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RESEARCH PAPER

Fatty Acid Content of Farmed Rainbow Trout: How Much Should We Consume for Enough EPA and DHA?

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Abstract

Omega-3 long-chain polyunsaturated fatty acids (LC-PUFAs), mainly eicosapentaenoic acid (20:5n-3; EPA) and docosahexaenoic acid (22:6n-3; DHA), have drawn increasing attention, recently due to their important disease-preventing and health-promoting functions. The present study investigates the fatty acids profile of rainbow trout cultured in different farms in the different provinces (Erzurum and Sakarya) of Turkey. After detecting lipids and fatty acids content, the amount of fillet required for weekly intake of 3.5 g EPA+DHA suggested by International Society for the Study of Fatty Acids and Lipids (ISSFAL) for human consumption was calculated for each farm. The amount of EPA+DHA in fillets from Erzurum and Sakarya were 236.2±91.8 and 193.8±75.1 mg/g lipid, respectively, with no significant difference between the two provinces. The amounts of fillet required for weekly intake of 3.5 g EPA+DHA suggested by ISSFAL were calculated as 714±215 and 896±590 g for the farms in Erzurum and Sakarya, respectively, with no significant difference between the two provinces. Based on our results, required EPA+DHA for healthy purposes could be achieved by consuming rainbow trout approximately two or three times a week depending on the farm and the portion size.

Introduction

Due to the rise in awareness of the importance of a healthy life, there has been a lot of interest in dietary oils/fats containing omega-3 long-chain polyunsaturated fatty acids (LC-PUFAs), which are known to have positive effects on health, recently. The most important omega-3 LC-PUFAs are eicosapentaenoic acid (20:5n-3, EPA) and docosahexaenoic acid (22:6n-3, DHA), primarily occuring in the fish and other seafood. Since they are essential and their synthesis from 18C omega-3 PUFAs is very limited in the human body, they should be provided by food such as fish and other seafood (de Roos et al., 2009).

According to the report by World Health Organization (WHO), chronic or non-communicable diseases are considered the most important cause of death in the World, and they account for 71% (57 million) of reported global deaths. This report also shows that an unhealthy diet with low omega-3 LC-PUFAs intake remains one of the main factors that directly or indirectly trigger chronic diseases (WHO, 2020).

The need for omega-3 LC-PUFAs begins in our body while they are still in the womb, and this need continues throughout childhood, adolescence, adulthood, and old age. Omega-3 LC-PUFAs are important compounds that act in every function of our body, from cells to tissues, tissues to organs to all body systems (Albert et al., 1998). Omega-3 LC-PUFAs reduce triglycerides and cholesterol, reducing the risk of atherosclerosis and related heart disease, heart attack, and acute stroke. They also have important roles in the regulation of the immune system, brain development and function, cancer protection, mental health, and visual functions (Ruxton et al., 2007;

Gutierrez et al., 2019). DHA has been reported to be the source of the hormone serotonin in the brain (Patrick and Ames, 2015). Beneficial effects on muscle mass and the walking speed of people with sarcopenia muscle disease who take more than 2 g of omega-3 LC-PUFAs supplements per day have been reported (Huang et al., 2020). Recently, anti-inflammatory, immunomodulatory and possible antiviral effects of omega-3 LC-PUFAs, especially EPA and DHA, have been reported in various symptoms of the new COVID-19 infection (Hathaway et al., 2020; Rogero et al., 2020; Arnardottir et al., 2021), including the tendency of reduced morbidity and mortality from this infection (Asher et al., 2021).

According to the recommendations of the Dutch Health Council, fish should be consumed twice per week to be able to get the dietary reference intake of 450 mg/day of omega-3 fatty acids while Superior Health Council of Belgium recommends approximately 667 mg/day of EPA+DHA for adults. On the other hand, International Society for the Study of Fatty Acids and Lipids (ISSFAL) recommends a minimum intake of EPA+DHA as 500 mg/day for cardiovascular health, and United Kingdom Scientific Advisory Committee on Nutrition's recommendation is 450 mg EPA+DHA per day (Kris-Etherton et al., 2009).

In 2018, aquaculture accounted for 46% of global seafood production and 52% of fish for human consumption, and it is estimated that around 60% of the fish consumed by humans will come from aquaculture in 2030 (FAO, 2020). As the fatty acids profile of farmed fish strongly depent on the dietary lipids/fatty acids (Arslan et al., 2012; Ofori-Mensah et al., 2020), feeding programs/protocols applied in fish farms become very important in the case of final product quality, especially EPA and DHA content.

