www.trjfas.org
ISSN 1303-2712
Turkish Journal of Fisheries and Aquatic Sciences 11: 69-75 (2011) DOI: 10.4194/trjfas.2011.0110

Fatty Acid Composition and Mineral Content of *Upeneus moluccensis* and *Mullus surmuletus*

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Received 14 June 2010
Accepted 22 October 2010

Abstract

Lipid, moisture, fatty acid, and mineral contents of gold band goatfish (*Upeneus moluccensis*) (Bleeker, 1855) and striped red mullet (*Mullus surmuletus*) (Linnaeus, 1758) were investigated. The lipid and moisture contents in the two species were found to be significantly different from each other (P<0.05). Lipids of striped red mullet include significantly (P<0.05) higher levels of C14:0, C15:0, C16:1, C17:1, C18:1n9, C18:2n6, C20:3n6, DHA (Docosahexaenoic Acid, C22:6n3) and EPA (Eicasapentaenoic Acid, C20:5n3) fatty acids than those of gold band goatfish. Proportions (%) of SFA (Saturated Fatty Acid), MUFA (Monounsaturated Fatty Acid), and PUFA (Polyunsaturated Fatty Acid), DHA/EPA, and n3/n6 were found to be 39.30, 26.81, 32.18, 3.26, and 5.35 for gold band goatfish and 36.72, 41.83, 18.92, 0.89, and 3.31 for striped red mullet, respectively. K and P were found to be predominant among the 11 measured minerals in the two species. Only the K, Ca, and Na content of the two fish species were found to be significantly different (P<0.05).

Keywords: Upeneus moluccensis, *Mullus surmuletus*, minerals, fatty acids, lipid content, gold band goatfish, striped red mullet.

Paşa Barbunu ve Tekir Balığının Yağ Asitleri Komposizyonları ve Mineral Madde İçerikleri

Özet

Bu çalışmada paşa barbunu veya Nil barbunu (*Upeneus moluccensis*, Bleeker, 1855) ve tekir balığının (*Mullus surmuletus*, Linnaeus, 1758) toplam yağ, nem, kül, yağ asitleri kompozisyonunu ve mineral madde içerikleri incelenmiştir. Bu iki türe ait yağ ve nem içerikleri birbirinden önemli derecede farklı bulunmuştur (P<0,05). Çalışmanın sonuçları tekir balığı yağında bulunan C14:0, C15:0, C16:1, C17:1, C18:1n9, C18:2n6, C20:3n6, DHA (Dokosahekzaenoik Asit, C22:6n3) ve EPA (Eikosapentaenoik Asit, C20:5n-3) yağ asitleri seviyelerinin paşa barbunu yağında bulunandan daha yüksek miktarlarda olduğunu göstermiştir (P<0,05). SFA (Doymuş Yağ Asitleri), MUFA (Tekli Doymamış Yağ Asitleri), PUFA (Çoklu Doymamış Yağ Asitleri), DHA /EPA ve n3/n6 miktarlarını (%) sırası ile paşa barbunda 39,30, 26,81, 32,18, 3,26 ve 5,35 ve tekir balığında ise 36,72, 41,83, 18,92, 0,89 ve 3,31 olduğu tespit edilmiştir. İncelenen mineraller içerisinden K ve P değerleri her iki türde en yüksek miktarlarda bulunmuştur. Bu iki tür balıkta incelenen minerallerden yalnızca K, Ca ve Na seviyelerindeki farklılık istatistiksel açıdan önemli bulunmuştur (P<0,05).

Anahtar Kelimeler: *Upeneus moluccensis*, *Mullus surmuletus*, mineraller, yağ asitleri, yağ içeriği, paşa barbunu, tekir balığı.

Introduction

Gold band goatfish and striped red mullet are two lessepsian migrant species that spread from the Red Sea into the Mediterranean Sea after the 1869 opening Suez Canal. Both are fish species high in demand by people living in the Northeast Mediterranean coastal region of Turkey. Increasing consumption of the species among the people in the region has led to an increase in the economic prominence of the two species over the last few years (Kaya *et al*., 1999). The two white muscle fish are similar in appearance, which often causes customers to buy gold band goatfish when they actually intend to buy striped red mullet or vice versa. Due to poor awareness of the possible differences between the two species among both consumers and scholars, it is necessary to investigate the lipid, moisture, fatty acid, and mineral content of the two species to elucidate any such differences.

