Comparison of Biometry Traits, Chemical and Fatty Acid Composition of Wild and Farmed Sea Bass (Dicentrarchus Labrax)

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Abstract

Sea bass is a fish widely produced, consumed and appreciated in Italy. Its intensive rearing system provide the consumption of valuable fish to wider population. Thanks to the use of an appropriate feed is possible to obtain reared sea bass richer in total lipid with a majority presence of polyunsaturated fatty acids, such as n-3 and n-6 families. A total of 75 specimens of European sea bass from three different origins (two farmed and one wild) were considered, 25 fish from each origin. Biometry traits were valuated as the chemical and fatty acid composition of fillets. Biometric indices, chemical composition and fatty acid profile resulted significantly affected by the rearing system. Fishes from the Intensive rearing system (IRS) showed the highest value of relative profile and condition factor; higher content of lipid and total n-6 that influenced the n-3/n-6 ratio and the atherogenic index; values that make their meats very healthy and indicated for human consumption as the wild fishes.

1. Introduction

Because of the increased demand for fresh sea bass (*Dicentrarchus labrax*) in Europe, the aquaculture industry has been experiencing an expansion in the last few decades; in contrast, traditional fishery is suffering from catch decline due to overfishing and habitat deterioration. Fish farming offers the possibility to control the quality of the entire production process and to obtain a final product with quality attributes as close as possible to those of wild fish.

The effect of rearing conditions may have a crucial role in the development of the external morphology of fish resulting in changes of morphometric ratios of fish due to altered stocking densities, swimming capacity, quality and quantity of food (Favaloro & Mazzolla, 2003). The shape appearance is an important attribute for the consumer and become even more important in the case of fish species of large commercial trade like the little size (300 g) European sea bass. Many pieces of research specified that in addition to its economical characteristics, sea bass makes positive contributions to human health in term of food composition (Mozzaffarian *et al.*, 2006; Reader *et al.*, 2007).

Also, the quality of fish flesh is the result of a complex set of characteristics involving factors such as chemical and fatty acid composition, the nutritional value and organoleptic characteristics of fish are especially affected by rearing conditions (BØrre sensen, 1992), so that the composition and sensory parameters are expected to be different between wild and farmed fish (Fuentes *et al.*, 2010). In farmed fish, artificial diets provide a wide range of nutrients, which not only determine the fish growth rate but also flesh composition (Izquierdo *et al.*, 2003). In particular, the chemical and fatty acid composition of farmed sea bass may be modulated qualitatively and quantitatively, within certain limits, through the formulation of feeds with high levels of n-3 polyunsaturated fatty acids (PUFA), which are now known to be responsible for the health-promoting effects of marine lipids. Seafood products are, in fact, the only significant source in the human diet of polyunsaturated fatty acids, in particular, those of the n-3 family (eicosapentaenoic acid, 20:5 n-3; docosahexaenoic acid, 22:6 n-3); these are precursors of hormone-like...
substances with anti-thrombogenic and anti-atherogenic properties, and they play a fundamental role in the development of neural and visual functions (Orban et al., 2003).

Due to these information we hypnotized that with the use of an appropriate feed is possible to obtain reared sea bass richer in total lipid with a majority presence of polyunsaturated fatty acids, such as n-3 and n-6 families.

The objective of this study was to identify the elements of differentiation of biometry traits, chemical composition and nutritional value that characterize wild and farm sea bass (*Dicentrarchus labrax*), fish widely produced and consumed in Italy.

2. Materials And Methods

A total of 75 specimens of European sea bass from three different origins (two farmed and one wild) were considered, 25 fish from each origin. The farmed sea bass was originated from two Apulian commercial farms chosen as representative of extensive rearing system (ES) and intensive rearing system in tanks (IRS); in both cases, farmed specimens were fed a commercial diet containing fish meal, fish oil, soybean meal, wheat meal, yeast and vitamin and mineral supplements, and harvested with about 36 months old for ES and 24 months old for IRS. The extensive rearing system was performed in a lake connected with the Adriatic Sea, included fish coming in from sea and fish transferred as juveniles in the lake; fishes received feed integration until one year old, then they feed exclusively on the resource of the aquatic environment. The intensive rearing system was performed in rearing plants with tanks supplied with continuous seawater flow (35‰, 10 l/min), fishes were fed twice a day with a commercial pellet feed.