Rainbow trout (*Oncorhynchus mykiss*) is one of the most popular cultured species worldwide, reaching 848.1 thousand tons in 2018 (FAO, 2020) and Turkey, one of the leading producers, shared 13.5% of the total production (TUIK, 2019). In the current study, we aimed to investigate the final fillet quality of rainbow trout from different farms operating in two distinct provinces (Erzurum and Sakarya) of Turkey, with an emphasis on omega-3 LC-PUFAs such as EPA and DHA. The amount of fillet required for weekly reference intake of 3.5 g EPA+DHA suggested by ISSFAL was calculated based on the fatty acids content of fish from both provinces.

Materials and Methods

Fish Supply and Storage

In the current study, market-sized (250-300 g) rainbow trout from 28 farms operating in two distinct provinces of Turkey (13 farms in Erzurum locating in North-Eastern Turkey; 39.9055° N, 41.2658° E, and 15 farms in Sakarya locating in North-Western Turkey; 40.7889° N, 30.4060° E) were used. The fish (3 from each farm) were transferred to the laboratory in ice, where they were filleted and kept at -20°C until further lipid/fatty acid analyses. Approximately 10 g (10±1) feed sample was also obtained from each farm and kept at -20°C until further analyses.

Lipids and Fatty Acids Analysis

The total lipid extraction from the fillets and feeds was carried out according to the method of Folch et al. (1957). After the lipids extraction with methanol and chloroform (1:2), the solvents were removed under nitrogen and the amount of lipids were determined. Fatty acids methyl esters (FAMEs) were prepared according to Metcalfe and Schmith (1961) and separated by gas chromatography (Agilent, 6890, Santa Clara, CA, USA) equipped with a flame ionization detector (Arslan et al., 2008). The individual fatty acids were identified by comparing their retention times to those of a standard mix of fatty acids (FAME 37, Sigma-Aldrich, Germany). Prior to the transmethylation, nonadecanoic acid (C19:0) was added to the samples as the internal reference standard for the quantification of fatty acids.

Amount of Fish to Be Consumed for Required EPA+DHA

After determining the fat and fatty acid content in the fillet, the amount of fillet that should be consumed per week for each farm was calculated based on the weekly amount of 3.5 g of EPA+DHA recommended by ISSFAL (ISSFAL, 2004). To do so, the following formula was used:

$$\text{Fillet to consume (g)} = 3.5 / [\text{EPA+DHA (g/g lipid)}] \times [\text{Fat content (g/g fillet)}]$$

Data Analysis

All data were given as mean ± SD. The comparison of the calculated parameters between Erzurum and Sakarya provinces was performed by using an independent *t*-test. Percentage data were arcsine transformed prior to the analysis. Differences were considered statistically significant when $P<0.05$. Statistical analyses were performed by using the software IBM SPSS Statistics for Windows (Armonk, NY).

Results

The lipid levels of feeds used by farms of Erzurum (13 farms) and Sakarya (15 farms) averaged 17.0±0.8 and 18.0±1.7%, respectively, with no significant difference. Regarding the fatty acids profile of the feeds, oleic acid (18:1n-9; OA) and linoleic acid (18:2n-6; LA) were the most abundant fatty acids in the feeds used on the farms of both provinces. The average EPA and DHA levels of feeds used by the farms in Erzurum (36.7±15.9 and 60.2±35.8 mg/g lipid, respectively) did not significantly differ from those of feeds used by the farms in Sakarya (37.8±3.9 and 46.0±6.9 mg/g lipid, respectively) (Table 1).

The lipid and fatty acids content of rainbow trout fillet from 13 farms in Erzurum was given in Table 2. The average amount of fillet lipid was found to be 2.6±1.6%. Fillets from farms, 2, 6, 9 and 13 had lipids above average while the lipid levels of those from the rest of the farms were below average. Lipid and fatty acids levels of rainbow trout fillet from 15 farms in Sakarya was given in Table 3. The lipid level of fillets from different farms of Sakarya averaged 3.1±1.8%. Farms 2, 3, 4, 5, 6, and 8 had an above-average fillet lipid content, while the fillets from the other farms had lipid levels close to the average. The lipid content of the fillets did not significantly change between the two provinces (Table 4).

