miles* (%)

Fatty acids	Specimen(1) $\bar{X} \pm S_x$	Specimen (2) $\bar{X} \pm S_x$	Specimen (3) $\bar{X} \pm S_x$	Specimen (4) $\bar{X} \pm S_x$
Lauric acid (C12:0)	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
Myristic acid (C14: 0)	2.47 ± 0.71^{b}	2.26 ± 0.23^{ab}	1.66 ± 0.44^{a}	2.25 ± 0.05^{ab}
Pentadecanoic acid (C15: 0)	0.52 ± 0.16^{ab}	0.60 ± 0.07^{b}	0.45 ± 0.08^{a}	0.48 ± 0.02^{ab}
Palmitic acid (C16: 0)	20.60 ± 1.15^{a}	22.55 ± 0.31^{b}	20.80 ± 1.29^{a}	23.50 ± 0.36^{b}
Heptadecanoic acid (C17: 0)	0.69 ± 0.12^{a}	0.97 ± 0.10^{b}	0.71 ± 0.06^{a}	0.62 ± 0.03^{a}
Stearic acid (C18: 0)	9.54 ± 1.14^{a}	9.32 ± 0.15^{a}	12.32 ± 1.21^{b}	9.83 ± 0.80^{a}
Arachidic acid (C20: 0)	0.31 ± 0.01^{a}	0.37 ± 0.03^{b}	0.47 ± 0.05^{c}	0.40 ± 0.02^{b}
Behenic acid (C22: 0)	0.13 ± 0.02^{bc}	0.09 ± 0.01^{ab}	0.16 ± 0.06^{c}	0.04 ± 0.05^{a}
ΣSFA	34.26	36.16	37.57	37.12
Myristoleic acid (C14: 1)	0.07 ± 0.08^{a}	0.12 ± 0.02^{a}	0.03 ± 0.06^{a}	0.08 ± 0.10^{a}
Pentadecenoic acid (C15:1)	0.05 ± 0.01^{b}	0.06 ± 0.01^{b}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
Palmitoleic acid (C16: 1)	3.49 ± 0.77^{a}	3.21 ± 0.04^{a}	3.05 ± 0.31^{a}	6.21 ± 0.10^{b}
Heptadecenoic acid (C17: 1)	0.28 ± 0.11^{a}	0.23 ± 0.02^{a}	0.20 ± 0.02^{a}	0.33 ± 0.17^{a}
Oleic acid (C18:1*n*9)	12.08 ± 1.07^{b}	10.83 ± 0.18^{a}	12.23 ± 0.95^{b}	10.90 ± 0.23^{a}
Vacceneic acid (C18:1*n*7)	1.76 ± 0.37^{a}	1.77 ± 0.06^{a}	1.63 ± 0.12^{a}	1.50 ± 0.09^{a}
Gadoleic acid (C20:1*n*9)	0.67 ± 0.13^{a}	0.62 ± 0.04^{a}	0.61 ± 0.06^{a}	0.81 ± 0.04^{b}
Cetoleic acid (C22:1n11)	4.40 ± 0.58^{b}	3.21 ± 0.24^{a}	4.46 ± 0.05^{b}	2.85 ± 0.09^{a}
Nervonic acid (C24:1n9)	0.32 ± 0.30^{a}	0.43 ± 0.05^{a}	0.39 ± 0.08^{a}	0.48 ± 0.12^{a}
ΣMUFA	23.12	20.48	22.60	23.16
Linoleic acid (C18:2*n*6)	1.15 ± 0.07^{b}	1.39 ± 0.08^{c}	1.04 ± 0.07^{a}	1.08 ± 0.05^{ab}
Alfa linolenic (C18:3*n*3)	0.23 ± 0.06^{bc}	0.25 ± 0.03^{c}	0.15 ± 0.03^{ab}	0.08 ± 0.09^{a}
Eicosadienoic acid (C20:2cis)	0.20 ± 0.12^{b}	0.09 ± 0.01^{a}	0.23 ± 0.01^{bc}	0.33 ± 0.02^{c}
Eicosatrienoic acid (C20:3n6)	0.19 ± 0.09^{a}	0.09 ± 0.00^{a}	0.16 ± 0.05^{a}	0.19 ± 0.07^{a}
Arachidonic acid (C20:4*n*6)	0.26 ± 0.02^{b}	0.28 ± 0.03^{b}	0.22 ± 0.01^{a}	0.26 ± 0.03^{b}
Eikosapentaenoic acid (C20:5*n*3)	3.21 ± 0.10^{a}	5.07 ± 0.10^{c}	4.38 ± 0.17^{b}	4.23 ± 0.12^{b}
Docosahexaenoic acid (C22:6*n*3)	20.27 ± 1.69^{ab}	20.74 ± 0.16^{b}	18.77 ± 0.67^{a}	19.47 ± 1.05^{ab}
Docosadienoic acid (C22:2cis)	0.15 ± 0.02^{b}	0.08 ± 0.00^{a}	0.04 ± 0.05^{a}	0.04 ± 0.04^{a}
ΣPUFA	25.66	27.99	24.99	25.68
SFA/PUFA	1.34	1.29	1.50	1.45

