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 provides the consumption of valuable fish to a wider population. Thanks to the use of an appropriate feed, it is possible to obtain reared sea bass which are richer in total lipid with a majority presence of polyunsaturated fatty acids, such as n-3 and n-6 families. In this study, a total of 75 specimens of European sea bass coming from three different origins (two farmed and one wild) were considered, 25 fish from each origin. Biometry traits were valued as of 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 indexes; values that make their meats very healthy and indicated for human consumption as the wild fishes.

Introduction

Due to the high demand of fresh sea bass in the European market, the aquaculture industry has been experiencing an expansion in the last few decades. However, the traditional fishery is suffering from catch decline due to overfishing and habitat deterioration. Fish farming offers the chances 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 which results in changes in the morphometric ratios of fish. This occurs due to altered stocking densities, swimming capacity, quality and quantity of food requested [1]. The visual appearance is an important attribute for the consumer/buyer and becomes even more important in the case of fish species of large commercial trade like the little size (300 g) European sea bass. Many studies have stated that in addition to its economical characteristics, sea bass makes positive contributions to human health in term of food composition [2, 3].

Furthermore, the quality of fish meat is the result of a complex set of characteristics involving factors such as chemical and fatty acid composition. Moreover, the nutritional value and organoleptic characteristics of fish are particularly affected by rearing conditions [4] therefore, 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 the meat composition [5]. In addition, 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). These 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 [6].

Due to this information, we hypothesize that with the use of an appropriate feed is possible to obtain reared sea bass which is richer in total lipid and with an increased 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*), but also fish that are widely produced and consumed in Italy.

Materials And Methods

For this research study, a total of 75 dead 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 salt lake connected with the Adriatic Sea, included fish coming in from sea and fish transferred as juveniles in the lake. The fishes received food integration until one year old, then they were feed exclusively on the resource of the aquatic environment. The intensive rearing system was performed in rearing plants with tanks supplied with continuous seawater flows (35‰, 10 l/min), fishes were fed twice a day with a commercial pellet feed.

Wild fish (WF) were caught in the south of the Adriatic Sea. During the capture, all the other factors, were not controlled or assessed. 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), as request by the laws in force in the field. Sampling was performed in August.

2.1 Chemical Composition of Feed

The representative samples of the pelleted feeds were mixed to obtain a single final pool, which was then analysed to determine the chemical composition and fatty acid profile (Table 1). Samples were ground in a hammer mill with a 1-mm screen and evaluated using the following association of Official Agricultural Chemistry AOAC [7] 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)	
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

In the day of caught, dead fishes were 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 length3) were calculated. All the specimens were dissected and carcass, head, skin, viscera and fillet weight were individually recorded to calculate the relative somatic indexes and commercial yield (% of total weight).

On the analysis's day, fillets were rapidly thawed, then skinned, chopped, combined in a pool, and homogenized for 1 min. AOAC procedures were used to assess the moisture, ether extract, raw protein, and the ash. The total lipids were extracted according to the method of Folch [8], 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 [9] and analyzed by gas chromatography (Shimadzu GC-17A) using a silicone-glass capillary column (70% Cyanopropyl Polysilphenylene-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 (AI) and Thrombogenic (TI) Indexes [10]:

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

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

where MUFA are monounsaturated fatty acids.

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

2.3 Statistical analysis

The collected data was analyzed using the general linear procedure (GLM). This is a procedure of the SAS application package [11]. Differences among treatments mean, for significant origin effects, were detected and compared by Tukey's HSD.

Results And Discussion

3.1 Biometric parameters

The morphometric parameters and biometric indexes 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 indexes 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 [12] and Di Turi [13] who investigated growth performance and biometry traits of sea bass from different farming systems.

