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Nutritional and lipid profiles in marine fish species from Brazil

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ABSTRACT

Centesimal composition and lipid profiles were evaluated in muscle tissue of four species of Brazilian fish using the Kjeldahl and Bligh & Dyer gravimetric methods and gas chromatography, respectively. The moisture, protein, total lipid, and ash values (g/100 g) ranged from 71.13 to 78.39; 18.10 to 19.87; 1.05 to 9.03; and 1.03 to 1.73, respectively. Palmitic acid was prevalent among the saturated fatty acids (10.89–20.38%) and oleic acid was the main monounsaturated acid identified (4.26–15.77%). The eicosapentaenoic-EPA (6.41–10.66%) and docosahexaenoic-DHA (9.12–30.20%) acids were the most prevalent polyunsaturated acids. The average values, which are indicative of nutritional quality, were: Polyunsaturated/saturated (P/S) (1.11–1.47), ω6/ω3 (0.08–0.21), hypocholesterolemic/hypercholesterolemic acid ratios (HH) (0.87–2.43), atherogenicity index (IA) (0.26–0.60), and thrombogenicity index (IT) (0.20–0.44). These results demonstrated that the lipid profiles of the studied species are of nutritional quality.

1. Introduction

Fish is not only a source of high nutritional quality protein, but also a significant reserve of polyunsaturated fatty acids, especially the eicosapentaenoic (EPA-C20: 5 ω−3) and docosahexaenoic (DHA-C22: 6 ω−3) acids. These two fatty acids are known to present health benefits to humans because they reduce risk factors associated with cardiovascular disease, hypertension, general inflammation, asthma, arthritis, psoriasis, and various types of cancer. The ω−3 and ω−6 fatty acids are primarily supplied in the diet because they cannot be synthesized by the human body (Calder & Yagoob, 2009; Hooper, Thompson, Harrison, Summerbell, et al., 2009).

The ω−6/ω−3 ratio in human food was recorded in ratios between 1:1 and 2:1 before the agricultural and food industrialization revolution. Currently, this ratio has varied between 15:1 and 40:1 and is strongly correlated to increased incidence of chronic non-transmissible diseases (Santos, Gagliardi, Xavier, et al., 2013; Simopoulos, 2002). Therefore, the western diet, composed of high contents of red meat, refined flours, and industrial products, consequently with high levels of ω−6 and low levels of ω−3, is considered an unbalanced diet. Therefore, increasing ω−3 and reducing ω−6 consumption to mitigate the ω−6/ω−3 ratio has been suggested as being beneficial to health (Kris-Etherton, Fleming, & Harris, 2010). However, the validity of only using the ω−6/ω−3 ratio in clinical practice as one of the cardiovascular risk indicators has been questioned by experts who suggest that dietary recommendations should be made not only based on the ω−6/ω−3 ratio, but also on the basis of total consumption of each polyunsaturated fatty acid (Griffin, 2008).

Marine fish are a source of ω−3 long-chain polyunsaturated fatty acids and contain a higher proportion of this nutrient than freshwater fish, which are usually characterized by high levels of ω−6 polyunsaturated fatty acids, especially linoleic (18:2 ω−6) and arachidonic acids (20:4 ω−6) (Huynh & Kitts, 2009; Ozogul & Ozogul, 2007).

The fatty acid composition in tissues of marine fish can vary among species and among individuals, depending on their diet, size, age, gender, environmental conditions, season, and method of capture (Erkan & Özden 2007; Luzia, Sampaio, Castellucci, & Torres, 2003).

Brazil has about 8500 km of coastline with tropical and subtropical environmental conditions and waters with high temperature and salinity (Monteiro, Nóbrega, Ribeiro, & Lessa, 2009). Nevertheless, regardless of Brazil's highly diverse ichthyofauna

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and extensive hydrographic systems, information about chemical composition and lipid profiles in marine fish species is scarce. Most of the published studies about lipid content have analyzed fish species from the Pacific, Mediterranean, and Indian oceans (Huynh & Kitts, 2009; Ozogul, Ozogul, & Alagoz, 2007; Zotos & Vouzanidou, 2012; Zuraini, Somchit, & Solihah, 2006).

Statistical reports indicate a clear expansion of the fishing sector in Brazil (extractive fishing and aquaculture); however, the "per capita" consumption of fish at the national level has not been growing at the same rate (Brasil., 2012). This could be attributed to lack of information on the nutritional composition of Brazilian fish, a factor which could represent an important stimulus for the consumption of this food, such as recommended in the Mediterranean Diet Guide.

Hence, this study evaluated the chemical composition and lipid profiles in black needle (*Hemiramphus brasiliensis*), white needle (*Hyporhamphus unifasciatus*), mackerel (*Scomberomorus cavalla*), and sardines (*Opisthonema oglinum*), which are the most important commercial fish species in northeastern Brazil.

