GAZİOSMANPAŞA BİLİMSEL ARAŞTIRMA DERGİSİ (GBAD)
Gaziosmanpasa Journal of Scientific Research
ISSN: 2146-8168
http://dergipark.gov.tr/gbad
Araştırma Makalesi (Research Article)

Cilt/Volume : 11
Sayı/Number: 2
Yıl/Year: 2022
Sayfa/Pages: 123-134

***Alınış tarihi (Received)*:** 24.05.2022
***Kabul tarihi (Accepted)*:** 06.09.2022

Comparative Analysis of Proximate and Fatty Acid Composition and Mineral Matter Contents of Cultured Rainbow Trouts (*Oncorhynchus Mykiss)* in Different Farms

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ABSTRACT: In the study, the proximate and fatty acid composition and mineral content of rainbow trout reared at different farms were compared. For this purpose, rainbow trout obtained from five different farms were kept in ice in styrofoam boxes and brought laboratory. Fillet samples were taken separately for each fish and homogenized in order to determine the body and fatty acid profiles from the muscle tissue just below the dorsal fin by dissection of the fish brought to the laboratory individually. As a result of the analysis, in terms of nutritional composition, rainbow trouts fillets obtained from the A farm had the highest protein and lipid ratio. The lowest protein ratio was determined in the D farm, and the lowest oil ratio was determined in the C farm. Although the fatty acid contents of the feeds used by the enterprises were different between them, they were almost close to each other. Myristic (C14:0), stearic (C18:0), palmitic (C16:0), oleic (C18:1 n-9c), linoleic (C18:2 n-6c), linolenic (C18:3 n-3), arachidonic (C20:4 n-6), EPA (Eicosapentaenoic acid) and DHA (Docosahexaenoic acid) were determined to be dominant in the fillet fatty acid compositions of the cultured rainbow trouts at all the farms. Although the n-3/n-6 ratio, AI, FLQ and H/H indexes in fish muscles were at desired nutritional quality values, the TI index was at undesirable nutritional quality values. It was determined that the mineral substance amounts of the feeds obtained from different farms were Ca>P>K>Na>Fe>Mg>Zn>Mn>Se. The mineral substance amounts of rainbow trout obtained from different farms were determined as K>P>Mg>Na>Ca>Zn>Zn>Fe>Se. The amount of mineral substances in the fish samples taken from all the farms was determined to be quite high. As a result, it was determined that the trout obtained from all farms had suitable nutritional criteria. All fish can be considered good sources of nutrients, fatty acids and minerals.

Keywords- Nutrition quality index, reared fish, meat quality, lipids.

1. Introduction

Nutrition and health are inextricably linked because adequate nutrition is the cornerstone of health and indeed essential for good health. Because of its nutritive qualities, fish is one of the most important contributors to a healthy human diet. In addition to its important role in protein and fat-soluble vitamin intake, the nutritional benefits of fish consumption are linked to the fatty acid (FA) profile, particularly long-chain polyunsaturated fatty acids (PUFA) and PUFAs are considered essential because they cannot be synthesized by humans and are obtained only through diet (Amoussou et al., 2022). The lipid and fatty acid composition of fish are generally related to fish species, environmental temperature, season, physical and chemical properties of water, geographical location, age, sex, rearing conditions, physical activity and feeding habits of animals (Gills and Weatherley, 1984; Yılmaz, 1995). It is stated that although the fish taken from different farms in aquaculture are the same species, their aromas differ and this is mostly due to the difference in feeding and water (Haliloğlu, 2001).

Minerals are known as micronutrients and are essential for cell metabolism and therefore the physiological development of living organisms. For this reason, people take mineral supplements daily to improve their quality of life and the quality of their mental and physical

activities. For this reason, fish and other aquatic products with rich mineral substances and trace element content have special importance in the healthy diet of people (Turan et al., 2006; Tacon and Metian, 2013).

Fish farming is increasing day by day due to decreasing fish stocks due to various reasons (overfishing, pollution, global warming, etc.). However, despite the increase in aquaculture production, consumers' prejudices towards these products are still a matter of debate. In fact, many studies have been conducted comparing the meat yield of cultured fish and natural fish to break this prejudice (Erdem et al., 2009; Dagtekin et al., 2017; Krstić et al., 2017; Dernekbaşı and Hamzaoğlu, 2018). This study, it was aimed to determine the body and fatty acid profiles and mineral substance contents in the fillet tissues of trout cultured at different farms.

2. Material and Methods

2.1. Fish material and sampling

In the present study, 5 healthy rainbow trout with an average weight of 197.85±9.24 g, reaching market size, were used as fish material. 5 samples taken from each group were used as replicates at the same time. Analyzes were made for each fish separately and studied in three parallels (25x3=75 samples). The fish were randomly selected from fish harvested from 5 different farms (A, B, C, D and E farms). The fish obtained from the enterprises were kept in ice in styrofoam boxes and brought to the Aquaculture Laboratory of Sinop University Fisheries Faculty. Fillet samples were taken separately for each fish and homogenized in order to determine the proximate and fatty acid profiles from the muscle tissue just below the dorsal fin by dissection of the fish brought to the laboratory individually. Some of the homogenized samples were used for analysis, and some of them were sealed in plastic bags and kept at -20°C in order to repeat the analysis against any possible mishaps. The enterprises used different feeds in the feeding of the fish.