Regarding the fatty acids composition of fillets from farms of Erzurum, OA was the most abundant fatty acid in farms 2, 3, 5, 6, 8, 9, 11, and 12, while DHA took the first place in farms 1, 4, 7 and 10. Unlike other farms, LA was the predominant fatty acid in farm 13. The highest and lowest total saturated fatty acids (SFA) in fillets were observed in farms 1 (215.3 mg/g lipid) and 13 (180.3 mg/g lipid), respectively. While the total amount of monounsaturated fatty acids (MUFA) was highest in farm 6 (357.1 mg/g lipid), it was detected at the lowest amount in farm 10 (168.2 mg/g lipid). The total amount of LC-PUFAs was the highest in farm 10 (434.3 mg/g lipid), while the lowest value was recorded in farm 2 (105.4 mg/g lipid). The highest and lowest n3/n6 ratios were found in farms 10 (4.2) and 13 (0.5), respectively. The highest amount of EPA+DHA was observed in farm 10 (403.7 mg/g lipid), while the lowest value was determined in farm 2 (90.5 mg/g lipid).

Regarding the fatty acids profile of fillets from farms of Sakarya, OA was the predominant fatty acid in farms 1-7, 11, and 13-15, while DHA was the most abundant fatty acid in farms 9, 10, and 12. Unlike other farms, LA had the highest amount in farm 8. The highest total SFA was observed in farm 12 (218.4 mg/g lipid), while the lowest amount was detected in farm 8 (142.8 mg/g lipid). While the total amount of MUFA was highest in farm 4 (380.5 mg/g lipid), the lowest amount was observed in farm 12 (159.6 mg/g lipid). The highest total amount of LC-PUFA was observed in the fillets from farm 12 (418.9 mg/g lipid), while the lowest was from farm 4 (127.5 mg/g lipid). The highest n3/n6 ratio was observed in fillets from farm 12 (3.5), while the lowest values were observed in farms 2 and 8 (0.5). The highest total amount of EPA+DHA was found in fillets from farm 12 (390.2 mg/g lipid), while the lowest value was in farm 8 (121.8 mg/g lipid).

The amounts of individual fatty acids such as 18:0, linolenic acid (18:3n-3; LNA), and DHA were significantly higher in fillets from farms operating in Erzurum was significantly higher than in those from Sakarya, while LA was significantly lower (P<0.05). The total amounts of 18C-PUFAs and n-6 were significantly higher in fillets from farms of Sakarya than in those from Erzurum, while the total amounts of LC-PUFAs, n-3, and the n-3/n-6 ratio were significantly lower than in Erzurum (P<0.05) (Table 4).

Regarding the farms of Erzurum, the amounts of the fillet to be consumed weekly to meet the recommended amount of 3.5 g EPA+DHA varied between 460 g (farm 13) to 1145 g (farm 11), averaging 714±215 g (Figure 1A). For Sakarya, 180 g fillet from farm 10 was enough to meet the weekly requirement of 3.5 g EPA+DHA, while the weekly amount of fillet for enough EPA+DHA was calculated as 1715 g for farm 5. The average value for Sakarya was 896±590 g (Figure 1B) and there was no significant difference between the two provinces.

Table 1. Comparion of lipid (%) and fatty acid contents (mg/g lipid) of feeds between the farms of Erzurum and Sakarya

Parameter	Erzurum	Sakarya	*P*
Lipid	17.0±0.8	18.0±1.7	0.081
16:0	103.4±18.6	119.9±10.2	**0.006**
18:0	36.5±3.6	36.9±4.0	0.735
18:1n-9	312.8±42.5	268.8±30.0	**0.003**
18:2n-6	156.7±38.7	182.7±39.4	0.090
18:3n-3	37.7±9.7	38.7±3.5	0.706
20:4n-6	0.7±1.5	4.0±1.5	**0.000**
20:5n-3	36.7±15.9	37.8±3.9	0.785
22:6n-3	60.2±35.8	46.0±6.9	0.146
ΣSFA	159.3±25.6	186.3±16.4	**0.002**
ΣMUFA	367.0±38.4	327.1±34.6	**0.007**
Σ18C-PUFA	194.3±47.5	221.4±36.4	0.100
ΣLC-PUFA	104.3±49.7	90.2±9.2	0.290
Σn-3	141.2±40.0	124.9±9.6	0.135
Σn-6	157.4±38.3	186.8±39.2	0.056
n3/n6	1.0±0.7	0.7±0.2	0.081

SFA, saturated fatty acid; MUFA, monounsaturated fatty acid; 18C-PUFA, 18-carbon-polyunsaturated fatty acid; LC-PUFA, long-chain (20-22 carbon)-polyunsaturated fatty acid.