2. Material and methods

2.1. Sample collection and preparation

The study samples were obtained from fishing communities located on the coastline of Pernambuco State, northeastern Brazil.

Batches of 4 kg per studied species were collected at the beginning and end of February, March, June, and July 2011, a total of eight batches per species. Samples were transported to the laboratory in coolers with ice where all fish were weighted and lengths (standard) were measured (Table 1).

Heads and guts were removed, and fillets were ground in a food processor until formation of a homogeneous mass, which was used for the analyses.

2.2. Proximate analysis

Moisture was determined gravimetrically after drying the material in an oven at 105 °C according to the AOAC method (2002). Total lipids were determined using the Bligh and Dyer (1959) method, and protein content was determined according to the Kjeldahl method described in ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS. (2002). The determination of mineral residues was measured gravimetrically after burning the material in a muffle furnace at 550 °C (ASSOCIATION OF OFFICIAL ANALYTICAL CHEMISTS., 2002). All analyses were performed in triplicate.

2.3. Determination of fatty acids profiles

Lipid extracts were esterified according to the method proposed by Hartman and Lago (1973). Extracts were stored in amber glass tubes and frozen (−18 °C) until chromatographic readings were performed.

Fatty acid profiles were analyzed in a GC 17A/QP – 5050 (Shimadzu), chromatograph equipped with a "split/splitless" injector (1:10) and DB-5MS capillary column (30 m × 0.25 mm) with injector and detector temperatures of 250 and 280 °C, respectively, 1.3 ml mim^{-1} Helium flow, and programmed temperature (140–200 °C/1 °C per minute, 200–280 °C/0.8 °C per minute, maintained at 280 °C for 5 min). The range (m/z) of the MS detector was from 40 to 600. Fatty acids were identified by comparison using the WILEY 221/1995 database and quantified after normalizing the methyl esters areas; the results were expressed as percentage of the area (%).

2.4. Lipids nutritional quality indexes (IQN)

The data from fatty acids composition analysis were used to determine the nutritional quality of the lipid fraction. Nutritional quality was assessed by three indexes using the following calculations:

(1) Atherogenicity index (AI) = [(C12:0 + (4 × C14:0) + C16:0)]/(ΣAGMI + Σω6 + Σω3) (Ulbricht & Southgate, 1991).
(2) Thrombogenicity index (IT) = (C14:0 + C16:0 + C18:0)/[(0.5 × ΣAGMI) + (0.5 x Σω6 + (3 × Σω3) + (Σω3/Σω6)] (Ulbricht & Southgate, 1991).
(3) Fatty acids hypocholesterolemic/hypercholesterolemic ratios (HH) = (C18:1cis9 + C18:2ω6 + C20:4ω6 + C18:3ω3 + C20:5ω3 + C22:5ω3 + C22:6ω3)/(C14:0 + 16:0) (Santos-Silva, Bessa, & Santos-Silva, 2002).

2.5. Statistical analysis

The data from centesimal composition and fatty acid profiles were subjected to analysis of variance (ANOVA) and compared by the Tukey's test at 5% level of significance using the "Statistic for Windows 6.1" software (STATSOFT, 1997).

3. Results and discussion

3.1. Proximate analysis

The chemical composition of fish fillets is shown in Table 2. The moisture values obtained were within ranges previously established for fish (70% and 90%) (Çelik, Diler, & Küçükgülmez, 2005).

Protein content amongst the four species studied varied significantly. Protein composition of fish can vary according to the species, size, gender, and season. However, muscle generally contains about 20% protein (Erkan & Özden, 2007). In this study, protein values ranged from 18.10% to 19.87% consistent with literature

Table 1
Biometric data of the studied fish species.

Period (Month/Year)	Species white needle		Black needle		Sardine		Mackarel	
	Weight (g)*	Length (cm)*	Weight (g)*	Length (cm)*	Weight (g)*	Length (cm)*	Weight (g)*	Length (cm)*
02/11	73.2	16.3	84.2	19.4	186.2	22.3	1562.5	77.0
02/11	83.5	18.1	90.1	20.1	270.3	23.6	1537.1	80.3
03/11	80.2	18.4	84.8	19.2	312.2	22.0	1434.5	70.6
03/11	83.1	17.6	86.0	20.7	220.8	21.2	1460.0	72.2
06/11	76.8	16.5	75.2	16.2	307.2	23.8	1438.7	74.0
06/11	77.4	17.0	76.1	17.0	279.6	24.6	1413.8	72.4
07/11	78.6	17.4	77.7	17.3	226.0	22.7	1482.0	73.0
07/11	82.0	18.6	81.0	18.6	235.6	24.1	1502.3	75.6

* Averages in analyzed batches.