Comparison of fatty acids, lipid quality index and amino acid profiles of whiting (*Merlangius merlangus euxinus Nordman*, 1840) meat and roe during fishing season in Black Sea

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Abstract

Introduction. The aim of research is to determine the fatty acid and amino acid composition of the whiting meat and roe caught in different months in Black Sea.

Materials and methods. The whiting (*Merlangius merlangus euxinus* Nordman, 1840) caught from the Sinop region of the Middle Black Sea Region. Sampling were carried out twice a month. And the whiting meat and roe were compared in view of its fatty acid (FA) and amino acid (AA) composition during fishing season in Black Sea.

Results and discussion. During the six months, the length and weight of whiting used in the study varied between 14.15–16.60 cm and 24.49–29.68 g, respectively. Minimum length and weight were determined in March. Maximum crude protein values of fish meat and roes was determined in May (18.61g/100g) and in April (16.30g/100g), respectively. SFA's (saturated fatty acids), MUFA's (monounsaturated fatty acids) and PUFA's (polyunsaturated fatty acids) of fish meat and roes had been varied during the season. The minimum and maximum EPA, DHA contents were found as 7.42–10.72, 3.39–22.67g/100g in meat and 0.03-0.37, 3.79–4.76 g/100g in roe, respectively. The maximum and minimum n3/n6 values were found to be 14.01 in April and 4.47 in March in the fish meat, respectively.

Lysine was the highest EA (essential amino acids) in both meat and roe in whole months' write values. The amounts of lysine and glutamic acid in fish meat were higher than in roe write values. The content of glutamic acid in fish meat was found higher than in fish roe during the study write values. The ratio of EA/non-EA were found to be max. 0.9 at March in meat. The fish roe's EA/nonEA ratio were found between 0.7–0.9 in fishing season.

It has been found that whiting meat and roe contains high amounts of essential FA and AA.

Conclusion. The nutritional quality of fish meat and roe varies seasonally. Otherwise, the umami source aromatic AAs content of fish meat higher than roe.

Abbreviations

AI: Atherogenicity Index
ALA: Alpha Linolenic Acid
DHA: Docosahexaenoic Acid
EA: Essential Amino Acids
EPA: Eicosapentanoic Acid
FLQ: Flesh Lipid Quality Index
MUFA: Monounsaturated Fatty Acids
n3: Omega 3 Fatty Acids
n6: Omega 6 Fatty Acids
PUFA: Polyunsaturated Fatty Acids
SFA: Saturated Fatty Acids
TI: Thrombogenicity Index

Introduction

Along with the awareness of the world's population and the increasing demand for healthy nutrition, the importance of seafood has also increased. People prefer seafood due to high essential amino acids and fatty acids, mineral substances and dietary fiber content. One of the favorite sea foods that can be caught almost all seasons in the territorial waters of our country is the whiting fish. Whiting **(***Merlangius merlangus euxinus* Nordman 1840**)** is a demersal fish species which is preferred by consumers and which can reach to 50cm in length and hunting in the Black Sea coasts throughout the year [1, 2]. Whiting which is spawning irregularly throughout and it usually begins in October and end of July to August [3, 4]. This means that the whiting roes can be consumed during the fishing season. These roes, called caviar by the public, are considered as a distinct flavor. In 2016, 11540 tones whiting were caught in Turkey land waters. This amount corresponds to about 4.3% of all fish caught in our seas. 11354 tons of the 11540 tons of whiting were landed and freshly presented for human consumption [5].

Some studies have been carried out on the whiting, some of which are related with changes in nutritional composition [6–10] and others related with meat yield and spawning grounds [11–13], processing technologies [14, 15].

In this study, it was monthly investigated the proximate composition, fatty acids and amino acid contents of the whiting meats and their roes caught in the Middle Black Sea Region (Sinop).

Materials and methods

Materials

The study was carried out between December 2016 and May 2017 with the whiting (*Merlangius merlangus euxinus* Nordman, 1840) caught from the Sinop region of the Middle Black Sea Region. Sampling were carried out twice a month. For sampling, three kilos fresh fish were obtained from the fisheries co-operative. The fish were transported to the laboratory under cold storage conditions, the length and weight measurements were made. Then the roes were separated from the fish and filleted.

Proximate and amino acids analysis of samples

Crude protein, crude ash and moisture analyses were performed according to AOAC [16] (Ref. no: 925.52, 923.03, 925.10), crude fat analysis was performed according to the Soxhalet method [17] and energy value was determined according to Falch et al. [18].

Atwater Method

$$C\ (g/100g) = 100- (W + F + P + A),$$
$$Energy\ (Kcal) = (F \cdot 9) + (P \cdot 4) + (C \cdot 4)$$

where C: Carbohydrate content of sample (g/100g);
W: Water content of sample (g/100g);
F: Crude fat content of sample (g/100g);
P: Crude protein content of sample (g/100g);
A: Crude ash content of sample (g/100g).

Amino acid analyzes and fatty acids composition were performed after digestion derivatization method according to HPLC pre-column [19] and IID-19 method [20], respectively.

Lipid quality indexes of sample lipids

Lipid quality indexes of lipid [22-24], following formulas were used;

$$AI = [(C12:0 + (4 \cdot C14:0) + (C16:0)] / [(\sum n6 + \sum n3 + \sum MUFA)]$$
$$TI = [(C14:0 + C16:0 + C18:0)] / [(0.5 \cdot \sum MUFA) + (0.5 \cdot \sum n6) + (3 \cdot \sum n3) / (\sum n6)]$$
$$FLQ = 100 \cdot [(EPA\% + DHA\%) / (Total\ fatty\ acids\ \%)]$$
$$HH = (C18:1n\text{-}9 + C18:2n\text{-}6 + C20:4n\text{-}6 + C18:3n\text{-}3 + C20:5n\text{-}3 + C22:5n\text{-}3 + C22:6n\text{-}3) / (C14:0 + C16:0)$$

where AI: Atherogenicity Index;
TI: Thrombogenicity Index;
FLQ: Flesh Lipid Quality Index;
HH: Hypocholesterolaemic/Hypercholesterolaemic Ratio.

