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Potential Contribution of Farmed Fishes to The Recommended Nutrient Intakes (RNIs): A Case Study of Farmed Atlantic Salmon (*S. salar*) and Different Origin Large Rainbow Trout (*O. mykiss*)

Demet KOCATEPE[1]*, Bengünur ÇORAPCI[2], Can Okan ALTAN[3], Bayram KÖSTEKLİ[4], İrfan KESKİN[5], Hülya TURAN[6]

Abstract

In this study, different source species such as the large rainbow trout (*O. mykiss*) and Norwegian salmon (*S. salar*) were compared in terms of nutritional properties. The groups consisted of large rainbow trout of France-origin (Group A), large rainbow trout of local-origin (Group B) and imported Norwegian salmon (Group N). Group B had the highest crude protein content compared to the others. Group N's crude fat, protein and energy content was lower than that of Groups A and B. In the amino acid profile of the groups, lysine, glutamic acid and aspartic acid were determined at high rates, respectively. Group A's PUFA content was similar to that of Group N. The most important factor that makes Groups A and B superior to N, was the higher EPA+DHA, vitamin A, iron and selenium content. Accordingly, it was determined that the crude protein, crude oil, energy values and lysine, EPA+DHA, vitamin A, and selenium contents of large rainbow trout sampled from fish grown in the Black Sea were higher than Norwegian salmon.

Keywords: Trout, Black Sea, salmon, nutrient composition, nutrition.

Yetiştiricilik Balıklarının Tavsiye Edilen Besin Alımına Potansiyel Katkısı: Norveç Somonu ve Farklı Orijinli Büyük Gökkuşağı Alabalığına İlişkin Bir Vaka Çalışması

Öz

Bu çalışmada farklı orijinli büyük gökkuşağı alabalıkları (*O. mykiss*) ile ithal Norveç somonunun (*S. salar*) besinsel özellikleri karşılaştırılmıştır. Gruplar: Fransa orijinli büyük gökkuşağı alabalığı (Grup A), yerli orijinli büyük gökkuşağı alabalığı (Grup B) ve ithal Norveç somonudur (Grup N). Çalışmada B grubunun diğer gruplara göre daha yüksek ham protein içeriğine sahip olduğu belirlenmiştir. Grup N'nin ham yağ, ham protein ve enerji içeriği Grup A ve B'ye göre daha düşüktür. Grupların aminoasit profilinde sırasıyla lizin, glutamik asit ve aspartik asit yüksek oranda belirlenmiştir. Grup A'nın PUFA içeriği Grup N ile benzerdir. Grup A ve B'yi grup N'den üstün kılan en önemli faktör EPA+DHA, A vitamini, demir ve selenyum içeriklerinin yüksek olmasıdır. Buna göre, Karadeniz'de yetiştirilen balıklardan örneklenen büyük gökkuşağı alabalıklarının ham protein, ham yağ, enerji değerleri ile lizin, EPA+DHA, A vitamini ve selenyum içeriklerinin Norveç somonuna göre daha yüksek olduğu tespit edilmiştir.

Anahtar kelimeler: Alabalık, Karadeniz, Somon, Besin kompozisyonu, Beslenme.

[1,2,3,4,5,6]Sinop University, Department of Fish Processing Technology, Faculty of Fisheries, Sinop, Turkey,
demetkocatepe@hotmail.com, bengucorapci@hotmail.com, okanaltan@hotmail.com, bkostekli@sinop.edu.tr, irfankskn@gmail.com, turahulya@gmail.com

*Sorumlu Yazar/Corresponding Author
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1. Introduction

Salmon, which is very nutritious, such as essential fatty acids, amino acids, minerals and vitamins. Due to the high meat yield and tasty taste, salmon is one of the most widely grown fish in the world. The salmon farming sector is growing rapidly. From its beginnings in the 1960s, the farmed salmon industry has grown significantly in recent decades and today around 70% of the world's salmon production is farmed. More than 2.3 million tons of farmed salmon were produced in 2018 compared to around 930,000 tons of wild-caught salmon (Shahbandeh, 2021). Global salmon consumption is three times what it was in 1980. Once a luxury food, salmon is one of the most popular fish species in the US, Europe and Japan. Salmon farming is the fastest growing food production system in the world, accounting for 70% (2.5 million tonnes) of the market (WWF, 2022). Wild salmon is the commonly used name for species in the Salmonidae family (Purser and Forsyth, 2012). The rainbow trout (*Oncorhynchus mykiss*) is a species of Pacific trout and belongs to the Salmonidae family. They survive in cold, clear, and well-oxygenated lakes, rivers and streams with an ideal temperature between 13 and 15.5 °C. However, rainbow trout have a temperature tolerance of 0 to over 25°C (Fallah et al., 2011). The water temperature of the Black Sea is suitable for breeding large rainbow trout. A large rainbow trout farms operate in Türkiye in the southern Black Sea, which can compete with the world salmon farm. Large rainbow trout farming aims to raise fish with high meat quality in safe water resources. It is offered to the world market to compete to with farmed large rainbow trout and Norwegian salmon. Salmon producers routinely monitor multiple dietary parameters and change feed programmers as necessary to achieve target levels (Sprague et al., 2020). Therefore, an attempt was made to compare to nutritional content of large rainbow trout (trade name: Turkish salmon) of different origins farmed in net cages in the Black Sea and imported Norwegian salmon.

