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Comparison of proximate and fatty acid composition of the flesh of wild and cultured fish species

Vergleich der Grundzusammensetzung und der Fettsäurezusammensetzung von wilden und gefarmten Fischarten

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Summary

The proximate and fatty acid compositions of the flesh of cultured and wild common dentex *(Dentex dentex),* brown meagre *(Sciaena umbra)* and sharp-snout sea bream *(Diplodus puntazzo)* were evaluated. In all batches, cultured fish had higher values of fat contents. The lipids of cultured sharp-snout sea bream contained significantly ($p<0.05$) higher proportions of 18:1n-9cis, 20:1n-9, 22:1n-9, 18:2n-6cis and 22:2cis than the wild form. In addition, cultured common dentex contained significantly ($p<0.05$) higher proportions of 14:0, 20:1n-9, 18:2n-6cis, 20:5n-3cis and 22:6n-3. For these two species, the total polyenoic fatty acids content and the n-3/n-6 ratio were higher in the cultured than in the wild forms. Cultured brown meagre contained significantly ($p<0.05$) higher proportions of 14:0, 20:0, 16:1, 18:1n-9cis, 20:1n-9, 22:1n-9, 24:1n-9, 18:2n-6cis, 20:5n-3cis and 22:6n-3 than wild brown meagre. The total monoenoic and polyenoic fatty acid contents were higher in the cultured brown meagre, whereas the corresponding total saturated fatty acid content and the n-3/n-6 ratio were lower.

Keywords: proximate composition, fatty acid composition, cultured fish, brown meagre, common dentex, sharp-snout sea bream

Zusammenfassung

Es wurde die Grundzusammensetzung und die Fettsäurezusammensetzung von drei gefarmten und wilden Fischarten, Zahnbrasse *(Dentex dentex),* Brauner Adlerfisch *(Sciaena umbra)* und Spitzbrasse *(Diplodus puntazzo)* untersucht. Bei allen drei Fischarten war der Fettgehalt der gefarmten Fische hoch. Die Lipide der gefarmten Spitzbrasse enthalten teilweise beträchtlich höhere Gehalte an 18:1(n-9)cis, 20:1(n-9), 18:2(n-6)cis und 22:2cis als die Wildfänge ($p<0,05$). Bei den gefarmen Zahnbrassen sind die Fettsäuren 14:0, 20:1(n-9), 18:2(n-6)cis, 20:5(n-3)cis und 22:6(n-3) höher als bei den Wildfängen ($p<0,05$). Bei den gefarmten Tieren dieser zwei Fischarten war der Gesamtgehalt an hochungesättigten Fettsäuren und der Quotient (n-3)/(n-6) höher als bei den Wildfängen. Bei den gefarmten Braunen Adlerfischen lagen die Gehalte an den Fettsäuren 20:0, 16:1, 18:1(n-9)cis, 20:1(n-9), 22:1(n-9), 24:1(n-9), 18:2(n-6)cis, 20:5(n-3)cis und 22:6(n-3) teilweise erheblich höher als bei den Wildfängen ($p<0,05$). Bei dieser Fischart lagen die einfach ungesättigten Fettsäuren und die mehrfach ungesättigten Fettsäuren bei den gefarmten Tieren hoch, während die gesättigten Fettsäuren und der Quotient (n-3)/(n-6) niedrig waren.

Schlüsselwörter: Grundzusammensetzung, Fettsäurezusammensetzung, gefarmter Fisch, Brauner Adlerfisch, Zahnbrasse, Spitzbrasse

Introduction

The quality difference of fish from the wild and from aquaculture is always a subject of discussion. The chemical parameters of wild fish are strongly influenced by the environmental conditions, which determine the availability of nutrients. Various environmental conditions and the different diets of wild and reared fish affect their chemical composition, including their fatty acid profile (Grigoriakis et al., 2002; Saglik et al., 2003; Cejas et al., 2004; Periago et al., 2005). In farmed fish, feeding with artificial diets provides a wide range of nutrients and this fact not only determines fish growth rate but flesh composition, in particular the lipid content, which may be quantitatively and qualitatively modified (Izquierdo et al., 2003). However, the flesh protein content is influenced less by external feeding since it is mainly dependent on intrinsic factors such as the fish species, variety and size (Huss, 1999). Concerning the organoleptical properties, a high content of fat in the farmed fish could lead to a softer texture, but texture is also related to other factors, such as the collagen content of the flesh and the muscle fibre size (Johnston et al., 2000).

