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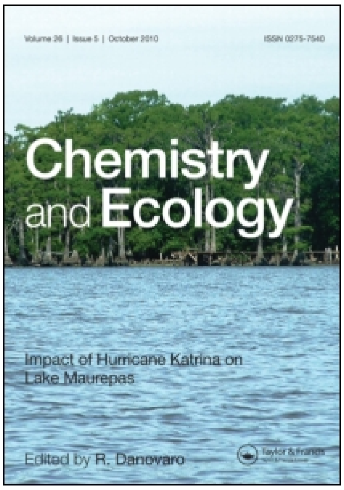

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Chemical composition and nutritional value of some marine species from the Egadi Islands

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Information available on the chemical composition and nutritional value of marine species harvested from the Mediterranean Sea is very limited. In this study, the target species were *Scorpaena porcus*, *Scorpaena scrofa*, *Palinurus elephas*, and *Sepia officinalis*, selected among those with the greatest commercial value and caught using local traditional gear. Samples were analysed for moisture, ash, protein, total lipid content, and for fatty acid percentage distribution. All the species showed high amounts of proteins (mean value 18.15%) and can be considered lean (fat content <3%), with a high content of polyunsaturated fatty acids of the n-3 series. Significant differences ($P < 0.05$) were observed among the different species for some of the most representative fatty acids. All species (except *S. officinalis*) had a good value for the prevention of cardiac illnesses as can be deduced from their low atherogenic and thrombogenic indexes.

Keywords: Egadi Islands; Chemical composition; Nutritional value; Atherogenic index; Thrombogenic index

1. Introduction

Seafood is an important constituent in the human diet and is a valid alternative to other food products [1]. In fact, from a nutritional point of view, fish is considered a precious food for its easy digestibility, high mineral, vitamin, and protein content, and composition of lipid fraction [2]. Animal experiments show that fatty acids from n-3 fish oils are stored in the cell membranes of heart cells and can prevent sudden cardiac death or fatal arrhythmias. Excessive Na and Ca currents in the heart can cause dangerous and erratic changes in the heart rhythm. Studies of individual heart cells demonstrated that the n-3 essential polyunsaturated fatty acids (n-3 PUFAs) specifically block these excessive electrical discharges [3], so the high-n-3 PUFAs mean that fish is a particularly good food for the prevention of some complex

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illnesses. The two active ingredients that make up omega 3 fatty acids are eicosapentenoic acid (EPA) and docosahexenoic acid (DHA). It was also seen that the lack of DHA in membrane phospholipids of erythrocytes is inversely proportional to the insurgence of cardiac illnesses [4–6]. Furthermore, recent studies [7] have related the lack of these fatty acids to patients suffering from major depressive disorders.

In the last few years, fish demand in Italy has greatly increased, and contextually a cultural change has been taking place in the food sector at both production and distribution levels. In today's society, consumers seem to be strongly conditioned by the search for quality; this term assumes a particular significance when it is applied to an alimentary product. The nutritional quality is the aspect of a food product that has recently attracted general interest; in the choice of different food items, the contribution of fundamental elements, such as, protein, lipids, sugar, minerals, and vitamins, tends to represent almost a common point of reference in the daily diet, because they are the best for growth and maintenance of the human organism.

However, in spite of the enormous economic value of seafood, limited information is available on the chemical composition and nutritional value in marine species found in the Mediterranean and neighbouring seas.

The primary focus of this research was to determine the chemical and nutritional profile of some marine species from the Marine Protected Area (MPA) of the Egadi Islands, which are very important for the economy of these islands and for the human diet.