Σ*n*7	1.76	1.77	1.63	1.50
Σ*n*6	1.60	1.76	1.42	1.53
Σ*n*3	23.71	26.06	23.30	23.78
Σ*n*9	13.07	11.88	13.23	12.19
Σ*n*11	4.40	3.21	4.46	2.85
*n*6/*n*3	0.07	0.07	0.06	0.06
*n*3/ *n*6	14.82	14.81	16.41	15.54
DHA/EPA	6.31	4.09	4.29	4,60
AI	0.63	0.65	0.58	0.67
TI	0.33	0.33	0.35	0.36
Unidentified	16.96	15.37	14.84	14.04

Uppercases in same lines indicates difference ($p<0.05$). $\overline{X} \pm S_X$: Average±Standard deviation

The accumulation amounts of heavy metals in the tissues were found as Fe> Zn> As> Cu> Cr> Pb, respectively. The accumulation levels of each metal in the tissues were determined as follows: liver>gill>brain>muscle (29.19-384.43 μg g^{-1}dw) for Fe, gill>brain>liver>muscle (16.08-56.68 μg g^{-1}dw) for Zn, muscle>brain>gill>liver (2.69-7.88 μg g^{-1}dw) for As, liver> brain>gill>muscle (0.74-7.05 μg g^{-1}dw) for Cu, brain>gill>muscle>liver (0.35-2.67 μg g^{-1}dw) for Cr, brain>gill>muscle>liver (0.26-2.11 μg g^{-1}dw) for Pb (Table 4).

Table 4. The metal levels of some tissues of the lionfish (μg g^{-1})

Metal	Brain $\overline{X} \pm S_{\overline{x}}$	Gill $\overline{X} \pm S_{\overline{x}}$	Muscle $\overline{X} \pm S_{\overline{x}}$	Liver $\overline{X} \pm S_{\overline{x}}$
Cr	2.67 ± 0.71^{b}	1.01 ± 0.04^{a}	0.51 ± 0.02^{a}	0.35 ± 0.04^{a}
Fe	166.32 ± 20.36^{b}	216.20 ± 32.87^{b}	29.19 ± 7.69^{a}	384.43 ± 57.96^{c}
Cu	4.79 ± 1.29^{bc}	2.22 ± 0.15^{ab}	0.74 ± 0.12^{a}	7.05 ± 1.50^{c}
Zn	36.78 ± 0.63^{c}	56.68 ± 1.62^{d}	16.08 ± 0.78^{a}	23.73 ± 3.19^{b}
As	5.85 ± 1.77^{ab}	3.74 ± 0.88^{ab}	7.88 ± 1.67^{b}	2.69 ± 0.56^{a}
Pb	2.11 ± 0.40^{b}	0.57 ± 0.04^{a}	0.26 ± 0.07^{a}	0.26 ± 0.09^{a}

Uppercases in same lines indicates difference ($p<0.05$). $\overline{X} \pm S_{\overline{x}}$: Average±Standard error

Discussion

Nutritional benefits of fish consumption relate to the use of certain biologically valued proteins as well as certain minerals and vitamins provided by fish. It was determined that lion fish had high protein level (20.05-21.08%) in the study.