Statistical analysis

All analyzes were performed in 2 replicates with 3 parallel. The data obtained at the end of the study were evaluated with one-way ANOVA using Minitab Release 17 package program and Tukey test was used for determination of the significance level of differences in-groups and between groups [25]. Figures and schedules are prepared using MS Office 2010 software.

Results

Length and weight data's

Figure 1. shows the length and weight data of the whiting fish between December and May. The maximum weight of whiting fish during the study was 29.68±0.74 g in December and the max. length was 16.60±0.14 cm in May. The length of the fish used in the sampling was minimum 14.15±0.08 cm. Although the fish weight varied between months, it did not fall below 22.25±0.37g (Figure 1).

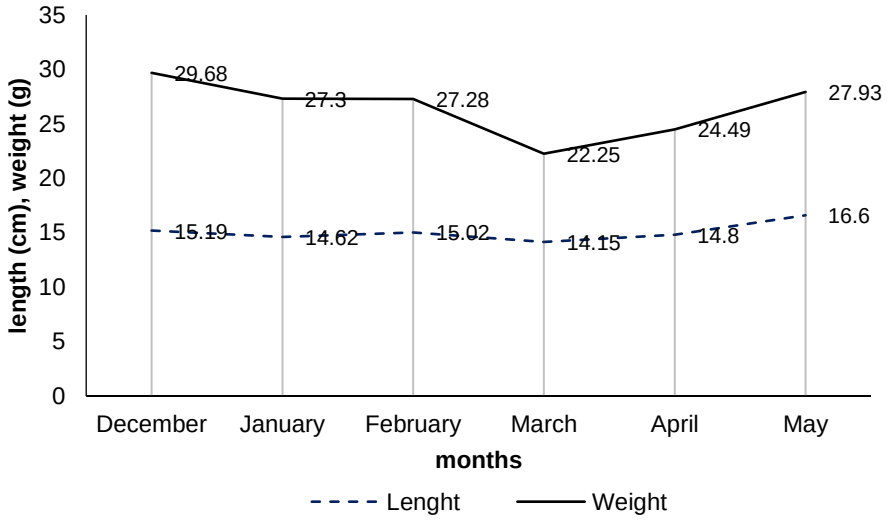

Figure 1. The length and weight of whiting fish

Proximate composition and energy value of whiting meat and roe

Crude fat, crude protein, crude ash, moisture, carbohydrate contents and energy values of the whiting meat and roe used in the study are given in Table 1.

While the crude fat ratio of the whiting meat was determined at the minimum level in April, the crude fat ratio in fish roe reached the maximum value at the same month. The moisture content of fish meat was found the higher in April, compared to other months ($p<0.05$). Although the highest protein content of fish meat was determined in May (18.61g/100g), fluctuations in protein value were statistically insignificant during 6 months except for April ($p>0.05$). The carbohydrate content of fish meat varied between 0.09–1.06 g/100g.

The crude fat, crude ash, carbohydrate, water and energy values of fish roe determined every month were not different statistically ($p>0.05$) but the crude protein contents were different statistically during six months.

In general, the amount of crude ash of fish roes were found quite high when compared to meat except for January ($p<0.05$). The amount of crude ash did not change with respect to the month of both meat and roe ($p>0.05$).

The minimum amount of carbohydrate in the whiting roe was 0.63g/100g and the maximum was 1.97g/100g. When the fish meat and roes were compared in terms of energy content, the maximum value was determined as 78.79 kcal in January for fish meat. The minimum amount of energy was obtained in fish roes in the same month but the difference between the groups was statistically insignificant (p>0.05).

Table 1

Proximate composition of Whiting meat and roe (g/100g) and energy value (Kcal)

		Crude fat	Water	Crude ash	Crude Protein	Carbohydrate	Energy (Kcal)
Whiting meat	**Dec.**	0.38 ±0.02Aab	81.50 ±0.03Ab	0.38 ±0.02Ba	17.66 ±0.07Aa	0.09 ±0.03Bb	74.38 ±0.13Ab
	Jan.	0.48 ±0.01Aa	80.42 ±0.00Acd	0.48 ±0.01Ba	18.29 ±0.10Aa	0.33 ±0.12Bab	78.79 ±0.01Aa
	Feb.	0.37 ±0.01Aabc	81.19 ±0.00Bbcd	0.37 ±0.01Ba	17.01 ±0.10Aab	1.06 ±0.12Aa	75.63 ±0.01Aab
	Mar.	0.26 ±0.00Abc	81.52 ±0.37Bbc	0.24 ±0.02Ba	17.88 ±0.46Aa	0.11 ±0.07Ab	74.27 ±1.54Bc
	Apr.	0.17 ±0.00Bc	82.88 ±0.07Aa	0.23 ±0.00Ba	15.92 ±0.09Ab	0.79 ±0.02Aab	68.40 ±0.27Aab
	May.	0.32 ±0.07Aab	80.36 ±0.08Bd	0.57 ±0.14Ba	18.61 ±0.09Aa	0.14 ±0.03Bb	77.89 ±0.12Ba
Whiting roe	**Dec.**	0.41 ±0.03Aa	83.66 ±0.71Ba	1.09 ±0.07Aa	13.96 ±0.46Bab	0.87 ±0.19Aa	63.04 ±2.63Ba
	Jan.	0.42 ±0.05Aa	84.89 ±2.03Aa	0.96 ±0.13Aa	11.77 ±1.21Bb	1.97 ±0.66Aa	58.69 ±7.86Aa
	Feb.	0.41 ±0.03Aa	84.33 ±0.14Aa	1.11 ±0.05Aa	13.03 ±0.13Bab	1.12 ±0.08Aa	60.25 ±0.73Ba
	Mar.	0.41 ±0.03Aa	84.73 ±0.44Aa	1.03 ±0.05Aa	12.22 ±0.03Bb	1.61 ±0.38Aa	59.01 ±1.73Ba
	Apr.	0.46 ±0.03Aa	81.50 ±0.03Ba	1.12 ±0.00Aa	16.30 ±0.10Aa	0.63 ±0.11Aa	71.85 ±0.26Aa
	May.	0.38 ±0.03Aa	84.34 ±0.74Aa	1.08 ±0.04Aa	12.61 ±0.58Bab	1.59 ±0.11Aa	60.24 ±2.94Bb

↓ (a, b….) Means with different lowercase letters in the same column are significantly different (p<0.05) from month to month in same group. n=6±Std.Error, p<0.05.
↓ (A, B...) Means with different capital letters in the same column are significantly different (p<0.05) between groups in same month. n=6±Std.Error, p<0.05.