2.2. Proximate analysis

Feed and fish fillet samples were analyzed according to the standard methods of the Association of Official Analytical Chemists (AOAC 1995). The samples for dry matter detection were dried at 105°C until a constant weight was achieved. The ash content of samples was determined after being burned at 550°C for 6 h in a muffle furnace. Crude protein amount was analyzed by the Kjeldahl method, and crude lipid was determined after extraction with petroleum ether by the Soxhlet method.

2.3. Indices of the nutrition quality of muscle lipids

The lipid nutritional value of the fillets is referred to as the index of atherogenicity (AI), the index of thrombogenicity (TI), the flesh lipid quality (FLQ) measurements and Hypocholesterolemic/Hypercholesterolemic (H/H). These measurements were determined using the following formulas (Graffo et al., 2011; Dagtekin et al., 2017; Yu et al., 2018; Dernekbaşı and Karayücel, 2021).

The Index of Atherogenicity (AI) =[(4×C14:0) + C16:0 + C18:0] /(ΣMUFA + n-6 PUFA + n-3 PUFA)

The Index of Thrombogenicity (TI) =(C14:0 + C16:0 + C18:0) / (0.5×ΣMUFA + 0.5×n-6 PUFA + 3×n-3 PUFA) + (n-3 PUFA/n-6 PUFA)

The Flesh Lipid Quality (FLQ) = C20:5 n3 + C22:6 n3 / Σtotal FA

Hypocholesterolemic/Hypercholesterolemic (H/H)= (C18:1n-9 + C18:2n-6 + C20:4n-6 + C18:3n-3 + C20:5n-3 + C22:5n-3 + C22:6n-3) / (C14:0+C16:0)

2.4. Fatty acid analysis

Total lipid was determined by modified Bligh and Dyer Method (Hanson and Olley 1963). 0.25 g of extracted oil from fish fillets and diets was thawed by adding 4 ml of heptane and 0.4 ml of 2N KOH was added. This mixture was stirred in vortex for 2 minutes, then centrifuged at 5000 rpm for 5 minutes. After centrifugation, 1.5-2 ml of the heptane phase was collected and transferred to glass tubes for GC/MS analysis. The injection of samples into the device was performed with the autosampler AI 1310. Samples were analyzed by Thermo Scientific ISQ LT model GC/MS gas chromatography by spectrometer. For this analysis, with 0.25µm film thickness was used a Trace Gold TG-WaxMS capillary column (Thermo Scientific code: 26088-1540) in 0.25µm inner diameter and 60µm length. The injection block temperature was adjusted to 240°C and the column temperature program to be increased from 100°C to 240°C. Helium gas (1 ml/min) was used as a carrier gas and 1:20 split ratio was applied. The MS unit (ISQ LT) was used in electron ionization mode. Fatty acids were defined by comparing the standard FAME mixture of 37 components [Chem-Lab Fame mix (37C) standard solution; Art. Nr. CL40. 13093; Lot Nr. 221.561.102.100] with respect to their arrival time.

2.5. Mineral matter analysis

EPA Method 200.3 (Sample Preparation Procedure For Spectrochemical Determination of Total Recoverable Elements In Biological Tissues) taken into account for our measurements. Fresh fish meat samples (up to 1.5g) were digested in Teflon vessels including a mixture of concentrated supra pure grade HNO3 and H_2O_2 (7:1) according to (HPR-FO-67) temperature and pressure profile using a microwave digestion system (Milestone SK10). After adding the acid Teflon bombs closed and heated at 200ºC for 15 minutes and stayed at the same temperature for 15 minutes. The digested solution was transferred into 50 mL polypropylene falcon tubes and filled up to 50 ml with ultra-pure water. Concentrations of elements were measured by an Inductively Coupled Plasma Mass Spectrophotometer (ICP-MS, Agilent 7700X). Quality assurance and control were performed using triplicate measurement and certified reference material (UME CRM 1201 spring water, Lobster TORT-2, BCR-185r liver, SEM 2016). Standard solutions supplied by Agilent (27 element mix: 8500-6940 2A and 8500-6940 Hg) were used for calibration curves. The analytical precision was within ±10%. 1 ppm internal standard (Agilent 5188-6525) was analyzed continuously with samples. The accuracy of elements in the CRM varied from 90 % to 100%. All analyses were done in triplicate, and the mean values were used for data analysis.

2.6. Statistical analysis

Anderson-Darling and Levene's tests were used for the homogeneity of variances and equality of variance of the groups, respectively. The differences between the results were analyzed using a one-way analysis of variance (ANOVA) and then Tukey's multiple comparison method was used for the determination of the significance level of differences

in-groups and between groups. Before the statistical analysis, the square root transformations of the percent data were made for the homogeneity of the variances. Differences were considered significant when $p < 0.05$. All analyses results were presented as mean ± standard error (SEM) values. Analyzes were performed using Minitab 17 (Minitab Inc., State College, PA, USA) software for Windows.

