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Comaprative fatty acid composıtıon of European seabass *Dıcentrarchus labrax* (Linnaeus, 1758) farmed in cages in the Aegean Sea and the Black Sea coasts of Turkey

BIROL BAKI, DILARA KAYA OZTURK AND MURAT KERIM
Sinop University, Faculty of Fisheries, Department of Aquaculture, Sinop, Turkey
e-mail: dilara.kaya55@gmail.com

ABSTRACT

The aim of this study was to analyse the fatty acid composition of European seabass *Dicentrarchus labrax* (Linnaeus, 1758), farmed in marine cages in the Aegean Sea and in the Black Sea coasts of Turkey. The study was conducted between June 2014 and September 2015 using the same feed in all the cage farms. Fish samples representing the stock were collected at regular intervals and morphometric measurements were taken in the laboratory. Fatty acid analyses were carried out by gas chromatography. Biochemical composition of harvested European seabass indicated high dry matter and crude fat values in the Black Sea region and high crude protein and crude ash values in the Aegean region. Significant regional differences between fatty acid composition ($p<0.05$) was observed, despite being fed with the same diets.

Keywords: Biochemical composition, *Dicentrarchus labrax,* Fatty acid, Seabass culture

Introduction

In the late 1980s, Mediterranean mariculture witnessed a shift from farming of invertebrates and detritivorous fish to the farming of more carnivorous species *i.e.,* European seabass *Dicentrarchus labrax* and gilthead sea bream *Sparus aurata* (Tsikliras *et al.,* 2014). World production of farmed seabass increased from around 60,000 t in 2003 to an estimated 3,30,000 t in 2017 (Tveteras, 2016). Turkey and Greece are the leading producers representing 67% of the production. Seabass are the most important cultured species in the Mediterranean (Arechavala-Lopez *et al.,* 2013). High economic value and high salinity tolerance, increase the importance of European seabass to the aquaculture sector (Ayala *et al.*, 2010; Costa *et al.,* 2011).

Fish contain highly unsaturated fatty acids, the amount of which in their bodies depends on the species, age, season, diet, habitat and in farmed fish, the feeding method as well as the feed composition. Protein is the most important component for growth and most expensive macronutrient in formulated fish feeds (NRC, 1993) which plays an important role in metabolic activities in fish. Lipid is the source of energy and when lipid level is not sufficient in the diet as energy source, protein is used as compensatory energy source. Fatty acids and amino acids which are the building blocks of lipids and proteins actively participate in biochemical and physiological processes. Lipids are catabolised as energy substrates and are responsible for maintaining membrane properties and are precursors of bioactive molecules (Finn *et al.,* 1991; Zhu *et al.,* 2003). Fish lipids are particularly rich in long chain omega-3 (ω-3) polyunsaturated fatty acids (PUFA), especially eicosapentaenoic acid (EPA, C20:5n-3) and docosahexaenoic acid (DHA, C22:6n-3). These fatty acids play vital role in human nutrition and disease prevention (Alasalvar *et al.,* 2002a; Jankowska *et al.,* 2008). Several studies have been carried out earlier to estimate the fatty acid composition of various fish species (Mustafa and Medeiros, 1985; Bergstrom, 1989; Nettleton *et al.*, 1990). The aim of the present study was to assess the comparative fatty acid composition of European seabass *Dicentrarchus labrax* (Linnaeus, 1758) farmed in cages in the Aegean Sea and in the Black Sea

Materials and methods

Animals, sampling and experimental conditions

The study was conducted between June 2014 and September 2015 in cage farms in the Aegean Sea (Mugla-Milas) and the Black Sea (Samsun-Yakakent) coasts of Turkey. In both regions, seabass obtained from the same hatchery, were stocked at an average weight of 8.55±0.18 g. During the feeding period, fish sampled during specific periods : Initial=June 2014; Period 1=July to September 2014; Period 2= October to November 2014; Period 3=December 2014 to February 2015, Period 4=March to April 2015; Period 5=May to June 2015 and Final=September 2015, following random

sampling method to represent the stock. Water parameters were determined with a field type YSI 556 MPS model multiparameter instrument. Fish and feed samples were stored in a deep freezer (WiseCryo/WUF-D500-80ºC) until analysis, and the samples were transported to the laboratory was carried out under cold chain conditions.