Table 2
Morphometric and biometric indices for each origin of sea bass

	Origin[1]				
	ES	IRS	WF	SEM[2]	p Value
Total body weight (g)	292.65	325.90	347.97	32.54	0.655
Total body length (cm)	30.77 B	30.92 B	32.64 A	0.87	0.007
Fork length (cm)	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

The chemical composition depends 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) (Table 3). Consequently, we obtain a 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 could be considered the result of the high stocking density and intensive feeding of fish in the rearing tanks [6]. Periago [14] and Fuentes [15] in a comparison of wild and farmed sea bass, showed the highest value of moisture and protein in farmed sea bass and a higher total fat in wild sea bass. In the same comparison, Baki [16] showed a 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 (%)

	Origin[1]				
	ES	IRS	WF	SEM[2]	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 4. The totality of the saturated fatty acids were higher in wild fish fillets. Moreover, the same trend agrees with results for sea bass and other fish species [14, 15, 17]. Palmitic acid (C16:0) was the primary SFA in all samples, followed by stearic acid (C18:0), with 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 docosahexaenoic acid (DHA), showing the highest (P = 0.024 and P = 0.036) levels in wild specimens, which agrees with those of Alasalvar [18, 19]. 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 [6].

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, maybe the reason for the low per cent content of arachidonic acid in farmed fish [6].

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 salt lake and in intensive farming. In fact, while fish from salt lake 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.

Table 4
Mean (± SE) fatty acid composition (% of total fatty acid methyl esters) of filet of sea bass for each origin (%)

	Origin[1]				
	ES	IRS	WF	SEM[2]	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
∑ SFA[3]	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
∑ MUFA[4]	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[1]				
C20:5 n3 (EPA)	5.61 c	6.74 a	6.09 b	0.33	0.024
C22:5 n6 (DPA)	0.43B	0.23 C	1.05 A	0.05	0.003
C22:5 n3	1.28 B	1.14 B	2.31 A	0.09	0.004
C22:6 n3 (DHA)	12.13 a	10.42 b	12.05 a	0.68	0.036
Total n-6 [5]	11.21 A	9.54 B	8.32 C	1.06	0.008
Total n-3 [6]	21.97	21.45	22.61	0.19	0.084
∑ PUFA [7]	33.18	30.98	30.93	1.11	0.102
∑ UFA [8]	68.02	67.39	66.73	0.85	0.097
n-3/n-6	1.96 B	2.25 B	2.74 A	0.11	0.007
A.I. [9]	0.56 b	0.66 a	0.55 b	0.05	0.045
T.I. [10]	0.34	0.35	0.35	0.01	0.061

[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: $p < 0.01$.

There is no significant difference between wild and farmed sea bass fillets as regard the total n-3 polyunsaturated fatty acids. However, a significantly higher percentage of total n-6 polyunsaturated fatty acids was found in lipids of extensively reared fishes in comparison with the other two groups. This value influenced the ratio n-3/n-6 ($P = 0.007$), in fact, ES group showed a lower value in comparison with the WF ones. A higher intake of preformed 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. There is a need of a deeper understanding and knowledge on the fatty acid composition and the natural diet of the fish which lives in the salt lake to confirm this hypothesis.

The use of formulated feeds rich in n-3 PUFA in aquaculture – desirable from a human nutritional standpoint in consideration of the role played by n-3 PUFA in the prevention of cardiovascular and inflammatory diseases – also has a positive incidence on the growth rate and feed conversion efficiency of fish [6].

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 [10]. In

this study, the meat of reared sea bass showed a markedly greater atherogenic (P = 0.045) compared to the other two groups, the result that confirms that the use of formulated feeds rich in n-3 PUFA in aquaculture is the best choice for human health.

Aside from the relative proportions of fatty acids in total lipids, which allowed 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 also has an importance in view of its human consumption. In this study, because of the higher total lipid content, farmed sea bass showed higher levels of total n-3 and n-6 PUFA in their muscles compared to 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 [20].

Conclusion

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 salt lake 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 ones. We found a greater quantity of total lipid, characterized by a 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. These values ensure the high quality of their meats and which are 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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