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2. Materials and methods

This study was conducted in the fishery of Favignana and Marettimo in the Egadi Islands (figure 1). Initially, we defined the typology of fishing practised by the boats of the fishery of

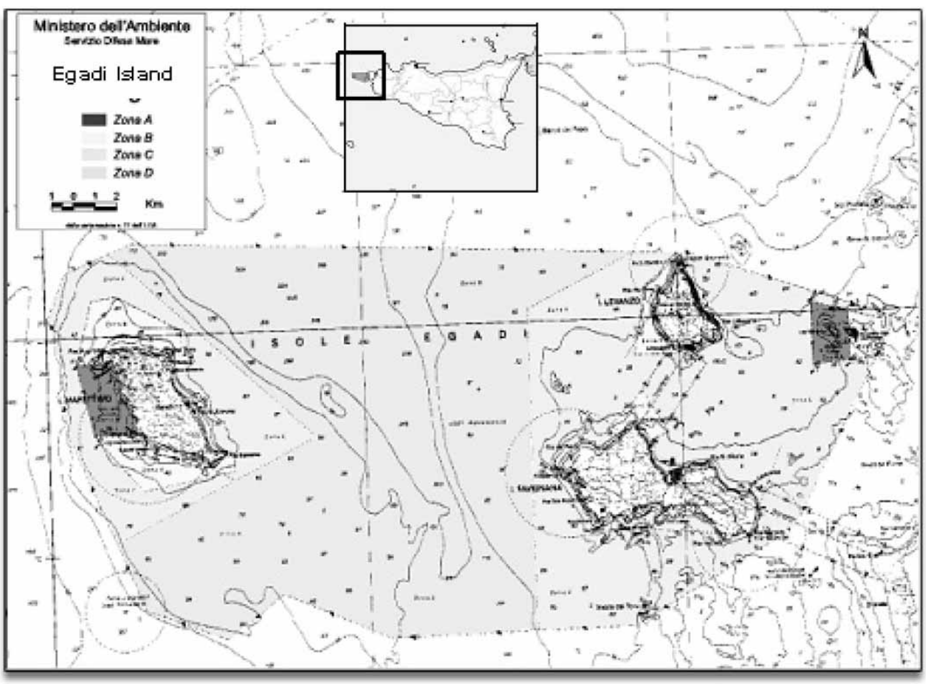

Figure 1. Map of Egadi Island.

Favignana and Marettimo, to characterize the most utilized gears and the species caught most often. From these, we selected the "target species" for our analyses to qualify the fish products of the Egadi Islands. The target species, *Scorpaena porcus* (Linnaeus, 1758), *Scorpaena scrofa* (Linnaeus, 1758), *Palinurus elephas* (Fabricius, 1787), and *Sepia officinalis* (Linnaeus, 1758), were caught in the typical areas used by local fishermen of Egadi Islands, by trammel net, during the months of June and July 2003.

The samples were kept cold until they were transferred to the laboratory for analysis on fresh products. In each month, eight samples of each species were weighed, gutted, and filleted, and homogeneous samples were prepared (two replicates for each species to be used for analysis). The live weight of *Scorpaena porcus* was 250–350 g, for *Scorpaena scrofa* 350–450 g, for *Palinurus elephas* 1000–1700 g, and for *Sepia officinalis* 400–600 g.

Each sample was analysed in duplicate for moisture, ash, protein, total lipid content, and for fatty-acid percentage distribution. The moisture and ash content was determined according to AOAC official methods [8, 9]; protein content was determined by the Kjeldhal method [10]; for the determination of total lipids, the minced samples were extracted with a mixture of chloroform/methanol (2:1, v/v) according to the Folk method [11], modified by Ways and Hanahan [12]. Weighed portions (around 15 mg) of the total lipid were converted to fatty-acid methyl esters (FAMEs) [13] by direct transesterification with 1% sulphuric acid/methanol under reflux and in an argon atmosphere. FAMEs were analysed [14] by gas chromatography with a DANI 1000 gas chromatograph equipped with a hydrogen flame ionization detector (FID). Separations were realized with a 30 m $\times$ 0.32 mm i.d. fused silica capillary column Omegawax 320 (Supelco, Italy) with a 0.25 mm film thickness. The individual FAMEs were identified by comparison with the retention times of standard mixtures (Supelco PUFAs 1–2 and Menhanden Oil Test Mix).