Content and attributes of diets

Extruder feeds containing 45-55% protein and 14-20% lipid with sizes from 1 and 6 mm, produced by a commercial feed company were used. The feed used for the entire study was produced in the same factory and exhibited the same characteristics. Biochemical composition of the feed is given in Table 1.

Table 1. Biochemical compositon of feed

Biochemical composition	Initial	Final
Moisture (max %)	10	10
Crude protein (min %)	55	45
Digestible protein (%)	51	40.5
Crude fat (min %)	14	20
Crude ash (max %)	10	10
Crude cellulose (max %)	1.3	2.5

Biochemical analyses

Fish muscle and feed samples were dried at 105ºC for 20 h to estımate dry matter (DM) content. Crude ash (CA) was determined by igniting a known weight of dried tissue at 500ºC for 15 h in a muffle furnace until constant weight was recorded (AOAC, 1990). Dry meat samples were analysed in triplicate for crude fat (CF) according to the Soxhlet method in the Fisheries Faculty of Sinop University and crude protein (CP) content was determined by estimating total nitrogen content by Kjeldahl method (AOAC, 1990).

Fatty acid analyses

Fatty acid analyses were performed in the Marmara Research Center of the Scientific and Technological Research Council of Turkey (TUBITAK MAM) using IUPAC gas chromatography (Frestone and Horwitz, 1979).

Statistical analysis

The data were tested with one-way ANOVA using IBM SPSS 21 statistical analysis software. The differences between the average values were compared using Tukey's multiple comparison tests at $p<0.05$ significance level.

Ethical approval for research

This study was conducted in compliance with the rules for animal experiments for scientific purposes and permission was given by the Sinop University Animal Experiments Local Ethics Committee with the permission No. 2014/02 on 17.03.2014.u

Results

Environmental parameters

During the study, annual average seawater temperature in the Aegean Sea and the Black Sea were 20.16±0.17°C and 14.95±0.30°C, respectively ($p<0.05$). Average dissolved oxygen (DO_2), salinity and pH values ranged from 9.33±0.36 to 9.75±0.04 mg l^{-1} ($p>0.05$), 35.42±0.07 to 16.20±0.11‰ ($p<0.05$) and 8.49±0.04 to 8.71±0.04 ($p<0.05$), respectively.

Growth performance

European seabass with an initial weight of 8.55±0.18 g, reached 454.99±22.20 g and 299.26±7.59 g in the Aegean Sea and Black Sea, respectively, on termination of the 15 months culture period ($p<0.05$).

Biochemical and fatty acid composition

The CP content of European seabass was initially 19.07±0.07% and subsequently on harvest it was 21.44±0.19% in the Aegean Sea and 19.37±0.01% in the Black Sea ($p<0.05$). The CF content was determined to be 6.77±0.08% in the Aegean Sea and 9.72±1.35% in the Black Sea ($p<0.05$). CP and CF content increased in both areas compared to the initial level. The biochemical composition of European seabass from both regions are given in Table 2.

Fatty acid composition of the feed and fish are given in Table 3. In fish tissue, the highest levels of fatty acids were determined to be for oleic acid, palmitic acid and linoleic acid.

European seabass cultured in the Aegean Sea and Black Sea differed significantly in the levels of C12:0, C14:0, C15:0, C16:0, C17:0, C20:0, C16:1, C18:1n-9c, C20:1n-9c, C18:2n-6c, C18:3n-3, C18:3n-6, C20:2, C20:3n-3, C20:5n-3, C20:4n-6, C22,6n-3 and C22:5n-3 ($p<0.05$). Fatty acids C12:0, C16:0, C14:1, C18:1n-9c, C18:3n-3, C18:3n-6 and C20:2 were higher in the seabass cultured in the Black Sea, and fatty acids C13:0, C14:1, C15:0, C17:0, C20:0, C16:1, C20:1n-9c,C24:1, C20:3n-3, EPA, DHA and C22:5n-3 were higher in the Aegean Sea ($p<0.05$). Arachidonic acid (C20:4n-6) was found at significantly higher levels in the Aegean Sea ($p<0.05$), whereas its precursor, linoleic acid (C18:2n-6), was higher in fishes from the Black Sea. Fatty acids C18:0, C22:0 and C24:0 were similar in fishes from both regions.