Table 2. Lipid (%) and fatty acid contents (mg/g lipid) of rainbow trout fillets from the farms of Erzurum

Lipid/ fatty acid	Fish farms												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Lipid	1.6±0.1	7.0±1.4	2.2±0.4	1.8±0.1	1.9±0.1	4.0±0.7	1.5±0.2	1.7±0.1	3.5±0.8	1.4±0.1	1.7±0.4	1.8±0.3	4.7±0.6
16:0	153.6±1.1	122.3±7.2	124.5±2.5	137.1±2.9	123.2±19.7	126.9±2.2	137.8±1.3	129.4±7.6	128.6±7.2	145.3±2.4	141.2±12.0	133.4±7.8	134.7±2.8
18:0	51.0±2.1	46.0±2.0	44.5±0.9	50.4±2.5	46.8±1.7	43.5±4.9	39.0±13.0	46.4±2.8	41.2±0.2	51.8±1.5	48.4±0.0	45.9±0.8	30.4±0.7
18:1n-9	161.6±25.2	292.3±10.9	255.4±15.1	191.5±18.3	268.8±30.8	303.3±22.6	217.3±24.9	267.2±19.0	299.9±4.9	137.5±16.9	261.5±28.7	262.4±2.3	239.7±5.0
18:2n-6	106.3±18.7	255.8±2.2	119.9±14.1	95.7±19.5	137.7±18.1	148.5±11.4	88.5±1.1	118.5±12.5	152.8±8.3	74.1±3.9	148.1±16.2	161.0±17.0	256.5±5.7
18:3n-3	21.6±2.9	30.7±8.1	22.4±0.7	18.1±4.0	21.7±4.2	26.2±4.4	18.4±4.8	24.2±1.1	29.9±0.4	14.0±1.0	20.4±0.8	23.2±1.0	1.0±0.1
20:4n-6	12.1±0.3	7.8±1.0	14.8±4.5	34.2±2.0	11.0±3.0	9.6±3.5	41.2±2.5	9.3±1.8	8.0±1.0	15.9±1.3	13.8±7.5	17.1±1.7	11.2±0.7
20:5n-3	36.5±1.4	13.1±0.6	29.4±0.4	30.9±3.7	35.0±3.2	25.3±2.9	51.9±3.6	29.6±6.2	23.3±3.7	39.5±2.2	41.8±0.9	31.4±5.0	22.7±3.9
22:6n-3	298.5±7.9	77.4±12.6	210.5±12.6	279.9±2.7	204.9±10.3	154.0±7.1	283.1±18.7	207.6±9.0	151.2±17.5	364.2±3.8	170.6±14.8	138.7±9.6	139.7±8.3
ΣSFA	215.3±5.0	183.3±3.6	187.0±0.4	199.8±8.8	182.7±18.6	186.4±5.5	185.1±12.5	192.7±7.3	187.2±7.8	211.3±13.2	202.4±9.4	191.0±10.6	180.3±2.0
ΣMUFA	196.3±20.0	338.7±14.5	300.2±18.2	229.0±10.7	313.4±20.6	357.1±28.1	261.5±18.2	308.1±14.6	342.0±23.1	168.2±15.8	323.3±36.2	305.2±8.7	287.4±3.5
Σ18C-PUFA	128.0±21.6	286.5±10.5	142.3±14.7	113.8±23.5	159.4±22.4	174.7±15.8	106.9±5.9	142.7±13.7	182.7±7.9	88.1±4.8	168.4±17.0	184.2±18.0	257.5±5.8
ΣLC-PUFA	362.4±6.6	105.4±9.3	280.0±22.8	369.4±7.5	266.5±2.7	193.9±24.1	396.3±28.7	258.5±6.4	190.0±23.2	434.3±2.3	237.8±29.7	221.7±37.3	176.8±11.4
Σn-3	368.7±3.4	122.2±2.6	277.0±17.0	334.3±3.1	273.3±9.5	207.7±16.1	357.5±22.6	264.5±4.8	209.5±23.4	429.1±2.2	241.1±21.4	207.4±21.2	165.5±12.1
Σn-6	121.7±18.4	268.4±5.7	145.5±9.3	147.7±17.4	151.8±14.3	160.8±7.7	146.0±0.1	136.6±2.5	163.2±8.1	93.4±4.7	165.2±8.8	198.5±1.9	268.8±6.5
n3/n6	3.1±0.5	0.5±0.0	1.9±0.2	2.4±0.1	1.8±0.1	1.3±0.1	2.4±0.2	1.9±0.0	1.3±0.2	4.6±0.3	1.5±0.2	1.0±0.1	0.6±0.1

SFA, saturated fatty acid; MUFA, monounsaturated fatty acid; 18C-PUFA, 18-carbon-polyunsaturated fatty acid; LC-PUFA, long-chain (20-22 carbon)-polyunsaturated fatty acid.