2. Materials and methods

Sampling took place in May 2021. Female large rainbow trout (*Oncorhynchus mykiss* Walbaum, 1792) and imported female Norwegian salmon (*Salmo salar*) were used for sampling. All samples were shipped to the laboratory in styrofoam boxes on ice. Study groups and their characteristics are given below.

Group A: Large rainbow trout of France origin taken from net cages at sea in southern Black Sea, Yakakent, Samsun, Türkiye. The average overall length and eviscerated weight of the specimens were 58.7±1.2 cm and 2795.3±236 g, respectively (n=3).

Group B: Large rainbow trout of local origin (Sivas, Türkiye), samples from net cages in the sea in the southern Black Sea, Yakakent, Samsun, Türkiye. The average overall length and eviscerated weight of the specimens were 56.6±0.4 cm and 2736.5±176.8 g, respectively (n=3).

Group N: Imported Norwegian salmon (*Salmo salar*). Norwegian Salmon (Packing Date: 210510, Printing Station: 0501, Box Type: 000, Serial Number: 2880627) was purchased from Samsun Metropolitan Municipality Fish Market, Samsun, Türkiye. The average overall length and eviscerated weight of the specimens were 79.8±1.4 cm and 5413.9±172.6 g, respectively (n=3).

2.1. Analysis

First, the length and weight of the fish were measured. A boneless fillet was then removed from the fish and analyzed for trans fatty acids, cholesterol, total amino acids, total fatty acid analysis, riboflavin (vitamin B_2), vitamin A, cholecalciferol (vitamin D_3), folic acid (vitamin B9), cyanocobalamin (vitamin B_{12}) and lead (Pb), cadmium (Cd), arsenic (As), mercury (Hg), selenium (Se), iron (Fe), phosphorus (P) fish muscle were homogenized, vacuum packed and frozen in a freezer at -86ºC. These frozen samples were sent to TUBITAK Marmara Research Center Kocaeli, Türkiye (TUBITAK MAM) in styrofoam boxes in ice. Proximate composition analyzes were performed at Sinop University, Faculty of Fisheries, and all other analyzes were performed at TUBITAK MAM.

2.1.1. Proximate Composition analysis

In the study, dry matter, crude ash, and crude protein analyzes were carried out according to AOAC (1995). Crude oil analysis was performed according to AOAC (2005). The energy content of the samples was calculated using the Atwater method and the result given in kcal (Falch et al., 2010).

2.1.2. Total fatty acid, trans-fatty acid composition and cholesterol analysis

The analysis of the fatty acid composition and the trans fatty acid composition was carried out according to the IID-19 method (IUPAC, 1979). The fatty acid results were expressed as a percentage of the GC area (%). Cholesterol analysis was performed by the chromatographic method of Fenton and Sim (1991). The results of the trans fat analysis and the cholesterol content of the samples were determined in g/100g and mg/100g, respectively.

2.1.3. Amino acid analysis

TÜBİTAK MAM in-plant method D.05.G105 was used in HPLC UV for amino acid analysis. A total of 16 amino acids; aspartic acid, glutamic acid, serine, glycine, histidine, arginine, threonine, alanine, proline, tyrosine, valine, methionine, lysine, leucine, isoleucine, and phenylalanine were determined in mg/100 g.

2.1.4. Vitamin analysis

Analysis of retinol (Vit. A) was performed according to AOAC (2000). The samples are kept in an autoclave at 121°C in 0.1 N HCl for 30 minutes, then subjected to enzymatic incubation at 45°C for riboflavin analysis (Vit. B2) and that the peak area reported on the HPLC-FL detector is a measure (Eitenmiller et al. 2016). R-BioPharm Vitafast Folate (Vit. 9), microbiological microtiter plate test for quantification of folate kits (R-Biopharm, 2022). For cyanocobalamin (Vit. B12), a quantitative method was used in samples determined by enzymatic incubation at 37°C and determination of the peak area reported by the HPLC-UV detector after separation in the immunoaffinity column (R-Biopharm, 2011). After saponification extraction, the sample was taken up in the appropriate solvent and the extract determined by analytical normal and reverse phase HPLC for the analysis of cholecalciferol (Vit. D3) (CEN, 1999).

2.1.5. Mineral and heavy metal analysis

According to AOAC (1988), magnesium (Mg), potassium (K), sodium (Na), calcium (Ca) are used for analytical methods (AOAC 985.35). The analysis method AOAC 999.10 was used for the iron (Fe) analysis (AOAC, 2002). AOAC (1997) analysis procedure used for phosphorus (P) (AOAC 986.24).