Lambertsen (1978) distinguishes 4 groups according to the amount of fat they have, and they are classified as lean fish (<2%), low-fat fish (2-4%), medium-fat fish (4-8%), fatty fish (> 8%). In another similar study (Polish Standard PN-A-86770, 1999), it was defined as lean fish (<2%), low-fat fish (2-7%), fatty fish (7-15%), very fatty fish (> 15%). In our study, since the fat level of the lion fish varied between 1.11-1.84%, it was defined as a lean fish.

Long chain omega-3 polyunsaturated fatty acids (LC n3 PUFAs) including eicosapentaenoic acid (EPA, 20: 5 ω-3), docosapentaenoic acid (DPA, 22: 5 ω-3) and docosahexaenoic acid (DHA, 22: 6ω) are the main nutrients responsible for the potential cardiovascular effects of fish-based consumption (Schmidt, 1997; Sidhu, 2003). The biochemical, cellular and physiological functions of these three PUFAs in other vertebrates are the same in fish, and are divided into two categories: (a) a generalized role in protecting the structural and functional integrity of cell membranes; (b) being the precursor of biologically highly active paracrine hormones, collectively known as eicosanoids (Sargent et al., 1999). The ideal n-6/n-3 ratio of 4.0 at a maximum is recommended by the UK Department of Health (HMSO UK, 1994). Values higher than 4.0 have negative effects on health and may promote cardiovascular diseases (Moreira et al., 2001). In this study, the ratio of n-6/n-3 was in the range of 0.06-0.07 for lionfish. The index of AI and TI varied between 0.58 and 0.67, 0.33 and 0.36, respectively.

DHA is taken by the brain according to other fatty acids, it is necessary for the growth and functional development of the brain in babies. In adults, DHA is also needed to maintain normal brain function. While the abundance of DHA in the diet improves learning ability, DHA deficiencies are associated with learning gaps (Horrock & Yeo, 1999). Chuang et al. (2012) reported that the level of DHA in *Mullus barbatus* was 9.97%. In a similar study, DHA levels of *Boops boops*, *Mugil cephalus*, *Saurida aurita* and *Solea solea* were found to be 18.7%, 7.69%, 13.3%, 18.7%, respectively by Ozoğul & Ozogul (2007). It has been found that *P. miles* has a higher DHA value (%18.77-20.74) than the commercially consumed species in the Mediterranean Sea. This result is important to ensure that this species is consumed by humans.

Arsenic (As), Mercury (Hg), cadmium (Cd) and lead (Pb), which are known to have no function in metabolic events, are also found in aquatic environments, while heavy metals such as copper (Cu), zinc (Zn) and iron (Fe) are used by organisms at certain levels for metabolic events. In fish, heavy metal accumulation changes depending on the tissues and organs. Studies by various researchers have shown that significant differences were obtained among the tissues in various fish species and that accumulation was highest in the liver and lowest in muscle (Kalay et al., 1999; Karayakar et al., 2010). A similar relationship was observed in this study in terms of iron and copper levels. The highest zinc level in this study was accumulated in the gills. In fish, gill is a respiratory organ and is directly related to the environment, so it is selected as the target organ in toxicology studies (Pelgrom et al., 1995). Cu in *Oncorhynchus kisutch* (Buckley et al., 1982), Pb in *Tilapia zilli* (Karatas & Kalay, 2002) and Zn in *Cyprinus carpio* (Cicik, 2003) have been found to be the highest accumulation in the gill tissue according to other tissues and organs. In this study, zinc level was found to be the highest accumulation in the gill from the other investigated metals, while the lowest accumulation was in the muscle.

