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Do the nutrient compositions and mineral matter contents of meagre (*Argyrosomus regius*) vary depending on the rearing environment?

by

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Abstract

This study aimed to compare the nutrient compositions and element contents of meagre (*Argyrosomus regius*) reared in different environments. The biochemical analyses revealed that the ash contents of cage and earth pond-cultured fish were higher than that of wild fish ($p < 0.05$), while there were also significant differences in the protein, fat and moisture contents ($p > 0.05$). The cage-reared fish had the lowest Ca, Mg, P and S levels, while the highest levels were determined in wild fish. The highest Fe, Se and Mn levels were determined in the earth pond-reared fish. Wild fish had the lowest Fe, Zn, Se and Cr levels, while the lowest Cu and Mn levels were determined in the cage-reared fish. The cage-reared fish had the highest Zn, Cr and Ni levels. Wild fish were determined to contain high levels of As, Hg and Pb. The earth pond-reared fish had a high Cd level, while having lower As and Hg levels than those of fish reared in other environments. As a result, farmed meagre are thought to be affected by the metal content in both the feed and the water. The results of the study showed that the content of the meagre flesh varied depending on the rearing conditions.

Key words: *Argyrosomus regius*, chemical composition, element contents, meagre, rearing system

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1. Introduction

The number of fish species is limited in the Mediterranean aquaculture, which leads to a growing need to increase their diversity. Meagre (*Argyrosomus regius*) attracts attention in Europe because of its suitability for aquaculture, rapid growth, high food conversion ratio and relatively problem-free larval production (Li et al. 2016). Its appearance, meat yield and quality, taste and demand for the species in the market add to the growing interest in meagre (Monfort, 2010). Farmed fish grow in more stable environments than wild fish, and the rearing methods affect the quality of the meat (Orban et al. 2000; Johnston et al. 2006). The biochemical differences in the fatty acid, macro and micro nutrient contents of wild and cultured fish stemmed from the use of different feeds (Ortea & Gallardo, 2015).

Despite their importance for human health because of their essential element contents, water products can also contain heavy metals that can have a toxic effect. The concentrations of these elements in fish can vary depending on biological (species, size, age, sex and sexual maturity) and environmental (food, chemical composition of the waters, salinity, temperature) factors (Lall & Kaushik, 2021). The mineral matter contents differ depending on the rearing methods and rearing environments (Li et al. 2016; Roth et al. 2010).

The debate over whether there is a difference between the quality of wild fish and farmed fish and which fish type is healthier continues. Therefore, this study aimed to investigate the nutrient compositions and mineral matter contents of meagre reared in different environments (wild, cage and earth pond).

2. Materials and methods

2.1. Fish samples

The study was conducted in 2018 using wild, earth pond and cage-reared meagre that weighed an average of 1500 ± 80 g and were purchased from the local market. The study was carried out using three fish for each group. Since the most suitable fish part for human consumption is the muscle tissue, the flesh of the fish samples was used in the study.

2.2. Proximate analysis

Crude protein, moisture, and ash contents were determined according to the AOAC methods (AOAC, 2000). The total fat content was determined by extracting the fat with a 2:1 mixture of chloroform and methanol (Flynn & Bramblett, 1975). Data were expressed as the percent of dry weight.

2.3. Multielement analysis

Prior to the metal analysis, the fish samples were digested using a microwave platform (Milestone, model Ethos Easy). For the incineration of the samples, 0.2 g of sample was weighed and digested with 10 ml HNO_3 in Teflon tubes. Inductively coupled plasma/mass spectroscopy (ICP-MS; Agilent Technologies, 7800) was used in the determination of the element contents of the samples potassium (K), phosphorus (P), sulfur (S), sodium (Na), calcium (Ca), magnesium (Mg), iron (Fe), zinc (Zn), Selenium (Se), copper (Cu), manganese (Mn), nickel (Ni), cobalt (Co), chromium (Cr), cadmium (Cd), mercury (Hg), lead (Pb), and arsenic (As). The operational parameters of ICP-MS are presented in Table 1.