TUBITAK MAM in-operation method was used for arsenic (As), mercury (Hg), cadmium (Cd), lead (Pb) and selenium (Se) (D.05.G376). Samples were analysed with an Atomic Absorption spectrophotometer (AAS) and Inductively Coupled Plasma Mass Spectrometry (ICP-MS) after Microwave Digestion. Elements were detected at ppm (mg/kg).

2.1.6. Statistical analysis

All analyzes were performed in triplicate. All data were expressed as mean and standard deviation (mean S). A one-way analysis of variance (ANOVA) was performed to determine significant differences (Tukey's test) between the groups in the analysis results. Statistical significance was set at $p<0.05$. All statistical analyzes were performed using MINITAB Version 21. The correlation values were examined between fish muscle colour values and crude oil quantities in the MINITAB Version 21.

3. Results and discussion

Since farming large rainbow trout is a new sector in the Black Sea region and therefore studies on the subject have just started. For this reason, the literature data on large freshwater farmed rainbow trout were used in the discussion part.

3.1. Proximate composition of groups

Proximate composition values of the groups are shown in Table 1. The highest protein content was found in group B ($p<0.05$). Fish muscle demand by consumers due to its high protein content. The crude protein content of the A and B groups examined in the study was higher than that of the N group. Some previous studies found higher protein levels for trout and salmon, for example, 18.7% in farmed rainbow trout (Fallah et al., 2011); 20.28% in Atlantic salmon (Şengör et al., 2013); 18.81% in Atlantic salmon (Atanasoff et al., 2013); 20.18% in large trout (Kaya Öztürk et al., 2019), 20.50-20.63% in rainbow trout (Çelik, 2020).

The highest crude lipid content was determined in group A ($p<0.05$). Researchers had reported that lipid content in the large trout muscle varied between 12.29% (Kaya Öztürk et al., 2019); 5.21% in wild brown trout; 6.42 % in cultured brown trout; 5.11% in farmed rainbow trout (Fallah et al., 2011); 17.23% in Atlantic salmon (Şengör et al., 2013); 2.17-20.02% in rainbow trout (Çelik, 2020);13.5-19% in Atlantic salmon (Reksten et al., 2022); 6.30% in Turkish salmon and 8.57% in Atlantic salmon (Keskin et al. 2022). Many factors affect the proximate composition of fish muscle, and the most important is fish species and food content.

The crude ash, moisture and carbohydrate content of the N group were higher than that of the A and B groups. According to literature (Fallah et al., 2011; Şengör et al., 2013; Atanasoff et al., 2013; Çelik, 2020) the ash content of salmon and rainbow trout varies between 0.5 and 2.5%, they obtained results similar to that in the present study.

Since the crude lipid content of group A was higher than that of the other groups, their energy content was also higher ($p<0.05$). This affects the energy value of large rainbow trout. Şengör et al. (2013), and Esaiassen et al. (2022) determined the energy values of Atlantic salmon to be 236.95 and

208 kcal/100g. The main reasons for this difference in energy levels are changes in crude protein, crude fat and carbohydrate contents, and differnces in energy method.

3.2. Amino acid composition of groups

Fish protein provides humans need of essential amino acids (EAA) in the quantity needed (Chasanah et al., 2019). The changes in the amino acid composition of groups are shown in Table 1. In the study, 16 amino acid types could be detected, 9 of them were essential amino acids (EAA) and 7 of them were non-essential amino acids (NEAA). The NEAA content of the groups ranged from 7.54 to 7.63. The EAA content was higher in groups A and B. The highest EAA/NEAA ratio was found in group A. The amino acid profile of groups was dominated by lysine followed by glutamic acid and aspartic acid.

Groups A and B group statistically similar lysine levels ($p>0.05$), while group N had low levels ($p<0.05$). Similar to the present study, aspartic acid, glutamic acid, leucine and lysine were the dominant amino acids in rainbow trout and salmon fillets (Kaya Öztürk et al., 2019; Esaiassen et al., 2022). Esaiassen et al. (2022) compared the EAA content of organic and conventional Atlantic salmon with the reference protein given in FAO/WHO/UNU (2007). They stated that the EAA content of organic salmon and conventional salmon protein was significantly higher than the reference protein at 44.7% and 45.6%, respectively. In the three groups examined in the present study, the EAA% values were higher than in the literature

Table 1. Changes in proximate and amino acid composition (g/100g) of groups. Energy values of (Kcal /100g) of groups