Fish culture in the Mediterranean Sea is essentially based on two species, sea bream and sea bass. Production has increased in a spectacular way in recent years, from 37 179 t in 1994 to 139 873 t in 2007 (TUIK, 2007). This increase in output has led to market saturation and to a fall in price. One of the forms in which the market supply may be increased and a contribution may be made to the development and/or expansion of aquaculture, is to increase the number of cultured species. In this regard, dentex, brown meagre and sharp-snout sea bream are the candidate species, offering good possibilities. These species are native to the Mediterranean Sea and are widely farmed in Greece, Italy and Spain. Further, these species have the same market price as the presently and commonly cultured fish.

The overall fishery production of Turkey is approximately 772 323 t. Of this amount, aquaculture accounts for 139 873 t (TUIK, 2007). The preferred species are trout in fresh water culture (58 433 t), together with sea bass (41 900 t) and sea bream in marine aquaculture (33 500 t). The farming of sea bass and sea bream has been successfully undertaken in Turkey since 1990. The rearing of dentex began in 2000 at a few locations and nowadays remains a successful and productive activity.

The high content of polyenoic long-chain fatty acids of the n-3 family distinguishes fish from other food products and allows fish to be described as functional food. Docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA) cannot be synthesised in the human body and their health promoting actions are manifested in the regulation of the functions of the cardiovascular system and their effect on the development and functioning of the nervous system and the immune system (Kolanowski and Laufenberg, 2005). Fish lipids are well known to be rich in long-chain n-3 polyunsaturated fatty acids (LC n-3 PUFA), especially EPA (20:5n-3) and DHA (22:6n-3). These fatty acids play a vital role in human nutrition, disease prevention and health promotion (Horrocks and Yeo, 1999). Studies have confirmed that the fatty acid compositions of cultured and wild fish are different and the diet has been identified as the main reason for the observed differences (Jahncke et al., 1988). The composition of the commercial feed used for cultured fish also influences the mineral composition of those fish. Wide variations have been observed in the reported values of mineral concentrations in the same species of fish. However, variability in the sampling procedures and analytical techniques employed may well have influenced the results (Lal, 1995).

The objective of this study was to investigate the differences between cultured and wild common dentex, brown meagre and sharp-snout sea bream in their proximate and fatty acid compositions.

Material and Methods

Material

In this study, samples of wild and farmed common dentex *(Dentex dentex),* brown meagre *(Sciaena umbra)* and sharp-snout sea bream *(Diplodus puntazzo)* were used. The farmed samples were taken from an Aegean Fish Farm (Akuvatur Su Urunleri Tic), which is located in the western part of Turkey. The cage facilities of this particular farm are located in the bay of Balıklıova, approximately 70 km north of the Aegean City of Izmir. The wild samples were caught by trammel net operation in April 2006 on the southern, outer part of the Aegean Sea's Izmir Gulf, and the farmed samples were harvested at that same time. Biometrical measurement values of the samples can be seen in Table 1.

TABLE 1: *Biometrical measurement values of samples.*

Biometrical measurement	Common dentex		Brown meagre		Sharp-snout sea bream	
	Cultured	Wild	Cultured	Wild	Cultured	Wild
Average weight (g)	256.00 ± 10.12	264.00 ± 16.4	228.12 ± 6.42	212.45 ± 10.21	245.12 ± 9.12	229.72 ± 12.12
Average length (cm)	24.32 ± 5.85	27.16 ± 2.42	27.50 ± 3.65	25.45 ± 4.12	23.51 ± 4.06	27.21 ± 3.78

Arithmetic means and standard deviation. n = 5.

Sample preparation

The samples were kept in ice after harvesting and transferred to the laboratory. The fish were immediately beheaded, eviscerated and filleted. Proximate and fatty acid composition analyses were performed on these fresh samples, and these analyses were performed in triplicate.

Proximate composition analysis

Dry matter was determined by drying the samples at 105 °C to a constant weight (AOAC, 1990). The crude protein content was calculated by converting the nitrogen content as determined by Kjeldahl's method (AOAC, 1995). Fat was determined using the method described by Bligh and Dyer (1959). The analyses of the pooled samples were all carried out in triplicate.

