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Original Article

Proximate, unsaponifiable lipid and fatty acid composition of bogue (*Boops boops*) and horse mackerel (*Trachurus trachurus*) from the Italian trawl fishery

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ABSTRACT

This study was aimed at evaluating the nutritional properties of bogue (*Boops boops*) and horse mackerel (*Trachurus trachurus*), fish species present throughout the Mediterranean and highly represented in the catch of the Italian trawl fishery. In Italy such fish species are scarcely known by consumers and are not sought-after on the market, especially when the fish are small. Proximates, unsaponifiables and fatty acid profile of bogue and horse mackerel caught by trawlers in different seasons of the year along the southern Adriatic coast of Italy were evaluated. Results showed that both species were characterised by good protein contents (18–20 g/100 g) and low lipid (1–2 g/100 g) and cholesterol (50–70 mg/100 g) levels at any season considered. Along with α-tocopherol (0.45–0.70 mg/100 g), δ-tocopherol was found at a lower level (0.04–0.09 mg/100 g) while no detectable amounts of the γ-isomer were observed in either species. The fatty acid profiles of horse mackerel and bogue exhibited a seasonal fluctuation. They were characterised by high proportions of polyunsaturated fatty acids (PUFA), ranging from about 30% of total fatty acids in summer to more than 40% of total fatty acids in spring and winter, and by high n-3/n-6 PUFA ratio values (4.4–6.8 for bogue, 7.4–8.2 for horse mackerel). On a quantitative basis, in bogue total n-3 PUFA amounted to 0.29–0.43 g out of 0.33–0.54 g of total PUFA per 100 g wet fillet. In horse mackerel total n-3 PUFA ranged between 0.37 g and 0.43 g/100 g and total PUFA between 0.41 and 0.49 g/100 g wet fillet. The atherogenic (0.46–0.63) and thrombogenic (0.22–0.38) indexes calculated on bogue and horse mackerel were comparable to those of fish species of higher commercial value. The nutritional properties of these underutilised species may be considered comparable to those of other low-fat fish species from the wild and also from aquaculture present on the Italian market and meeting consumers' preferences.

1. Introduction

Trawl fishery in the Mediterranean is a multi-species fishery characterised by a wide range of commercial species but also by an abundance of fish species with low commercial value. In fact, together with the target fish species, other non-target species, often of no economic interest, or undersized or damaged individuals of the target species, are caught by trawling. In the Mediterranean, among the various fishing techniques, trawling has the strongest impact in terms of discards and bycatch species, although a precise knowledge of the discards still needs to be carried out.

In the Code of Conduct for Responsible Fisheries of the Food and Agriculture Organization of the United Nations (1995), governments are encouraged to develop activities aimed at reducing post-catch losses and discards and at improving the use of bycatch through responsible fisheries management practices. Recently the Food and Agriculture Organization of the United Nations (2010) released International Guidelines for bycatch management and reduction of fishing discards. The purpose of these Guidelines is to assist States in the effective management of bycatch and reduction of discards and to promote responsible fisheries by minimizing the capture and mortality of species or sizes not specifically targeted.

In Italy, the catch of trawl fishery, accounting for about 35% of the total marine catch, is highly represented by small pelagic species with low economic value, scarcely known by consumers and poorly appreciated and commercialised (Ministero delle Politiche Agricole, Alimentari e Forestali, 2007). Bogue (*Boops boops*), horse mackerel (*Trachurus trachurus*), scaldfish (*Arnoglossus laterna*), Atlantic stargazer (*Uranoscopus scaber*) and picarel (*Spicara smaris*) are some of the species that fishermen treat as discards and often return to the sea together with inedible, undersized or damaged organisms. Bogue (*B. boops*), gregarious and omnivorous species inhabiting the sea bottom, and horse mackerel (*T. trachurus*), pelagic and carnivorous, are both fish species common throughout the Mediterranean and highly

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represented in the catch of the Italian trawl fishery. In 2006 the Italian fishery production of bogue and horse mackerel amounted to 3042 and 5470 tons, respectively, about 50% being contributed in either case by trawl fishery (Ministero delle Politiche Agricole, Alimentari e Forestali, 2007). In spite of their abundance, in Italy bogue and horse mackerel, especially at the small sizes, have a low economic interest finding no appreciation on the market. In fact, especially in urbanized areas, the global market trends affect mostly the consumers' preference thus privileging those species with a higher commercial value present on the market like hake (*Merluccius merluccius*) or sole (*Solea vulgaris*), from fishery, or gilthead sea bream (*Sparus aurata*), sea bass (*Dicentrarchus labrax*) and trout (*Oncorhynchus mykiss*), from aquaculture. Bogue and horse mackerel are also reported to be highly present, especially if undersized, in the discards generated by bottom trawling or other fishing techniques in different Mediterranean areas (Machias et al., 2001; Cabral et al., 2003; Sanchez et al., 2004; Gonçalves et al., 2007; Batista et al., 2009). In particular *T. trachurus*, although of a certain commercial interest, is often reported as discarded, at the smallest sizes, by Greek trawlers in the eastern Ionian Sea and Cyclades Islands (Machias et al., 2004). Horse mackerel is also reported to be present in the discards of French benthic trawlers in the Celtic Sea (Rochet et al., 2002) and of Dutch pelagic trawlers (Borges et al., 2008) and to be one of the top 10 most discarded species by English and Welsh otter trawlers (Enever et al., 2007).