	Group A	Group B	Group N
		Proximate composition	
Crude protein	17.65 ± 0.07^{A}	18.09 ± 0.13^{B}	17.33 ± 0.02^{A}
Crude lipid	19.83 ± 0.02^{A}	18.42 ± 0.14^{B}	13.99 ± 0.12^{C}
Crude ash	1.23 ± 0.06^{B}	1.37 ± 0.03^{AB}	1.72 ± 0.13^{A}
Moisture	60.37 ± 0.16^{A}	61.51 ± 0.30^{B}	65.84 ± 0.15^{C}
Carbohydrate	0.70 ± 0.13^{A}	0.61 ± 0.07^{A}	1.12 ± 0.33^{A}
Energy value	251.88 ± 0.64^{A}	240.61 ± 1.99^{B}	199.73 ± 1.07^{C}
		Amino acid composition	
Aspartic acid	1.81 ± 0.00^{B}	1.94 ± 0.02^{A}	1.90 ± 0.01^{A}
Glutamic acid	2.27 ± 0.00^{A}	2.30 ± 0.04^{A}	2.26 ± 0.01^{A}
Serine	0.58 ± 0.00^{B}	0.66 ± 0.01^{A}	0.62 ± 0.00^{A}
Glycine	0.75 ± 0.00^{B}	0.80 ± 0.01^{A}	0.76 ± 0.00^{AB}
Alanine	0.96 ± 0.00^{B}	1.00 ± 0.01^{A}	0.99 ± 0.01^{AB}
Proline	0.57 ± 0.00^{A}	0.58 ± 0.01^{A}	0.55 ± 0.00^{A}
Tyrosine	0.60 ± 0.01^{A}	0.60 ± 0.00^{A}	0.55 ± 0.00^{B}
∑NEAA	**7.54**	**7.88**	**7.63**
Histidine	1.18 ± 0.00^{B}	1.21 ± 0.02^{AB}	1.24 ± 0.00^{A}
Arginine	0.71 ± 0.00^{C}	0.74 ± 0.00^{B}	0.78 ± 0.00^{A}
Threonine	0.66 ± 0.00^{C}	0.74 ± 0.01^{A}	0.71 ± 0.00^{B}

Valine	0.89±0.00^{A}	0.88±0.01^{A}	0.84±0.00^{A}
Methionine	0.52±0.00^{A}	0.52±0.00^{A}	0.49±0.00^{B}
Isoleucine	0.89±0.00^{A}	0.83±0.01^{B}	0.79±0.00^{B}
Leucine	1.18±0.05^{A}	1.21±0.02^{A}	1.16±0.00^{A}
Phenylalanine	0.76±0.01^{A}	0.76±0.01^{A}	0.68±0.00^{B}
Lysine	3.36±0.02^{A}	3.27±0.03^{A}	3.03±0.01^{B}
Tryptophan	**N/A**	**N/A**	**N/A**
∑EAA	**10.15**	**10.16**	**9.72**
∑ AA	**17.69**	**18.04**	**17.35**
EAA %	**57.34**	**56.31**	**56.02**
∑EAA/∑NEAA	**1.35**	**1.30**	**1.27**

Different letters (A, B, C) on the same row indicates statistical differences between groups ($p<0.05$).
∑EAA: Total essential amino acids, **∑NEAA:** Total non-essential amino acids, **N/A:** not analysed. **Group A:** Large rainbow trout of France-origin, **Group B:** Large rainbow trout of local-origin (Sivas, Türkiye), **Group N:** Imported Norwegian salmon

3.3. Fatty acid, trans fatty acid composition and cholesterol content of the groups

Norwegian salmon is preferred for its high unsaturated fat content. It contains more unsaturated fatty acids and eicosapentaenoic acid (EPA) + docosahexaenoic acid (DHA) than many farmed fish species. The main purpose of the large rainbow trout farmed in the Black Sea, is to match the meat fat quality to that of Norwegian salmon. In this study, the fatty acid contents of groups A and B and the imported group N were compared. As shown in Table 2 significant differences in trans-fatty acids and cholesterol content were observed between groups ($p<0.05$). The total saturated fatty acid (SFA) content of the A and B groups was not statistically different ($p>0.05$), and the N group was lower than both groups ($p<0.05$). The total monounsaturated fatty acids (MUFA) contents of the groups was statistically different ($p<0.05$). Although the polyunsaturated fatty acid (PUFA) contents of the groups was very close the content of group B was minimal ($p<0.05$). Esaiassen et al. (2022) gave the PUFA content of salmon from organic and conventional farming at 33.2 and 28.9%. The PUFA content of all groups was similar to that in study. EPA and DHA are fatty acids with proven effects on human brain and heart health. Groups A and B had higher EPA+DHA levels than group N ($p<0.05$). Unlike our study, Keskin et al. (2022) found the EPA+DHA content of Turkish salmon lower than Atlantic salmon. This difference may be caused by many factors such as the size, weight, gender, age, freshness of the fish.

An optimal ∑PUFAn-6/∑PUFAn-3 ratio is suggested to be 2:1-5:1. However, in the Western diet, the actual ratio is between 15:1 and 16.7:1 (Simopoulos, 2008). This value influenced by all foods in the daily diet and consumption fish with a low ∑PUFAn-6/∑PUFAn-3 ratio is important. The ∑PUFAn-6/∑PUFAn-3 content of all groups included in the present study was below 2. In aquaculture fish, the properties of the plant oil contained in the feed influence the ∑PUFAn-6/∑PUFAn-3ratio (Esaiassen et al. 2022).