At the beginning of the study SFA, MUFA and PUFA values of European seabass were estimated as 21.77±0.06%, 41.19±0.01% and 27.91±0.01%,

Table 2. Biochemical composition of European seabass during the experimental period (%)

Periods	Production areas	Dry matter	Crude protein	Crude fat	Crude ash
Initial		25.57±0.13	19.07±0.07	3.31±0.03	3.37±0.14
Period 1	Aegean Sea	25.56±0.09^{a}	19.60±0.04^{b}	5.22±0.01^{b}	1.35±0.02^{a}
	Black Sea	25.94±0.03^{b}	18.88±0.07^{a}	4.36±0.07^{a}	1.43±0.02^{a}
Period 2	Aegean Sea	26.07±0.01^{a}	20.10±0.04^{b}	5.85±0.53^{a}	1.29±0.02^{a}
	Black Sea	26.59±0.12^{b}	19.41±0.03^{a}	5.12±0.55^{a}	1.46±0.03^{a}
Period 3	Aegean Sea	27.13±0.06^{b}	19.47±0.03^{b}	6.60±0.26^{a}	1.41±0.02^{a}
	Black Sea	26.97±0.13^{a}	18.38±0.07^{a}	6.78±0.33^{a}	1.39±0.02^{a}
Period 4	Aegean Sea	26.99±0.14^{a}	20.60±0.01^{b}	7.93±0.18^{a}	1.36±0.05^{a}
	Black Sea	26.74±0.15^{a}	19.90±0.10^{a}	7.91±0.51^{a}	1.37±0.03^{a}
Period 5	Aegean Sea	27.30±0.41^{a}	20.45±0.15^{b}	5.71±0.12^{a}	1.31±0.01^{a}
	Black Sea	26.48±0.25^{a}	19.35±0.15^{a}	6.47±0.06^{b}	1.35±0.01^{a}
Final	Aegean Sea	26.71±0.11^{a}	21.44±0.19^{b}	6.77±0.08^{a}	1.47±0.05^{a}
	Black Sea	29.68±0.08^{b}	19.37±0.01^{a}	9.72±1.35^{b}	1.44±0.04^{a}

Values bearing different superscrips in the same row are significantly different ($p<0.05$)