A good knowledge of the nutritional properties of fish species with a low commercial interest represents the first step toward a process of valorisation of underutilised products and divulgation to the market and to consumers of their inherent quality. The aim of this study was to evaluate the nutritional properties of bogue (*B. boops*) and horse mackerel (*T. trachurus*) caught by trawl along the Southern Adriatic coast of Italy. Knowledge of their nutritional properties would help individuate elements useful to their valorisation and promotion on the market.

2. Materials and methods

2.1. Fish sampling and treatment

Bogue (*B. boops*) and horse mackerel (*T. trachurus*) were caught by trawl along the Southern Adriatic coast of Italy in three sites of the Apulia Region: S.Foca (Lecce), Lesina (Foggia) and Manfredonia (Foggia). At each site, fishing campaigns occurred in different seasons of the year: bogue was captured in September 2006 and in March 2007; horse mackerel was captured in September 2006 and in March and December 2007.

At landing, fish were transferred in polystyrene boxes containing ice and quickly transported in refrigerated conditions (4 °C) to the National Research Institute for Food and Nutrition, in Rome, for chemical analyses. Upon arrival at the laboratory, somatometric measurements were taken on single specimens (Table 1). Soon after, fish were beheaded, washed, filleted, vacuum-packed in multilayer barrier bags and frozen at −75 °C to be analysed within one week. Within each seasonal sampling 2 pools of fish per fishing site, each composed of 10–15 specimens of comparable body size, were analysed separately in duplicate.

2.2. Proximate composition

On the day of analyses fish fillets were rapidly thawed, skinned, chopped, combined in a pool, and homogenised for 1 min in a Waring blender (model 8010E, Waring® Products Division, New Hartford, CT., USA) at a low speed using a previously cooled stainless steel cup.

In the muscle tissues were determined moisture, by oven-drying at 105 °C until a constant weight was reached, crude protein

Table 1
Somatometric data of bogue (*Boops boops*) and horse mackerel (*Trachurus trachurus*) caught by trawl along the Southern Adriatic Coast of Italy in different seasons: means ± standard deviations.

	Bogue[†]		
	September ($n=3$)	March ($n=3$)	*t*-Test
Length (cm)	14.8 ± 1.0	16.1 ± 2.7	
Weight (g)	33.19 ± 6.89	40.60 ± 19.54	
Edible portion (% weight)	68.74 ± 2.47	62.15 ± 1.66	*

	Horse mackerel[††]		
	September ($n=3$)	March ($n=3$)	December ($n=2$)
Length (cm)	22.7 ± 4.9[a]	23.9 ± 3.6[a]	23.2 ± 5.9[a]
Weight (g)	108.46 ± 60.93[a]	116.23 ± 48.19[a]	108.28 ± 77.29[a]
Edible portion (% weight)	67.58 ± 0.95[b]	62.42 ± 0.77[a]	64.22 ± 2.91[ab]

[†] *t*-Test: $^{*}P \leq 0.05$.
[††] ANOVA: within a row, values not sharing the same superscript letter are significantly different ($P \leq 0.05$).

($N \times 6.25$), after determination of total nitrogen with a Kjeldahl digestion, and ash contents, after ignition in a muffle furnace, following the Association of Official Analytical Chemists (1990) methods 950.46, 955.04 and 938.08, respectively. The pH was measured at 20 °C on a water:fish homogenate (2:1, w/w). Nonprotein nitrogen was determined by the Kjeldahl method 955.04 (Association of Official Analytical Chemists, 1990) after protein precipitation with 10% (w/v) trichloroacetic acid (Carlo Erba, Milano, Italy). Total lipids were extracted following the method of Bligh and Dyer (1959) slightly modified according to Kinsella et al. (1977) in the presence of tert-butyl-hydroquinone (TBHQ, Fluka Chemie AG, Buch, Switzerland) dissolved in methanol (1% w/v) as antioxidant.

2.3. Unsaponifiable lipids

Cholesterol, squalene, α-tocopherol, γ-tocopherol and δ-tocopherol in total lipids were quantified by High Performance Liquid Chromatography (HPLC) after saponification with ethanolic potassium hydroxide (Carlo Erba, Milano, Italy) under nitrogen atmosphere at 70 °C in the presence of TBHQ (Orban et al., 2000). The HPLC system used was a Hewlett-Packard (Waldbronn, Germany) 1100 Series liquid chromatograph equipped with an UV/visible photodiode array detector. The analytical separations were performed using a stainless steel (25 cm × 4.6 mm inner diameter) 5 μm Ultrasphere C18 column (Beckman, Palo Alto, CA., USA). Analytes were identified by their retention times and UV–vis spectra. Peak areas were used to determine analyte concentrations in the samples by reference to standard curves obtained by chromatographing pure cholesterol, squalene, α-tocopherol, γ-tocopherol and δ-tocopherol (Sigma Aldrich, St. Louis, MO, USA) under identical conditions.

2.4. Fatty acids

Fatty acid profiles of total lipids were determined after transesterification with a 1:1 (v/v) 14% boron trifluoride in methanol (Sigma Aldrich, St. Louis, MO, USA)/methanol solution. Fatty acid methyl esters were extracted with hexane and quantified by Gas Chromatography (GC) using a 6890 Hewlett-Packard gas chromatograph with a flame ionisation detector, equipped with a SPB™ PUFA fused silica capillary column, 30 m × 0.25 mm inner diameter, 0.20 μm film thickness (Supelco Inc., Bellefonte, PA, USA). Operating conditions were as previously described (Orban et al., 2000).

Fatty acids were identified by comparison of retention times to authentic standards for percent area normalisation and by Mass-GC (3900/SATURN 2100T GC/MS from Varian, Walnut Creek, CA.,