Asian Journal of Chemistry Vol. 20, No. 2 (2008), 1251-1259

Comparison of the Proximate Compositions and Fatty Acid Profiles of Gilthead Sea Bream (*Sparus aurata*) and Sole (*Solea solea*)

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Seasonal changes in the proximate composition and fatty acids of gilthead sea bream (*S. aurata*) and sole (*S. solea*) were investigated. The fish species (*S. aurata* and *S. solea*) analyzed were fairly high in protein (20.41-22.63 %). The highest lipid levels of gilthead sea bream were found in September and December. However the lipid levels of sole displayed fluctuations according to months with the highest values in September. The percentages of EPA and DHA of gilthead sea bream were between 3.86-4.59 and 5.96-19.64 %, respectively, according to the months. However, The EPA and DHA of the sole were also found 2.17-2.94 and 6.33-10.99 %, respectively. The ratios of n-3/n-6 PUFA content indicating the availability of n-3 PUFA that are beneficial for human health were 8.06, 18.97, 6.45 for gilthead sea bream and 5.53, 6.46, 6.65 for sole in December, April, September, respectively. The results of this study show that the consumption of gilthead sea bream and sole could meet this demand in terms of n-3 PUFA contents and the effects on health.

Key Words: *Sparus aurata*, *Solea solea*, Seasonal changes, Fatty acids, Proximate composition.

INTRODUCTION

Due to the increased interest in defining the biological roles of nutritients and their function in the etiology of chronic diseases, knowledge of dietary nutrient intake is needed to optimize human health[1].

Seafood is a source of top-quality protein food that is low in calories, total fat and saturated fat when compared to other protein-rich animal foods. In addition, large proportion of the fat is polyunsaturated[2,3]. Fish lipids consist mainly of long-chain n-3 polyunsaturated fatty acids (PUFA) such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA)[4,5].

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Epidemiological evidence suggests that the consumption of fish oil containing n-3 PUFAs reduces the risk of coronary heart disease. Other hand long-chain n-3 PUFA may be beneficial for the prevention and treatment of a myriad of other conditions and diseases, *e.g.*, arthritis and inflammation, autoimmune disease, type 2 diabetes, hypertension, kidney and skin disorders and cancer. n-3 PUFA is also important for the development at the eye and brain[6-9]. Nutritionists believe that the desirable ratio n-6/n-3 (n-6 to n-3 fatty acids) should be 5. More recently, nutritionist have focused on the type of PUFA and the balance in the diet between n-3 PUFA formed from α linolenic acid (18:3) is n-6 PUFA formed from linoleic acid (18:2)[10]. Rice[11] suggested that the amount of EPA and docosahexaenoic acid (DHA) daily ingested should be about 200-1000 mg. Simopoulos[12] recommends the daily ingestion of 800-1100 mg of linolenic acid and from 300-400 mg of long- chain n-3 PUFA.

Gilthead sea bream (*S. aurata*) and sole (*S. solea*) are most commecially valuable and highly consumed two fish species in Turkey and Mediterranean countries. It is known that proximate composition and fatty acid profile of fish is subject to seasonal variations. This condition can affect its processing and storage properties[13].

Although some studies have been conducted on the proximate composition and on comparisons of fatty acids in these species[14-18], less data is available on seasonal changes in the fatty acid profiles of these species in literature.

In order to determine a suitable fish diet, water, ash, protein, lipids and fatty acids in muscle tissues (fillet) of gilthead sea bream (*S. aurata*) and sole (*S. solea*) collected at different seasons were determined.

EXPERIMENTAL

This study was carried out using gilthead sea bream (*S. aurata*) and sole (*S. solea*) obtained quarterly (September, December, April) from the local fishers in Iskenderun Bay on the eastern Mediterranean coast of Turkey. The averages for total length of 45 gilthead sea bream and sole were 18.4 ± 0.74 and 24.19±2.67 cm and total weight 92.80 ± 7.41 and 114.68 ± 40.20 g, respectively. All samples were stored in freezer (-18°C) and analyses were carried out in triplicates, using homogenized muscle tissue (fillet) samples.

Proximate composition: Moisture content was determined by during the sample in a hot air oven at 105 °C until constant weight was obtained[19]. Ash content was determined by dry-ashing in a furnace at 550 °C for 5 h[19]. Total crude protein was determined by Kjeldahl's method (6.2 × N)[20] and total lipid content were extracted from the muscle tissues using Bligh and Dyer method[21]. The lipid content was gravimetrically determined.