FAME analysis

Methyl esters were prepared by transmethylation, using 2 M KOH in methanol and n-hexane, according to the method described by Ichihara et al. (1996) with the minor modification of Ozogul and Ozogul (2007). First, 10 mg of extracted oil was dissolved in 2 ml hexane, followed by 4 ml of 2 M methanolic KOH. The tube was then vortexed for 2 min at room temperature. The heating process was run at 100 °C for 7 min to hydrolize all of the fatty acids. On completion of the process, the tubes were cooled. After centrifugation at 4000 rpm for 10 min, the solution formed two phases. The lower phase, containing the fatty methyl

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TABLE 2: *Muscle proximate compositions of wild and cultured fish species.*

Species		Moisture (%)	Fat (%)	Protein (%)
Common dentex	Wild	75.17 ± 0.34[a]	1.61 ± 0.13[a]	21.95 ± 0.48[a]
	Cultured	72.44 ± 1.17[b]	4.05 ± 1.39[b]	20.90 ± 3.01[b]
Brown meagre	Wild	77.32 ± 0.33[a]	1.47 ± 0.07[a]	20.76 ± 0.10[a]
	Cultured	75.02 ± 0.73[b]	3.12 ± 0.25[b]	20.40 ± 0.25[b]
Sharp-snout sea bream	Wild	76.68 ± 1.05[a]	1.92 ± 0.12[a]	19.24 ± 0.05[a]
	Cultured	74.48 ± 1.05[b]	3.84 ± 0.21[b]	19.85 ± 0.47[b]

Arithmetic means and standard deviation. Different superscript letters characterize significant differences in each species ($p<0.05$). n = 3.

esters was transferred to a clean, 10 ml bottle and dried. Then, the hexane layer was taken for GC analyses.

Gas chromatographic conditions

The fatty acid composition was analyzed by a GC IUPAC II D19, equipped with a flame ionization detector and a fused silica capillary SGE column (30 m 0.32 mm ID 0.25 lm BP20 0.25 UM, USA). The oven temperature was initially set at 140 °C, held for 5 min, raised to 200 °C at the rate of 4 °C/min, held again at 220 °C and then held for a further 10 min, while the injector and the detector temperatures were set at 220 °C and 280 °C, respectively. The sample size was 1 µl and the carrier gas was controlled at 16 ps. The split used was 1:100. Fatty acids were identified by comparing the retention times of FAME with the standard 37 component FAME mixture (Supelco, Poole, Dorset). Two replicate GC analyses were performed and the results were expressed in GC area % as mean values ± standard deviation.

Statistical analyses

The SPSS 9.0 program was used to search for significant differences between the mean values of the different results. Differences between means were analyzed by a one-way analysis of variance (ANOVA), followed by Tukey and Duncan tests. The results are presented as means ± SD.

Results and Discussion

Proximate composition

Muscle proximate compositions of wild and cultured fish species are presented in Table 2. In the cultured and the wild samples the fat and moisture contents showed significant differences ($p<0.05$). In all batches the cultured fish had higher fat contents. The fat contents of cultured common dentex, brown meagre and sharp-snout sea bream were 4.05 %, 3.12 %, and 3.84 %, respectively. The fat content, as determined in the wild forms, was 1.61 %, 1.47 %, and 1.92 %, respectively. In both cases, wild fish were found to have lower lipid and higher water contents in their muscle ($p<0.05$). The published data (Alasalvar et al., 2002; Orban et al., 2002) supports our results that farmed fish have a higher fat content than wild fish and also a different fat composition.

Fatty acid composition

Muscle fatty acid compositions of wild and cultured fish species are presented in Tables 3, 4 and 5. The lipids of cultured sharp-snout sea bream contained significantly ($p<0.05$) higher proportions of 18:1n-9, 20:1n-9cis, 22:1n-9, 18:2n-6cis and 22:2 and lower proportions of 14:0, 16:0, 16:1, 24:1n-9, 20:5n-3 and 22:6n-3 fatty acid residues than those of wild sharp-snout sea bream. The percentages of the total monoenoic fatty acid content and the n-3/n-6 ratios were higher in the cultured sharp-snout sea bream than in the wild specimens. However, the corresponding, total, saturated and

TABLE 3: *Comparison in fatty acid contents of cultured and wild sharp-snout sea bream.*