Table 1

ICP-MS instrument operating conditions

Instrument parameter	Operating condition
RF applied power (W)	1550
Number of replicates	3
Nebulizer type	MicroMist
Carrier gas (l min^{-1})	1.08
He flow rate in cell gas (ml min^{-1})	4.3

3. Results and discussion

3.1. Nutrient composition

Various factors including age, environmental conditions, type and presence of food, dietary regimen and season affect the nutritional value of fish species (Wang et al. 2014; Oz & Dikel, 2015a; Oz, 2019). The nutritional behaviours, growth performance and nutritional composition of fish species are affected by the differences in rearing systems (Martelli et al. 2013). Due to their muscle tissue, chemical composition and fat content, farmed fish are less appreciated than wild fish (Saavedra et al. 2015). Meagre is preferred for consumption due to its growth performance, low fat content and taste (Monfort, 2010). The fillets of cage-reared sea bass (*Dicentrarchus labrax*) and sharpsnout sea bream (*Diplodus puntazzo*) had a poorer quality than the fish reared in earth ponds and tanks (Roncarati et al. 2010). Table 2 shows the chemical compositions of the wild, earth pond and cage-reared meagre. The protein, fat and moisture contents of the earth pond and cage-reared fish were close to each

other (p > 0.05). The ash content of the cage-reared fish was significantly higher than that of wild fish. This is attributable to the feed content. The moisture, ash and protein levels of the cage and tank-reared meagre were close to each other, but cage-reared fish had a higher fat content (Martelli et al. 2013). The protein and ash contents in the aforementioned study were higher than those found in this study, while the fat content was lower than the values obtained in this study. In another study, some authors determined higher moisture, ash and protein levels in the earth pond-reared meagre than those found in this study (Costa et al. 2013), while the fat content determined in their study was lower than the value found in this study. Similar results were also obtained by other authors (Chaguri et al. 2017). The researchers noted that especially the protein and fat contents of the farmed fish were higher than those of wild fish and they ascribed this to the higher protein ratio of the feed consumed by farmed fish than the protein ratio consumed by wild fish. A similar case also applies to other rearing species including sea bream, sea bass and rainbow trout (*Oncorhynchus mykiss*) (Oz & Dikel, 2015b). Hence, the difference in their fat content emerges as an important factor in the identification of wild and farmed fish (Chaguri et al. 2017).

Table 2

The proximate compositions of meagre reared under different conditions (%)

	Earth Pond	Cage	Wild
Moisture	74.22 ± 0.89^{a}	75.15 ± 2.57^{a}	74.00 ± 2.06^{a}
Ash	0.42 ± 0.00^{ab}	0.50 ± 0.05^{a}	0.38 ± 0.38^{b}
Protein	16.77 ± 1.41^{a}	15.84 ± 0.71^{a}	16.09 ± 3.18^{a}
Fat	6.12 ± 3.08^{a}	5.58 ± 0.52^{a}	6.28 ± 1.24^{a}

The results were presented as the mean ± standard deviation of three replicates a, b, c (→): The difference between averages having the same letters is not statistically significant (p > 0.05)

3.2. Elemental composition

Table 3 shows the mean concentrations of macro, trace, ultra-trace and contaminant elements in cultured and wild meagre. The natural entry of metals into the sea environment (erosion and volcanic activity) is minimized by anthropogenic activities (industry, fuel emissions, mining, agricultural chemicals, etc.) (Araujo & Cedeno-Macias, 2016). The metal content in the meat of wild fish is affected by factors such as the season, species, size, tissue, sex, sexual maturity, food source and environment (salinity, temperature, pH, water hardness and pollutants), while farmed fish are affected by the metal content of feeds and the suspended materials in the water (Orban et al. 2006; Hosseini Alhashemi et al. 2012). Despite the numerous studies about the elemental composition of different sea fish species, especially sea bream and sea bass, the number of studies about meagre is limited (Martelli et al. 2013; Costa et al. 2013; Chaguri et al. 2017).