Table 2. Changes in fatty acid composition (%), trans fatty acid (g/100g) and cholesterol content (mg/100g) of the groups.

Fatty acids	Group A	Group B	Group N
C12:0	0.05 ± 0.00^{A}	0.05 ± 0.00^{A}	0.03 ± 0.00^{B}
C14:0	2.03 ± 0.00^{A}	1.9 ± 0.00^{A}	2.32 ± 0.00^{B}
C16:0	14.04 ± 0.03^{A}	13.92 ± 0.13^{A}	8.54 ± 0.02^{B}
C16:1	3.70 ± 0.00^{A}	3.94 ± 0.00^{B}	2.53 ± 0.00^{C}
C18:0	3.89 ± 0.01^{B}	4.37 ± 0.06^{A}	2.22 ± 0.01^{C}
C18:1n9c	34.97 ± 0.03^{C}	36.34 ± 0.09^{B}	41.08 ± 0.01^{A}
C18:2n6c	16.77 ± 0.00^{A}	15.45 ± 0.02^{B}	15.08 ± 0.00^{C}
C18:3n3	3.48 ± 0.06^{B}	3.26 ± 0.00^{B}	6.63 ± 0.01^{A}
C20:1 cis_11_eikosenoik_asit	2.19 ± 0.00^{B}	2.15 ± 0.00^{B}	2.83 ± 0.04^{A}
C22:5n3	0.89 ± 0.01^{B}	0.85 ± 0.00^{C}	0.95 ± 0.00^{A}
C20:5n3 cis_58111417	1.49 ± 0.00^{B}	1.43 ± 0.01^{C}	2.34 ± 0.00^{A}
C22:6n3 cis_410131619	4.29 ± 0.00^{B}	4.35 ± 0.00^{A}	2.46 ± 0.00^{C}
∑SFA$^{2.3}$	20.73 ± 0.03^{A}	20.96 ± 0.19^{A}	13.92 ± 0.03^{B}
∑MUFA$^{2.4}$	41.54 ± 0.04^{C}	43.04 ± 0.09^{B}	47.03 ± 0.02^{A}
∑PUFA$^{2.5}$	30.74 ± 0.07^{A}	29.11 ± 0.02^{B}	30.64 ± 0.03^{A}
∑PUFAn-3	10.54 ± 0.07^{B}	10.34 ± 0.01^{B}	12.56 ± 0.02^{A}
∑PUFAn-6	17.73 ± 0.00^{A}	16.37 ± 0.02^{B}	15.75 ± 0.01^{C}
∑PUFAn-6/∑PUFAn-3	1.68 ± 0.01^{A}	1.58 ± 0.00^{B}	1.25 ± 0.00^{C}
∑PUFA /∑SFA	1.48 ± 0.01^{B}	1.39 ± 0.01^{C}	2.20 ± 0.01^{A}
EPA+DHA	5.78 ± 0.00^{A}	5.77 ± 0.00^{A}	4.79 ± 0.01^{B}
Trans fatty acids (g /100g)	0.02 ± 0.00^{B}	0.01 ± 0.00^{C}	0.03 ± 0.01^{A}
Cholesterol (mg/100g)	106.73 ± 0.00^{B}	103.52 ± 0.00^{C}	128.87 ± 0.00^{A}

Values are mean of repeat groups (n=6); Different letters (**A, B, C**) on the same line indicates statistical differences between groups ($p<0.05$).

∑ were obtained by summing the fatty acids of those contained at a level of <0.01 g/100g total fatty acids; C12:0, C13:0, C14:0, C15:0, C16:0, C17:0, C18:0, C20:0, C22:0, C24:0, C14:1, C16:1, C18:1n9c, C18:1n9t, C20:1cis_11, C22_1n9, C24:1, C18:2n6c, C18:3n3, C18:3n6, C20:2 cis_11_14, C20:3n6 cis_8_11_14, C22:2 cis_13_16, C22:5n3 cis-7,10,13,16,19, C20:5n cis_58111417, C22:6n3 cis_410131619, C20:4n6, C20:3n:3 cis-11,14,17.

∑SFA: Saturated fatty acids (C12:0, C13:0, C14:0, C15:0, C16:0, C17:0, C18:0, C20:0, C22:0, C24:0)

∑MUFA: Monounsaturated fatty acid (C14:1, C16:1, C18:1n9c, C18:1n9t, C20:1cis_11, C22_1n9, C24:1)

∑PUFA: Polyunsaturated fatty acids. (C18:2n6c, C18:3n3, C18:3n6, C20:2 cis_11_14, C20:3n6 cis_8_11_14, C22:2 cis_13_16, C22:5n3 cis-7,10,13,16,19, C20:5n cis_58111417, C22:6n3 cis_410131619, C20:4n6, C20:3n:3 cis-11,14,17).