Fatty acid analysis: The lipids were esterified according to Metcalfe *et al.*[22]. The fatty acid methyl esters were analyzed on a Thermoquest trace gas chromatograph equipped with SP-2330 fused silica capillary column, 30 × 0.25 mm ID 0.20 μm film thickness. Column injector and detector temperatures were 240 and 250 °C, respectively. Carrier gas, helium; split ratio 1/150; column flow 75 mL/min; make-up 30 mL/min (He) range 1; sample injection 0.5 μL. The fatty acid methyl mixture No. 189-19 was used for standards (Sigma).

Statistical analysis: The analytical data were subjected to the analysis of variance (one-way Anova) using[23] SPSS 10.023 and the Duncan's multiple range tests. The test was performed to determined significant differences among means.

RESULTS AND DISCUSSION

Proximate composition: Table-1 shows proximate composition of gilthead sea bream and sole collected at different seasons with ± standard deviation.

TABLE-1
PROXIMATE COMPOSITION OF GILTHEAD SEA BREAM AND SOLE AT DIFFERENT SEASONS

Species	Component (%)	December	April	September
Gilthead sea bream	Moisture	74.32 ± 0.20a	76.85 ± 0.05c	75.64 ± 0.24b
	Ash	1.03 ± 0.04a	1.11 ± 0.01b	1.40 ± 0.01c
	Crude Protein	22.63 ± 0.18c	21.43 ± 0.01b	21.26 ± 0.01a
	Lipid	1.75 ± 0.03b	0.23 ± 0.01a	1.70 ± 0.03b
Sole	Moisture	76.93 ± 0.01ab	76.57 ± 0.45a	77.40 ± 0.23b
	Ash	1.39 ± 0.01c	1.33 ± 0.03b	1.21 ± 0.02a
	Crude Protein	20.81 ± 0.16b	21.44 ± 0.04c	20.41 ± 0.02a
	Lipid	0.24 ± 0.02a	0.34 ± 0.02b	0.55 ± 0.03c

Values are shown as mean ± standard deviation of triplicate, n = 3; Within the column values with different letters are significantly different ($p < 0.05$).

The lipid level of gilthead sea bream in April was significantly lowest than those in December and September ($p < 0.05$). Although Grigorakis *et al.*[15] found the lower lipid level of wild gilthead sea bream in May while Özyurt *et al.*[18] reported the lowest lipid level for this species found in winter season. Significant seasonal changes were observed in mean lipid values of sole ($p < 0.05$). The lowest lipid levels (0.34-0.24 %) of sole were found in the reproductive season of the species and at the December. The reproductive season of sole is between April and June[24]. This species stops feeding during maturation and lipid stores are directed to gonad lipids or used energy[25]. Similarly to our finding, Gökçe *et al.*[16] detected that the lowest lipid levels was in reproductive season and at the end of autumn.

Increasing of lipid level is concerned with increasing of dry matter content in this month[26,27]. Krzynowek[28] reported that the fat content of some fish species might vary to the season. The percentage of body fat is known to depend on the life cycle stage and energy intake of the animal[29,30].

In present study, significant seasonal changes were observed in mean protein levels of fish samples ($p < 0.05$). The highest protein levels of gilthead sea bream (22.63 %) and sole (21.44 %) were found in December and April, respectively ($p < 0.05$). Similarly, Grigorakis *et al.*[15] found the highest protein level (20.05 %) in fillets of wild gilthead sea bream in January. The seasonal changes in the protein levels of sole and gilthead sea bream were not coincident with reported by Gökçe *et al.*[16] and Özyurt *et al.*[18].

Moisture content is usually inversely related to fat content[31]. The investigation indicates that the change of moisture content is difference in fish species. The highest moisture level of gilthead sea bream fillets was found in April (76.85 %). Özyurt *et al.*[18] reported that the highest moisture levels (77.3 %) of this species were found in winter season. The moisture content of sole fillets in September was the highest (77.40 %) when compared to other months. Similarly, the highest moisture content of sole fillets was noted in August by Gökçe *et al.*[16].

The ash contents of gilthead sea bream and sole increased significantly ($p < 0.05$) in September and December, respectively. It was reported that ash content is affected from seasonal changes and varies according to moisture content of muscle. However, it should be noted that trace elements requirement must be varies according to life cycle, age of fish and to season[32].

Fatty acid profile: Fatty acid profiles of gilthead sea bream and sole at different seasons are presented in Tables 2 and 3, respectively.