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The saturated/unsaturated fatty-acid ratio (S/P), atherogenicity index (AI), and thrombogenicity index (TI) were calculated according to Ulbricht and Southgate [15].

The SPSS 11.5 (2002) software package (SPSS, Chicago, IL) was used for statistical treatment of the data. A one-way analysis of variance (ANOVA) was applied to the data to determine the presence of significant differences (Duncan test, significant level $P < 0.05$) in the gross composition and fatty-acid distribution among the four species, and for each species between the June and July samples.

3. Results and discussion

The fishing activity practised by fishermen of the Egadi Islands Marine Protected Area (MPA) was characterized principally by small boats that practise artisan fishing, alternating the use of more gears during the year. During the summer period, this activity is supported by fishing tourism, which has undergone a development in the last year and is increasing, thanks to the presence of the MPA.

The Favignana fishery had the highest number of boats, with 30 boats in service, followed by Marettimo's fishery, which has 11 boats and, finally, by the Levanzo fishery with only two boats.

The main fishing activity is carried out using the trammel net (91%), whereas the use of gillnets (49%), surrounding nets (33%) and entangling nets (26%) is limited to those seasonal periods suitable for the capture of species like *Boops boops*, *Maena* sp., *Trachurus* sp., *Oblada melanura, Scomber japonicus*, *Gymnammodites cicerellus*, and *Belone belone gracilis*. The bottom trawl is used very little. The use of pots for species such as *Palinurus elephas* has been greatly reduced (2%). Local fishermen said that they were very widespread until 10 yr

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ago. The bottom longline is used very often (63%), because in the MPA the sea bottom is rich with *Posidonia oceanica*, and there are areas of rocky substratum that are conducive for this activity.

Considering these local traditional gears, the species *Scorpaena porcus*, *Scorpaena scrofa*, *Palinurus elephas*, and *Sepia officinalis* were found to be the most representative and with the greatest commercial value.

Table 1 shows the approximate chemical composition (% w/w of raw material) of the four species considered, regardless of the catch month as, from the analysis of the variance of the data, no statistically significant differences ($P > 0.05$) were found between the June and July samples of the same species. Considering the different species, ANOVA showed that *P. elephas* had the highest ($P < 0.05$) ash content, whereas the lipid amount was found to be significantly higher for *S. officinalis* and lower for *S. scrofa* and *S. porcus*. All species showed the same ($P > 0.05$) moisture (mean value 79.22%) and protein content (mean value 18.15%).

The protein content of *Scorpaena porcus* and *Scorpaena scrofa* from the Egadi Islands is similar to that reported for these species caught in different areas [16] but was found to be higher than the protein content of species considered valuable, such as cod, dentex, or sole. However, *Palinurus elephas* and *Sepia officinalis* had a protein content higher than other specimens of the same species harvested in different areas [17].

Regarding the fat content, all the values obtained were less than 3%, so the species analysed can be considered lean. However, it is interesting to note how all the samples showed an enrichment of fat compared with samples of the same species from different origins [17–19].

Tables 2 and 3 list the fatty acid percentage distribution (% w/w of total fatty acids) and sum of saturated, monounsaturated, and polyunsaturated acids for the species analysed and, within each species, for samples caught in June and July, respectively.

The analysis of the variance of the data in tables 2 and 3 emphasized that for each species, samples caught in different months showed similar fatty-acid profiles. In fact, only a few fatty acids present at very low percentages showed any significant differences ($P < 0.05$) between the June and July samples, whereas the most abundant fatty acids and the sums of saturated, monounsaturated, and polyunsaturated fatty acids were not significantly different ($P > 0.05$).

