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Original Article

Chemical composition of Atlantic spider crab *Maja brachydactyla*: Human health implications

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ABSTRACT

The Atlantic spider crab *Maja brachydactyla* is highly appreciated and widely consumed in Southern European countries. Because there is a lack of nutritional information concerning this species, this study aimed to characterize the chemical composition of muscle, hepatopancreas and gonads of *M. brachydactyla* and to analyze the health implications for consumers. All tissues were valuable sources of high quality proteins, amino acids (e.g. glutamic acid, aspartic acid, arginine, leucine and taurine) and macro and trace elements (e.g. Na, Cl, Cu, Zn and Se). Muscle and gonads were particularly richer in essential polyunsaturated fatty acids (e.g. 20:5*n*-3, 22:6*n*-3), and had lower fat, calories, Ca, Fe, Cd, saturated and monounsaturated fatty acids than hepatopancreas. Low to moderate cholesterol values were found in all tissues. Consequently, the consumption of the muscle and gonads of Atlantic spider crab is adequate for cholesterol-restricted, low fat, balanced and safe meat diets to meet consumers' requirements. In contrast, hepatopancreas consumption is not recommended in such diets due to the high levels of fat, energy, Cd, and saturated and monounsaturated fatty acids.

1. Introduction

It is generally accepted that seafood is important in a healthy, safe, nutritious and balanced diet (WHO, 2003). Seafood is an important source of valuable nutrients, like minerals (e.g. calcium, iron, zinc, iodine, selenium, copper), vitamins, fatty acids (e.g. long chain *n*-3 poly-unsaturated fatty acids) and high-quality proteins with essential amino acids, and is low in saturated fats (Kris-Etherton et al., 2002; Nesheim and Yaktine, 2008). Polyunsaturated *n*-3 fatty acids are known to decrease the risks of coronary heart disease and cancer and to improve the response to inflammatory diseases, like eczema, psoriasis and rheumatoid arthritis (Gil, 2002; Roynette et al., 2004; Harper and Jacobson, 2005). However, seafood under certain circumstances poses risks to consumers as it can contain high levels of contaminants (e.g. As, Hg, Cd and Pb) that either occur naturally or result from human interventions and processes (Sioen et al., 2008).

The Atlantic spider crab *Maja brachydactyla* is a decapod crustacean of the Majidae family, which contains approximately 900 species and is widely distributed in marine waters. This species is found along northeast Atlantic coasts, from North Africa to the North Sea and from sea level to 90 m. It has been recently separated from the Mediterranean endemic spider crab *M. squinado* (Hines et al., 1995; Neuman, 1998). Both species are highly appreciated in the coastal areas of southern European countries (e.g. France, Spain, Italy and Portugal), with peak consumptions during summer holidays and Christmas festivities. Catches of *M. squinado* are rather limited (around 150 tonnes, mostly from Croatia, Serbia and Morocco) compared to *M. brachydactyla* (around 5000 tonnes, mostly from France and UK) (data from 2005; EUROSTAT, 2009). *M. brachydactyla* lives in different habitats and feeds on a variety of organisms, like seaweeds, mollusks and echinoderms, depending on availability (Bernardez et al., 2000). These factors, combined with the intrinsic physiological needs of spider crabs, probably affect their nutritional quality to consumers. Although the nutritional compositions of several crustaceans were reported in previous studies (e.g. Rosa and Nunes, 2003; Chen et al., 2007), to the best of our knowledge none have been carried out on the Atlantic spider crab.

Fundamental knowledge about the nutritional quality of crustaceans and human health implications of its consumption are still lacking, and these would be essential to facilitate the utilization and marketing of this seafood. The purpose of the present study was to determine the proximate chemical

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composition, amino acid and fatty acid profiles, and the elemental (macro, trace and toxic) and cholesterol contents in the edible tissues of *M. brachydactyla*. Additionally, the human health implications of consuming this species are also discussed.