Among saturated fatty acid (SFA) and monounsaturated fatty acid (MUFA), the largest concentration acid in both gilthead sea bream and sole fillets during all of the seasons was for palmitic acid (C16:0), stearic acid (C18:0) and oleic acid (C18:1n9). It was reported that palmitic acid, myristic acid (C14:0), stearic acid, palmitoleic acid (C16:1), oleic acid, linoleic acid (C18:2n6)., EPA (C20:5n3) and DHA (C22:6n3) were dominant in gilthead sea bream and sole[14,15,18].

Palmitic acid values of gilthead sea bream and sole ranged from 20.99 to 21.48 % and from 17.32 to 28.32 % , respectively. The concentrations of gilthead sea bream was the higher than reported by Özyurt *et al.*[18] and Ibarz *et al.*[17]. However, those values was the lower than those found by Grigorakis *et al.*[15]. Palmitic acid level of sole was the higher than those reported by Gökçe *et al.*[16].

TABLE-2
FATTY ACID PROFILES OF GILTHEAD SEA BREAM AT DIFFERENT SEASONS (% OF TOTAL FATTY ACIDS)[a]

Fatty acids	December	April	September
C12:0 Lauric	0.25 ± 0.00c	0.07 ± 0.00a	0.12 ± 0.00b
C13:0 Tridecanoic	0.06 ± 0.00b	-	0.05 ± 0.00a
C14:0 Myristic	4.14 ± 0.03c	1.58 ± 0.01a	3.26 ± 0.00b
C15:0 Pentadecanoic	0.88 ± 0.00b	0.62 ± 0.00a	1.39 ± 0.00c
C16:0 Palmitic	21.18 ± 0.15ab	21.48 ± 0.19b	20.99 ± 0.03a
C17:0 Heptadecanoic	1.23 ± 0.01a	1.23 ± 0.07a	2.25 ± 0.05b
C18:0 Stearic	6.29 ± 0.03a	6.96 ± 0.08c	6.53 ± 0.01b
C20:0 Arachidic	0.63 ± 0.00c	0.39 ± 0.00b	0.30 ± 0.01a
C21:0 Henicosanaic	0.34 ± 0.00b	0.20 ± 0.00a	0.53 ± 0.00c
C22:0 Behenic	0.33 ± 0.00c	0.13 ± 0.01b	0.05 ± 0.00a
C23:0 Tricosanoic	0.06 ± 0.00a	0.12 ± 0.03b	0.29 ± 0.00c
C24:0 Lignoceric	0.18 ± 0.01a	0.32 ± 0.05b	1.60 ± 0.01c
ΣSFA[b]	**35.57**	**33.10**	**37.36**
C14:1 Myristoleic	0.23 ± 0.00c	0.08 ± 0.00a	0.10 ± 0.00b
C15:1 *cis*-10-Pentadecenoic	0.20 ± 0.00ab	0.11 ± 0.00a	0.33 ± 0.00b
C16:1 Palmiteloic	10.44 ± 0.09c	4.05 ± 0.05a	7.64 ± 0.01b
C17:1 *cis*-10-Heptadecenoic	0.92 ± 0.01bc	0.62 ± 0.06a	0.86 ± 0.00b
C18:1n9t Elaidic	0.43 ± 0.00a	-	0.50 ± 0.01b
C18:1n9c Oleic	17.47 ± 0.06b	6.99 ± 0.08a	17.79 ± 0.03c
C20:1n9 Eicosanoic	0.43 ± 0.00b	0.39 ± 0.00a	0.94 ± 0.00c
C22:1n9 Erucic	0.24 ± 0.01a	0.32 ± 0.29a	0.23 ± 0.00ba
C24:1n9	0.26 ± 0.01a	1.32 ± 0.08c	0.76 ± 0.01b
ΣMUFA[b]	**30.62**	**13.88**	**29.15**
C20:2	0.34 ± 0.00a	0.70 ± 0.00c	0.64 ± 0.00b
C20:4	-	-	0.32 ± 0.00
C22:2	3.15 ± 0.01b	7.61 ± 0.05c	2.84 ± 0.00a
C18:2n6t	0.08 ± 0.00a	0.40 ± 0.05b	0.44 ± 0.00b
C18:2n6c	1.05 ± 0.00b	0.80 ± 0.05a	0.84 ± 0.00a
C18:3n6g	0.27 ± 0.00b	0.08 ± 0.00a	0.33 ± 0.03c
C18:3n3a	0.32 ± 0.00b	0.17 ± 0.00a	0.33 ± 0.01c
C20:3n-3	0.26 ± 0.00a	0.28 ± 0.01a	0.26 ± 0.00a
C20:5n-3	4.59 ± 0.02c	4.02 ± 0.00b	3.86 ± 0.00a
C22:6n-3	6.09 ± 0.11a	19.64 ± 0.19b	5.96 ± 0.01a
Σn-3	11.26	24.11	10.41
Σn-6	1.40	1.27	1.61
ΣPUFA[b]	**16.15**	**33.70**	**15.82**
n-3/n-6	8.04	18.98	6.46
Unknown	17.66	19.32	17.67

[a]Values are shown as mean ± standard deviation of triplicate, n = 3; Within the column values with different letters are significantly different ($p < 0.05$).
[b]SFA: Saturated fatty acids; MUFA: Monounsaturated fatty acids; PUFA: Polyunsaturated fatty acids.