Table 3. Fatty acid composition of the feed and the seabass

Fatty acids	Feed			Seabass	
	Initial	Final	Initial	Final	
				Black Sea	Aegean Sea
(C12:0)	0.11±0.01^{b}	0.05±0.01^{a}	0.03±0.01^{x}	0.09±0.03^{z}	0.06±0.01^{y}
(C13:0)	0.04±0.01^{b}	0.01±0.01^{a}	0.01±0.01^{x}	0.01±0.01^{x}	0.02±0.01^{x}
(C:14:0)	3.29±0.02^{b}	1.09±0.01^{a}	3.25±0.01^{z}	2.10±0.01^{x}	2.63±0.01^{y}
(C15:0)	0.47±0.01^{b}	0.14±0.01^{a}	0.39±0.01^{z}	0.28±0.01^{x}	0.34±0.01^{y}
(C16:0)	16.49±0.02^{b}	12.69±0.01^{a}	13.97±0.01^{x}	16.43±0.01^{z}	16.11±0.01^{y}
(C17:0)	0.46±0.03^{b}	0.20±0.01^{a}	0.28±0.01^{x}	0.29±0.01^{x}	0.34±0.01^{y}
(C18:0)	4.64±0.01^{a}	4.60±0.01^{a}	2.92±0.01^{x}	3.55±0.02^{y}	3.56±0.01^{y}
(C20:0)	0.13±0.01^{b}	0.05±0.01^{a}	0.42±0.02^{z}	0.38±0.02^{x}	0.40±0.01^{y}
(C22:0)	0.39±0.01^{a}	0.41±0.01^{a}	0.11±0.01^{x}	0.11±0.01^{x}	0.11±0.01^{x}
(C24:0)	0.18±0.01^{a}	0.16±0.02^{a}	0.08±0.01^{y}	0.04±0.01^{x}	0.04±0.01^{x}
SFA	26.17±0.08^{b}	19.38±0.01^{a}	21.77±0.06^{x}	23.40±0.01^{y}	23.74±0.02^{y}
(C14:1)	0.14±0.01^{b}	0.04±0.01^{a}	0.03±0.01^{x}	0.04±0.01^{x}	0.03±0.01^{x}
(C16:1)	3.84±0.01^{b}	1.40±0.01^{a}	3.68±0.01^{y}	3.30±0.01^{x}	3.78±0.01^{y}
(C18:1n9c)	23.09±0.03^{b}	24.81±0.01^{a}	32.87±0.01^{z}	26.09±0.02^{y}	23.65±0.01^{x}
(C20:1n9c)	1.17±0.01^{b}	0.58±0.01^{a}	3.65±0.01^{y}	1.12±0.01^{x}	1.20±0.01^{x}
(C22:1n9)	0.35±0.01^{b}	0.12±0.02^{a}	0.55±0.01	-	-
(C24:1)	0.31±0.01^{b}	0.08±0.01^{a}	0.42±0.01^{y}	0.11±0.01^{x}	0.15±0.01^{x}
MUFA	28.89±0.02^{b}	27.02±0.03^{a}	41.19±0.01^{y}	30.66±0.03^{x}	28.81±0.01^{x}
(C18:2n-6c)	23.77±0.01^{a}	42.66±0.03^{b}	13.60±0.02^{x}	26.06±0.02^{z}	24.74±0.01^{y}
(C18:3n3)	3.35±0.01^{a}	5.94±0.01^{b}	3.09±0.01^{x}	3.29±0.01^{z}	3.15±0.01^{y}
(C18:3n6)	0.58±0.02^{b}	0.44±0.01^{a}	0.27±0.01^{x}	0.31±0.01^{y}	0.27±0.01^{x}
(C20:2)	0.96±0.02^{b}	0.30±0.01^{a}	1.67±0.01^{z}	0.83±0.01^{y}	0.77±0.02^{x}
(C20:3n3)	0.24±0.01^{b}	0.13±0.01^{a}	0.07±0.01^{x}	0.12±0.01^{y}	0.16±0.01^{z}
(C20:5n-3)	5.14±0.01^{b}	1.50±0.01^{a}	3.09±0.01^{y}	2.26±0.01^{x}	3.60±0.04^{z}
(C20:4n:6)	1.12±0.06^{b}	0.32±0.02^{a}	0.32±0.01^{y}	0.29±0.01^{x}	0.43±0.01^{z}
(C22:6n-3)	8.73±0.01^{b}	1.93±0.01^{a}	4.01±0.01^{x}	4.39±0.01^{y}	4.75±0.04^{z}
(C22:5n-3)	0.71±0.01^{a}	0.26±0.02^{b}	1.02±0.01^{z}	0.04±0.01^{x}	0.65±0.01^{y}
PUFA	44.57±0.03^{a}	52.49±0.99^{b}	27.91±0.01^{x}	38.09±0.02^{y}	38.65±0.01^{y}
ω-3	18.16±0.01^{b}	8.78±0.96^{a}	11.27±0.01^{y}	10.47±0.01^{x}	12.31±0.01^{z}
ω-6	25.46±0.04^{a}	43.42±0.05^{b}	14.38±0.01^{x}	26.75±0.03^{z}	25.55±0.01^{y}
ω-3/ω-6	0.71±0.01^{b}	0.20±0.02^{a}	0.78±0.01^{z}	0.39±0.01^{x}	0.48±0.01^{y}
ω-9	24.60±0.02^{a}	25.50±0.02^{b}	37.07±0.01^{z}	27.21±0.02^{y}	24.85±0.01^{x}