Fatty acids composition of whiting meat and roe

The fatty acid composition results of whiting meat (Figure 2) and roe shown in Figure 3.

The amount of SFA (saturated fatty acids), MUFA (monounsaturated fatty acids) and PUFA (polyunsaturated fatty acids) of fish meat was max. 43.42% (in March), max. 38.21% (in March) and max. 37.97% (in April), respectively (Figure 4). A large amount of SFA

content is composed from palmitic acid (max 18.42%), stearic acid (max 8.74%), butyric acid (max 7.59%) and behenic acid (max 4.42%). While, about 56% of the MUFAs composed of oleic acid. The predominant n3 fatty acids found in fish meat are EPA and DHA. Most of the n6 fatty acids form was linoleic acid. During the study, the maximum n3/n6 proportional value was determined as 14.01 in April.

SFA's, MUFA's and PUFA's of fish roes were determined as max. 33.90% (in December and May), max. 58.45% (in April) and max. 13.13% (in January), respectively (Figure 5). A large amount of SFA content constituted butyric acid (max. 7.59%) and stearic acid (max. 7.77%). While about 53% of the MUFA's were composed of oleic acid, the total MUFA contains oleic acid, palmitoleic acid, erucic acid, nervonic acid and eicosenoic acid in abundance. The EPA content of fish roes was significantly lower than meat in all months ($p<0.05$). The predominant n3 fatty acids found in fish roe were DHA and alpha linolenic acid. Most of the n6 fatty acids were linoleic acid. The maximum amount of linoleic acid in fish roes determined in January (4.25%) but this difference between the months was not statistically significant ($p>0.05$).

The maximum n3/n6 proportional value was found to be 1.45 in the fish roe in March, but this value was statistically different from the value determined in only January ($p<0.05$). The maximum and minimum n3/n6 values were found to be 14.01 in April and 4.47 in March in the fish meat, respectively.

Amino acids composition of whiting meat and roe

The results of the amino acid compositions of the whiting meat and roe in the study were shown in Figure 6–7. Total nine essential amino acids and seven non- essential amino acids; histidine, threonine, arginine, valine, methionine, phenylalanine, isoleucine, leucine and lysine were identified in the meat and roe of whiting. The maximum amount of aspartic acid in whiting meat was detected in February, but this value was not different from the amounts detected in the other months ($p>0.05$). The content of glutamic acid in fish meat was found to be high during the study period, but the difference was statistically insignificant ($p>0.05$).

Fish roes also contained high levels of aspartic acid (max 2393.5mg/kg), glutamic acid (max 2232.0mg/kg) and lysine (max 1894.8 mg/kg), which were similar with meat. The ratio of EA / non-EA of fish roe was maximum 0.9. This rate determined in January and February, was statistically similar with other months ($p<0.05$). EA/non-EA ratio of fish roes was higher than fish meat in January and February ($p>0.05$).

The highest amount of essential amino acids was detected for lysine in both groups. The amount of lysine was higher in fish meat than in roe. The ratio of essential amino acids to non-essential amino acids (EA/non-EA) in fish meat was found to be 0.9 in March ($p>0.05$). The fish roe's EA/nonEA ratio were found between 07-09 in fishing season.