The lipids of marine fish have gained attention because they are rich in fatty acids, especially docosahexaenoic acid (DHA) and eicasapentaenoic acid (EPA), which are predominant (Ackman, 1989)

among the essential fatty acids and important for the human health. Most fatty acids can be synthesised in the body, however a human body lacks the enzymes required to produce the two essential fatty acids EPA and DHA. These fatty acids must be taken from the diet (Lunn and Theobald, 2006).

Some mineral elements have plenty of benefits to the biological functioning of a human body whereas others (such as heavy metals, which are not easily biodegradable) can be toxic (Whithney and Rolfes, 2008). Minerals represent 0.2-0.3% of the total intake of all nutrients in the human diet. They are so important that without them, the remaining 99.7% of the food intake would be difficult to utilize (Nabrzyski, 2002).

The objective of this study was to determine the lipid levels, fatty acid profiles, and mineral content of gold band goatfish and striped red mullet and to compare their nutritional content.

Materials and Methods

Materials and Sample Preparation

Gold band goatfish and striped red mullet samples from Iskenderun Bay (Northeastern Mediterranean Sea, Turkey) were purchased in March 2008 from a local fisherman in Iskenderun Bay (Northeastern Mediterranean Sea/Turkey). The fish were caught the night before the procedure, kept in ice and transferred to the laboratory for analyses.

Twenty representative fish samples were drawn from the batch of each species and divided into two groups. Each group was pooled for analyses. The first group was used for moisture and lipid analysis while the second group was used for mineral analysis. The samples were beheaded, eviscerated, and minced in a laboratory blender. Triplicate subsamples were taken for moisture and lipid analyses and in quadruplicate for the mineral analyses. A glass knife previously washed with nitric acid solution (4%) was used to draw samples for mineral analyses.

Lipid, Moisture, and Ash Content Analyses

Lipid determination of the fish was carried out by modified Bligh and Dyer Method (Hanson and Olley, 1963), moisture and ash contents of the fish were determined according to the recommended method (Commission of European Communities) ISOR 1442 (CEC, 1979), and AOAC., 35.1.14 (2003) method no 938.08, respectively.

FAME Preparation

Approximately 30 mg of lipid were saponified by using methaonolic alkali and methylated with 14% methanolic boron trifloride. FAMEs were extracted with 2 ml of iso-octane. Separation and identification of FAMEs were carried out as described in Oksuz *et al*. (2009).

Chromatographic Conditions

GC-MS apparatus (Hewlett Packard Model, 6890/5972) equipped with a mass selective detector and coupled with HP-INNOWAX Polyethylene Glycol Capillary Column, Model Number: HP 19091N-133, nominal length: 30.0 m, nominal diameter: 250 µm, nominal film thickness: 0.25 µm. Injection temperature was set at 250°C and MS detector temperature was set at 270°C with a split ratio: 20:1. Split flow was maintained at 9.9 ml/min; total flow: 13.9 ml/min; Gas type: Helium.

Oven temperature was programmed initially at 120°C and held for 3 minutes. The temperature was then increased to 250°C in steps 10°C per min. ramp rate and held at this temperature for four minutes. The identification of individual fatty acids was carried out by comparing those retention time of FAME standard (Supelco 47085U PUFA No: 3) and Supelco 37 component Fame mix (47885-U, Bellefonte, Pennsylvania/USA). Confirmation of FAME was also performed by using a MS data base library FAMEDB23.L.

Extraction and Determination of Mineral Elements

The wet ash method was used for digestion of organic matter. This procedure was carried out according to (AOAC Method 975.03) with a minor modification. Fish flesh (2 g) was weighted into a polypropylene screw capped tube and 10 ml of 65% HNO_3 (Merck) were added to the sample, followed by the addition of 3 ml of 60% perchloric acid. Samples were left overnight to complete digestion. Further heating was then carried out in a hot water bath at 90°C for 6 hours. Digests were filtered into a 25 ml volumetric flask, using ash-free filter paper and made up to 25 ml the volume with ultra pure water.

The determination and quantification of elements were done by ICP-AES (Inductively Coupled Plasma- Atomic Emission Spectrometry, Varian Model- Liberty series II). Calibration curves for each of the individual elements were prepared from ICP Multi element stocks (Merck). The phosphorus standard solution was prepared by dissolving KH_2PO_4 in ultra pure water to obtain a 1000-ppm stock phosphorus standard. The standard stock solution was then acidified (100 µl/100 ml) with 65% HNO_3.