TABLE-3
FATTY ACID PROFILES OF SOLE AT DIFFERENT SEASONS
(% OF TOTAL FATTY ACIDS)[a]

Fatty acids	December	April	September
C12:0 Lauric	0.14 ± 0.00b	0.13 ± 0.00a	0.13 ± 0.00a
C13:0 Tridecanoic	0.10 ± 0.00b	0.06 ± 0.00a	-
C14:0 Myristic	4.40 ± 0.01c	4.05 ± 0.02b	2.59 ± 0.01a
C15:0 Pentadecanoic	1.29 ± 0.01c	1.14 ± 0.04b	1.05 ± 0.00a
C16:0 Palmitic	17.79 ± 0.11b	17.32 ± 0.11a	28.32 ± 0.01c
C17:0 Heptadecanoic	2.02 ± 0.01b	1.67 ± 0.04a	2.14 ± 0.19b
C18:0 Stearic	5.54 ± 0.01b	5.42 ± 0.07a	8.38 ± 0.02c
C20:0 Arachidic	0.89 ± 0.00c	0.73 ± 0.00b	0.44 ± 0.00a
C21:0 Henicosanaic	0.21 ± 0.00b	0.18 ± 0.00b	0.11 ± 0.03a
C22:0 Behenic	0.20 ± 0.00b	0.23 ± 0.00a	-
C23:0 Tricosanoic	0.28 ± 0.00a	0.95 ± 0.01b	0.27 ± 0.27a
C24:0 Lignoceric	0.22 ± 0.01a	0.22 ± 0.03a	2.12 ± 0.27b
ΣSFA[b]	**33.08**	**32.10**	**43.16**
C14:1 Myristoleic	0.54 ± 0.00c	0.32 ± 0.02b	0.19 ± 0.00a
C15:1 *cis*-10-Pentadecenoic	0.78 ± 0.03b	0.42 ± 0.00a	0.99 ± 0.00c
C16:1 Palmiteloic	9.27 ± 0.00c	5.61 ± 0.05b	4.12 ± 0.02a
C17:1 *cis*-10-Heptadecenoic	2.14 ± 0.00c	1.37 ± 0.04b	0.51 ± 0.03a
C18:1n9t Elaidic	0.64 ± 0.00b	0.35 ± 0.05a	0.34 ± 0.02a
C18:1n9c Oleic	9.21 ± 0.01b	7.23 ± 0.03a	7.29 ± 0.00a
C20:1n9 Eicosanoic	1.48 ± 0.01b	1.76 ± 0.00c	0.73 ± 0.00a
C22:1n9 Erucic	0.98 ± 0.00c	0.78 ± 0.00b	0.37 ± 0.01a
C24:1n9	0.21 ± 0.01a	2.52 ± 0.01c	1.76 ± 0.01b
ΣMUFA[b]	**25.25**	**20.36**	**16.3**
C20:2	0.45 ± 0.00b	0.71 ± 0.00c	0.41 ± 0.01a
C20:4	0.13 ± 0.00	-	-
C22:2	4.34 ± 0.00a	6.50 ± 0.00c	5.29 ± 0.29b
C18:2n6t	0.63 ± 0.00b	0.49 ± 0.01a	0.64 ± 0.02b
C18:2n6c	0.81 ± 0.02a	1.54 ± 0.02c	1.24 ± 0.11b
C18:3n6 g	0.13 ± 0.01a	0.10 ± 0.00a	0.28 ± 0.09b
C18:3n3 a	0.13 ± 0.00a	0.16 ± 0.00b	0.79 ± 0.02c
C20:3n-3	0.16 ± 0.00a	0.26 ± 0.00c	0.22 ± 0.00b
C20:5n-3	2.17± 0.00a	2.35 ± 0.00b	2.94 ± 0.07c
C22:6n-3	6.33 ± 0.03a	10.99 ± 0.09c	10.41 ± 0.08b
Σn-3	8.79	13.77	14.36
Σn-6	1.59	2.13	2.16
ΣPUFA[b]	**15.28**	**23.10**	**22.22**
n-3/n-6	5.53	6.46	6.65
Unknown	26.39	24.44	18.32

[a]Values are shown as mean ± standard deviation of triplicate, n = 3; Within the column values with different letters are significantly different ($p < 0.05$).
[b]SFA: Saturated fatty acids; MUFA: Monounsaturated fatty acids; PUFA: Polyunsaturated fatty acids.