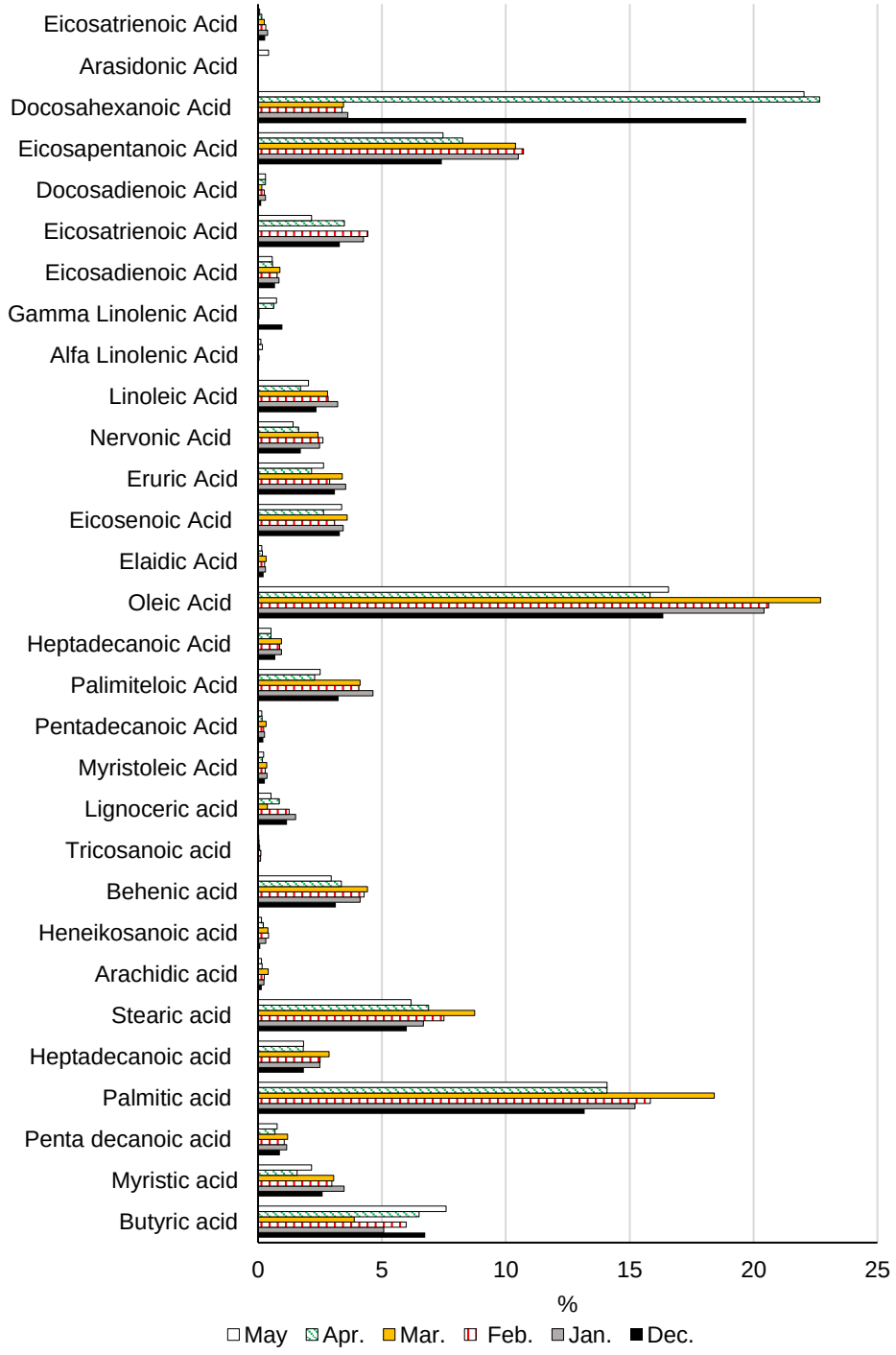

Figure 2. Fatty acid composition of whiting meat (%)

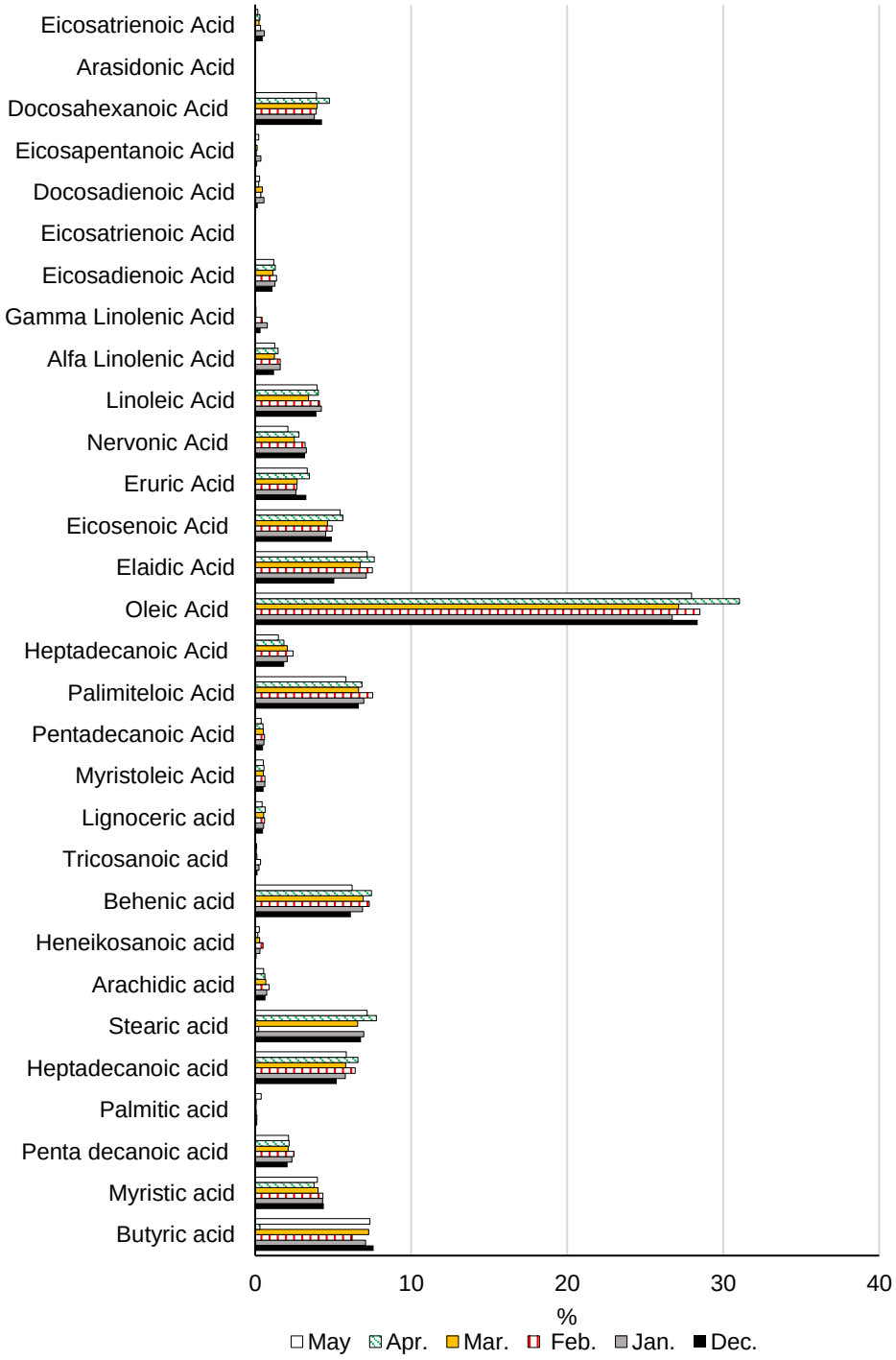

Figure 3. Fatty acid composition of whiting roe (%)