Statistical Analysis

Data were subjected to analysis of variance (ANOVA) and mean comparison was carried out using Duncan's test. Statistical analysis was performed with SPSS. Significance was established at $P<0.05$.

Results and Discussion

Lipid, Moisture and Ash Content Gold Band Goatfish

The lipid and moisture content of gold band goatfish and striped red mullet are shown in Table 1. The lipid content of gold band goatfish and striped red mullet were found to be 4.35±1.05% and 10.38±1.9%, respectively. The lipid level of striped red mullet was significantly (P<0.05) higher than that of gold band goatfish. Lipid levels in striped red mullet are also higher than those in red mullet (*Mullus barbatus*), which is another species of goatfish, in all seasons, as reported previously by Polat *et al*. (2009).

In Ackman's (1989) grading of fish with respect to lipid levels, he classified the fish into the four following types: 1) Lean (<2% fat; e.g., cod, haddock, and shellfish), 2) Low-fat (2-4% fat; e.g., sole, halibut, and flounder), 3) Medium-fat (4-8% fat; e.g., salmon), and 4) High-fat (>8% fat; e.g., herring, mackerel, and sablefish). The gold-banded fish and striped red mullet used in the present study were not considered in Ackman's (1989) grading; however, based on the present data, gold band goatfish and striped red mullet can be classified as medium-fat fish and high-fat fish, respectively. It should be noted that these two fish may require different cooking methods due to their different lipid content.

The moisture contents of gold band goatfish and striped red mullet were found to be 79.41±1.8% and 73.14±2.6%, respectively. The moisture level of gold band goatfish was found to be significantly higher than that of striped red mullet (P<0.05). Compared to a previous study reported by Polat *et al*. (2009) on mullet, the moisture contents measured for gold band goatfish which were also caught in the spring in this present study is almost the same as that of red mullet caught in the spring.

Previous studies have revealed that the lipid and moisture composition of fish can differ depending on seasonal changes, age, maturity, sex, availability of food, and spawning period (Yeannes and Almandos, 2003; Ackman, 1989). Kaya *et al*. (1999) reported that gold band goatfish's spawning period is between August and September. The samples of gold band goatfish and striped red mullet used for this research were caught in March. Therefore, their lipid content should not be affected by the spawning period. Remarkably, the results of the present study indicate that two fish species belonging to the same family and living in the same habitat can have different lipid levels. In addition, our results also confirmed the previously accepted inverse correlation between the moisture content and the lipid level in fish. Measuring the water content permits the estimation of flesh (edible part) protein content for lean fish and lipid content for fat fish, with a corresponding cost savings as only one instead of two analytical determinations need to be performed (Yeannes and Almandos, 2003).

The ash content of gold band goatfish and striped red mullet determined in this study were 1.1±0.1% and 1.6±0.2%, respectively. The ash content of gold band goatfish and striped red mullet were found to be significantly (P<0.05) different from each other. The ash content shows the richness of the fish in minerals. The element content of striped red mullet is suppose to be higher than that of gold band goatfish

Fatty Acid (FA) Composition

The FA composition of gold band goatfish and striped red mullet are shown in Table 2. A total of 19 FA in gold band goatfish and 18 FA for striped red mullet were identified in this study. The determination of the fatty acid compositions of gold band goatfish and striped red mullet were performed by GC-MS. The composition of saturated (SFA), monounsaturated (MUFA), and polyunsaturated fatty acid (PUFA) of gold band goatfish were found to be 39.30%, 26.81%, and 32.18%, while those of striped red mullet were found to be 36.72%, 41.83%, and 18.92%, respectively. Accordingly, the SFA level in gold band goatfish and the MUFA level in striped red mullet were the highest among the other fatty acid groups. The PUFA/SFA ratios for gold band goatfish and striped red mullet were 0.81 and 0.52 respectively.