Total fatty acids (%)	Cultured sharp-snout sea bream	Wild sharp-snout sea bream
C12:0	0.09 ± 0.01[a]	0.09 ± 0.00[a]
C13:0	0.27 ± 0.19[a]	0.14 ± 0.03[b]
C14:0	5.23 ± 0.10[a]	6.29 ± 0.33[b]
C15:0	0.79 ± 0.04[a]	0.72 ± 0.42[b]
C16:0	21.31 ± 0.56[a]	21.89 ± 0.56[b]
C17:0	0.91 ± 0.09[a]	1.44 ± 0.10[b]
C18:0	3.08 ± 0.07[a]	3.13 ± 0.06[a]
C20:0	1.31 ± 0.04[a]	1.11 ± 0.15[b]
C21:0	0.28 ± 0.01[a]	0.37 ± 0.17[b]
C22:0	0.55 ± 0.02[a]	0.64 ± 0.10[b]
C23:0	0.43 ± 0.45[a]	0.47 ± 0.48[a]
C24:0	0.58 ± 0.04[a]	0.61 ± 0.04[a]
∑SAFA	34.82	36.90
C14:1	0.20 ± 0.00[a]	0.21 ± 0.00[a]
C15:1	0.16 ± 0.01[a]	0.19 ± 0.01[a]
C16:1	7.96 ± 0.20[a]	8.60 ± 0.49[b]
C17:1	0.91 ± 0.03[a]	1.10 ± 0.09[b]
C18:1n-9trans	0.05 ± 0.04[a]	0.06 ± 0.01[b]
C18:1n-9cis	28.55 ± 0.26[a]	25.84 ± 1.40[b]
C20:1n-9	2.83 ± 0.03[a]	2.03 ± 0.67[b]
C22:1n-9	1.19 ± 1.13[a]	0.71 ± 0.52[b]
C24:1n-9	1.90 ± 0.06[a]	2.27 ± 0.26[b]
∑MUFA	43.74	41.00
C18:2n-6trans	0.20 ± 0.00[a]	0.33 ± 0.13[b]
C18:2n-6cis	7.27 ± 0.12[a]	4.95 ± 0.12[b]
C18:3n-6	0.22 ± 0.08[a]	0.16 ± 0.08[a]
C18:3n-3	0.10 ± 0.01[a]	0.96 ± 0.69[b]
C20:2cis	0.45 ± 0.05[a]	0.25 ± 0.12[b]
C20:3n-3	0.10 ± 0.02[a]	0.09 ± 0.07[a]
C20:5n-3cis	0.13 ± 0.02[a]	4.17 ± 0.58[b]
C22:2cis	3.79 ± 0.16[a]	0.00 ± 0.00[b]
C22:6n-3	9.17 ± 0.47[a]	10.91 ± 2.44[b]
∑PUFA	21.44	21.82
PUFA/SAFA	0.61	0.59
n-6	7.69	5.44
n-3	13.19	16.13
n-3/n-6	1.71	2.97
EPA/DHA	0.01	0.38
Unidentified	0.00	0.00

Arithmetic means and standard deviation (±). Different superscript letters characterize significant differences ($p<0.05$). n = 3.

polyenoic fatty acids content was lower (Tab. 3). In a study of Periago et al. (2005) similar results were observed in the content of most of the fatty acids in wild and farmed fish. The saturated fatty acids (SAFA) and monounsaturated fatty acids (MUFA) were significantly higher in farmed sea bass, whereas wild sea bass showed a higher content of polyunsaturated fatty acids (PUFA). Wild specimens showed a higher content of fatty acids, but the total ω3 fatty acids did not show significant differences between groups. Besides, wild sea bass showed a high content of linoleic (18:2n-6) and docosahexaenoic (22:6n-3) acids, which are considered essential fatty acids due to their beneficial effects on human health. The higher values of linoleic, eicosapentaenoic, docosahexaenoic and n-3 series acids in farmed fish muscle make reared sharp-snout more favorable for human consumption.