3. Results and Discussion

3.1. Proximate composition of the diets and fillets

Feeds with different nutrient compositions were used at all farms (Table 1). Differences in moisture content among the feeds used were statistically significant ($P<0.05$). The feed used by farm A had the highest protein and lowest lipid. The feed used by farm E had the lowest protein content and the highest lipid content. In terms of protein ratios, the difference between the other farms was significant ($P<0.05$), except for the C, D and E farms. While the feed used by farm A had the highest ash content ($P<0.05$), there was no difference in the ash content of the feed used by the other farms. These differences between the feeds are probably because they have different formulations and are produced in different factories. There were differences between farms except for B and E in terms of moisture content in the fish fillets. The highest protein and lipid ratio was determined at A farm, the lowest protein at D, and the lowest lipid ratio at C farms ($P0<0.05$). The difference between A-C and B-E in terms of fillet ash ratio was not significant ($P>0.05$).

Table 1. Proximate composition of the diets and fillets of rainbow trout cultured at different farms (%)
Tablo 1. Yemlerin ve farklı çiftliklerden alınan gökkuşağı alabalığı filetolarının besin kompozisyonu (%)

Farms	Moisture (%)	Crude protein (%)	Crude lipid (%)	Crude ash (%)
Diets				
A	3.40±0.20^{d}	51.51±0.28^{a}	16.98±0.04^{e}	10.76±0.04^{a}
B	4.66±0.00^{c}	48.69±0.55^{b}	20.55±0.25^{b}	9.92±0.00^{b}
C	5.06±0.12^{b}	47.72±0.26^{c}	18.91±0.27^{c}	10.01±0.01^{b}
D	5.54±0.14^{a}	47.25±0.21^{c}	18.35±0.03^{d}	10.03±0.14^{b}
E	4.51±0.17^{c}	46.65±0.13^{c}	21.97±0.19^{a}	9.72±0.03^{b}
Fillets				
A	72.25±0.19^{e}	23.44±0.19^{a}	5.22±0.46^{a}	2.10±0.87^{c}
B	74.74±0.10^{c}	22.34±0.78^{b}	3.34±0.39^{c}	3.45±0.19^{a}
C	75.07±0.08^{b}	22.16±0.18^{b}	1.87±0.09^{e}	2.60±0.48^{b}
D	75.67±0.09^{a}	21.81±0.78^{c}	3.05±0.01^{d}	2.15±0.04^{c}
E	73.89±0.07^{d}	23.24±0.07^{a}	4.67±0.33^{b}	3.64±0.56^{a}

Data are mean ± SEM. Means with different superscript letter in a row are significantly different ($p>0.05$).

Since the baits used in all farms have different nutrient compositions, the nutrient compositions determined in fish fillets were also determined at different values. Krstic et al. (2017) reported that the reason for the difference in the nutritional composition of rainbow trout grown in two different environments may be due to environmental factors and age, as well as feeding. As with all living things, the metabolic demands of fish vary according to their environment. As a matter of fact, although the feed used in farmA had the lowest lipid content ratio, the highest lipid rate was found in the fish fillets. Again, while the feed used in farm E had the lowest protein content, it was determined that the product obtained had the highest protein. It can be said that this situation may be due to the fact that fish obtained from farms located in different regions have different environments (water, temperature, pH, etc.) and that their metabolisms evaluate the nutrients taken in different ways.

3.2. Fatty Acid Profiles of the Diets and Fillets

There are statistical differences between the feeds used in the farms in terms of fatty acid compositions ($p<0.05$). Myristic (C14:0), stearic (C18:0), palmitic(C16:0), linoleic (C18:2 n-6c), oleic (C18:1 n-9c), linolenic (C18:3 n-3), arachidonic (C20:4 n-6), eicosapentaenoic (C20:4 n-6; EPA) and docosahexaenoic (C22:6 n-3; DHA) acids are dominant fatty acids in all feeds (Table 2).

Table 2. Fatty acid composition of the diets (% total fatty acids)
Tablo 2. Yemlerin yağ asit kompozisyonu (toplam yağ asitlerinin %'si)