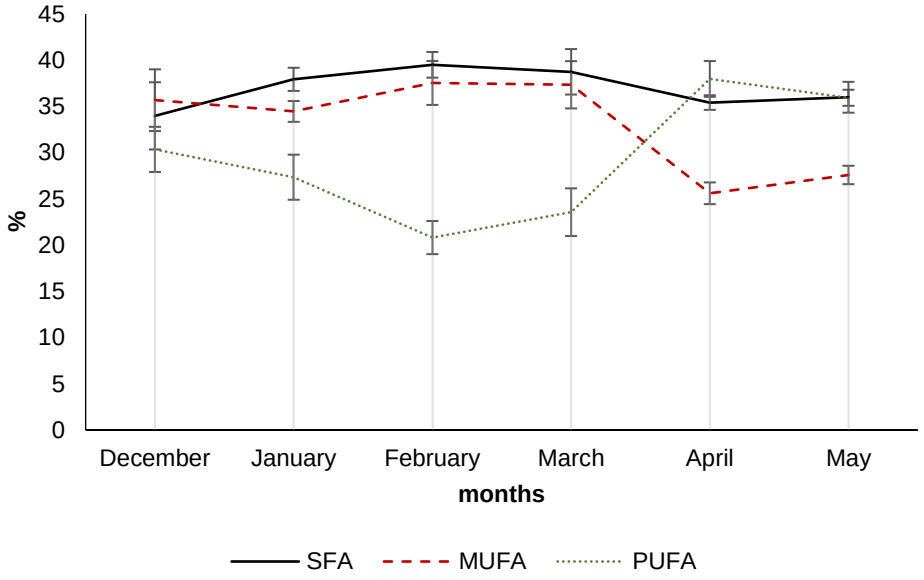

Figure 4. The total fatty acid composition of whiting meat (%)

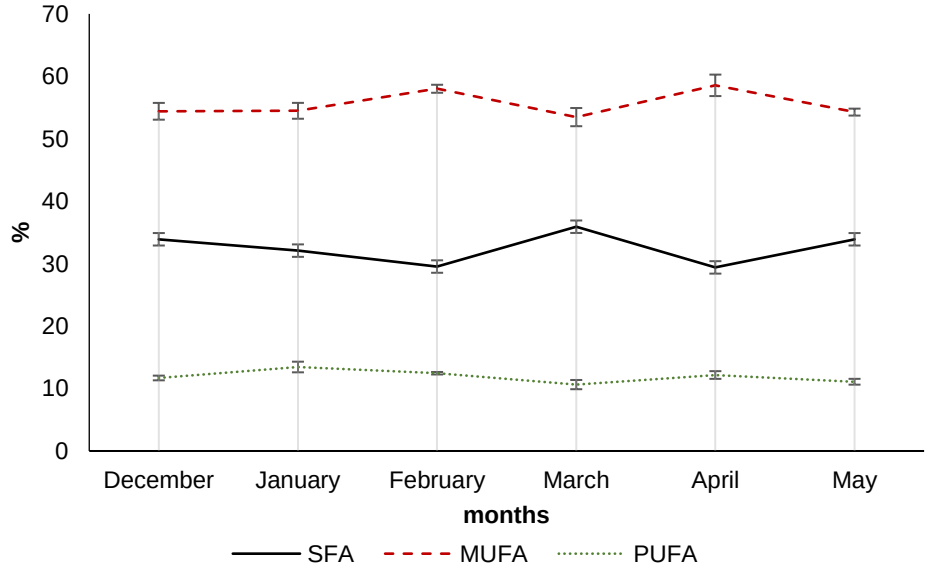

Figure 5. Total fatty acid composition of whiting roe (%)