The common dentex *(Dentex dentex)* is a fast growing sparid, which represents a possible candidate for Mediter-

TABLE 4: *Comparison in fatty acid contents of cultured and wild common dentex.*

Total fatty acids (%)	Cultured common dentex	Wild common dentex
C12:0	0.07 ± 0.01^a	0.10 ± 0.00^a
C13:0	0.09 ± 0.00^a	0.00 ± 0.00^b
C14:0	5.15 ± 0.18^a	3.10 ± 0.03^b
C15:0	1.02 ± 0.00^a	0.94 ± 0.06^a
C16:0	19.55 ± 0.47^a	25.35 ± 0.02^b
C17:0	1.67 ± 0.03^a	1.76 ± 0.04^b
C18:0	4.66 ± 0.13^a	7.51 ± 0.00^b
C20:0	0.48 ± 0.01^a	0.38 ± 0.00^b
C21:0	0.15 ± 0.02^a	0.19 ± 0.00^a
C22:0	0.62 ± 0.69^a	0.20 ± 0.00^b
C23:0	0.10 ± 0.01^a	0.27 ± 0.01^b
C24:0	0.43 ± 0.04^a	1.13 ± 0.02^b
∑SAFA	33.99	40.94
C14:1	0.23 ± 0.00^a	0.18 ± 0.00^b
C15:1	0.04 ± 0.03^a	0.19 ± 0.01^b
C16:1	6.71 ± 0.01^a	7.12 ± 0.02^b
C17:1	0.79 ± 0.04^a	1.15 ± 0.03^b
C18:1n-9trans	0.11 ± 0.09^a	0.35 ± 0.01^b
C18:1n-9cis	19.25 ± 0.16^a	21.72 ± 0.05^b
C20:1n-9	3.21 ± 0.08^a	2.06 ± 0.01^b
C22:1n-9	0.95 ± 0.02^a	0.94 ± 0.05^a
C24:1n-9	2.79 ± 0.17^a	3.75 ± 0.06^b
∑MUFA	34.06	37.46
C18:2n-6trans	0.36 ± 0.01^a	0.55 ± 0.01^b
C18:2n-6cis	4.68 ± 0.01^a	1.83 ± 0.00^b
C18:3n-6	0.13 ± 0.00^a	0.20 ± 0.00^a
C18:3n-3	0.90 ± 0.01^a	1.22 ± 0.01^b
C20:2cis	0.39 ± 0.01^a	0.66 ± 0.00^b
C20:3n-3	0.09 ± 0.01^a	0.19 ± 0.00^b
C20:5n-3cis	4.91 ± 0.06^a	3.70 ± 0.04^b
C22:2cis	0.00 ± 0.00^a	4.06 ± 0.03^b
C22:6n-3	18.98 ± 0.15^a	9.15 ± 0.10^b
∑PUFA	30.44	21.57
PUFA/SAFA	0.90	0.53
n-6	5.17	2.58
n-3	24.88	7.42
n-3/n-6	4.82	2.88
EPA/DHA	0.26	0.40
Unidentified	0.056	0.11

Arithmetic means and standard deviation. Different superscript letters characterize significant differences ($p<0.05$). n = 3.

TABLE 5: *Comparison of fatty acid content in cultured and wild brown meagre.*

Total fatty acids (%)	Cultured brown meagre	Wild brown meagre
C12:0	0.12 ± 0.03^a	0.24 ± 0.04^b
C13:0	0.06 ± 0.07^a	0.13 ± 0.22^b
C14:0	5.35 ± 0.20^a	3.66 ± 0.39^b
C15:0	0.84 ± 0.02^a	1.20 ± 0.02^b
C16:0	24.78 ± 0.55^a	30.44 ± 2.61^b
C17:0	1.44 ± 0.03^a	1.73 ± 0.03^b
C18:0	4.50 ± 0.02^a	10.72 ± 1.32^b
C20:0	1.12 ± 0.26^a	0.65 ± 0.28^b
C21:0	0.48 ± 0.02^a	1.23 ± 0.21^b
C22:0	0.54 ± 0.03^a	3.75 ± 0.69^b
C23:0	0.33 ± 0.30^a	0.14 ± 0.14^b
C24:0	0.36 ± 0.26^a	1.84 ± 0.74^b
∑SAFA	39.93	55.70
C14:1	0.19 ± 0.00^a	0.29 ± 0.06^b
C15:1	0.18 ± 0.01^a	0.45 ± 0.02^b
C16:1	8.00 ± 0.15^a	6.08 ± 0.29^b
C17:1	0.85 ± 0.03^a	1.54 ± 0.04^b
C18:1n-9trans	0.05 ± 0.00^a	0.29 ± 0.00^b
C18:1n-9cis	25.02 ± 0.44^a	19.70 ± 0.57^b
C20:1n-9	2.44 ± 1.34^a	1.89 ± 1.36^b
C22:1n-9	1.54 ± 0.43^a	0.36 ± 0.23^b
C24:1n-9	2.08 ± 0.34^a	1.47 ± 0.04^b
∑MUFA	40.36	32.07
C18:2n-6trans	0.21 ± 0.10^a	0.41 ± 0.20^b
C18:2n-6cis	8.00 ± 0.13^a	2.54 ± 0.40^b
C18:3n-6	0.14 ± 0.03^a	0.19 ± 0.10^a
C18:3n-3	1.44 ± 1.03^a	1.45 ± 0.32^a
C20:2cis	0.02 ± 0.04^a	0.10 ± 0.17^b
C20:3n-3	0.08 ± 0.01^a	0.02 ± 0.04^a
C20:5n-3cis	3.21 ± 0.28^a	2.39 ± 0.19^b
C22:2cis	0.17 ± 0.04^a	0.30 ± 0.51^b
C22:6n-3	6.45 ± 1.11^a	3.66 ± 0.10^b
∑PUFA	19.70	11.06
PUFA/SAFA	0.49	0.20
n-6	8.35	3.14
n-3	11.17	7.52
n-3/n-6	1.33	2.39
EPA/DHA	0.50	0.65
Unidentified	0.00	1.14