Wild fish (WF) was caught in the south of the Adriatic Sea; all other factors during capture were not controlled or assessed. Sampling was performed in August.

2.1 Chemical Composition of Feed

Representative samples of the pelleted feeds were mixed to obtain a single final pool, which was then analyzed to determine the chemical composition and fatty acid profile (Table 1). Samples were ground in a hammer mill with a 1-mm screen and analyzed using the following Association of Official Agricultural Chemistry AOAC (2000) procedures: Dry matter (method 934.01), total lipid (method 920.39), ash (method 942.05), crude protein (method 954.01), crude fibre (method 945.18).
Table 1
Chemical and fatty acid composition of feed (%)

| Proximate composition (% on DM basis) | %     |
|--------------------------------------|-------|
| Moisture                             | 10.0  |
| Crude protein                        | 50.0  |
| Total lipid                          | 18.5  |
| Ash                                  | 9.0   |
| Crude fibre                          | 1.5   |

Fatty acid composition (% FA methyl esters)

| Fatty acid | %     |
|------------|-------|
| C14:0 (myristic) | 5.1   |
| C15:0 (pentadecanoic) | 0.4   |
| C16:0 (palmitic) | 15.8  |
| C18:0 (stearic) | 5.1   |
| C16:1 n7 (palmitoleic) | 5.4   |
| C18:1 n9 (oleic) | 16.5  |
| C20:1 n9 (eicosanoic) | 2.9   |
| C18:2 n6 (linoleic) | 11.3  |
| C18:3n6 (γ-linolenic) | 1.1   |
| C18:3n3 (α-linolenic) | 1.9   |
| C18:4n3 | 1.6   |
| C20:4 n6 (ARA) | 0.7   |
| C20:5 n3 (EPA) | 7.9   |
| C22:5 n6 (DPA) | 0.3   |
| C22:5 n3 | 0.4   |
| C22:6 n3 (DHA) | 10.2  |

2.2 Sample treatment and analysis

Wild and farmed fish were caught by net, selected according to their market sized (≈ 300 g) and slaughtered by immersing in ice-cold water (hypothermia) and delivered to the laboratory in refrigerated conditions (4°C).
Upon arrival, fish were weighted, on a 0.01 g precision balance, singularly for total body weight (TBW) and measured, with a 0.1 cm precision scale, to determine total and fork length; head length and maximum height. From linear and weight measurements, morphometric indexes, as relative profile (100 x maximum height/ fork length), cranial index (100 x head length/ fork length) and condition factor (100 x bodyweight/total length$^3$) were calculated. All the specimens were dissected and carcass, head, skin, viscera and fillet weight were individually recorded to calculate the relative somatic indices and commercial yield (% of total weight).

On the day of analysis, fillets were rapidly thawed, then skinned, chopped, combined in a pool, and homogenized for 1 min. AOAC procedures were used to assess moisture, ether extract, raw protein, ash. Total lipids were extracted according to the method of Folch et al. (1957), using a 2:1 chloroform/methanol (v/v) solution to determine the fatty acid profile. The fatty acids were then methylated using a KOH/methanol 2N solution (Crhistie, 1982) and analyzed by gas chromatography (Shimadzu GC-17A) using a silicone-glass capillary column (70% Cyanopropyl Polyselphenylene-siloxane BPX 70 by Thermo Scientific, length = 60 m, internal diameter = 0.25 mm, film thickness = 0.25 µm). The starting temperature was 135°C for 7 min, then increased by 4°C/min up to 210°C. Fatty acids were identified by comparison of retention times to authentic standards for percentage area normalization. Relative quantities are expressed as weight percentage (wt/wt) of total methylated fatty acids.