x,y,z values of seabass in rows marked with different superscript letters are significantly different ($p<0.05$)
a,b values of feed in rows marked with different superscript letters are significantly different ($p<0.05$)

respectively. On termination of the study, SFA values increased to 23.74±0.02% in the Aegean Sea and 23.40±0.01% in the Black Sea ($p<0.05$), MUFA values decreased to 28.81±0.01% in the Aegean Sea and 30.66±0.03% in the Black Sea ($p<0.05$). PUFA values increased to 38.65±0.01% in the Aegean Sea and 38.09±0.02% in the Black Sea ($p<0.05$) (Fig. 1). The omega-3, omega-6 and omega-9 values of European seabass in Aegean Sea were 12.31±0.01%, 25.55±0.01% and 24.85±0.01%, respectively. The values for Black Sea were 10.47±0.01%, 26.75±0.03% and 27.21±0.01%, respectively and there was siginificant difference ($p<0.05$) between omega-3, omega-6 and omega-9 values of European seabass farmed in the two regions (Fig. 2).

Apart from the relative proportions of fatty acids in total lipids (allowing a direct comparison of the lipid quality of fish from different sources), an estimation of the actual contents of total ω-3 and of ω-6 PUFA in fish flesh is very important in view of its use for human consumption. European seabass cultured in the Aegean Sea, in addition to the higher total lipid content, also showed higher absolute levels of total ω-3 and ω-6 PUFA, compared to Black Sea. Including EPA and DHA, large numbers of significant PUFA levels were recorded in European seabass cultured in the Aegean Sea (Fig. 3).

DHA (C22:6n-3), which plays an important role in brain and retina development during the early stages of human life, was present in European seabass in both regions at comparatively high levels (4.75±0.05-4.39±0.01%, $p<0.05$). The EPA (C20:5n-3) value at the beginning of the study was found to decrease in the Black Sea and found to increase in the Aegean Sea towards the end of the study ($p<0.05$). The relationship between selected fatty acids of European seabass and environmental parameters are given in Table 4.

According to the results of regression analysis, water salinity was determined to have an effect on fatty acids in fish meat. The study clearly indicated a negative relationship between C14:0, C15:0, C16:0, SFA, C14:1, C16:1, C24:1, C20:5n-3 and ω-3 values and salinity, while a positive relationship is evident between C18:2n-6, C18:3n-3,PUFA and ω-6 levels and salinity.

Discussion

Crude protein and crude fat values of European seabass were found to have increased towards the end of culture period in both Agan Sea and Black Sea samples. The biochemical composition values were significantly different between periods except for crude ash. Since the feeding regime and feed used were the same in both the