Arithmetic means and standard deviation. Different superscript letters characterize significant differences ($p<0.05$). n = 3.

ranean aquaculture. The lipid of cultured common dentex contained significantly ($p<0.05$) higher proportions of 14:0, 20:1n-9, 18:2n-6cis, 20:5n-3cis and 22:6n-3, and lower proportions of 16:0, 18:0, 16:1, 18:1n-9cis, 24:1n-9 and 18:3n-3 fatty acid residues than wild common dentex. The percentages of the total polyenoic fatty acids content and the n-3/n-6 ratio were higher in the cultured than in the wild common dentex. The SAFA and MUFA were significantly higher in wild dentex, whereas cultured dentex showed a higher content of PUFA (Tab. 4). In the study of Grigorakis et al. (2002), major quality parameters, such as muscle composition, fat deposition, muscle fatty acid composition and external appearance were studied in wild and cultured gilthead sea bream. The lipid content of cultured sea bream was much higher than that of wild fish. Differences were also observed in the fatty acid profiles. Cultured fish were characterized by higher levels of monoenes, n-9 and 18:2n-6 fatty acids and wild fish by higher levels of saturates, 20:4n-6, n-3 fatty acids and n-3/n-6 ratios.

The lipid content of cultured brown meagre contained significantly ($p<0.05$) higher proportions of 14:0, 20:0, 16:1, 18:1n-9cis, 20:1n-9, 22:1n-9, 24:1n-9, 18:2n-6cis, 20:5n-3cis and 22:6n-3, and lower proportions of 16:0, 17:0, 21:0, 22:0, 24:0 and 17:1 fatty acid residues than wild brown meagre. The percentages of total monoenoic and polyenoic fatty acid contents were higher in the cultured than in the wild brown meagre, whereas the corresponding total saturated fatty acid content and the n-3/n-6 ratio was lower (Tab. 5). The most abundant fatty acids were oleic (18:1n-9cis), followed by palmitic (16:0), linoleic (18:2n-6cis) and docosahexanoic (22:6n-3) acid. The PUFA and MUFA were significantly higher in farmed meagre, whereas wild meagre showed a higher content of SAFA. Palmitic acid (16:0) was the primary saturated fatty acid found, contributing approximately 50–70 % to the total saturated fatty acid content of the lipids, for both cultured and wild fish species. Similar results for sea bass (Orban et al., 2003) and for other fish species have also been reported in the literature (Saglik et al., 2003). Oleic acid was identified as the primary monoenoic fatty acid in both fish and was significantly ($p<0.05$) higher in the cultured than in the wild fish. The higher amounts of oleic acid in cultured sea bass and sea bream have been reported to arise from its dominance in commercial feeds (Grigorakis et al., 2002). Among the n-6 series of the fatty acids, cultured fish have a higher level of 18:2n-6 (linoleic acid) than wild fish. This fatty acid is present in plant oils used in the feed of cultured fish.