	Diets				
Fatty acids	**A**	**B**	**C**	**D**	**E**
C14:0	5.67±0.03^{a}	4.52±0.01^{b}	4.32±0.00^{bc}	4.79±0.02^{b}	4.10±0.17^{c}
C15:0	0.61±0.01^{a}	0.61±0.01^{a}	0.54±0.00^{b}	0.51±0.00^{bc}	0.48±0.01^{c}
C16:0	15.53±0.11^{a}	13.57±0.06^{c}	13.11±0.00^{c}	14.28±0.08^{b}	13.50±0.22^{c}
C17:0	0.71±0.01^{a}	0.71±0.01^{a}	0.66±0.00^{b}	0.59±0.00^{b}	0.54±0.00^{b}
C18:0	7.38±0.01^{a}	7.36±0.03^{ab}	7.22±0.03^{b}	7.06±0.04^{c}	6.83±0.04^{d}
C20:0	1.20±0.01^{b}	1.24±0.02^{a}	1.20±0.02^{b}	1.15±0.00^{c}	1.10±0.01^{d}
C21:0	0.02±0.02	0.04±0.00	0.04±0.00	0.01±0.00	0.02±0.01
C22:0	0.54±0.01^{b}	0.59±0.01^{a}	0.60±0.01^{a}	0.53±0.00^{b}	0.59±0.00^{a}
C23:0	0.11±0.01	0.12±0.01	0.12±0.01	0.11±0.00	0.13±0.01
C24:0	1.04±0.00^{a}	1.04±0.01^{a}	0.92±0.01^{b}	0.94±0.00^{b}	0.87±0.01^{c}
ΣSFA	32.81±0.12^{a}	29.80±0.05^{b}	28.73±0.05^{c}	29.97±0.05^{b}	28.15±0.38^{c}
C14:1	0.21±0.00^{b}	0.24±0.0.01^{a}	0.19±0.00^{c}	0.17±0.02^{d}	0.19±0.00^{c}
C15:1	0.07±0.00^{a}	0.08±0.00^{a}	0.07±0.01^{a}	0.08±0.00^{a}	0.07±0.00^{a}
C16:1	0.47±0.01^{b}	0.55±0.01^{a}	0.47±0.00^{b}	0.42±0.00^{c}	0.41±0.00^{c}
C17:1	0.39±0.01^{b}	0.47±0.02^{a}	0.45±0.00^{a}	0.37±0.01^{b}	0.39±0.01^{b}
C18:1 n-9c	19.01±0.06^{b}	19.43±0.10^{b}	19.83±0.22^{b}	20.20±0.12^{ab}	21.24±0.78^{a}
C18:1 n-9t	0.22±0.00^{c}	2.79±0.05^{b}	3.08±0.01^{a}	0.22±0.00^{c}	3.00±0.03^{a}
C20:1	3.98±0.02^{a}	4.55±0.05^{a}	4.27±0.51^{a}	4.69±0.01^{a}	4.75±0.05^{a}
C20:1 n-9	2.97±0.01^{d}	3.26±0.02^{c}	3.49±0.03^{ab}	3.52±0.01^{b}	3.40±0.04^{a}
C24:1	1.20±0.01^{c}	1.24±0.03^{c}	1.35±0.01^{a}	1.27±0.00^{bc}	1.31±0.01^{ab}
ΣMUFA	28.52±0.10^{d}	32.61±0.12^{b}	33.20±0.28^{ab}	30.94±0.09^{c}	34.76±0.68^{a}
C18:2 n-6c	12.48±0.07^{b}	12.76±0.03^{ab}	13.03±0.10^{a}	12.80±0.02^{ab}	12.84±0.11^{a}
C18:2 n-6t	0.69±0.00^{b}	0.75±0.01^{a}	0.66±0.00^{c}	0.63±0.00^{d}	0.59±0.00^{e}
C18:3 n-3	4.97±0.00^{d}	5.67±0.03^{c}	5.97±0.04^{ab}	5.91±0.01^{b}	6.08±0.06^{a}
C18:3 n-6	0.73±0.01^{b}	0.77±0.01^{a}	0.68±0.01^{c}	0.63±0.01^{d}	0.66±0.01^{cd}

C20:2	1.60±0.01^{d}	1.95±0.02^{b}	2.06±0.01^{a}	1.88±0.00^{c}	2.10±0.02^{a}
C20:3 n-3	0.03±0.00	0.05±0.00	0.02±0.00	0.03±0.00	0.02±0.00
C20:3 n-6	0.79±0.00^{c}	0.95±0.02^{a}	0.87±0.00^{b}	0.78±0.00^{c}	0.89±0.01^{b}
C20:4 n-6	1.99±0.01^{a}	1.75±0.01^{b}	1.73±0.02^{b}	1.65±0.00^{c}	1.50±0.01^{d}
C20:5n-3	7.95±0.06^{a}	6.47±0.04^{c}	6.27±0.05^{c}	7.41±0.04^{b}	5.98±0.07^{d}
C22:2	0.24±0.01^{b}	0.31±0.01^{a}	0.30±0.01^{a}	0.28±0.01^{b}	0.32±0.01^{a}
C22:6 n-3	7.01±0.02^{a}	5.96±0.04^{c}	6.29±0.04^{b}	6.88±0.04^{a}	5.94±0.05^{c}
ΣPUFA	38.47±0.05^{a}	37.39±0.15^{b}	37.87±0.25^{ab}	38.87±0.05^{a}	36.93±0.32^{b}
Σn-3 PUFA	19.96±0.08^{a}	18.15±0.09^{bc}	18.56±0.13^{b}	20.23±0.08^{a}	18.02±0.17^{c}
Σn-6 PUFA	16.68±0.08^{c}	16.98±0.03^{bc}	16.96±0.12^{b}	20.86±0.02^{a}	16.49±0.14^{bc}
n-3/n-6	1.20±0.01^{a}	1.07±0.00^{b}	1.09±0.00^{b}	0.97±0.00^{c}	1.09±0.00^{b}
DHA/EPA	0.88±0.00^{c}	0.92±0.00^{b}	1.00±0.00^{a}	0.93±0.00^{b}	0.99±0.00^{a}
PUFA/SFA	1.17±0.01^{c}	1.25±0.01^{b}	1.32±0.01^{a}	1.30±0.00^{a}	1.31±0.01^{a}