Table 3. Lipid (%) and fatty acid contents (mg/g lipid) of rainbow trout fillets from the farms of Sakarya

Lipid/ fatty acid	Fish farms														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Lipid	2.7±0.2	4.4±0.4	5.3±1.3	5.8±0.3	5.0±0.1	5.8±0.2	2.4±1.0	3.6±0.1	2.1±0.4	1.8±0.7	2.8±0.1	1.4±0.0	3.1±0.2	2.6±0.3	2.4±0.5
16:0	136.2±4.2	139.7±8.1	130.6±11.4	138.6±0.1	115.0±0.1	120.2±2.7	153.6±15.4	93.8±8.2	143.0±2.7	134.3±8.5	144.4±18.7	160.4±15.2	139.8±3.2	143.8±8.4	131.6±14.7
18:0	38.7±1.5	37.9±0.2	39.2±1.8	38.0±0.3	38.2±0.7	40.8±0.4	49.3±9.7	39.4±0.6	42.1±2.5	47.7±4.7	38.7±1.0	50.0±1.0	39.6±0.4	37.9±4.2	39.2±2.1
18:1n-9	242.5±3.1	267.8±10.1	263.7±23.7	319.6±10.8	282.6±11.9	288.1±12.6	223.7±2.7	268.5±4.6	206.3±11.8	198.0±17.2	273.6±1.0	130.8±5.8	308.2±4.0	238.0±6.9	259.5±1.5
18:2n-6	215.9±1.5	245.9±7.0	234.8±7.9	195.2±5.8	229.9±17.4	198.5±1.6	219.9±10.9	288.0±10.7	150.4±14.7	144.2±5.5	159.1±19.0	87.9±10.4	117.4±1.2	200.1±15.8	150.0±9.1
18:3n-3	1.0±0.0	1.9±0.1	28.4±4.8	1.8±0.1	23.1±4.3	28.3±2.0	4.4±3.7	26.6±0.1	11.0±1.4	22.3±4.2	1.8±0.0	17.3±1.6	2.3±0.1	1.5±0.2	1.8±0.1
20:4n-6	11.5±0.3	10.3±0.3	8.1±0.2	8.4±2.3	7.9±0.8	6.3±0.6	20.5±9.0	12.9±4.2	10.8±1.6	22.3±3.2	10.3±2.6	17.9±2.2	9.4±0.2	10.7±1.0	9.8±0.7
20:5n-3	29.5±0.2	1.9±0.1	25.6±1.6	2.4±0.4	26.3±1.2	26.2±2.5	24.0±5.6	14.6±0.3	39.4±7.0	44.2±5.9	32.5±1.8	61.1±3.9	2.9±0.2	30.0±0.9	44.5±1.9
22:6n-3	164.5±3.5	126.8±6.4	113.2±5.1	113.5±6.5	117.1±7.1	113.6±7.8	126.2±2.4	107.2±4.6	234.4±2.3	242.0±6.6	161.0±9.3	329.1±10.7	189.9±13.1	170.6±6.7	192.0±13.6
ΣSFA	187.9±1.5	192.0±10.0	186.9±11.8	197.0±2.2	168.3±0.6	179.1±2.8	210.8±23.7	142.8±9.3	203.2±5.3	193.2±8.7	202.3±20.4	218.4±14.5	201.5±5.4	196.1±3.8	189.5±16.0
ΣMUFA	285.0±4.6	320.1±9.2	317.9±30.2	380.5±12.2	333.6±13.2	345.4±14.4	257.1±5.2	302.0±5.8	253.0±5.1	237.0±29.9	331.1±5.0	159.6±6.4	373.8±7.1	296.1±18.8	310.4±5.6
Σ18C-PUFA	216.9±1.5	247.8±6.9	263.2±12.7	197.1±5.9	252.9±13.1	226.8±0.3	224.3±7.2	314.6±10.6	161.4±13.3	166.6±9.7	160.9±19.0	105.1±12.0	119.7±1.3	201.6±16.0	151.7±9.2
ΣLC-PUFA	212.2±4.6	142.1±6.1	149.9±6.7	127.5±8.6	156.4±12.5	150.7±11.9	179.7±16.9	142.7±4.5	291.1±10.7	314.0±18.6	207.7±6.4	418.9±3.9	207.0±13.8	215.9±4.3	254.9±3.6
Σn-3	198.7±1.2	132.7±6.6	169.4±11.3	119.9±6.3	169.6±14.5	170.1±8.8	160.2±8.4	153.7±0.4	289.1±8.8	311.8±11.6	197.3±7.9	407.5±5.2	198.1±13.5	203.9±5.5	240.1±10.5
Σn-6	230.4±1.9	257.1±7.4	243.8±8.1	204.7±8.2	239.7±15.0	207.4±2.7	243.8±1.3	303.5±14.7	163.4±11.5	168.8±2.8	171.3±17.5	116.5±13.3	128.6±1.0	213.6±17.2	166.5±16.2
n3/n6	0.9±0.0	0.5±0.0	0.7±0.0	0.6±0.0	0.7±0.1	0.8±0.0	0.7±0.0	0.5±0.0	1.8±0.2	1.8±0.1	1.2±0.1	3.5±0.4	1.5±0.1	1.0±0.1	1.5±0.2