Group A: Large rainbow trout of France-origin, **Group B:** Large rainbow trout of local-origin (Sivas, Türkiye), **Group N:** Imported Norwegian salmon

United States Department of Agriculture (USDA, 2009) reported significantly lower cholesterol level (59 mg/100 g meat) in farmed and wild rainbow trout compared to these study results. Similarly, Şengör et al. (2013) give the cholesterol content of Atlantic salmon as 50,20 mg/100g; Fallah et al. (2011) reported 40.10 mg/100g. In the present study, the cholesterol content of the groups found to be significantly higher than in the literatures. The highest amount of cholesterol was detected in Group N.

Trans fats or transfatty acids, an undesirable group among fats of great nutritional importance, are a form of unsaturated fatty acids that can be derived from natural or industrial sources. Trans fat content of foods; may vary depending on many factors such as food type, fat type, amount, type of food processing, heat treatment. The main sources of trans fatty acid intake were meat and meat products, milk and milk products, and cereal and cereal products. The maximum trans fatty acid content that can be found in food is limited to 1g/100g (Turkish Food Codex, 2007). The trans fatty acid content of all groups in this study was quite low.

3.4. Vitamins, minerals, and heavy metals content of the groups

As shown in Table 3 significant differences in vitamin content were observed between groups ($p<0.05$). Vit. A and Vit. D_3 contents of the groups were different ($p<0.05$). Vit. D_3, Vit. B_{12} and Vit. B_2 content of groups A and B were lower than that of group N. The Vit. A and Vit. B_2 contents were found to be 33 µg/100g, 0.041mg/100g for salmon and 8.8 µg/100g, 0.040 mg/100g for rainbow trout (Dias et al., 2003). The data of the present study were similar to Vit. A content of this literature. Vit. B_2 content was twice that of this literature. Kocatepe et al. (2022) reported that the vitamin A content of large rainbow trout was higher than Atlantic salmon. The folate content of the groups was similar to the salmon folate content and was given as 10 µg/100g by (Dias et al., 2003). Salmon is a fatty fish that is generally credited with being high in Vit. D content. The Vit. D content in salmon (*Oncorhynchus* sp.) (Malesa-Ciećwierz & Usydus, 2015) and farmed salmon (*Salmo salar*) (Jakobsen et al., 2019) has been reported as 8 and 6 µg/100g, respectively. Reksten et al. (2022) found that Vit. D_3 content has remained relatively stable over the years, with median values between 6 and 9.2 µg/100g for farmed Atlantic salmon. The Vit. D_3 content of all groups was lower than the cited literature.

Table 3. Changes in vitamin, mineral and heavy metal content of groups

	Group A	**Group B**	**Group N**
Vitamin A (µg/100g)	30.82 ± 0.43^{A}	24.39 ± 0.26^{B}	10.81 ± 0.41^{C}
Vitamin B_{12} (µg/100g)	2.27 ± 0.02^{B}	2.15 ± 0.06^{B}	4.83 ± 0.07^{A}
Vitamin B_2 (mg/100g)	0.08 ± 0.00^{B}	0.07 ± 0.00^{B}	0.09 ± 0.00^{A}
Vitamin D_3 (µg/100g)	1.83 ± 0.03^{C}	2.26 ± 0.03^{B}	4.71 ± 0.00^{A}
Folate (µg/100g)	10.07 ± 0.83^{B}	9.60 ± 0.70^{B}	14.51 ± 0.39^{A}
Mg (mg/kg)	211.11 ± 0.00^{C}	247.80 ± 0.00^{A}	222.50 ± 0.00^{B}
K (mg/kg)	3090.00 ± 0.00^{C}	3406.00 ± 0.00^{A}	3282.00 ± 0.00^{B}
Ca (mg/kg)	95.00 ± 0.00^{B}	121.00 ± 0.00^{A}	81.45 ± 0.00^{C}
Na (mg/kg)	322.20 ± 0.00^{B}	301.80 ± 0.00^{C}	414.60 ± 0.00^{A}
Fe (mg/kg)	4.16 ± 0.00^{B}	3.50 ± 0.00^{C}	6.24 ± 0.00^{A}
Se (mg/kg)	0.22 ± 0.02^{A}	0.05 ± 0.003^{C}	0.14 ± 0.02^{B}
As (mg/kg)	0.16 ± 0.02^{A}	0.10 ± 0.006^{B}	0.10 ± 0.006^{B}

P (mg/kg)	2246.40±0.00^{C}	2566.40±0.00^{A}	2488.2±0.00^{B}
Pb (mg/kg)	<0.013 ^{A}	<0.013 ^{A}	<0.013 ^{A}
Hg (mg/kg)	<0.05^{A}	<0.05^{A}	<0.05^{A}
Cd (mg/kg)	<0.011^{A}	<0.011^{A}	<0.011^{A}