The aquatic organisms show a high accumulation capacity of arsenic (As) (1-1000 $\mu g\ g^{-1}$) (Maher & Batley, 1990; Francesconi & Edmonds, 1998). When they are fed and are exposed to arsenic in other ways / sources such as water, soil, particles, they accumulate As and turn them into their bodies. (Edmonds et al., 1997; Hasegawa et al., 2001; Suhendrayatna & Maeda, 2001). In this study, it was determined that arsenic accumulates at the highest levels in muscle tissue and at the lowest levels in liver tissue.

The amount of chromium in the food is important because Cr is an important micronutrient for homeostasis and is involved in lipid metabolism (Bratakos et al., 2002).

Bioaccumulation and physiological and toxicological results for chromium may be due to a number of reasons such as exposure concentration, exposure route, and Cr (VI) sensitive susceptibility of specific species (Chen et al., 2016; Woltering, 1984). In this study, total chromium was detected at the highest levels in brain tissue and at the lowest levels in liver tissue.

Lead was detected at the highest levels in brain tissue and at the lowest levels in liver and muscle tissues. The accumulation of lead in the brain most often can be attributed to the fact that the lead enters the neuronal intracellular environment by acting as calcium (Van Oasten, 1957), primarily due to chemical similarity, preventing the opening of voltage-sensitive calcium channels (Bressler & Goldstein, 1991; Sen &Karaytug, 2017).

Table 5. Estimated Weekly Intakes (EWI) and Estimated Daily Intakes (EDI) of the metals in tissue of the red mullet from the Black Sea coast of Turkey.

Metals	**PTWI* (mg/week/70 kg body wt.)**	**PTDI* (mg/day/70 kg body wt.)**	**EWI (mean)**	**EDI (mean)**
Fe	392 (FAO/WHO, 2011)	56	0,7774	0,1111
Cu	245 (EC, 2006; WHO, 1996)	35	0,0197	0,0028
Zn	490 (EC, 2006; WHO, 1996)	70	0,4282	0,0612
Cr	-	-	0,0136	0,0019
Pb	1.75 (FAO/WHO, 2010; WHO, 2000)	0.25	0,0072	0,0010
As	-	-	0,2096	0,0299

PTWI: Provisional Tolerable Weekly Intake, PTDI: Provisional Tolerable Daily Intake, EWI: Estimated Weekly Intake, EDI: Estimated Daily Intake * Internationally accepted safe levels for the studied metals.

Muscle tissue in fish is not an effective tissue for binding metals in general (Blevins & Pancorbo, 1986; Kargın, 1998). However, it is important for metals to be transported to people through food chain. Because of this, it is important for fish to have less metal accumulation in the muscles used as fish especially for human food. The lowest accumulation of all heavy metals except arsenic and chromium in the lion fish was detected in muscle tissue. However, all metal levels are within the safe limits recommended by FAO / WHO (JECFA, 2003) (Table 5).

Conclusion

Aquatic species are seen as a major source of protein by humans and their consumption is increasing day to day due to the nutrient molecules they contain. In addition, they contain the omega-3 fatty acids which reduce cholesterol levels and thus reduce the risk of diseases such as heart attack, stroke and premature birth. For this reason, knowing the quantities of the toxic substances contained in the tissues and organs of aquatic organisms is extremely important both in terms of "food safety" and in the health of other organisms.

Therefore, in this study, it is aimed to determine the chemical composition of *P. miles* that started to increase in invasive pressure in the Mediterranean Sea and to determine the levels of heavy metals such as Fe, Cu, Zn, Cr, As and Pb in consumable muscle tissues and to determine

the accumulation mechanism of these metals in tissues. As a result; while lionfish muscle tissue contains high levels of protein, unsaturated fatty acids, minerals and trace elements, it has been determined that levels of heavy metals in this consumable tissue are not at levels that could threaten human health.

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