SFA, saturated fatty acid; MUFA, monounsaturated fatty acid; 18C-PUFA, 18-carbon-polyunsaturated fatty acid; LC-PUFA, long-chain (20-22 carbon)-polyunsaturated fatty acid

Discussion

Omega-3 LC-PUFAs such as EPA and DHA are known to be essential nutrients for human health due to their physiological functions. In other words, these substances cannot be synthesized by the human body and should be taken from food. Fish and other seafood are the main source of omega-3 LC-PUFAs, as well as a source of high-quality proteins, vitamins, and minerals. Although there are various recommendations on the amount of EPA and DHA that should be consumed for a healthy life, the most accepted recommendation was made by ISSFAL. Accordingly, the amount of EPA+DHA that should be consumed weekly is recommended as 3.5 g (ISSFAL, 2004). Beside several health benefits, anti-inflammatory, immunomodulatory and possible antiviral effects of dietary omega-3 LC-PUFAs have been reported as having a protective effect on diseases such as sarcopenia and COVID-19 by secreting cytokines and chemokines, increasing phagocytosis ability and improving the function of macrophages by activating macrophages with polarization (Hathaway et al., 2020; Huang et al., 2020).

The need for fish/seafood increases with the increasing world population and it is no longer able to be met by capture fisheries that has reached the plateau already. On the other hand, the increasing need for fish consumption has led to the development of the aquaculture production sector and has made this sector the fastest growing food production sector in the world for the last 30 years. Currently, 52% of the fish and other seafood consumed in the world are produced by aquaculture (FAO, 2020). The rapid growth in the aquaculture production sector has naturally brought with it the increasing need for aquafeeds. The main lipid raw material in aquafeeds traditionally used in aquaculture is fish oil. Although this ensures that the fish grown are of high quality in terms of omega-3 LC-PUFAs content, the world's fish oil production has reached its maximum limit and has even started to decrease. In other words, fish oil production is not sufficient to meet the needs of the ever-growing sector and the use of alternative oil sources for fish feed has been inevitable. Vegetable oils could be used as alternative lipid resources in aquafeeds. The fact that vegetable oils are produced abundantly, that their prices are cheaper than fish oil, and that they are low in organic pollutants such as dioxins/furans and polychlorobiphenyls (PCB) increase the popularity of vegetable oils. The use of vegetable oils in fish feeds, especially in freshwater fish does not cause a decrease in growth but causes changes in fatty acid profile (Boujard et al., 2004). The amount of EPA and DHA usually decreases in fish fed vegetable oils instead of fish oil (Arslan et al., 2008; Arslan et al., 2012; Ofori-Mensah et al., 2020). On the other hand, the fact that freshwater fish have the mechanism to convert LNA, which is widely found in vegetable oils, especially linseed oil, into EPA and DHA, stands out as an important advantage for sustainability (Sargent et al., 1995; Arslan et al., 2012). Therefore, when vegetable oils rich in ALA are used instead of fish oil in freshwater fish feeds, a significant level of EPA and DHA accumulation can be achieved in the final product.

The aquaculture industry is often more criticized than other farmed animal sectors. The most common misjudgment among consumers is that fish grown on farms are thought to be at a lower level in terms of nutritional quality than those caught from nature. In reality, it is known that fish reared on farms have as much EPA+DHA as those caught in nature, and even in most cases more EPA+DHA per serving consumed (EFSA, 2005; USDA, 2015). Farmed fish generally contain higher levels of lipid but lower levels of EPA and DHA than those caught from nature. Therefore, considering the unit portion to be consumed, the total amount of EPA and DHA consumed is less in wild fish than in farmed ones because the lipid content of fish caught from nature is often quite low (USDA, 2015).