Values are means±standard errors of three determinations. SFA: Saturated fatty acids, MUFA: Monounsaturated fatty acids, PUFA: Polyunsaturated fatty acids, DHA: Docosahexaenoic acid, EPA: Eicosapentaenoic acid

These results were supported by Krstic et al. (2017) and are similar to the results of myristic, palmitic and stearic acid from SFA, oleic acid from MUFA and linoleic acid from PUFA, as EPA and DHA are the dominant fatty acids in feed. In addition, they reported that MUFA and PUFA values were higher than SFA values in feeds, as in fish fillet. Beyter (2008), on the other hand, found that palmitic acid in SFA, oleic acid in MUFA, and linoleic acid and DHA in PUFA were remarkably high. In the current study, the highest SFA A was determined in the feeds taken from MUFA E and PUFA D farms. Since the amount of n3 was determined more than the amount of n6, this farm was also reflected in the n3/n6 ratio and it was determined at very high values. PUFA/SFA ratio was found to be between 1.32-1.17%.

Depending on the feed used at the farms, the most dominant fatty acids in fish fillets were determined as myristic, stearic, palmitic, linoleic, oleic, linolenic, arachidonic, EPA and DHA, although 20:2, 20:3 n3 and 20:3 n in fish fillets. -6 fatty acids were also determined at very high values (Table 3). The highest SFA and MUFA A were determined at PUFA E farms. Since the amount of n3 is higher than the amount of n6 in the fish samples taken from all farms, the n3/n6 ratio was also found to be high. Although the PUFA/SFA ratio varied between 1.37-1.61, it was determined to be higher than the desired value (>0.45). The DHA/EPA ratio was found to be higher than the diets.

The differences in SAFA, MUFA, PUFA, n3 and n6 values in the fish muscles of the farms using different feed sources indicate that the user feeds are effective in the formation of the fatty acid profile of the fish. Krstic et al. (2017) reported that the fatty acids in the fillet of rainbow trout fed under different conditions and with different feeds reflect the fatty acid profiles taken with the feed, and the MUFA and PUFA values in fish fillets are higher than the SFA values, as in the feed. Santos et al. (1993), Bessonart et al. (1999), Halver and Hardy (2002) stated that the fatty acid content of fish is affected by the food intake, DHA contains more than EPA, and body composition reflects the fatty acid profile of the diet, especially in trout. In the present study, it was determined that the DHA ratio was higher than the EPA ratio in body fatty acid profiles of fish taken from all farms. From the research results, although the fish farmed at these farms differ in their fatty acid composition, reasonably favorable proportions of n-3 and n-6 fatty acids, as well as high levels of EPA and DHA, shows that trout at all farms may be suitable for use as biologically valuable foods in human nutrition (Kaya et al., 2004).

Table 3. Fillet fatty acid compositions of the rainbow trout, *Oncorhynchus mykiss* (% total fatty acids) cultured at different farms

Tablo 3. Farklı çiftliklerden alınan gökkuşağı alabalıklarının yağ asit kompozisyonu, Oncorhynchus mykiss (toplam yağ asitlerinin %'si)