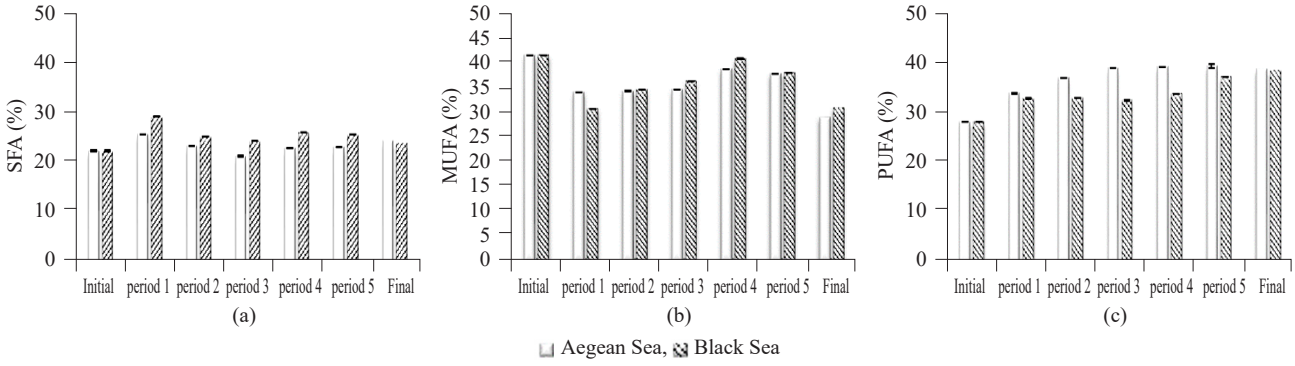

Fig. 1. SFA, MUFA and PUFA values of European seabass

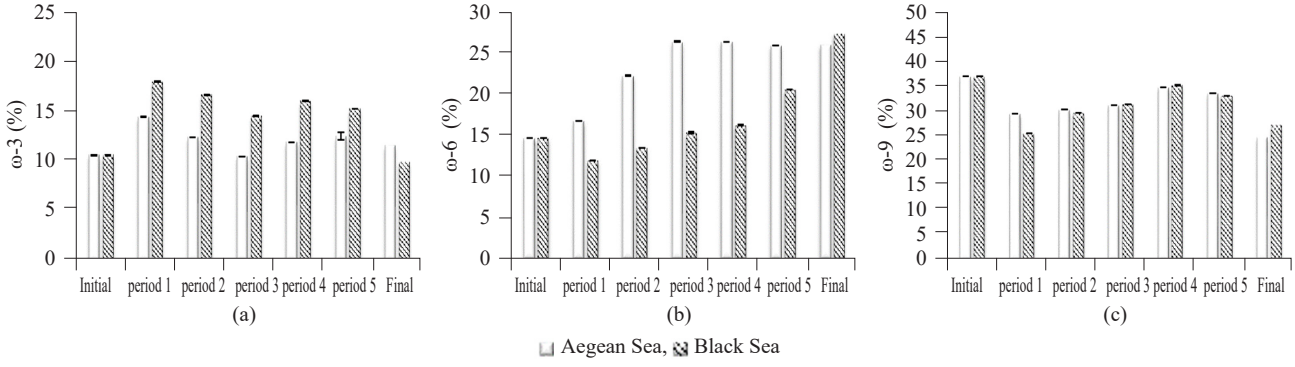

Fig. 2. ω-3,ω-6 and ω-9 values of European seabass

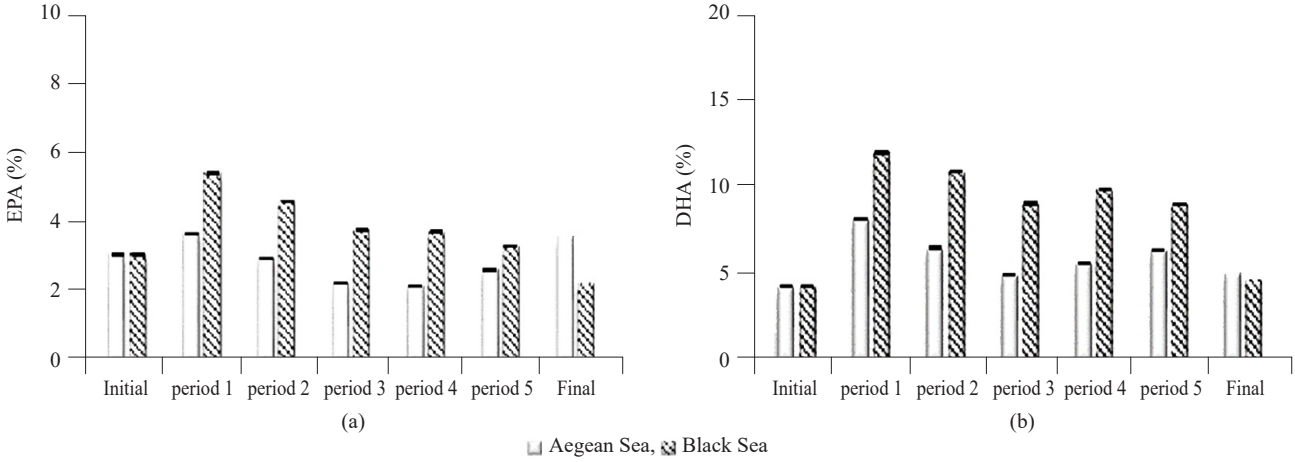

Fig. 3. EPA and DHA values for European seabass

Table 4. Relationship between fatty acid values of European seabass with water temperature and salinity