The stearic acid presented lower values in fish samples. The levels of stearic acid in both species ranged from 6.29 to 6.96 % and from 5.42 to 8.38 %, respectively. Romero *et al.*[33] reported that stearic acid concentration in marine fish was 4.50 %, when compared to the present study. In the present study, the lowest total saturated fatty acid (∑SFA) level was determined in April and the highest total level was determined in September for both species (Tables 2 and 3).

Among monounsaturated fatty acids, oleic acid presented larger percentage for fish samples. The values for gilthead sea bream and sole were between 6.99-17.79 and 7.23-9.21 %, respectively. The other researchers found 16.06 and 13.70-20.41 % for gilthead sea bream and sole species, respectively. Gökçe *et al.*[16] noted that this value ranged from 7.57 to 10.1 % for female common sole. The highest total monounsaturated fatty acids (∑MUFA) level was determined in December both species (Tables 2 and 3). In present study, the levels of EPA and DHA were dominant polyunsaturated fatty acids (PUFA). The levels of EPA and DHA of sole were found 2.17-2.94 and 6.33-10.99 % throughout all the seasons, respectively. However, the levels of EPA and DHA of gilthead sea bream were also found 3.86-4.59 and 5.96-19.64 %, respectively. The highest total polyunsaturated fatty acids (∑PUFA) level was determined in April for both species (Tables 2 and 3).

In other study, EPA and DHA level of common sole in different months was found between 3.36-4.26 and 18.8-20.2 %, respectively. The values were lower than reported by Gökçe *et al.*[16]. Imre and Saglik[14] found that EPA and DHA levels of sole were as 0.01 and 0.03 %, respectively. The values were lower than present values. In another study, Grigorakis *et al.*[15] determined EPA and DHA percentages of gilthead sea bream sampled in November and was found that EPA and DHA percentages is 6.96 and 17.61 %, respectively. The values were found higher than the values determined for September in present study.

Özyurt *et al.*[18] determined EPA and DHA percentages 4.27-5.42 and 7.02-15.37, respectively. These values found for seasons were similar to or higher than present values for the same species. Alasalvar *et al.*[34] determined that wild sea bass (*D. labrax*) had higher total n-3 quantity in comparison to present study.

The n-3/n-6 ratio is a good index for comparing relative nutritional value of fish oils[35]. The Department of Health, UK[36] recommends an ideal relationship of n-3/n-6 of 4.0, at maximum. The present data show that the n-3/n-6 ratio for gilthead sea bream was 8.04 in December, 18.98 in April, 6.46 in September and for sole was 5.53 in December, 6.46 in April, 6.65 in September.

Recent studies suggest that eating fish oil daily reduces the risk of heart disease. The most efficient way to add these important oils to human diet is to eat two meals per week of fish rich in this fatty acid prepared without additional oil.

It was suggested that the amount of EPA and DHA daily ingested should be about 0.2-1.0 g[11]. The present study suggest that the daily consumption of 100 g of gilthead sea bream in December and September and daily consumption of 100 g of sole in December could meet this demand, but these fish species should be consumed in greater amounts in especially April season (Table 4).

TABLE-4
EPA+DHA COMPOSITION OF GILTHEAD SEA BREAM AND SOLE COLLECTED AT DIFFERENT SEASONS (g/100 g)

Species	Season	Lipid	EPA	DHA	EPA+DHA
Gilthead sea bream	December	1.75	0.08	0.11	0.19
	April	0.23	0.01	0.04	0.05
	September	1.70	0.06	0.10	0.16
Sole	December	0.24	0.01	0.33	0.34
	April	0.34	0.01	0.04	0.05
	September	0.55	0.02	0.06	0.08

This study has shown that gilthead sea bream and sole are suitable item in the human diet during the fishing period in the Eastern Mediterranean Coast of Turkey when the levels of EPA, DHA and n-3/n-6 ratio are considered.

Further studies will be necessary to determine n-3/n-6 and the optimum ratio of DHA and EPA in diet of another fish species from the eastern Mediterranean Sea.

ACKNOWLEDGEMENT

This study was supported by the research fund of University of Çukurova, Adana, Turkey.

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(*Received*: 12 February 2007; *Accepted*: 4 October 2007) AJC-5965