When approximately 200 g of Atlantic salmon (*Salmo salar*) fed a diet containing fish oil is consumed per week, the ISSFAL recommendation of 3.5 g EPA+DHA is met. On the other hand, in order to meet this need, it

Table 4. Comparison of lipid (%) and fatty acid contents (mg/g lipid) of rainbow trout fillets between the farms of Erzurum and Sakarya

Parameter	Erzurum	Sakarya	*P*
Lipid	2.6±1.6	3.1±1.8	0.135
16:0	133.7±10.7	135.0±17.4	0.739
18:0	45.0±6.4	41.1±4.8	**0.011**
18:1n-9	239.9±55.3	251.4±47.5	0.405
18:2n-6	143.3±56.3	189.1±53.1	**0.003**
18:3n-3	20.9±7.8	11.6±11.3	**0.001**
20:4n-6	15.8±10.2	11.8±5.1	0.062
20:5n-3	31.6±9.9	27.0±16.6	0.228
22:6n-3	206.2±79.1	166.7±62.1	**0.041**
ΣSFA	192.7±12.9	191.3±19.6	0.762
ΣMUFA	286.9±58.3	300.2±56.6	0.394
Σ18C-PUFA	164.2±56.5	200.7±56.7	**0.019**
ΣLC-PUFA	268.7±96.1	211.4±79.1	**0.018**
Σn-3	266.0±86.3	108.1±75.3	**0.009**
Σn-6	166.7±50.8	203.9±50.9	**0.009**
n3/n6	1.9±1.0	1.2±0.8	**0.008**

SFA, saturated fatty acid; MUFA, monounsaturated fatty acid; 18C-PUFA, 18-carbon-polyunsaturated fatty acid; LC-PUFA, long-chain (20-22 carbon)-polyunsaturated fatty acid is necessary to consume 750 g of salmon fed a diet with solely vegetable oil, and 450 g of salmon fed a diet with 75% vegetable oil and 25% fish oil. While 340 g of rainbow trout, fed a diet containing only fish oil, meets the weekly amount of EPA+DHA recommended by ISSFAL, it is necessary to consume 650 g of rainbow trout, fed diets containing only vegetable oil. While 580 g of sea bream (*Sparus aurata*), fed a diet with fish oil from sea fish, meets the weekly need, 2300 g should be consumed per week to meet this need if the same fish is fed diets containing vegetable oil (Bell, 2008).

In our study, the amount of rainbow trout fillets that need to be consumed to meet the weekly EPA and DHA needs recommended by ISSFAL varied between 460-1145 g for farms in Erzurum and was determined as an average of 714 g. This amount, which should be consumed, varies between 180-1715 g for farms operating in Sakarya and is calculated as 896 g on average. The amount of fillets to meet the weekly EPA and DHA needs shows large variations between farms in both provinces. However, the average amount of fillets to consume did not change significantly between Erzurum and Sakarya. The reason for this variation between farms is due to the EPA and DHA content of the fillets as well as the lipid content. Different proportions of lipid storage in the fillets of fish may have been caused by genetic factors as well as environmental factors such as temperature. Variations between EPA