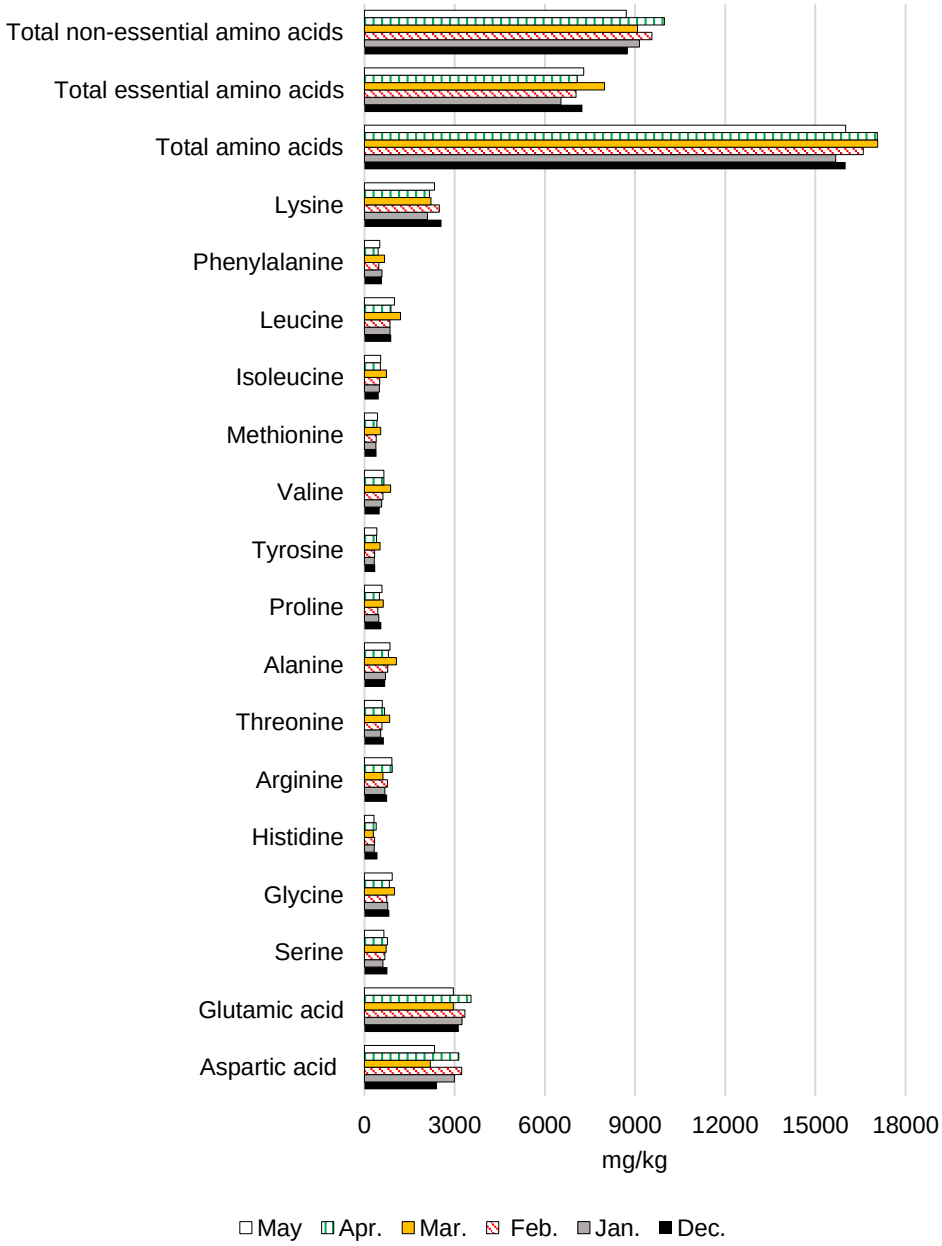

Figure 6. Amino acid composition of whiting meat (mg/kg)

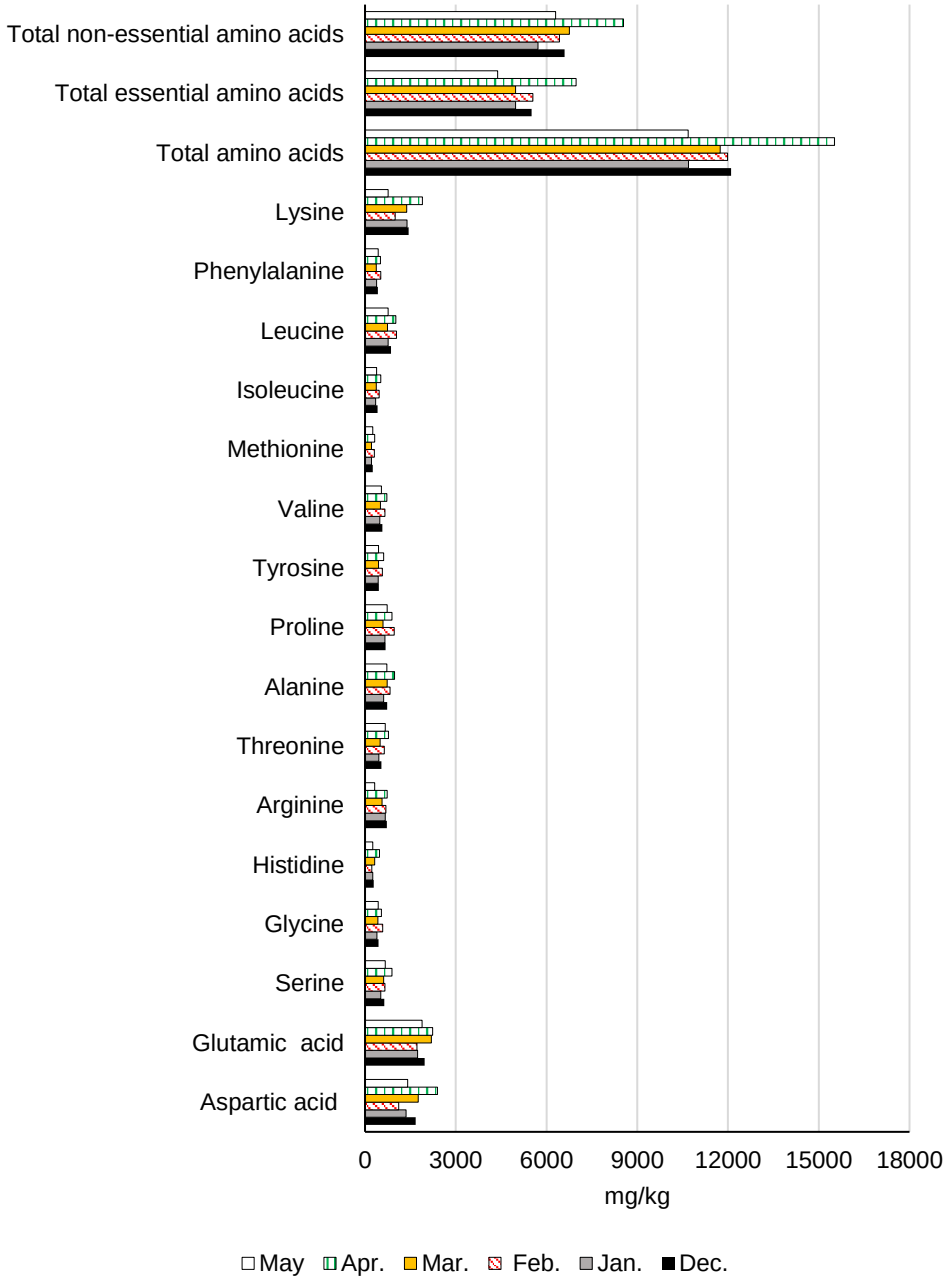

Figure 7. Amino acid composition of whiting roe (mg/kg)

Discussion

Lengths and weights of whiting and proximate composition of whiting meat and roes

During the six months, the length and weight of whiting used in the study varied between 14.15–16.60 cm and 24.49–29.68 g, respectively. Minimum length and weight were determined in March. Similarly, Kaba et al. [10], the minimum length and weight found in male individuals in March.