Differences in the fatty acid profile between wild and cultivated fish were greatest among polyunsaturates; linoleic acid was substantially higher in all cultivated fish samples than in wild fish. The n-3 fatty acid levels were related to the species and were higher in cultivated dentex and meagre than in wild fish samples owing to the higher fat content. Concerning the total ω-6 fatty acids, cultured samples had higher levels, which is mainly due to their higher content of linoleic acid (18:2n-6cis). This fatty acid is present in vegetable oils which are used in the formulation of diets, hence farmed fish usually have higher levels of this fatty acid than wild samples. A strong dependence of body fatty acid composition on dietary fatty acids has been shown in previous studies for sea bass (Pirini et al., 2000). Fatty acids of the n-3 series and especially 20:5n-3 and 22:6n-3 play a vital role in human health (Horrocks and Yeo, 1999). Aquatic organisms are the only sources of these fatty acids available to humans. Cultured sea bream (compared with wild) provide the consumer with much higher levels of n-3 fatty acids because of their higher fat content. In general, wild fish are characterized by higher n-3/n-6 ratios (George and Bhopal, 1995). Increased intakes of n-6 fatty acids have been reported as having adverse effects on human health (Okuyama et al., 1997). Therefore, the supply of diets for cultured fish that would maximize their n-3/n-6 ratio or at least reach the ratios found in wild species has been suggested (George and Bhopal, 1995). The values of n-3/n-6 ratios reported for wild compared with cultured Mediterranean fish have been found to be both higher (Renon et al., 1994; Ozogul et al., 2007) and lower (Rueda et al., 2001) because of the significant contribution of arachidonic acid to n-6 fatty acids of wild fish. It has been reported that the type and amount of fatty acids in fish tissues vary mainly with the diet of the fish, but other factors may also influence thei fatty acid composition. Size or age, reproductive status, geographic location, and season all influence fat content and composition of fish muscle (Ackman, 1989; Codier et al., 2002).

Conclusion

EPA and DHA are the n-3 fatty acids abundant in fish. A growing literature strongly supports the observation that EPA and DHA promote cardiovascular health and can help prevent coronary heart disease in people with known cardiovascular disease or at high risk for cardiovascular disease (Kris-Etherton et al., 2002; Cahu et al., 2004). The n-3 fatty acids offer distinct health benefits and are essential to normal neuron development. All fish contain some n-3 fatty acids and these new culture species are an important source of these nutrients. The consumption of 100 g wild and cultured common dentex *(Dentex dentex)* brown meagre *(Sciaena umbra)* and sharp-snout sea bream *(Diplodus puntazzo)* daily in all seasons could meet this demand.

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References

Ackman RG (1989): Nutritional composition of fats in sea foods. Prog Food Nutr Sci 13: 161–241.

Alasalvar C, Taylor KDA, Zubcov E, Shahidi F, Alexis M (2002): Differentiation of cultured and wild sea bass *(Dicentrarchus labrax),* total lipids content, fatty acid and trace mineral composition. Food Chem 79: 145–150.

AOAC (1990): Official methods of analyses of the Association of Analytical Chemists, 15th ed. Washington DC, USA.

AOAC (1995): Official methods of analysis, 16th ed. AOAC International, Arlington, Va., USA.

Bligh EG, Dyer WJ (1959): A rapid method of total lipid extraction and purification. Can J Biochem Physiol 37: 911–917.

Cahu C, Salen P, de Lorgeril M (2004): Farmed and wild fish in the prevention of cardiovascular diseases: assessing possible differences in lipid nutritional values. Nutr Metab Cardiovasc Dis 14: 34–41.

Cejas JR, Almansa E, Jérez S, Bolanos A, Samper M, Lorenzo A (2004): Lipid and fatty acid composition of muscle and liver from wild and captive mature female broodstocks of white seabream, *Diplodus sargus.* Comp Biochem Physiol Biochem Mol Biol 138: 91–102.

Codier M, Brichon G, Weber JM, Zwingelstein G (2002): Changes in the fatty acid composition of phospholipids in tissues of farmed sea bass *(Dicentrarchus labrax)* during an annual cycle. Roles of environmental temperature and salinity. Comp Biochem Physiol Biochem Mol Biol 133: 281–288.

George R, Bhopal R (1995): Fat composition of free living and farmed fish species: implications for human diet and sea farming techniques. Brit Food J 97: 19–22.

Grigorakis K, Alexis MN, Taylor KDA, Hole M (2002): Comparison of wild and cultured gilthead sea bream *(Sparus aurata);* composition, appearance and seasonal variations. Int J Food Sci Technol 37: 477–484.

Horrocks LA, YEO YK (1999): Health benefits of docosohexaenoic acid (DHA). Pharmacol Res 40: 211–225.