Among SFA, palmitic acid (C16:0) was the most abundant in both gold band goatfish and striped red mullet (P<0.05). Stearic acid (C18:0) was the next most abundant in the two species, at 7.59% and 6.04%, respectively. Significant differences (P<0.05) were observed between both fish for all SFA components mentioned here. Gold band goatfish feeds mainly on crustaceans (Kaya *et al*., 1999), which are rich in SFA (Rosa *et al*., 2007). The SFA level of gold band goatfish was found to be the highest among all fatty acids. This result may be attributed to the effect

Table 1. Lipid, moisture, and ash contents of gold band goatfish and striped red mullet*

Components	Gold band goatfish (%)	Striped red mullet (%)
Lipid	4.35 ± 1.05^{a}	10.38 ± 1.9^{b}
Moisture	79.41 ± 1.8^{a}	73.14 ± 2.6^{b}
Ash	1.1 ± 0.1^{a}	1.6 ± 0.2^{b}

* (a-b) means in a row with the identical letters are not significantly different (P<0.05).
Values were presented as mean SD (n=3).

Table 2. Fatty acid profiles (% of total fatty acids*) of gold band goatfish and striped red mullet**

Fatty acid %	Gold band goatfish	Striped red mullet
C14:0	2.68±0.09 [a]	3.39±0.02 [b]
C15:0	1.02±0.01 [a]	1.18±0.01 [b]
C16:0	26.61±0.39 [a]	25.21±0.17 [b]
C17:0	1.40±0.01 [a]	0.91±0.03 [b]
C18:0	7.59±0.02 [a]	6.04±0.08 [b]
SFA	39.30	36.72
C16:1	6.52±0.19 [a]	12.01±0.24 [b]
C17:1	0.81±0.01 [a]	0.89±0.03 [b]
C18:1n9	18.35±0.51 [a]	25.68±0.11 [b]
C20:1n9	1.14±0.03 [a]	3.25±0.13 [b]
MUFA	26.81	41.83
C18:2n6	1.09±0.03 [a]	1.16±0.02 [b]
C18:3n3	0.61±0.01 [a]	0.42±0.01 [b]
C18:4n3	0.41±0.00 [a]	0.42±0.01 [b]
C20:2n6	0.57±0.05 [a]	0.52±0.04 [a]
C20:3n6	0.38±0.04 [a]	0.59±0.03 [b]
C20:4n6	2.52±0.11 [a]	2.37±0.04 [a]
C20:5n3	5.50±0.12 [a]	6.13±0.07 [b]
C22:4n6	1.46±0.12 [a]	ND[c]
C22:5n6	1.70±0.06 [a]	1.84±0.07 [b]
C22:6n3	17.93±0.86 [a]	5.47±0.03 [b]
PUFA	32.18	18.92
Σn-3	24.45	15.31
Σn-6	4.57	4.63
Σn3/n6	5.35	3.31
DHA/EPA	3.26	0.89
Σ Unsat	58.88	60.75
UNSFA/SFA	1.50	1.65
PUFA/SFA	0.81	0.52

* Values are expressed as percentages of total fatty acids.
** (a-b) means in a row with the identical letters are not significantly different (P<0.05). Values were presented as mean SD (n=3).
[c] Not detected.

of fish digestion. Fish should consume diet including high levels of C16:0. Levels of C16:0 in both fish were found to be higher than that in Atlantic bonito and mackerel (1.97 and 1.77 mg/100 g) (Saglik and Imre, 2001), and both cultured and wild sea bass (20.5% and 22.6%) (Alasalvar *et al*., 2002). However, the amount of C16:0 in either fish was found to be lower than that in blue fish (4.08 g/100 g), European pilchard (3.17 g/100 g), and anchovy (2.89 g/100 g) (Saglik and Imre, 2001), and red mullet (33.9% in winter and 32.3% in spring) (Polat *et al*., 2009).

The level of MUFA in striped red mullet (41.83%) was found to be higher than that in gold band goatfish (26.81%). In addition, the C18:1n9 ratio of striped red mullet was found to be significantly higher than that of gold band goatfish (P<0.05). Furthermore, some other significant differences (P<0.05) were also noted between these fish species in terms of C16:1, C20:1n9, and C17:1. Polat *et al*. (2009) reported that the total MUFA level in red mullet was 29.08% in autumn, 31.60% in winter, and 29.89% in spring. The level of MUFA in both striped red mullet and gold band goatfish determined in this study is quite different from the level of MUFA previously measured in red mullet by Polat *et al*. (2009).