	Temperature (°C)			Salinity (‰)		
Fatty acids	PC	p values	F values	PC	p values	F values
C14:0	0.04	0.915	0.012	-0.98	0.002	90.132
C15:0	0.01	0.997	3.943	-0.89	0.041	11.926
C16:0	0.16	0.654	0.216	-0.81	0.096	5.731
C18:0	0.35	0.325	1.099	-0.41	0.493	0.607
SFA	0.20	0.576	0.339	-0.93	0.020	20.451
C14:1	-0.11	0.754	0.105	-0.84	0.076	7.106
C16:1	-0.20	0.577	0.336	-0.90	0.037	12.760
C18:1n-9c	-0.34	0.324	1.102	-0.29	0.641	36.508
C24:1	0.17	0.631	0.249	-0.95	0.111	31.635
MUFA	-0.41	0.236	1.641	-0.59	0.293	1.621
C18:2n-6	0.33	0.353	0.974	0.94	0.016	24.287
C18:3n-3	0.34	0.330	1.077	0.96	0.007	43.887
C18:3n-6	0.59	0.072	4299	0.53	0.354	1.192
C20:5n-3	-0.10	0.785	0.079	-0.94	0.014	26.184
C20:4n:6	-0.17	0.629	0.252	-0.64	0.243	2.098
C22:6n-3	-0.27	0.452	0.626	-0.17	0.780	0.092
PUFA	0.41	0.235	1.645	0.87	0.055	9.273
ω-3	-0.18	0.616	0.272	-0.94	0.016	24.615
ω-6	0.33	0.348	0.994	0.94	0.015	25.285
ω-9	-0.37	0.295	1.257	-0.36	0.548	0.454

PC: Pearson correlation

study areas, it can be presumed that these differences in biochemical composition are due to the physicochemical properties of the culture environment. The crude protein contents of fish observed in the present study were similar to earlier reports (Alasalvar *et al.*, 2002b; Yıldız *et al.,* 2007; Ozden and Erkan, 2008; Atalay and Bilal, 2014; Baki *et al*.. 2015; Tibaldi *et al.,* 2015), but crude fat contents were found to be higher compared to earlier studies (Alasalvar *et al.* 2002; Dias *et al.,* 2005; Ozogul *et al.* 2007; Ozden and Erkan, 2008; Lenas *et al*. 2011; Chuang *et al.,* 2012; Atalay and Bilal, 2014). Different culture systems, protocols and feeding regimes may affect flesh quality, especially fatty acid contents and flavour profile (Grigorakis 1999; Lanari *et al.,* 1999; Poli *et al.,* 2001; Alasalvar *et al.,* 2002a, b; Izquierdo *et al.,* 2003; Periago *et al*., 2005; Ambrosio *et al.,* 2008). In this study, high levels of saturates, especially miristic (C14:0) and palmitic (16:0) acid levels were observed in tissues compared to the diets. Towards the end of culture period, the total amount of SFA and PUFA increased and the total MUFA levels decreased compared to the initial values, for both regions. This increase in the levels of of PUFA

and decrease in MUFA in fish meat could be attributed to the values of PUFA and MUFA in the feed. But, the change in the amount of SFA could be due to variation in environmental parameters (Table 4). In earlier studies, SFA amounts in seabass reaching harvest weights were similar to our study (Chuang *et al*., 2012; Makol *et al*., 2012; Messina *et al.,* 2013; Tibaldi *et al*., 2015; Torrecillas *et al.,* 2015; Baki *et al*., 2015).