The food risk factors of meat were determined by calculating the Atherogenic (Al) and Thrombogenic (TI) Indices (Ulbricht & Southgate, 1991):

$$Al = \frac{[(C12:0 + 4 \times C14:0 + C16:0)]}{[\Sigma MUFA + \Sigma n-6 + \Sigma n-3]};$$

$$TI = \frac{[(C14:0 + C16:0 + C18:0)]}{[(0.5 \times \Sigma MUFA + 0.5 \times \Sigma n-6 + 3 \times \Sigma n-3 + \Sigma n-3)/\Sigma n-6]};$$

where MUFA are monounsaturated fatty acids.

Fatty acids were expressed as percentage (wt/wt) of total methylated fatty acids.

**2.3 Statistical analysis**

Data were analyzed using the general linear procedure (GLM) procedure of the SAS application package (SAS, 2000). Differences among treatment means for significant origin effects were detected and compared by Tukey’s HSD.

**3. Results And Discussion**

**3.1 Biometric parameters**

The morphometric parameters and biometric indices are shown in Table 2. While no statistically significant difference in the total body weight was observed between the three groups, total body length and fork length are significantly higher in wild sea bass than in the other two.
The biometric indices resulted significantly affected by the rearing system: fishes from the Intensive rearing system showed the highest value of relative profile (P = 0.022) and condition factor (P = 0.004) and the lowest value of the cranial index (P = 0.002). The same group recorded the lowest value of carcass yield (P = 0.009) while the value of edible yield was more uniform into the group. Our results are more similar to Tulli et al. (2009) and Di Turi et al. (2009) who investigated growth performance and biometry traits of sea bass from different farming systems.

### Table 2

| Origin | ES      | IRS     | WF      | SEM | p Value |
|--------|---------|---------|---------|-----|---------|
| ES     | 292.65  | 325.90  | 347.97  | 32.54| 0.655   |
| IRS    | 30.77 B | 30.92 B | 32.64 A | 0.87 | 0.007   |
| WF     | 29.36 B | 29.45 B | 31.00 A | 0.94 | 0.004   |
| Viscera (% of TBW) | 5.28 | 8.28 | 5.51 | 1.21 | 0.065 |
| Relative profile | 22.27 b | 23.14 a | 22.31 b | 1.04 | 0.022 |
| Cranial index | 26.84 A | 25.10 B | 26.58 A | 0.88 | 0.002 |
| Condition factor | 1.15 B | 1.28 A | 1.17 B | 0.08 | 0.004 |
| Carcass yield (%) | 94.72 A | 91.72 B | 94.49 A | 1.21 | 0.009 |
| Edible yield (%) | 56.55 | 56.77 | 56.70 | 2.17 | 0.078 |

1 ES: extensive system; IRS: intensive rearing system; WF: wild fish; 2 SEM: Standard error of means; a, b: p < 0.05; A, B: p < 0.01.

### 3.2 Chemical composition

Chemical composition depending on many factors including culture environment, the region of fishing, season and nutrition habits. In the present study, ISS fillet is characterized by a significantly higher content of protein (P = 0.008), lipid (0.006), ash (P = 0.009) and N free extract (P = 0.037) and, consequently, lower moisture compared to the other two groups (P = 0.003). The difference in the mean total lipid content was particularly marked between wild and ISS sea bass (1.04 % vs 3.05 %; P = 0.006). Dietetic and practical implications may occur in consequence of this observation since wild sea bass may be considered a lean fish, while reared sea bass may not. The higher lipid content of farmed compared to wild fish may be considered the result of the high stocking density and intensive feeding of fish in the rearing tanks (Orban et al., 2003). Periago et al. (2005) and Fuentes et al. (2010) in a comparison of wild and farmed sea bass, showed the highest value of moisture and protein in farmed sea bass and higher total fat in wild sea bass; Baki et al. (2015) in the same comparison, showed higher value of moisture, crude protein and crude lipid in cultured sea bass.
Table 3
chemical composition of filet of sea bass for each origin (%)