Table 3

Concentration of mineral elements and contaminants (mg kg^{-1}) in meagre

	Wild	Cage	Earth pond
Macroelements			
K	11404.75 ± 30.86^{b}	12365.09 ± 108.81^{a}	11503.75 ± 87.14^{b}
P	9783.40 ± 80.80^{a}	7420.98 ± 86.71^{c}	8376.93 ± 54.17^{b}
S	8166.20 ± 59.85^{a}	625.73 ± 90.30^{c}	7670.99 ± 73.51^{b}
Na	1934.39 ± 14.84^{b}	2477.20 ± 17.08^{a}	1568.53 ± 15.40^{c}
Ca	4749.81 ± 105.60^{a}	939.93 ± 27.50^{c}	2639.45 ± 57.55^{b}
Mg	1049.35 ± 0.77^{a}	826.73 ± 10.77^{c}	986.77 ± 0.84^{b}
Trace and ultra-trace elements			
Fe	16.61 ± 0.24^{c}	18.81 ± 0.14^{b}	22.12 ± 0.62^{a}
Zn	19.29 ± 0.24^{c}	29.06 ± 0.21^{a}	21.23 ± 0.06^{b}
Se	1.09 ± 0.07^{ab}	0.94 ± 1.21^{b}	1.32 ± 0.22^{a}
Cu	1.54 ± 0.01^{a}	1.34 ± 0.00^{c}	1.40 ± 0.04^{b}
Mn	1.35 ± 0.02^{b}	0.62 ± 0.01^{c}	1.94 ± 0.04^{a}
Ni	0.97 ± 0.05^{b}	1.20 ± 0.04^{a}	0.62 ± 0.02^{c}
Co	0.33 ± 0.00^{a}	0.24 ± 0.01^{b}	0.26 ± 0.04^{b}
Cr	0.57 ± 0.09^{c}	1.72 ± 0.01^{a}	0.96 ± 0.14^{b}
Contaminants			
Cd	0.00 ± 0.00^{b}	0.02 ± 0.00^{ab}	0.06 ± 0.04^{a}
Hg	551.70 ± 26.27^{a}	231.91 ± 33.03^{b}	287.28 ± 27.99^{b}
Pb	0.33 ± 0.00^{a}	0.13 ± 0.00^{c}	0.25 ± 0.04^{b}
As	2.06 ± 0.06^{a}	1.48 ± 0.02^{b}	1.17 ± 0.01^{c}

The results were presented as the mean ± standard deviation of three replicates a, b, c (→): The difference between averages having the same letters is not statistically significant (p > 0.05)

3.3. Macro elements

Na, Mg, Ca, K and P levels were observed to be higher in wild fish (Fuentes et al. 2010). In this study, the most abundantly found macro element was K and the highest K level was determined in the cage-reared fish. The P, S, Ca and Mg contents of wild fish were higher than those of fish from rearing environments, but the Na and K levels of the cage-reared fish were higher than those of other fish samples. Similar results were also obtained by other researchers. The Ca and S contents of wild meagre were significantly higher than those of the farmed fish (Chaguri et al. 2017), while there were no significant differences in their K contents. In contrast to these studies, in another study the researchers found that there were no significant differences in the Na, Mg, Ca, K and P contents of farmed and wild sea bass (Fuentes et al. 2010). In their study in which earth pond-reared meagre from

Portugal were investigated, the most abundantly found macro elements in meagre were K, S, Cl and Na (Costa et al. 2013). Similar results were also obtained in this study, but the concentrations determined in this study were higher than those reported by other researchers. In these studies, the differences in the elemental contents of wild and earth pond-reared fish were associated with the season, species, size, age, sex, sexual maturity, food source and environment, while the differences in farmed fish were attributed to the elemental composition of the feeds (Orban et al. 2006).