The PUFA level in gold band goatfish was found to be considerably higher than in striped red mullet. In addition, the level of EPA in the flesh of gold band goatfish is similar to those previously reported in marine fish such as bluefish (Saglik and Imre, 2001) and cultured sea bass (Alasalvar *et al*., 2002). On the other hand, the level of DHA in gold band goatfish was found to be higher than that of EPA in the same fish whereas an inverse correlation between DHA and EPA was observed in striped red mullet. The EPA content of gold band goatfish was found to be significantly (P<0.05) lower than that of striped red mullet. However, the percentage of DHA in gold band goatfish was found to be approximately three times higher than that of DHA in striped red mullet (P<0.05). Regardless of difference in levels of EPA and DHA, both fish can be considered as good sources of n3 fatty acids such as EPA and DHA.

Arachidonic acid (C20:4n6) levels in both fish were very close to each other with a values of 2.52% and 2.37%. In addition, the levels of n3, n6, and the n3/n6 ratio were found to be 24.45%, 4.57%, and 5.35 in gold band goatfish muscle and 15.31%, 4.63%, and 3.31 in striped red mullet flesh, respectively. A high level of n-3, as it was found in this study, is very important for human health because it prevents many health-related problems such as cardiovascular disease risk factors (Mayneris-Perxachs *et al*., 2010).

A low level of n-6 fatty acids was determined in the two fish species. The levels of long chain fatty acids C20:2n6, C20:3n6, C18:3n3 and C18:4n3 were very low compared to the other PUFA.

Mineral Composition

A total of 11 mineral elements were analysed in the muscle of striped red mullet and gold band goatfish (Table 3). The mineral content of both fish are mostly different, but that the observed differences in the levels of some of the listed mineral elements were not statistically significant (P>0.05) whereas the differences in other elements (K, Ca, and Na) were found to be statistically significant (P<0.05).

A very high intake of Cd, Cu, and Zn may cause health problems such as liver and kidney damage (Agency for Toxic Substances and Disease Registry, 2004). Cd, Cu, and Zn levels were found to be 0.18, 0.43, and 4.82 mg/kg in gold band goatfish and 0.25, 0.20, and 4.55 in striped red mullet, respectively. The observed differences in Cd, Cu, and Zn levels between gold band goatfish and striped red mullet were not statistically significant (P>0.05). The Cd level reported in Alasalvar *et al*. (2002) is almost the same as the Cd level determined in gold band goatfish in this current study. In addition, The Cu level found in this study is also between the 0.2 and 0.5 mg/kg weight limits reported by Oehlenschlager (2002), providing further evidence that the consumption of both these fish species poses no danger in terms of their Cu content. Furthermore, Zn levels were previously reported to be 45.1 µg/g in cultured sea bass and 43.6 µg/g in wild sea bass by Alasalvar *et al*. (2002). These levels of Zn are almost ten times higher than those of Zn determined in both fish in this study.

The amounts of Cr in both fish were found to be very low and close to each other, being 0.10 mg/kg in gold band goatfish and 0.09 mg/kg in striped red mullet. Accordingly, these amounts of Cr in fish are considered to be safe. A high level of Cr may have some negative effects on human health (Agency for Toxic Substances and Disease Registry, 2004). Additionally, the difference in Cr levels found in both fish was insignificant (P>0.05). Cr levels determined in both gold band goatfish and striped red mullet in this study are lower than those previously determined in cultured sea bass (0.17 mg/g), wild sea bass (0.15 mg/g) (Alasalvar *et al*., 2002), and canned fish (0.30 ppm) (Ikem and Egiebor, 2005).

The level of Mn in the flesh of gold-banded goat fish (0.18 mg/kg) was found to be slightly higher than that in striped red mullet (0.15 mg/kg) (P>0.05). Mn levels in gold band goatfish and striped red mullet were lower than in cultured sea bass (7.25 µg/g), wild sea bass (6.57 µg/g) (Alasalvar *et al*., 2002) and sardine (0.19–2.55 mg/kg) (Ikem and Egiebor, 2005). In addition, the Mn content of both fish species was found to be higher than that of red salmon (0.01–0.04 mg/kg) as reported by Ikem and Egiebor (2005). Moreover, the Mn levels determined in both fish species are similar to those previously found in salmon (0.01–0.46 mg/kg), mackerel (0.03–1.27 mg/kg), tuna (0.08–0.63 mg/kg), and herring (0.11–2.38 mg/kg) (Ikem and Egiebor, 2005).