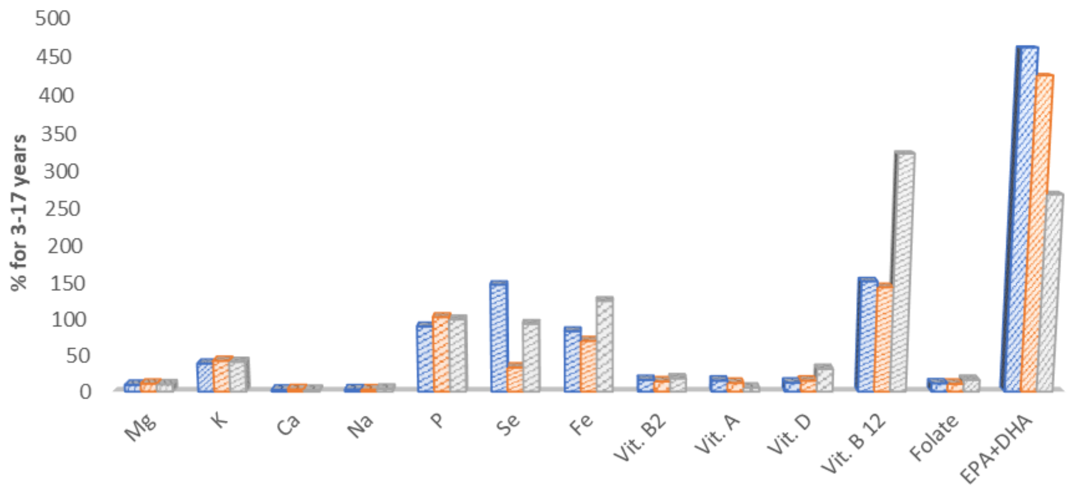
Different letters (**A, B, C**) in the same row indicate statistical differences between the groups (p<0.05).
Group A: Large rainbow trout of France-origin, **Group B:** Large rainbow trout of local-origin (Sivas, Türkiye), **Group N:** Imported Norwegian salmon

Fish muscle is rich in minerals, but there are reservations about eating fish due to the presence of heavy metals that can be transferred from fish to humans. Fish muscle is rich in Fe, Se, P, and Zn. The measured mineral and heavy metal contents in the groups are shown in Table 3. According to the results of the study, the Mg, K, Ca, Na, Fe, Se, and P contents of the groups were different from each other ($p<0.05$). The maximum content of K, Mg, Ca, and P was determined in group B, the local origin group. The Na and Fe content of group N was higher than other groups. The Na/K ratio is particularly important for heart health. The Na/K ratio of the A, B and N groups were 0.10, 0.09 and 0.13, respectively. Consumption of groups A and B was more effective in terms of heart health compared to group N due to the high K content.

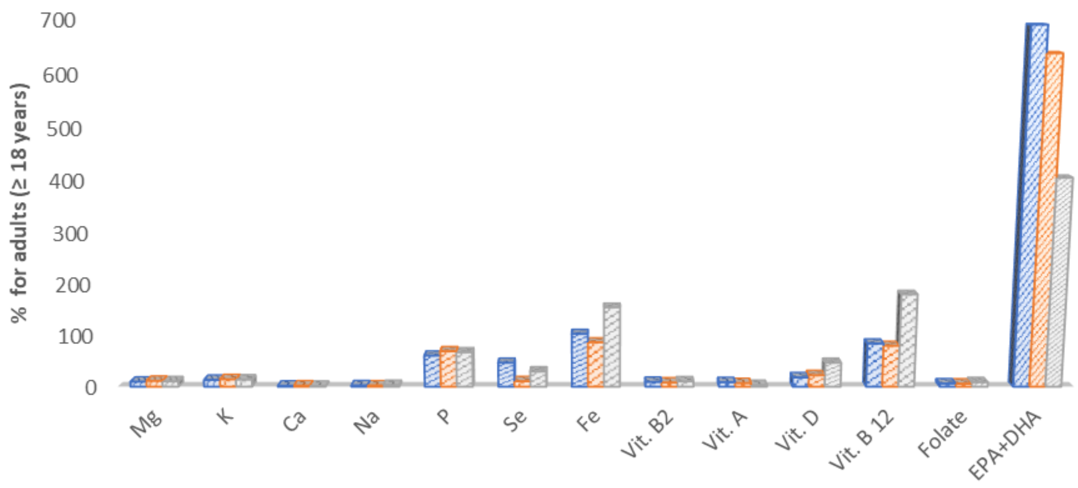
Bat et al. (2021) reported the Fe content of large rainbow trout farmed in the Black Sea (similar to groups A and B in the present study) to be 4.80 mg/kg. This literature is very close to the A and B groups in the present study. In contrast, Norwegian salmon had higher Fe content ($p<0.05$). The results obtained are presented in Table 3 and the maximum limits set by European Union regulation (Commission Regulation, 2008) are 1.0 mg kg^{-1} for As; 0.05 mg kg^{-1} for Cd; 0.2 mg kg^{-1} for Pb; 0.5 for Hg; heavy metal contents of these groups did not exceed these limit values.