3.4. Essential

In this study, the highest Fe, Se and Mn levels were found in the earth pond-reared fish. The lowest Se and Mn levels were determined in the cage-reared fish and the lowest Fe level was determined in wild fish. The highest Zn and Cr levels were found in the cage-reared fish, while the lowest levels were determined in wild fish. Again, the highest Ni level was found in the cage-reared fish and the lowest Ni level was found in the earth pond-reared fish. The highest Cu and Co levels were determined in wild fish and the lowest Cu and Co levels were determined in the earth pond-reared fish. The researchers reported differences in the S, Fe, Se and Zn contents of farmed and wild fish (Chaguri et al. 2017). The Fe and Se levels of meagre reared in the earth pond system were higher than those of cage-reared fish (Martelli et al. 2013). The Fe and Se levels of the tank-reared meagre were higher than those of cage-reared fish and this was attributed to the feeds (Martelli et al. 2013). The researchers emphasized that the Se level of meagre fish was lower than that of sea bream and sea bass and that the Fe level of meagre was higher than that of sharpsnout sea bream (Martelli et al. 2013). The iron level of tank-reared sharpsnout sea bream was higher than that of cage-reared fish (Orban et al. 2000). The Mn, Zn and Cr levels of cultured sea bass were determined to be higher than those of wild sea bass (Alasalvar et al. 2002). A comparison between the cage-reared sea bass and wild sea bass from Spain showed that the Fe, Cu, Mn and Zn levels of cultured fish were higher (Fuentes et al. 2010). The Cu and Se levels of both wild meagre fish and meagre fish in a rearing environment were higher than (Chaguri et al. 2017) the levels determined in this study for wild, pond and cage-reared fish. The Fe values found in this study for wild, cage and earth pond-reared fish were higher than those determined for wild fish and fish in a rearing environment. The Zn level determined for wild fish in the study carried out by some authors (Chaguri et al. 2017) was lower than the Zn level found in this study for wild fish; the Zn level found in their study for farmed fish was the same as the level found in this study for earth pond-reared fish and lower than the Zn level of cage-reared fish. The Fe and Se levels found in the study carried out by some authors (Martelli et al. 2013) for cage and tank-reared meagre were lower than those found in this study for cage and earth pond-reared fish. Compared with the Fe, Zn, Se, Cu and Mn levels for earth pond-reared meagre, the levels found in this study were higher both in the earth pond and cage-reared fish (Costa et al. 2013).

3.5. Heavy metals

In this study, the highest Cd level was found in the earth pond-reared fish and the lowest Cd level was found in wild fish; the highest Hg and Pb levels were determined in wild fish, while the cage-reared fish had the lowest levels; again, the highest As level was determined in wild fish and the lowest As level was determined in the earth pond-reared fish. Heavy metals are regarded as the leading pollutants in aquatic environments and they can accumulate at the top of the food chain because of their non-biodegradability (Yabanli et al. 2016; Raimundo et al. 2017). No differences were found in the Hg, Cd and Pb levels of wild and farmed meagre fish (Chaguri et al. 2017). The Hg level of meagre was determined to be lower than that of sea bass, sea bream and rainbow trout, while its Cd level was lower than that of the sea bass (Costa et al. 2013). Based on their comparison of the small and large wild and farmed meagre fish, there were no differences in the Hg and Cd levels, albeit there was a difference in the Pb levels (Chaguri et al. 2017). The As level of both wild and farmed meagre was higher than that of the wild, earth pond and cage-reared fish in this study (Chaguri et al. 2017). On the other hand, the As, Hg and Pb levels of the earth pond-reared meagre were lower than those of both earth pond and cage-reared fish in this study, while the Cd levels in their study were close to the levels determined in this study (Costa et al. 2013).

4. Conclusion

In conclusion, the ash levels of the cage and earth pond-reared meagre were higher than that of wild fish. There were no differences in protein, fat and moisture contents. This was attributed to nutrition. The highest Ca, Mg, P and S levels were determined in wild meagre, while the lowest levels were determined in the cage-reared. The highest K and Na levels were determined in the cage-reared fish, while the lowest K

value was obtained in wild meagre. The lower Ca, Mg, P and S levels in the fish from rearing environments were attributed to nutrition.

The highest Fe, Se and Mn levels were determined in the earth pond-reared fish, while the lowest Fe level was determined in wild fish. The highest Zn, Cr and Ni levels were obtained in the cage-reared fish, while the lowest Zn and Cr levels were obtained in wild fish. The contaminant levels of the fish samples, the highest As, Hg and Pb levels were determined in wild fish, while the lowest Hg and Pb levels were determined in the cage-reared fish and the lowest As level was determined in the earth pond-reared fish. The earth pond-reared fish had the highest Cd level, while the lowest Cd level was determined in wild fish.

The results of the study showed that content of the meagre flesh varied depending on the rearing conditions.

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