	Fillets				
Fatty acids	**A**	**B**	**C**	**D**	**E**
C14:0	4.21±0.40^{a}	3.41±0.02^{ab}	3.70±0.04^{ab}	3.25±0.06^{b}	3.40±0.05^{ab}
C15:0	0.75±0.04^{a}	0.47±0.02^{c}	0.60±0.02^{b}	0.42±0.01^{c}	0.45±0.01^{c}
C16:0	13.89±0.39^{a}	13.54±0.07^{a}	12.75±0.20^{b}	13.70±0.13^{a}	13.20±0.17^{a}
C17:0	0.73±0.01^{a}	0.57±0.01^{c}	0.61±0.01^{b}	0.55±0.00^{c}	0.54±0.01^{c}
C18:0	5.54±0.42^{b}	7.27±0.07^{a}	7.54±1.15^{a}	7.58±0.06^{a}	7.07±0.11^{a}
C20:0	1.05±0.02^{a}	0.78±0.01^{b}	0.97±0.04^{a}	0.80±0.01^{b}	0.71±0.01^{b}
C21:0	0.09±0.01^{a}	0.04±0.01^{b}	0.04±0.00^{b}	0.03±0.01^{b}	0.03±0.00^{b}
C22:0	1.11±0.28^{a}	0.36±0.00^{c}	0.51±0.03^{b}	0.38±0.01^{c}	0.35±0.01^{c}
C23:0	0.05±0.03	0.07±0.02	0.07±0.02	0.46±0.33	0.25±0.07
C24:0	1.10±0.03^{a}	0.48±0.04^{c}	0.96±0.04^{a}	0.61±0.04^{cb}	0.75±0.01^{b}
ΣSFA	28.53±0.19	27.00±0.08	27.75±0.79	27.76±0.11	26.76±0.30
C14:1	0.28±0.01^{a}	0.16±0.01^{b}	0.22±0.01^{a}	0.14±0.00^{b}	0.14±0.00^{b}
C15:1	0.08±0.00	0.07±0.01	0.09±0.01	0.06±0.00	0.06±0.00
C16:1	0.59±0.00^{a}	0.42±0.01^{b}	0.57±0.02^{a}	0.38±0.01^{bc}	0.40±0.00^{c}
C17:1	1.03±0.03^{a}	0.47±0.00^{d}	0.77±0.08^{bc}	0.41±0.01^{d}	0.61±0.01^{dc}
C18:1 n-9c	22.83±0.37^{b}	24.75±0.10^{a}	21.18±0.32^{c}	24.62±0.09^{a}	23.76±0.26^{ab}
C18:1n-9t	1.81±0.08^{c}	3.11±0.01^{a}	1.91±0.01^{c}	2.18±0.40^{b}	2.29±0.43^{b}
C20:1	4.00±0.14^{a}	0.52±0.00^{c}	3.62±0.11^{a}	0.52±0.00^{c}	1.72±1.24^{b}
C20:1 n-9	0.43±0.01^{b}	0.04±0.00^{d}	0.51±0.01^{a}	0.05±0.01^{d}	0.11±0.00^{c}
C24:1	1.01±0.02^{b}	1.65±0.11^{a}	1.04±0.02^{b}	0.98±0.01^{c}	0.92±0.01^{c}
ΣMUFA	32.06±0.15^{ab}	31.20±0.14^{b}	29.92±0.15^{c}	29.33±0.32^{c}	30.02±0.79^{cb}
C18:2 n-6c	10.57±0.73^{b}	14.22±0.02^{a}	13.36±0.29^{a}	13.54±0.09^{a}	13.59±0.15^{a}
C18:2 n-6t	0.81±0.07^{a}	0.52±0.00^{b}	0.75±0.02^{a}	0.50±0.00^{b}	0.53±0.00^{b}
C18:3 n-3	5.02±0.10^{ab}	4.94±0.02^{ab}	5.24±0.13^{a}	4.71±0.03^{b}	5.01±0.05^{ab}
C18:3 n-6	0.85±0.01^{a}	0.63±0.02^{ab}	0.87±0.13^{a}	0.56±0.01^{b}	0.48±0.02^{b}
C20:2	2.76±0.08^{b}	2.67±0.01^{b}	3.04±0.06^{a}	2.62±0.01^{b}	2.64±0.03^{b}
C20:3 n-3	1.75±0.22^{a}	1.10±0.01^{b}	1.37±0.03^{ab}	1.07±0.01^{b}	1.14±0.03^{b}
C20:3 n-6	1.37±0.04^{b}	1.32±0.01^{b}	1.62±0.01^{a}	1.42±0.02^{b}	1.28±0.01^{b}
C20:4 n-6	2.11±0.02^{a}	1.73±0.06^{b}	1.96±0.06^{ab}	1.87±0.04^{b}	1.88±0.05^{b}
C20:5n-3	4.16±0.21	3.87±0.03	3.85±0.06	3.89±0.04	4.15±0.08
C22:2	0.19±0.00	0.11±0.01	0.19±0.00	0.14±0.05	0.10±0.01
C22:6 n-3	9.60±0.40^{b}	10.47±0.09^{b}	9.90±0.24^{b}	12.40±0.19^{a}	12.30±0.14^{a}
ΣPUFA	39.18±0.14^{b}	41.59±0.06^{a}	42.16±0.77^{a}	42.72±0.36^{a}	43.12±0.50^{a}
Σn-3PUFA	20.53±0.49^{b}	20.39±0.14^{b}	20.36±0.45^{b}	22.07±0.26^{a}	22.60±0.27^{a}
Σn-6PUFA	15.70±0.68^{b}	18.42±0.07^{a}	18.57±0.25^{a}	19.00±0.12^{a}	17.77±0.21^{a}
n-3/n-6	1.32±0.09^{a}	1.11±0.01^{b}	1.10±0.01^{b}	1.16±0.01^{a}	1.27±0.00^{a}
PUFA/SFA	1.37±0.01^{c}	1.54±0.00^{b}	1.52±0.07^{b}	1.54±0.02^{b}	1.61±0.01^{a}
DHA/EPA	2.31±0.02^{e}	2.70±0.01^{c}	2.57±0.02^{d}	3.19±0.02^{a}	2.97±0.03^{b}

Data are reported as mean ± standard errors of three replicate. Means with different superscript letter in a row are significantly different (p>0.05). SFA: Saturated fatty acids, MUFA: Monounsaturated fatty acids, PUFA: Polyunsaturated fatty acids, DHA: Docosahexaenoic acid, EPA: Eicosapentaenoic acid.