2. Materials and methods

2.1. Samples

Twenty intermoult female *M. brachydactyla* from the Scottish coast (total weight: 569 ± 88 g; carapace width: 139.9 ± 6.8 mm; carapace length: 122.3 ± 5.4 mm) were purchased alive from a local importer (origin: English Channel; source: Viveiros Barrosinho, Setúbal, Portugal) and transported alive to the laboratory under refrigerated conditions (10–15 °C). Animals were kept under refrigerated conditions (4 °C) during one hour to decrease their metabolism before being euthanized by piercing of the two nerve centres by means of a stainless steel rod. The rod is inserted through one of the eyes and through the vent as recommended by the Codex Alimentarius Recommended International Code of Practice for crabs (Codex Alimentarius, 1983). The muscle (from claws and walking legs), hepatopancreas, gonads and gills from each animal were individually separated and weighed. Each tissue was subsequently homogenized with a grinder (Grindomix GM200; Retsch GmbH&Co., Haan, Germany; material: PP cup and stainless steel knifes), vacuum packed and stored at −20 °C. A portion of each frozen sample was freeze-dried for 48 h at −50 °C and low pressure (approximately 10^{-1} atm). Samples were powdered and stored at −20 °C under controlled humidity conditions (vacuum packed) until further analyses.

2.2. Proximate chemical composition and energy content

The proximate chemical composition was performed with composite samples of two animals ($n = 10$ for each tissue). Moisture content was obtained by drying each sample (10 g in Petri dishes) in an incubator (ULE500, Memmert GmbH & Co., Schwabach, Germany) overnight at 105 °C until a constant weight was obtained, while ash was quantified after combustion of dried samples (10 g each) for 16 h at 500 °C (AOAC, 2000). Crude protein content of each sample (1 g) was obtained by the Kjeldahl method (AOAC, 2000), with a conversion factor of 6.25 to convert total nitrogen into crude protein. Total lipid was determined for each sample (10 g) with the Soxhlet hot extraction method using ethyl ether AOAC, 2000). The energy content was estimated as: proteins, 4.27 kcal g^{-1} wet weight; lipids, 9.02 kcal g^{-1} wet weight; carbohydrates, 4.11 kcal g^{-1} wet weight; 1 kcal, 4.184 kJ (FAO, 1987). Accuracy was checked through analysis of certified biological material: canned matrix meat (SMRD-2000; Swedish Meats R&D and Scan Foods/National Food Administration) (Table 1).

2.3. Elements

The Energy Dispersive X-ray Fluorescence (EDXRF; EXTRA II A, Atomika Instruments, Temple, Arizona, USA) was employed to quantify the elements Cl, S, K, Ca, Fe, Ni, Cu, Zn, As, Se, Br, Rb and Sr.

Table 1
Summary of reference material concentration (μg g^{-1} DW; $n = 4$) and detection limits (DL) (±standard deviation) analyzed by the different techniques.