| Origin1 | ES    | IRS   | WF    | SEM2  | p Value |
|---------|-------|-------|-------|-------|---------|
| Moisture| 77.33 A | 73.07 B | 76.75 A | 0.684 | 0.003   |
| Crude Proteins | 19.65 B | 21.39 A | 19.95 B | 0.145 | 0.008   |
| Lipid   | 1.23 B | 3.05 A | 1.04 B | 0.155 | 0.006   |
| Ash     | 1.50 B | 1.64 A | 1.46 B | 0.030 | 0.009   |
| N free-extract | 0.60 b | 0.87 a | 0.95 a | 0.100 | 0.037   |

1 ES: extensive system; IRS: intensive rearing system; WF: wild fish; 2 SEM: Standard error of means; a, b: p < 0.05; A, B: p < 0.01.

3.3 Fatty acid composition of fillets

The fatty acid profiles of total lipids extracted from 3 groups of sea bass are reported in Table 3. Total saturated fatty acids were higher in wild fish fillets, same trend agree with results for sea bass and other fish species (Periago et al., 2005; Pirini et al., 2000; Fuentes et al., 2010). Palmitic acid (C16:0) was the primary SFA in all samples, followed by stearic acid (C18:0), these contents being higher in wild fish as the content of C12:0 (P = 0.002), C 15:0 (P = 0.003) and C17:0 (P = 0.001). On the contrary WF recorded the lowest value of C14:0 (2.23% vs 4.04% and 5.56%; P = 0.004).

Fillets of extensive reared sea bass showed the lowest value of C16:1n9 (P = 0.002), C16:1n7 (P = 0.006), C17:1 (P = 0.002), C18:1n7 (P = 0.005), and the highest (P = 0.005) value of oleic acid (C18:1 n9), who was identified as the major monounsaturated fatty acid in cultured and wild sea bass.

With regard to PUFA, sea bass can be considered as a good source of the n-3 series fatty acids, particularly of eicosapentaenoic acid (EPA) and docosahxaenoic acid (DHA), showing the highest (P = 0.024 and P = 0.036) levels in wild specimens, which agrees with those of Alasalvar et al. (2001, 2002). DHA, playing a fundamental role in brain and retina development during the early stages of human life, was present in wild and farmed sea bass at comparably high levels (Orban et al. 2003).

Arachidonic acid (C20:4 n6) was found at significantly higher levels in wild fish(P = 0.006), whereas its precursor, linolenic acid (C18:2 n6), accumulated in extensive farmed fish (P = 0.007). A scarce metabolic action of the latter, due to a feedback inhibition exerted on Δ6-desaturase by the n-3 polyunsaturated fatty acids, abundantly supplied with the diet, may be the reason for the low percent content of arachidonic acid in farmed fish (Orban et al., 2003).