Huss HH (1999): Quality and quality changes in fresh fish. FAO Fisheries Technical Paper (FAO) no. 348, FAO, Rome, Italy.

Ichihara K, Shibahara A, Yamamoto K, Nakayama T (1996): An improved method for rapid analysis of the fatty acids of glycerolipids. Lipids 31: 535–539.

Izquierdo MS, Obach A, Arantzamendi L, Montero D, Robaina L, Rosenlund G (2003): Dietary lipid sources for sea bream and sea bass: growth performance, tissue composition and flesh quality. Aquacult Nutr 9: 397–407.

Jahncke M L, Hale MB, Gooch JA, Hopkins JS (1988): Comparison of pond-raised and wild red drum *(Sciaenops ocellatus)* with respect to proximate composition, fatty acids profiles, and sensory evaluations. J Food Sci 53: 286–287.

Johnston IA, Alderson R, Sandham C, Dingwall A, Mitchell D, Selkirk C, Nickel D, Baker R, Roberstson B, Whyte D, Springate J (2000): Muscle fibre density in relation to the colour and texture of smoked Atlantic salmon (*Salmo salar* L.). Aquaculture 189: 335–349.

Kolanowski W, Laufenberg G (2005): Enrichment of food products with polyunsaturated fatty acids by fish oil addition. Eur Food Res Technol 222: 472–477.

Kris-Etherton PM, Harris WS, Appel LJ (2002): Fish consumption, fish oil, n-3 fatty acids, and cardiovascular disease. AHA Scientific Statement Circulation 106: 2747–2757.

Lal SP (1995): Macro and trace elements in fish and shellfish. In: Ruiter A (ed.), Fish and fishery products: composition, nutritive properties and stability. CAB International, Wallingford, 187–214.

Okuyama H, Kobayashi T, Watanabe S (1997): Dietary fatty acids – the n-6/n-3 balance and chronic diseases. Prog Lipid Res 35: 409–457.

Orban E, di Lena G, Nevigato T, Casini I, Santaroni G, Marzetti A, Caproni E (2002): Quality characteristics of sea bass intensively reared and from lagoon as affected by growth conditions and the aquatic environment. J Food Sci 67: 542–546.

Orban E, Nevigato T, di Lena G, Casini I, Marzetti A, Caproni E (2003): Differentiation in the lipid quality of wild and farmed sea bass *(Dicentrarchus labrax)* and gilthead sea bream *(Sparus aurata).* J Food Sci 68: 128–132.

Ozogul Y, Ozogul F (2007): Fatty acid profiles of commercially important fish species from the Mediterranean, Aegean and Black Seas. Food Chem 100: 1637–1638.

Ozogul Y, Ozogul F, Alagoz S (2007): Fatty acid profiles and fat contents of commercially important seawater and freshwater fish species of Turkey: a comparative study. Food Chem 103: 217–223.

Periago MJ, Ayala MD, Lopez-Albors O, Abdel I, Martinez C, Garcia-Alcázar A, Ros G, Gil F (2005): Muscle cellularity and flesh quality of wild and farmed sea bass, *Dicentrarchus labrax* L. Aquaculture 249: 175–188.

Pirini M, Gatta PP, Testi S, Trigari G, Monetti PG (2000): Effect of refrigerated storage on muscle lipid quality of sea bass *(Dicentrarchus labrax)* fed on diets containing different levels of vitamin E. Food Chem 68: 289–293.

Renon P, Malandra R, Biondi PA, Ronchi S (1994): Wild and aquacultured sea breams: studies on total lipids, cholesterol and fatty acids. Inginiera Alimentaria Cons Animal 10: 21–28.

Rueda FM, Hernández MD, Egea MA, Aguado F, Garcia B, Martinez FJ (2001): Differences in tissue fatty acid composition between reared and wild sharp snout sea bream, *Diplodus puntazzo* (Cetti, 1777). Br J Nutr 86: 617–622.

Saglik S, Alpaslan M, Gezgin T, Cinturk K, Tekinay A, Guven KC (2003): Fatty acid composition of wild and cultivated gilthead seabram *(Sparus aurata)* and sea bass *(Dicentrarchus labrax).* Eur J Lipid Sci Technol 105: 104–107.

TUIK (2007): Fishery statistics year book of Turkey. Turkish Statistical Institute, Ankara.

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