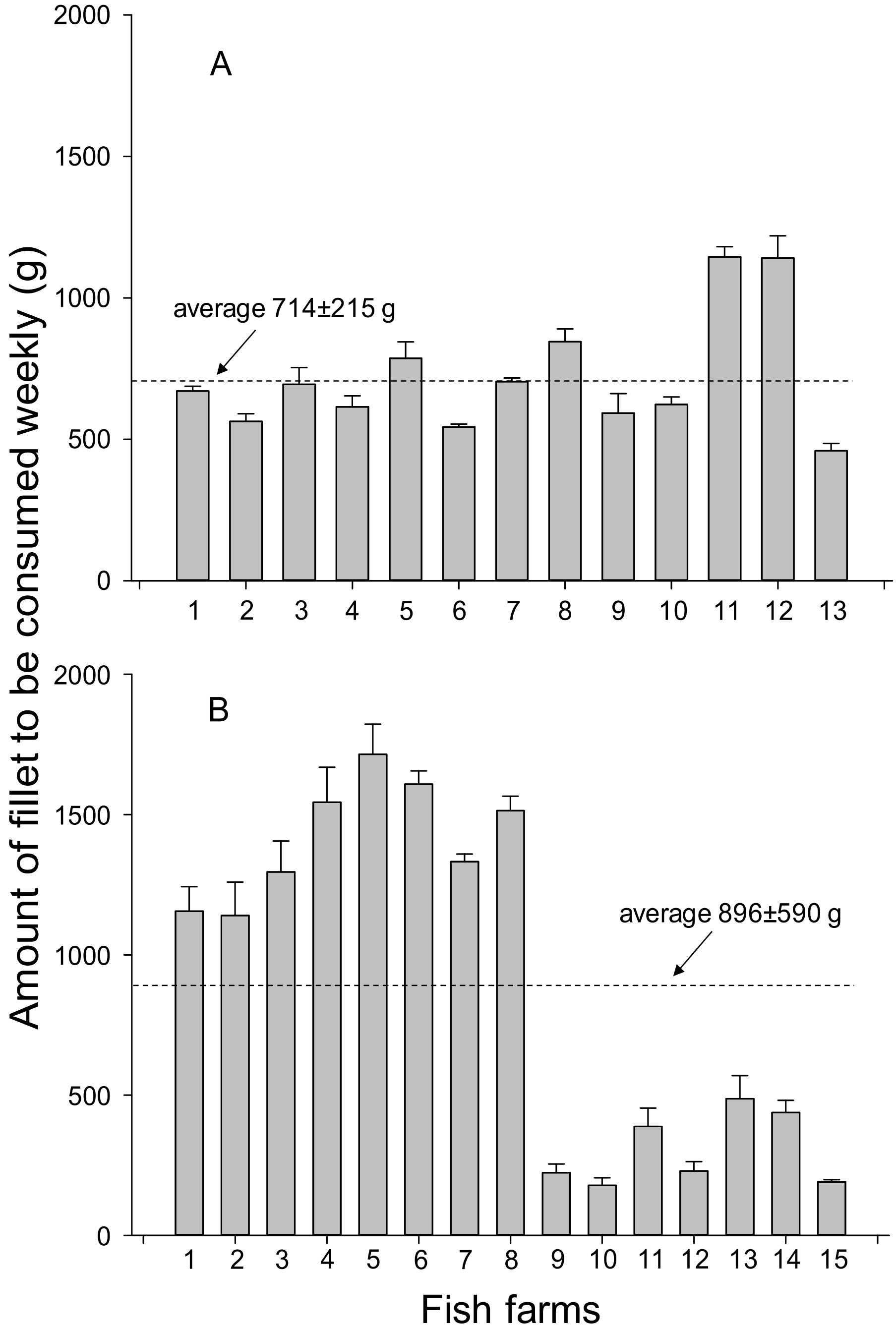

Figure 1. The amount of rainbow trout fillet (g) from the farms of Erzurum (A) and Sakarya (B) to be consumed weekly for 3.5 g EPA+DHA

and DHA amount of fillets is expected to be due to the dietary fatty acid profiles and also may be due to changes in fatty acid metabolism under the influence of different biotic and abiotic factors (Sargent et al., 1995).

In the current study, when the fatty acid profiles of feeds taken from farms are examined, it is generally seen that fatty acids such as OA and LA are predominant. The amount of EPA and DHA is quite low when compared to the amounts found in fish oil. In this case, it might be concluded that vegetable oils rich in OA and LA fatty acids are mainly used in fish feeds used by the farms. On the other hand, it was determined that the fatty acid profile of feeds used by the farms did not show significant correlations with the fatty acids profile of corresponding fillets. This may be due to the fact that a uniform feed is not used on a farm during the entire growing period. In other words, it is very likely that different feeds with different fatty acid profiles have been used for different periods on the same farm.

Conclusions

Omega-3 LC-PUFAs, mainly EPA and DHA, have drawn increasing attention due to their important disease-preventing and health-promoting functions. In this respect, consumption and nutritional value, especially EPA and DHA content, of the farmed fish have become more important. According to our results, consuming rainbow trout from farms in two selected provinces (Erzurum and Sakarya) of Turkey approximately two or three times a week based on the farm and portion size will cover the 3.5 g of EPA+DHA requirement recommended by ISSFAL.

Ethical Statement

Not applicable

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Author Contribution

HB: Investigation, Data curation, Formal analysis, Writing - Original draft preparation. **MA:** Conceptualization, Supervision, Investigation, Formal analysis, Visualization, Writing - review & editing.

Conflict of Interest

The authors claim no conflict of interest.

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