The fatty acid profiles of wild sea bass, selecting different organisms from the aquatic environment as their natural diet sources, showed species-specific patterns that were, at a certain extent, less evident in
intensively reared fish fed commercial diets with similar chemical composition. Some of the differences found between the fatty acid profiles of wild and farmed fish of either species may be attributed to the different dietary regimen followed by fish in the lagoon and in intensive farming. In fact, while fish from lagoon drew nutrients from the natural resources of their habitat, whose availability presumably varied, farmed fish received always the same diet containing fish and being therefore rich in n-3 long-chain polyunsaturated fatty acids.
| Origin                        | ES     | IRS    | WF     | SEM²  | p Value |
|-------------------------------|--------|--------|--------|--------|---------|
| C12:0 (lauric)                | 0.07 ab| 0.06 b | 0.08 a | 0.01   | 0.034   |
| C14:0 (myristic)              | 4.04 B | 5.56 A | 2.23 C | 0.15   | 0.004   |
| C15:0 (pentadecanoic)         | 0.50 B | 0.56 b | 0.67 Aa| 0.03   | 0.003   |
| C16:0 (palmitic)              | 21.96  | 21.98  | 22.99  | 0.50   | 0.058   |
| C17:0 (heptadecanoic)         | 0.47 Bc| 0.55 b | 0.65 Aa| 0.02   | 0.001   |
| C18:0 (stearic)               | 4.93 B | 3.88 C | 6.65 A | 0.13   | 0.002   |
| ∑ SFA⁴                        | 31.98  | 32.60  | 33.27  | 0.66   | 0.087   |
| C16:1 n9                      | 0.69 C | 0.86 B | 0.97 A | 0.03   | 0.002   |
| C16:1 n7 (palmitoleic)        | 5.63 B | 7.20 A | 7.37 A | 0.19   | 0.006   |
| C17:1                         | 0.33 Bc| 0.46 b | 0.63 Aa| 0.04   | 0.002   |
| C18:1 n9 (oleic)              | 21.59 a| 20.24 b| 20.54 ab| 0.40   | 0.039   |
| C18:1 n7                      | 3.12 B | 3.22 B | 4.88 A | 0.07   | 0.005   |
| C20:1 n9 (eicosanoic)         | 3.47 B | 4.44 A | 1.41 C | 0.08   | 0.005   |
| ∑ MUFA⁴                       | 34.84  | 36.41  | 35.80  | 0.59   | 0.077   |
| C18:2 n6 (linoleic)           | 7.65 A | 5.06 B | 2.24 C | 0.20   | 0.007   |
| C18:3n6 (γ-linolenic)         | 0.53 B | 0.57 B | 0.75 A | 0.02   | 0.001   |
| C18:3n3 (α-linolenic)         | 1.01   | 0.90   | 0.78   | 0.10   | 0.082   |
| C18:4n3                       | 0.94 B | 1.68 A | 0.85 B | 0.09   | 0.003   |
| C20:4 n6 (ARA)                | 2.60 C | 3.70 B | 4.28 A | 0.14   | 0.006   |
| C20:4 n3                      | 1.00 A | 0.55 B | 0.52 B | 0.05   | 0.004   |

1 ES: extensive system; IRS: intensive rearing system; WF: wild fish; ² SEM: Standard error of means; ³ ∑ SFA—saturated fatty acids (sum of C12:0 + C14:0 + C15:0 + C16:0 + C17:0 + C18:0); ⁴ ∑ MUFA—monounsaturated fatty acids (sum of C16:1 n9 + C16:1 n7 + C17:1 + C18:1 n9 + C18:1 n7 + C20:1 n9); ⁵ Total n-6 (sum of C18:2 n6 + C18:3 n6 + C20:4 n6 + C22:5 n6); ⁶ Total n-3 (sum of C18:3 n3 + C18:4 n3 + C20:4 n3 + C20:5 n3 + C22:5 n3 + C22:6 n3); ⁷ ∑ PUFA—polyunsaturated fatty acids (sum of n-6 + n-3); ⁸ ∑ UFA – unsaturated fatty acids (sum of MUFA + PUFA); ⁹ A.I. – atherogenic index; ¹⁰ T.I. – thrombogenic index; a, b, c: p < 0.05; A, B, C: p < 0.01.
| Origin | ES | IRS | WF |
|--------|----|-----|----|
| C20:5 n3 (EPA) | 5.61 c | 6.74 a | 6.09 b |
| C22:5 n6 (DPA) | 0.43B | 0.23 C | 1.05 A |
| C22:5 n3 | 1.28 B | 1.14 B | 2.31 A |
| C22:6 n3 (DHA) | 12.13 a | 10.42 b | 12.05 a |
| Total n-6 | 11.21 A | 9.54 B | 8.32 C |
| Total n-3 | 21.97 | 21.45 | 22.61 |
| \(\sum\) PUFA | 33.18 | 30.98 | 30.93 |
| \(\sum\) UFA | 68.02 | 67.39 | 66.73 |
| n-3/n-6 | 1.96 B | 2.25 B | 2.74 A |
| A.I. | 0.56 b | 0.66 a | 0.55 b |
| T.I. | 0.34 | 0.35 | 0.35 |