Among the different species, statistical significant differences were observed for almost all the fatty acids excluding stearic acid (C18:0) and DHA (C22:6 n3). Considering the most abundant fatty acids, palmitic acid (C16:0) showed the lowest level ($P < 0.05$) for *Palinurus elephas*, whereas same levels ($P > 0.05$) for *Sepia officinalis*, *Scorpaena scrofa* and *Scorpaena porcus*.

Oleic acid (C18:1 n9), the most representative of monounsaturated fatty acids, was found to be statistically higher in *Scorpaena scrofa* samples and lower in *Sepia officinalis* samples; this acid has particular importance in human feeding for the stimulation of bile secretion, which is necessary for digestion and absorption of fats.

Table 1. Proximate chemical composition (% w/w of row material).

	Palinurus elephas	*Sepia officinalis*	*Scorpaena scrofa*	*Scorpaena porcus*
Moisture	78.45 ± 0.62	78.68 ± 0.54	79.82 ± 0.54	79.93 ± 0.57
Ash	2.18 ± 0.04b	1.51 ± 0.28a	1.29 ± 0.04a	1.42 ± 0.09a
Protein	18.11 ± 0.58	18.32 ± 0.35	18.39 ± 0.47	17.78 ± 1.07
Total lipid (M ± S.D.)	1.91 ± 0.09ab	2.38 ± 0.39b	0.68 ± 0.10a	0.80 ± 0.16a

Note: Values in the same row with different letters are significantly different ($P < 0.05$).

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Table 2. Fatty-acid percentage distribution (% w/w of total fatty acids).

Fatty acid	*Palinurus elephas* June	*Palinurus elephas* July	*Sepia officinalis* June	*Sepia officinalis* July	*Scorpaena scrofa* June	*Scorpaena scrofa* July	*Scorpaena porcus* June	*Scorpaena porcus* July
C14:0	0.65ab	0.49a	1.60c	1.80c	1.32bc	0.75ab	1.86c	1.97c
C15:0	0.38abc	0.28ab	0.53c	0.47bc	0.32abc	0.19a	0.44bc	0.22a
C16:0 iso	0.05ab	0.04ab	0.07abc	0.08be	0.09be	0.10c	0.10c	0.04a
C16:0	13.35a	11.82a	30.78b	31.75b	29.53b	28.83b	29.14b	28.35b
C17:0 iso	0.36d	0.07ab	0.23c	0.04a	0.18c	0.15bc	0.16bc	0.06ab
C17:0	0.81bc	0.56ab	1.16c	0.95c	0.29a	0.26a	0.46ab	0.29a
C18:0	9.52	7.93	9.56	8.76	4.99	6.77	6.35	5.65
C20:0	0.50bc	0.37abc	0.41bc	0.30ab	0.57bc	0.06a	0.70c	1.10d
C22:0	0.48d	0.41d	0.34cd	0.21bc	0.02a	0.05a	0.08ab	0.07ab
C23:0	0.07bc	0.12d	0.10cd	0.06b	0.00a	0.00a	0.05b	0.04b
C24:0	0.03ab	0.08b	0.21c	0.00a	0.07b	0.01a	0.06b	0.03ab
C14:1	0.04a	0.04a	0.08ab	0.06ab	0.13c	0.06ab	0.09b	0.05a
C16:1n7	2.97bc	3.77bc	0.46a	0.38a	2.40b	0.99bc	5.93d	4.85cd
C18:1n9	9.19b	9.28b	2.10a	1.73a	7.75c	6.46c	13.06bc	11.31bc
C18:1n7	1.77ab	1.63ab	1.18a	0.89a	1.08a	1.00a	2.53bc	3.25c
C18:1n5	0.10b	0.10b	0.11b	0.07b	0.13b	0.00b	0.10b	0.02a
C20:1n11	0.21a	0.26a	2.91b	2.30b	0.17a	0.16a	0.50a	0.43a
C20:1n9	0.18b	0.22bc	0.15b	0.05a	0.17b	0.31c	0.00a	0.00a
C22:1n11	0.12b	0.15b	0.25c	0.12b	0.00a	0.00a	0.05a	0.05a
C24:1n9	0.03a	0.08ab	0.29b	0.00a	0.98d	0.72c	0.00a	0.00a
C18:3n3	0.33cd	0.21abc	0.29bc	0.07a	0.17ab	0.09bc	0.44d	0.17ab
C18:4n3	0.09ab	0.12ab	0.04a	0.10ab	0.17b	0.06a	0.32c	0.16b
C20:3n3	0.10ab	0.09ab	0.27d	0.22cd	0.05bc	0.00b	0.12ab	0.03a
C20:4n3	0.01a	0.06ab	0.12bc	0.01a	0.13bc	0.12bc	0.21d	0.16cd
C20:5n3	16.74c	12.62bc	7.64ab	11.14bc	1.83a	2.50a	6.59ab	5.01a
C21:5n3	0.21b	0.19b	0.15ab	0.07a	0.00b	0.00c	0.08a	0.07a
C22:5n3	0.80bc	0.44ab	0.50ab	0.52ab	0.24a	0.54ab	1.13c	1.00c
C22:6n3	6.80	10.48	12.68	16.46	9.11	11.29	11.70	16.14
C18:2n6	1.14d	0.98cd	0.27ab	0.21ab	0.74cd	0.56bc	1.46e	0.08a
C18:3n6	0.28d	0.21cd	0.21cd	0.15bc	0.14bc	0.07ab	0.14bc	0.02a
C20:2n6	0.63b	0.65b	0.30a	0.16a	0.78b	0.56b	0.19a	0.10a
C20:3n6	0.01a	0.05bcd	0.09e	0.07cde	0.07de	0.02ab	0.09e	0.04abc
C20:4n6	16.48b	17.90b	1.42a	1.19a	2.81a	2.90a	5.98a	6.13a
C22:4n6	0.25a	0.21a	0.19a	0.12a	0.28a	0.24a	0.49b	0.44b
C22:5n6	0.42a	0.44a	0.24a	0.25a	0.30a	0.72b	0.38a	0.76b
C16:4n1	1.65b	0.25a	0.35a	0.22a	0.29a	0.23a	0.27a	0.22a
C16:2n4	0.08abc	0.05ab	0.09bc	0.00a	0.35e	0.20d	0.15cd	0.06ab
C16:3n4	0.32ab	1.31c	0.20a	0.58b	0.27ab	0.24a	0.38ab	0.21a