Elements	Technique	DL	Certified biological material	Certified	Present work
Sodium (Na)	FAAS	0.37	Canned matrix meat—SMRD 2000	8533 ± 281	8346 ± 280
Magnesium (Mg)	FAAS	0.05	Non defatted lobster hepatopancreas—LUTS-1	89.5 ± 4.1	90.9 ± 2.2
Chloride (Cl)	EDXRF	100	Oyster tissue—SRM 1566	10,000*	10,200 ± 500
Sulphur (S)	EDXRF	100	Oyster tissue—SRM 1566	7600*	8200 ± 500
Potassium (K)	EDXRF	10	Oyster tissue—SRM 1566	9690 ± 50	10,000 ± 80
Calcium (Ca)	EDXRF	20	Oyster tissue—SRM 1566	1500 ± 200	1350 ± 50
Manganese (Mn)	FAAS	0.04	Non defatted lobster hepatopancreas—LUTS-1	1.20 ± 0.13	1.38 ± 0.03
Iron (Fe)	EDXRF	3	Oyster tissue—SRM 1566	195 ± 34	210 ± 15
Nickel (Ni)	EDXRF	1.1	Lobster hepatopancreas—TORT-2	2.5 ± 0.2	2.4 ± 0.5
Copper (Cu)	EDXRF	0.7	Oyster tissue—SRM 1566	63.0 ± 3.5	63.6 ± 4.0
Zinc (Zn)	EDXRF	1	Oyster tissue—SRM 1566	852 ± 14	830 ± 40
Arsenic (As)	EDXRF	0.7	Oyster tissue—SRM 1566	13.4 ± 1.9	13.4 ± 0.5
Selenium (Se)	EDXRF	0.6	Oyster tissue—SRM 1566	2.1 ± 0.5	2.3 ± 0.5
Bromine (Br)	EDXRF	1	Freeze-dried animal blood—IAEA-A-13	22 ± 3	22 ± 2
Rubidium (Rb)	EDXRF	1.1	Orchard leaves—SRM 1571	12 ± 1	11.5 ± 0.4
Strontium (Sr)	EDXRF	0.5	Oyster tissue—SRM 1566	10.4 ± 0.6	9.9 ± 0.8
Cadmium (Cd)	FAAS	0.01	Lobster hepatopancreas—TORT-2	26.7 ± 0.6	26.8 ± 0.1
Mercury (Hg)	FAAS	0.02	Lobster hepatopancreas—TORT-2	0.27 ± 0.06	0.28 ± 0.00
Lead (Pb)	FAAS	0.02	Lobster hepatopancreas—TORT-2	0.35 ± 0.13	0.35 ± 0.06
Moisture	Drying	nd	Canned matrix meat—SMRD 2000	68.8 ± 0.1	68.7 ± 0.0
Protein	Kjeldahl	nd	Canned matrix meat—SMRD 2000	1.63 ± 0.05	1.62 ± 0.06
Lipids	Soxhlet	0.01	Canned matrix meat—SMRD 2000	14.3 ± 0.4	14.4 ± 0.1
Ash	Combustion	0.1	Canned matrix meat—SMRD 2000	2.65 ± 0.07	2.69 ± 0.03
Fatty acids					
14:0	GC	0.4–1	Beef pork fat blend—BCR-163	2.29 ± 0.04	2.23 ± 0.04
16:0	GC	0.4–1	Beef pork fat blend—BCR-163	25.96 ± 0.30	25.39 ± 0.017
16:1	GC	0.4–1	Beef pork fat blend—BCR-163	2.58 ± 0.16	2.22 ± 0.03[a]
18:0	GC	0.4–1	Beef pork fat blend—BCR-163	18.29 ± 0.16	17.65 ± 0.06
18:1	GC	0.4–1	Beef pork fat blend—BCR-163	38.34 ± 0.36	38.65 ± 0.16[b]
18:2	GC	0.4–1	Beef pork fat blend—BCR-163	7.05 ± 0.17	7.19 ± 0.03[c]
18:3	GC	0.4–1	Beef pork fat blend—BCR-163	0.86 ± 0.14	0.81 ± 0.01[d]
Amino acids	HPLC	nd	No reference material used	nd	nd
Cholesterol	GC	nd	No reference material used	nd	nd

Reference materials suppliers and location: SMRD-2000 (Swedish Meats R&D and Scan Foods/National Food Administration, Sweden), LUTS-1/TORT-2 (National Research Council of Canada, Canada), SRM 1566/SRM 1571 (United States National Bureau of Standards, USA), IAEA-A-13 (International Atomic Energy Agency, Austria), BCR-163 (Institute for Reference Materials and Measurement, Belgium). (*) Non-certified values provided by the United States National Bureau of Standards. *Abbreviations*: Energy Dispersive X-ray Fluorescence (EDXRF), Flame Atomic-Absorption Spectroscopy (FAAS), Gas Chromatography (GC), High Performance Liquid Chromatography (HPLC), not determined (nd), 16:1*n*-7 + 16:1*n*-5 (a), 18:1*n*-9 + 18:1*n*-7 (b), 18:2*n*-6 (c), 18:3*n*-3 (d).