It is now well accepted that many aquatic species have a net requirement for the longer and more unsaturated fatty acids such as arachidonic acid, EPA and DHA (Sargent *et al.*, 1999). In this study, although 18: 2n-6 fatty acids were abundant in their diets, the final 20: 4n-6 fatty acid content was found to be low in European seabass. It has been reported that arachidonic acid metabolism in fish tissues is affected by seawater salinity and osmoregulation as well as diets (Harlıoglu, 2014). In this case, it can be concluded that the bioconversion of fatty acids in fish meat is influenced by diets as well as by environmental factors such as salinity and temperature. Izquierdo *et al.* (2003) showed that the inclusion of dietary vegetable oils for European seabass led to a diet-dependent reduction in 20:5n-3 and 20:4n-6 in the muscles, whereas 22:6n-3 was deposited in the fish tissue. In this study, the DHA value was higher in seabass farmed in the Aegean Sea. DHA values for seabass in both regions were lower than reported in other studies (Erdem *et al.,* 2009; Lenas *et al.*, 2011; Baki *et al.*, 2015; Tibaldi *et al.*, 2015). The EPA value of European seabass in the Aegean Sea was higher than in the Black Sea. However, the EPA values were found to be higher than those reported in other fishes (Ozden and Erkan 2008; Erdem *et al.*, 2009; Lenas *et al.,* 2011; Tibaldi *et al.,* 2015; Torrecillas *et al.,* 2015).

In the present study, it was observed that the correlation between EPA values in fish and salinity values was high, while the temperature changes had a lower relation (Table 4). As water salinity has an effect on fatty acid composition, the PUFA levels and the ω -3 to ω -6 fatty acid ratios are much lower in fishes living in low saline environments, compared to marine fishes (Steffens, 1997). It has also been reported that salinity affects the digestibility of dietary lipids in trout (Haliloglu *et al.,* 2004).)

PUFA in fish oil, particularly ω-3 fatty acids, are required to maintain normal tissue function in humans (Makoto *et al.,* 2000). In this study, PUFA values for both regions were higher in comparison with MUFA and SFA values, and ω -3 PUFA was found to be lower than ω-6 PUFA. A significant difference was found between the seabass fillets from Aegean Sea and the Black Sea with regard to the total ω-3 and ω-6 PUFA levels and the ω-3/ω-6 ratio values of total lipids. The ω-3/ω-6 ratio has been suggested to be a useful indicator for comparing the relative nutritional values of fish oils, and a ratio of 1:1 to 1:5 would constitute a healthy human diet (Osman *et al.,* 2001). The ratio in this study was determined to be very low compared to the reports of Osman *et al.* (2001). The present results are also contradictory to previous reports by several other authors (Alasalvar *et al.,* 2002a; Bayır *et al.,* 2006; Chuang *et al.,* 2012; Baki *et al.,* 2015), who found higher proportions of ω-3 PUFA in seabass.

The effect of temperature on fish fatty acid composition has not been well documented mainly for marine fish species. In European seabass, adaptation to low temperature did not induce major changes in fatty acid composition of the liver and heart (Trigari *et al.,* 1992) or gill and kidney (Ventrella *et al.,* 1993). The present study recorded significant influence of temperature on fatty acids, as previously shown on whole body fatty acid composition (Person-Le Ruyet *et al*., 2004). Hazel (1984) reported that at low temperatures the chemical structure of PUFA permits a greater degree of unsaturation compared with SFA. This means that cold and temperate water species require a certain level of PUFA to maintain digestion and metabolic activities at low temperatures. However, in this study, more long-chain PUFA were identified in seabass grown in the Aegean Sea, which recorded higher water temperatures during the study period.

The effect of feeds on the fatty acid composition of fish tissues is expected as fish tssues usually tend to reflect the composition in the feed (Bell *et al.*, 2001; Jobling, 2001). From the results of the present study it is evident that while fatty acids in fish muscle were affected by the fatty acid contents of the feed, significant differences existed between fishes of the two regions, indicating additional effect of environmental factors.

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