1 ES: extensive system; IRS: intensive rearing system; WF: wild fish; 2 SEM: Standard error of means; 3 \(\sum\) SFA—saturated fatty acids (sum of C12:0 + C14:0 + C15:0 + C16:0 + C17:0 + C18:0); 4 \(\sum\) MUFA—monounsaturated fatty acids (sum of C16:1 n9 + C16:1 n7 + C17:1 + C18:1 n9 + C18:1 n7 + C20:1 n9); 5 Total n-6 (sum of C18:2 n6 + C18:3 n6 + C20:4 n6 + C22:5 n6); 6 Total n-3 (sum of C18:3 n3 + C18:4 n3 + C20:4 n3 + C20:5 n3 + C22:5 n3 + C22:6 n3); 7 \(\sum\) PUFA—polyunsaturated fatty acids (sum of n-6 + n-3); 8 \(\sum\) UFA – unsaturated fatty acids (sum of MUFA + PUFA); 9 A.I. – atherogenic index; 10 T.I. – thrombogenic index; a, b, c: p < 0.05; A, B, C: p < 0.01.

No significant difference was found between wild and farmed sea bass fillets as regard the total n-3 polyunsaturated fatty acids; while significantly higher percentage of total n-6 polyunsaturated fatty acids were found in lipids of extensive reared fishes in comparison with the other two groups. This value influenced significantly the ratio n-3/n-6 (P = 0.007), in fact ES group showed the lower value in comparison with the WF ones. A higher intake of pre-formed long-chain PUFA in farmed fish and a different capability of sea bass to desaturate and elongate C18 PUFA could explain the low levels of PUFA found in wild sea bass. Knowledge of the fatty acid composition of the natural diet of fish living in lagoon would be necessary to confirm this hypothesis. The use of formulated feeds rich in n-3 PUFA in aquaculture – desirable from human nutritional standpoint in consideration of the role played by n-3 PUFA in prevention of cardiovascular and inflammatory diseases – also has a positive incidence on the growth rate and feed conversion efficiency of fish (Orban et al., 2003).

The indices of atherogenicity and of thrombogenicity are indicators assessing the level and the interrelation of some fatty acids that have effects on the occurrence of coronary heart diseases (Ulbricht & Southgate, 1982). In this study, the meat of reared sea bass showed a markedly greater atherogenic (P
compared to the other two groups, result that confirm that use of formulated feeds rich in n-3 PUFA in aquaculture is the best choice for human health. 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 n-3 and n-6 PUFA in fish flesh has importance in view of its human consumption. In this study farmed sea bass, because of the higher total lipid content, also showed higher levels of total n-3 and n-6 PUFA in their muscles than their wild counterparts. This observation has important nutritional implications considering that about 9.2% of the total marine fish purchased by Italian families in the year 2020 was represented by sea bass (Annuario settore ittico, 2020).

4. Conclusions
This study provides useful indications on the distinctive elements characterizing the nutritional quality of sea bass produced in Italy by intensive farming and grown in natural lagoon environments. Concerning the wild sea bass, there is a lack of information about their genetic lineage, age as well as the environmental and nutritional parameters affecting these fish during ontogeny. This makes it quite difficult to find a unique or direct explanation for their results of chemical and fatty acid composition.

As we expected, the filets of reared sea bass were similar to the wild one, we found a greater quantity of total lipid, characterized by similar value of SFA, MUFA and PUFA. The only significant difference was found on total n-6, higher than wild sea bass, that influenced the n-3/n-6 ratio and the atherogenic index; values that ensure their meats to be very healthy and indicated for human consumption as the wild fishes.

Declarations

Author Contributions: Conceptualization, PC; Data curation, PC; Formal analysis, PC and ST; Funding acquisition, AC; Investigation, PC and MR; Methodology, PC, MR and ST; Resources, AC; Supervision, PC and AC; Writing - original draft, ST and MR.

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