3.3. Nutrition Quality Indices of the Diets and Fillets

Various FA ratios and indices have been defined to assess the nutritional quality of food lipids for human consumption. According to nutritional recommendations, the PUFA/SFA ratio in human diets should be above 0.45 (Chen et al., 2007). Lower PUFA/SFA ratios in the diet may increase the incidence of cardiovascular disease. The PUFA/SFA ratio of the diets obtained in the current study was found to be between 1.32 and 1.17 (Table 4). A healthy animal product can be characterized by low AI and TI and high FLQ and H/H index (Woloszyn et al. 2020; Zorlu and Gümüş, 2022). AI and TI show the potential to stimulate platelet aggregation (Ghaeni et al., 2013). In addition, it has been reported that esterified FA can reduce cholesterol and phospholipid levels and thus prevent the emergence of micro and macrocoronary diseases (Turan et al., 2006). TI tends to form clots in blood vessels. This is defined as the relationship between prothrombogenic (saturated) and antithrombogenic fatty acids (Σ MUFA, Σ PUFA n-6 and Σ PUFA n-3). Therefore, the smaller the AI and TI values, the greater the protective potential for coronary artery disease. In terms of human health, AI and TI below 1.0 and 0.5, respectively, are recommended in the diet (Fernandes et al. 2014). Grigorakis (2007) reported that the atherogenic index of animals fed a diet in which fish oil is the only source of lipid was 0.62-0.64, while this value was in the range of 0.34-0.53 in animals fed a diet derived from vegetable oils. Although AI values were determined at very low values in this study, TI values were determined at very high values. Based on these values, it can be concluded that there is no vegetable oil in the feeds used in the farms. Alvarez et al. (2020) reported that the differences observed between both fatty acid profile and quality parameters in sea bream fed with fish and vegetable oil diets did not have a negative effect on health or quality indices.

Table 4. The nutritional quality indices of the fillet lipids of rainbow trout (*Oncorhynchus mykiss*) cultured at different farms
Tablo 4. Farklı çiftliklerden alınan gökkuşağı alabalıklarının fileto yağlarının besinsel kalite indeksleri (Oncorhynchus mykiss)

	AI	**TI**	**FLQ**	**H/H**
Fillets				
A	0.53±0.00^{a}	1.59±0.01^{a}	13.79±0.61^{b}	3.01±0.14^{c}
B	0.49±0.00^{b}	1.39±0.01^{d}	14.37±0.11^{b}	3.54±0.02^{a}
C	0.51±0.02^{ab}	1.38±0.01^{d}	13.78±0.30^{b}	3.37±0.02^{b}
D	0.49±0.01^{b}	1.43±0.01^{c}	16.32±0.23^{a}	3.60±0.02^{a}
E	048±0.01^{b}	1.53±0.00^{b}	16.47±0.21^{a}	3.66±0.02^{a}

Data are mean ±SEM. Means with different superscript letter in a column are significantly different (p>0.05).
AI: The index of atherogenicity, TI: The index of thrombogenicity, FLQ: Flesh lipid quality,
H/H: hypocholesterolemic/hypercholesterolemic.

Meat Lipid Quality (FLQ) indices indicate the global dietetic quality of lipids and their potential impact on coronary disease development (Senso et al., 2007) and are directly related to FLQ, EPA, and DHA ratios. A relatively high FLQ value was obtained in this study. Omega-3 fatty acids are beneficial for both healthy people and people suffering from cardiovascular diseases and have been reported to reduce the risk of arrhythmias (abnormal

heartbeats) that can cause sudden death (URL 2, 2016). The ratio (H/H index) between hypocholesterolemic and hypercholesterolemic fatty acids indicates the effects of specific fatty acids on cholesterol metabolism. It is thought that higher FLQ and H/H values in terms of nutrients are more beneficial for human health (Woloszyn et al. 2020). The H/H indexes obtained in this study ranged from 3.01 to 3.66 and did not differ significantly between farms, except for farm A. FLQ values ranged between 16.47 and 13.78, and significant differences were detected between farms A, B, C and D, E. In this context, it can be said that the rainbow trout obtained as a result of this study have a good nutritional quality for human consumption.

3.4. Mineral Matter Contents of the Diets and Fillets

Macro minerals such as calcium (Ca), potassium (K), magnesium (Mg), sodium (Na) and phosphorus (P) and micro minerals such as copper (Cu), iron (Fe), iodine (I), manganese (Mn) and selenium (Se) and zinc (Zn) are very important elements for fish and minerals that must be present in feeds for cultured species (NRC, 2011). In the current study, it was determined that the mineral substance amounts of the feeds obtained from different farms were respectively Ca>P>K>Na>Fe>Mg>Zn>Mn>Se (Table 5) and the statistical difference between the values was significant (P<0.05).

Table 5. Comparisons of the fillet and diet mineral matter contents *(mg kg^{-1})* of rainbow trout (*Oncorhynchus mykiss*) cultured at different farms
Tablo 5. Farklı çiftliklerden alınan gökkuşağı alabalıklarının (*Oncorhynchus mykiss*) yem ve fileto mineral madde içerikleri (*mg kg^{-1}*)