3.5. Contribution to the recommended intake of nutrients

Portion sizes for the “fish and other seafood” reported by European Member States differ for different age/population groups, ranging from 23 to 135 g (EFSA, 2015). In Türkiye Dietary Guidelines (2016), it is recommended to consume 150 g (1 serving) of fish per day for adults (≥ 18 years), and 100 g (1/3 serving) for children aged 3 years. Like many scientific organizations, the Türkiye Dietary Guidelines (2016) recommend eating 2-3 servings (80-360 g) of oily fish per week. Most European Food-Based Dietary Guidelines recommend (least) two servings (about 150 g each) of fish per week for older children, adolescents, and adults to ensure adequate intake of essential nutrients, particularly long chain n-3 PUFAs, but also Vit. D, I and Se (EFSA, 2015). Figure 1 shows the comparison of the fish used in the study with the recommended daily intake (RDI) values recommended by some authorities (EFSA, 2022; WHO/FAO/UNU, 2007). The nutritional content of the fish was calculated considering the daily consumption of 100 g for people aged 3-17 years and 150 g for adults over 18 (≥ 18 years) (Figure 1).



	Mg	K	Ca	Na	P	Se	Fe	Vit. B2	Vit. A	Vit. D	Vit. B 12	Folate	EPA+DHA
Group A	9	39	2	3	90	147	83	16	15	12	151	11	460
Group B	11	43	3	3	103	33	70	14	12	15	143	11	424
Group N	10	41	2	4	100	93	125	18	5	31	322	16	268



	Mg	K	Ca	Na	P	Se	Fe	Vit. B2	Vit. A	Vit. D	Vit. B 12	Folate	EPA+DHA
Group A	10	13	2	2	61	47	104	9	9	18	85	6	688
Group B	11	15	2	2	70	11	88	8	7	23	81	6	636
Group N	10	14	1	3	68	30	156	10	3	47	181	9	404

Figure 1. The contribution of serving of farmed large rainbow trout (groups A and B) and Atlantic salmon was compared to the RDI of Mg, K, Ca, Na, P, Se, Fe, vitamin B_2, vitamin A, vitamin D, vitamin B_{12}, Folate and EPA+DHA for 3-17 years and adults over 18 years. The calculations are based on the RDI presented in EFSA (2022) for Mg, K, Ca, Na, P, Se, Fe, vitamin B_2, vitamin A, vitamin D, vitamin B_{12}, folate, and in the WHO/FAO/UNU (2007) for EPA+DHA. A serving size is 100 g for 3 to17 years olds and 150 g for adults over 18 years old. **Group A:** Large rainbow trout of France-origin, **Group B:** Large rainbow trout of local-originated (Sivas, Türkiye), **Group N:** Imported Norwegian salmon.

A portion of large rainbow trout was able to provide about 424% and 460% of the RDI for 3 to 17-year-olds and about 636% to 688% for adults over 18. The daily intake of EPA + DHA was higher than Norwegian salmon. Reksten et al. (2022) reported that one serving of Atlantic salmon provides between about 340% and 750% of the daily EPA+DHA requirement. In our study, the EPA+DHA amount of 100 g large rainbow trout and Norwegian salmon was determined to be 1.15 g (group A), 1.06 g (group B) and 0.67 g (group N), respectively. Similar to the present study, Sprague et al. (2020) reported that the amount of EPA+DHA in Atlantic salmon varies between 0.30 and 2.36 g/130 g fish muscle. Considering all this data, large rainbow trout had very high EPA+DHA levels compared to Norwegian salmon. With 100 g fish muscle consumption from all groups, over 70% P, Se, Fe, vit. B12 and EPA+DHA required by people aged 3-17 are met. In addition, with a consumption of 150 g of fish muscle consumption from all groups more than 60% P, Fe, Vit. B12 and EPA+DHA, which people over 18 need daily, are covered. Sprague et al. (2020) found that an average daily selenium requirement of 60-75/day can be covered by 13.9% to 55% with the consumption of 130g Atlantic salmon. The Se contents of all groups are high compared to the cited literature.

4. Conclusion

To make a general assessment; group A was more nutritionally valuable than group B with its total PUFA, total omega-3, EPA+DHA, vit. B_2, vit. A, Folate, vit. B_{12}, Se and Fe content. The crude protein, and PUFA content of the N group was closer to that of the A group. The EPA+DHA content of large rainbow trout was higher than that of Norwegian salmon. Many factors influence the nutrient composition of aquaculture fish muscles. Factors such as rearing location, feeding, feed content, water quality, stocking influence the nutrient composition and muscle quality.

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Authors' Contributions

All authors contributed equally to the study.

Statement of Conflicts of Interest

There is no conflict of interest between the authors.

Statement of Research and Publication Ethics

The authors declare that all the rules required to be followed within the scope of "Higher Education Institutions Scientific Research and Publication Ethics Directive" have been complied with in all processes of the article, that The Black Sea Journal of Science and the editorial board have no responsibility for any ethical violations that may be encountered, and that this study has not been evaluated in any academic publication environment other than The Black Sea Journal of Science.

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