The proximate composition of fish meat varies according to the annual nutrition and ovulation cycle [26]. In our study, the proximate composition of both fish meat and roe varied during the caught season. The moisture content of fish meat in April was found to be maximum ($p<0.05$) compared to the other month, inversely proportional to the fat ratio, which is an indication of an inverse proportion between fat and water. So if the fat rate is low, the amount of water is high. The length and weight of fish in March was the minimum value. Although the highest protein content of fish meat was determined in May, during 6 months, fluctuations in protein value were insignificant except for April ($p> 0.05$). April is the month which the amount of water, crude fat and crude protein in fish meat was most affected. The highest fat and protein values in fish roes were determined in April. In general, the fat content of fish meat decreased from January to April, and increased again in May. Similarly, Tufan and Köse [27] also reported that the fat content of whiting decreased from December to April and increased after that period. The maximum crude protein content of the fish was determined to be 18.61 g/100 g in our study. Mol et al. [28] reported 20.35% of whiting meat protein in their study from larger whiting (average height: 22.29 cm, average weight: 104.6 g). Kaba et al. [10] reported that crude protein content of female whiting meat and roe varied between 12.50–16.02 g/100g and between 12.34–15.46 g/100g from November to March. The amount of protein in fish used in our study was higher than those found in the previous studies except for April.

The carbohydrate content of fish meat varied between 0.092-1.058 g/100g. The minimum content of carbohydrate in the whiting roe was 0.633g/100g, maximum 1.970g/100g. When the fish and roes were compared in terms of energy value, the maximum value was determined as 78.79 Kcal in January. The minimum energy value was obtained in fish roes in the same month ($p<0.05$).

In our study, crude protein, crude fat, crude ash and carbohydrate content of fish roe were as follows; maximum 16.29, 0.460, 1.115 and 1.970 g/100g, respectively. Kocatepe et al. [9] determined the crude protein, crude fat, crude ash and carbohydrate content of the roes of the whiting roe caught from the Black Sea for a period of 7 months, maximum 14.44, 9.71, 1.49 and 2.77 g/100g. Kaba et al. [10] reported that the protein content of female whiting roe varied between months and reached maximum of 15.46 mg/100g in January. In our study, when the maximum crude protein content in the roe was detected in April, the maximum value was reached in December in this literature [10]. April is the month which the fish rises again after reaching the minimum length and weight in March. The difference in crude fat ratios may be due to the difference in the length and weight of the fish. In addition, such as seasonal conditions, nutritional status, temperature factors are effective on fish composition. In general, the amount of crude ash of fish roes was found quite high compared to meat, and the two groups were different from each other except for January ($p<0.05$).

Bledsoe et al. [29] reported that crude fat contents of trout, berlam and whiting roe were 6.6–9.8%; 5–9% and 9% respectively. The crude fat content of the whiting roe in this study ranged from 0.383 to 0.460 g/100 g. While the crude fat, protein and ash contents of the roe

were at maximum level in April, these values decreased in May. Kocatepe et al. [9] stated that the energy value of the whiting roe was 108.52 kcal/100g on average. In our study, the energy value of the fish roe was determined as maximum of 71.85 kcal/100g in April. The energy of the roe decreased from 71.849 kcal to 60.236 kcal. A similar decrease was found [9] in the whiting in March, and they correlated this with the weakening of the gonads' proximate composition after spawning. Huss [26] noted that migrated fish naturally during migration and spawning periods due to natural causes and that this resulted in a very high energy expenditure, depending on the length of migratory routes during and after spawning.

Fatty acid composition of whiting meat and roes

When fatty acids content of fish meat was compared, it was seen that the amount of SFA, MUFA and PUFA were changed between 30–40%, 25–40% and 20–40%, respectively. Tufan ve Köse [27] reported that in their study, the meat of whiting varied between 20-25% of the SFA content, 10-25% of the MUFA content, and 25–50% of the PUFA content. In our present study, the PUFA content decreased after the February and increased again in June. The fatty acids composition of whiting was found as 29.6% SFA, 19.2% MUFA and 39.6% PUFA by Özogul et al [8]. Fish fats contain 20–30% of saturated fatty acids, 70-80% of unsaturated fatty acids. PUFAs are generally in the form of n-3 (omega 3 fatty acids) [30, 31]. The PUFA content of the fish roe was found less than meat in all months ($p<0.05$) during the experiment. Essential fatty acids cannot be synthesized while many fatty acids are synthesized in the human body. Essential fatty acids for human body are n-3 PUFA α-linolenic acid and n-6 PUFA linoleic acid [32]. In all months, linoleic acid and α-linolenic acid contents of fish roes were higher than fish meat ($p<0.05$).

The minimum value of PUFA/SFA ratio recommended is 0.45 [33]. PUFA/SFA ratio of fish meats were higher than the limit value in all months except for March (Table 2.). But PUFA/SFA value in fish roe was determined under the 0.45 value, all the months.

Table 2

PUFA/SFA ratio, lipid quality indices, EPA+DHA contents of whiting meat and roe (%)

	Dec.	Jan.	Feb.	Mar.	Apr.	May.
	Whiting meat					
PUFA/SFA	0.97	0.58	0.56	0.41	1.07	1.00
AI	0.37	0.50	0.49	0.56	0.33	0.36
TI	0.19	0.32	0.33	0.45	0.17	0.19
FLQ	27.12	14.20	14.29	13.89	31.25	29.65
H/H	3.19	2.26	2.25	1.85	3.38	3.18
EPA+DHA	27.12	14.14	14.11	13.84	30.93	29.5
	Whiting roe					
PUFA/SFA	0.34	0.41	0.41	0.35	0.44	0.33
AI	0.27	0.26	0.26	0.26	0.22	0.26
TI	0.24	0.24	0.09	0.23	0.23	0.25
FLQ	4.42	4.18	4.00	4.37	4.87	4.17
H/H	9.53	10.08	10.43	10.43	12.71	10.20
EPA+DHA	4.42	4.16	3.99	4.11	4.79	4.17

FLQ indicate the global dietetic quality of lipids and their potential effects on the development coronary disease [34]. AI and TI indexes should be low to prevent cardiovascular diseases related with lipid intake [22] and the high value of H/H ratio represents high quality lipids. Ouraji et al [35] and Stancheva et al. [36] reported that higher values of AI and TI (>1.0) are detrimental to human health. In this study, AI and TI indexes were measured to be lower than 1.0 but high in <h/H in whiting meat and roe. Especially the H/H ratio of roes were higher than meat. It was showed that the lipids of roe had higher quality of the dietary lipid source than whiting meats.