	Treatments				
	A	**B**	**C**	**D**	**E**
Diets (mg kg^{-1})					
Calcium (Ca)	30997.63±1.60^{a}	28826.85±1.60^{b}	31023.62±1.20^{a}	28963.46±2.00^{b}	28771.23±1.60^{b}
Iron (Fe)	380.79±0.54^{c}	386.50±1.07^{c}	416.49±0.64^{a}	400.14±0.94^{ab}	390.84±0.52^{b}
Potassium (K)	8227.40±1.30^{a}	7662.66±1.50^{c}	7870.89±0.91^{b}	7792.19±2.22^{bc}	8248.37±1.62^{a}
Magnesium(Mg)	292.49±2.40^{a}	296.20±2.00^{a}	280.79±0.06^{bc}	284.78±1.10^{b}	277.45±2.10^{c}
Sodium (Na)	3466.54±1.10^{c}	3176.33±0.80^{d}	3760.28±0.50^{a}	3565.65±1.20^{b}	3590.49±1.40^{b}
Phosphorus (P)	16164.64±1.19^{a}	15022.76±1.21^{b}	16013.08±1.99^{a}	15016.92±1.03^{b}	14485.54±0.99^{c}
Manganese(Mn)	82.16±0.11^{a}	67.55±0.07^{d}	79.22±0.06^{b}	78.95±0.07^{b}	70.90±0.11^{c}
Zinc (Zn)	221.69±0.10^{a}	199.84±0.06^{b}	213.37±0.09^{a}	203.22±0.09^{b}	184.23±0.07^{c}
Selenium (Se)	1.66±0.02^{b}	1.56±0.02^{c}	1.99±0.01^{a}	1.68±0.00^{b}	1.48±0.02^{d}
Fillets (mg kg^{-1})					
Calcium	288.79±2.20^{e}	205.76±0.78^{d}	267.03±1.50^{b}	262.77±0.70^{c}	331.13±1.22^{a}
Iron	4.52±0.07^{e}	5.43±0.05^{d}	6.52±0.18^{a}	5.85±0.11^{b}	4.45±0.04^{c}
Potassium	3738.54±1.68^{c}	4004.52±2.01^{a}	3839.45±1.98^{b}	3755.55±2.51^{c}	3933.65±2.05^{a}
Magnesium	2105.90±2.20^{b}	1924.28±2.50^{c}	1986.67±1.70^{a}	1996.54±1.60^{b}	2029.48±1.60^{a}
Sodium	534.09±0.90^{a}	637.97±2.30^{b}	596.20±1.80^{b}	672.96±1.40^{b}	663.13±2.80^{b}
Phosphorus	2504.19±1.81^{c}	2538.99±1.50^{b}	2448.57±1.92^{c}	2477.32±1.99^{c}	2425.05±2.12^{a}
Manganese	0.13±4.44^{c}	0.17±2.48^{c}	0.15±2.01^{a}	0.12±1.42^{b}	0.16±2.40^{b}
Zinc	6.39±0.64^{b}	7.03±0.97^{b}	6.21±0.71^{b}	6.93±0.78^{b}	7.50±0.99^{a}
Selenium	0.21± 0.01	0.24±0.01	0.20±0.01	0.23±0.01	0.23±0.01

Data are reported as mean ± standard errors of three replicates. Means with different superscript letter in a row are significantly different (p>0.05).

When the amount of mineral matter between farms was examined, the highest values were determined Ca, P, Mn and Zn in A, K in E, Fe in D, Mg in B, and Na and Se in C. The mineral substance amounts of rainbow trout obtained from different farms were determined as K>P>Mg>Na>Ca>Zn>Zn>Fe>Se and the statistical difference between the values was significant ($P<0.05$). When the amount of mineral substances in the fish fillets between farms was examined, the highest values were found K, P, Mn and Se in B, Ca and Zn in E, Fe in C, Mg in A and Na in D (Table 5).

As a part of the phospholipids that make up the membrane lipid bilayer, P plays an important role in both the bones and the cell membranes. The P deficiency in the body causes muscle defects and improvements in bone mineralization, as well as cardiac, cardiovascular, neurological, and metabolic disorders (Ghosh and Joshi, 2008). In the element analysis carried out in this study, the amount of P was determined at high rates in rainbow trout fillets grown on all farms. On the other hand, Bekhit et al. (2009) reported that the intake of 100 g of rainbow trout by the European Communities meets the P requirement (65.97-75.14%).

With fish collected from nature (Çelik et al., 2008; Ersoy and Özeren, 2009; Özyurt et al., 2009; Tacon and Metian, 2013), in comparative studies among cultured fish (Gökoğlu et al., 2004; Erkan and Özden, 2007; Özden and Erkan, 2008; Tacon and Metian, 2013; Siemianowska et al., 2016; Cieślik et al., 2017), it has been determined that the mineral content of the cultured fish is higher than the fish in nature. This may be due to the fact that cultured fish are fed regularly with balanced feeds.

4. Conclusion

The proximate compositions, fatty acid profiles and mineral matter content of the trout taken from the farms showed some differences. The protein and lipid contents of the samples taken from farm A were higher than the samples taken from other farms. The quality of the fatty acid profile in samples from all farms was quite high in terms of EPA and DHA contents. The nutritional quality indexes of the fish were within normal limits, except for the TI value. Not using vegetable oils in feeds increased the TI value. In addition, Ca, Na, K, Mg and P which were detected in sufficient and different amounts, were at high levels. As a result, it can be said that the trout obtained from all farms have suitable criteria in terms of nutrition. All fish can be considered a good source of nutrients, fatty acids and minerals.

5. Acknowledgment

We would like to thank the aquaculture facilities at all farms that supplied us with fish for the realization of our study.

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