Note: Values in the same row with different letters are significantly different ($P < 0.05$).

Table 3. Fatty-acid classes content (%) in total lipids.

	Palinurus elephas June	*Palinurus elephas* July	*Sepia officinalis* June	*Sepia officinalis* July	*Scorpaena scrofa* June	*Scorpaena scrofa* July	*Scorpaena porcus* June	*Scorpaena porcus* July
Saturated	26.21a	22.18a	45.02c	44.43c	37.38bc	37.18bc	39.41bc	37.81bc
Monounsaturated	14.62bc	15.53bc	7.53a	5.59a	22.83c	21.77c	22.27c	19.95c
Polyunsaturated	46.33b	46.23b	25.04a	31.52ab	24.06a	23.43a	31.69ab	30.81ab
Σ Poly n3	25.08	24.20	21.70	28.57	18.03	17.69	22.17	22.74
Σ Poly n6	19.20c	20.42c	2.71ab	2.15b	5.12ab	5.07ab	8.72b	7.58ab
n3/n6	1.31a	1.18a	8.01b	13.30b	3.52a	3.49a	2.54a	3.00a

Note: Values in the same row with different letters are significantly different ($P < 0.05$).

Among the polyunsaturated fatty acids, EPA showed the highest levels ($P < 0.05$) in *Palinurus elephas* followed by *Sepia officinalis* and the Scorpaenidae. Also, the C20:4 n6 acid showed the highest levels ($P < 0.05$) in *P. elephas*, but no statistical significant differences were found among the other species.