The amount of Ca in gold band goatfish flesh (617.4 mg/kg) was found to be higher than that in striped red mullet (389.6 mg/kg) (P<0.05). According to Lall (1995), fish are a poor source of calcium. However, calcium is very abundant in the muscles of gold band goatfish and has several roles in the body such as hard tissue structure, blood clotting, muscle contraction, cell division, nerve transmission, enzyme activity, hormone secretion (Miller, 2008). Gold band goatfish can be a good source of calcium for the human body, considering the suggested daily calcium intake amount of 800 mg/day (Whithney and Rolfes, 2008).

The Fe content of both fish species was found to be close to each other, being 7.3 (gold band goatfish) and 6.4 (striped red mullet) mg/kg. Fe is one of the essential trace elements and should be in the daily diet. Fe supplied in the diet must be in the range of 15 mg/day in order to meet daily requirement (Belitz *et*

Table 3. Mineral compositions (mg/kg wet weight base) of gold band goatfish and striped red mullet[A]

Species/Elements	Gold band goatfish	Striped red mullet	RDA[a] or SAI[b] mg per adult
Cd	0.18±0.23 [a]	0.25±0.22 [a]	0.07 mg/day***
Cr	0.10±0.06 [a]	0.09±0.10 [a]	---
Cu	0.43±0.24 [a]	0.20±0.16 [a]	1.5-3**
Mn	0.18±0.09 [a]	0.15±0.07 [a]	2-3**
Zn	4.82±0.95 [a]	4.55±1.10 [a]	12-15*
Fe	7.30±1.7 [a]	6.40±1.3 [a]	10-15*
Ca	617.4±90.5 [a]	398.6±105.9 [b]	800-1200*
K	1276.4±70.2 [a]	2064.8±91.1 [b]	2000 **
Mg	346.7±46.2 [a]	390.7±21.4 [a]	280-350**
Na	101.2±28.2 [a]	136.5±17.0 [b]	500**
P	1754.9±423 [a]	2065.8±89.3 [a]	800-1200*

[A] (a-b) means in a row with the identical letters are not significantly different (P<0.05). Values were presented as mean SD (n=3).
* RDA values; ** SAI safe and adequate daily intake (Nabrzyski, 2002)
*** Tolerable daily intake figures based on recommended by FAO and WHO for a 70 kg person
Values are shown as mean standard deviations of triplicates.
Within each row, values (mean±SD) not sharing common superscripts letters are significantly different (α=0.05).

al., 2004). One hundred gram portion of fish may provide almost 20% of daily Fe requirement of human. Therefore, both fish may be considered a good supplement source of Fe which performs several vital functions in human body. For example, it serves as a carrier of oxygen from the lungs to the tissues by red blood cells. It also helps to prevent some major health problems (Camara *et al*., 2005).

Although the quantity of Mg in the muscle of striped red mullet (390.7 mg/kg) was found to be higher than that of magnesium in gold band goatfish (346.7 mg/kg), the difference was not statistically significant ($P>0.05$). Magnesium toxicity is rare. An adequate intake of magnesium has some useful roles in a human body due to the fact that it, regulates enzyme systems, helps to maintain bone health, is required for energy metabolism, and acts as a part of the protein-making machinery in all cells of soft tissues (Whithney and Rolfes, 2008). There are also significant and important associations between intakes of potassium and magnesium and bone mass density (Tucker *et al*., 1999).

The level of Na in the edible portion of gold band goatfish and striped red mullet was found to be 101.2 and 136.5 mg/kg, respectively. The difference was statistically significant ($P<0.05$). The levels of sodium found in both the fish species are much lower than those measured in sea bass and sea bream by Erkan and Ozden (2007) and compared to other macro elements in this study. Results of this present study show that the both fish species suitable for low Na diets.

The amounts of P and K in the flesh of striped red mullet were found to be higher than those in the flesh of gold band goatfish ($P>0.05$). Fish are a good source of phosphorus (Lall, 1995), which is directly involved in energy-producing cellular reactions. Based on the amount of P and K found, we have found that striped red mullet is a good source of both these mineral elements.

In summary, the lipid levels, moisture, ash, fatty acid profiles, and mineral content of gold band goatfish and striped red mullet were investigated. Although the lipid content of the two fish were found to be different from each other, both are qualitatively and quantitatively suitable for a healthy diet. In addition, the two fish are rich in EPA and DHA, two very important fatty acids. Moreover, the mineral content of the two fish species were found to be within the ranges recommended for the elements we analyzed. Based on these results, the two lessepsian migrant species, well-adapted in the Mediterranean and popular with consumers, are safe for consumption regarding to mineral composition that were determined in the present study.

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