Tufan and Köse [27] investigated the change of fatty acids content in the whiting during a year and found that the amounts of palmitic acid, stearic acid, oleic acid, EPA, DHA were; 14.9–18.0, 4.6–6.2, 8.0–13.1, 4.5–9.0, 25.3–40.6, respectively. In our study, whiting fishes were analyzed for 6 months and the same fatty acids were found between 13.18–18.42, 6.01–8.74, 15.82–22.71, 7.42–10.72, 3.39–22.67 respectively. When two studies were compared, palmitic acid, stearic acid, and EPA contents were similar, while oleic acid and DHA contents were different. The oleic acid content of the whiting meat in our study was detected at maximum level in March. Similarly, Tufan ve Köse [27] stated that oleic acid content was maximum in January and March. In the same study, the DHA content of fish meat was about twice as high as in our study.

The ratio of n3/n 6 fatty acid is commonly used as an index for assessing the nutritional quality of fishery products [34]. The ratio of n3/n6 of whiting meat and roes were the highest in winter. The ratio of fish meat n3/n6 ranges from 5.13 (January) to 14.01 (April). The maximum amount of n3 of fish meat was detected in April. Tufan and Köse [27] also detected fish meat at the highest level of n3 content in spring. Tufan and Köse [27] reported the content of n3/n6 of whiting meat as 14.2 and 12.6 respectively for the same months. The difference in the fatty and fatty acid composition of seafood depends on different factors such as nutritional pattern, geographical conditions, environmental temperature, season, hunting area, fish size, sex and species [31, 37].

Tufan and Köse [27] reported that palmitic and stearic acids from the SFAs; oleic acid and palmitoleic acid as MUFAs and DHA, EPA, eicosatrienoic acid as PUFAs of the whiting gonad. In our study, butyric acid, stearic acid, heptadecanoic acid and myristic acid content were higher than the SFAs of fish roes. The proportion of MUFA was similar to result of Tufan ve Köse [27]. However, the oleic acid content was measured as 16.4% in the study mentioned above, but 31.05% in April. In our study, the n3/n6 ratio of fish roe examined ranged from 1.04 to 1.45, while that of Tufan ve Köse [27] ranged from 7.7 to 14.8.

2% of the energy of a healthy adult fed on a daily diet with 2000 kcal is consumed by linoleic acid (4.44 g/day), 3% from alpha linolenic acid (ALA) (2.22 g/day), 0.3% from DHA + EPA (0.65 g/day) is recommended [38]. With a daily consumption of 200 g whiting meat, a maximum of 70% (in January) and a minimum of 13% (in April) of the amount of linoleic acid are met, while a minimum of 63% (in March) and a maximum of 84% (in April) is met with the same amount of whiting roe consumption. Similarly, ALA coverage rate is maximum (60%) in January, minimum (5%) in April. During the season, the percentage of whiting roe receiving ALA varies between 52% and 76%.

The British Nutrition Foundation [39] has emphasized that people who care for balanced and healthy nutrition should get 0.2 g of EPA + DHA every day. Daily intake of 200 g whiting meat consumption is meet the EPA + DHA requirement of 100% in December, 95% in May; and the minimum value of 35% in March. On the other hand, whiting roe meet the requirement of 22% in April. On average around 18% in the other months.

Amino acid composition of whiting meat and roes

Fish meat is a nutritious food with high protein content. In fish meat containing all essential amino acid as aspartic acid, glutamic acid and lysine [40]; aspartic acid and glutamic acid are important amino acids that play a role in enzyme activation, preservation of the solubility and ionic character of proteins. One of the most important sources (50-85%) of non-protein nitrogen in fish meat is free amino acids. Free amino acids give fish meat a characteristic taste. Most of these are proline, arginine, glycine, alanine, histidine, glutamic acid and taurine [41]. In this research, whiting meat contained glutamic acid (max. 3548.5 mg/kg), alanine (max. 1065.3 mg/kg) and arginine (max.927.0 mg/kg) from free amino acids. In general, when comparing fish meat and roe, it can be said that the content of essential amino acid in meat was higher than that of roe. The difference between the groups was statistically important ($p<0.05$) except for January and April. In April, the essential amino acid content of fish meat protein reached a maximum level (7986.3 mg/kg).

The World Health Organization's [42] on protein and amino acid requirements for human nutrition reports an adult daily protein intake of 0.83g/kg, with essential amino acids; leucine 59 mg/g, lysine 45 mg/g, isoleucine 30 mg/g, threonine 23 mg/g, and methionine 16 mg/g. In our study, the leucine, valine and threonine content of the whiting meat and roe was determined about twice, about 1.5 times and more than 3 times of these amino acids daily requirement, respectively. In addition, fish meat meets half of the daily need for lysine.

Glutamate, aspartame and some nucleotides are associated with umami taste, which is called as the 5th taste. Glutamate is the free amino acid form of glutamic acid [43]. The content of glutamic acid in some foods is high and they are called as aromatic foods. For example; sea crab, blue crab, and Japanese fish sauces. The free glutamic acid content of these foods is high. By Yamaguchi and Ninomiya [44]; the free glutamic acid contents of foods were indicated as 140, 843 and 1383 mg/100 g, respectively. In this research glutamic acid content of both meats and roe were found at a maximum level in April. When compared with these foods given above, it can be said that the umami taste of both meat and roe were more dominant than, during study.

Conclusion

In conclusion; whiting fish meat and roe are good sources of n-3 PUFA, EPA and DHA. The n-3/n-6 ratio and EPA+DHA values of fish meat were higher than roe in all fishing months but the h/H ratios of roe were higher than fish meat. The index of AI and TI was no more than 1.0 which according to the data literature is detrimental to human health. The lipids nutritional quality of whiting meat and roe can be beneficial for human health. In addition, it can be said that the whiting is a delicious fish with essential amino acids content and high umami flavor. By the reason of the essential amino acid content and EPA + DHA content of both whiting meat and roes are high in April, it can be said that the nutritious quality of the whiting caught this month is higher.

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