Statistically significant differences ($P < 0.05$) were observed among the species for the sum of saturated, monounsaturated, and polyunsaturated fatty acids and for the sum of n-6 polyunsaturated fatty acids. Data reported in table 3 emphasize that, compared with the other species, *S. officinalis* had the highest values of saturated fatty acids and the lowest values of monounsaturated fatty acids, whereas *P. elephas* showed the lowest levels of saturated fatty acids and the highest levels of polyunsaturated fatty acids. No statistically significant differences were observed between the two Scorpaenidae for saturated and monounsaturated fatty acids, whereas *Scorpaena porcus* was found to be the species with the lowest amount of polyunsaturated fatty acids.

All the species showed a high content of polyunsaturated fatty acids due to high percentages of n-3 series, especially EPA and DHA, with an n-3/n-6 ratio always >1. The values of n-3 polyunsaturated fatty acids are also higher than those of the same or similar species caught in different areas [17].

The fatty acids of the n-6 series characterize the lipid composition of terrestrial animals and are precursory substances with a strong thrombotic and inflammatory effect.

The ratio n-3/n-6 is of great importance for human health due to the competition of both the fatty acid series for the enzymes involved in metabolism, leading to various pathologies [20]. Furthermore, for the phospholipids of the membrane and the plasma, this ratio n-3/n-6 plays a determined role in the fluidity of the membrane, in genetic expression, in the regulation of lipid levels, and in the immune response. All these factors can prevent or favour the onset not only of cardiac illnesses, but also of hypertension, diabetes, arthritis, multiple sclerosis, cancer, and other auto-immune pathologies [21]. The values of indexes relating to dietetic factors linked with coronary diseases are reported in table 4.

Statistically significant differences ($P < 0.05$) were observed among the different species; in particular, for *Palinurus elephas* the saturated/polyunsaturated ratio (S/P) and the atherogenic index (AI) were lower than those calculated for the other three species, on the contrary *Sepia officinalis* showed the highest values both for the saturated/polyunsaturated ratio and for the atherogenic index, whereas no significant differences were observed between the two Scorpaenidae. Thrombogenic indexes (TI) did not show any significant differences among the species.

The AI of *Sepia* was very high, even higher than that reported by Ulbricht and Southgate [15] for lamb (1.00); the values of AI for Scorpaenidae were very similar to the AI values reported for bovine meat (0.72), whereas *P. elephas* showed a good AI value very similar to that of mackerel (0.28).

Instead, TI were often lower than those of the aforementioned products: lamb (1.58), bovine meat (1.08), and lean pork (1.37), with the exception of mackerel (0.16), a marine fish with the highest content of n-3 polyunsaturated fatty acids.

Table 4. Ulbricht and Southgate indexes correlated with cardiovascular disease.

	Palinurus elephas	*Sepia officinalis*	*Scorpaena scrofa*	*Scorpaena porcus*
S/P	0.36a	1.22c	0.78b	0.70b
AI	0.25a	1.12c	0.74b	0.71b
TI	0.24	0.48	0.51	0.43

Note: Values in the same row with different letters are significantly different ($P < 0.05$). S/P: saturated/polyunsaturated fatty-acid ratio; AI: atherogenicity index; TI: thrombogenicity index.

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Finally, the saturated/polyunsaturated ratio was found to be very low for all the target species, except *Sepia officinalis*, also compared to the aforementioned aforementioned products, including mackerel.

It is important to highlight how all the species analysed showed TI values lower than AI values, whereas meat from terrestrial animals has TI indexes higher than AI indexes [3]. This indicates that fish can be considered as a food suitable for the prevention of thrombotic diseases.

In conclusion, this study can provide useful information on the chemical composition of several important species from the Egadi Islands, highlighting good nutritional values. As for marine species, the geographical location of catch, the season of the year, and the feeding habits of the species are uncontrollable variables in terms of their chemical composition, and further studies are in progress in order to fully characterize these species considering the seasonal variation.

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