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Original Research Article

The lipid content and fatty acid composition of four eastern central Pacific native fish species

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ABSTRACT

Fish is an important source of nutritious n-3 fatty acids, which are necessary for the prevention of cardiovascular and neurological diseases. The lipid content and fatty acid composition of economically important fishes from the eastern central Pacific, namely, *Caranx caballus*, *Cynoscion phoxocephalus*, *Lutjanus guttatus* and *Scomberomorus sierra*, were determined. Seasonal variations in their n-3 fatty acid composition were investigated as well. The lipid content of all these fish species was less than 4% by weight. In general, the studied species have moderate proportions of n-3 fatty acids. *C. caballus* was the fish species with the highest concentration of eicosapentaenoic acid (EPA) plus docosahexaenoic acid (DHA) (898 mg/100 g) followed by *S. sierra* (596 mg/100 g), *C. phoxocephalus* (421 mg/100 g) and *L. guttatus* (342 mg/100 g). The n-3/n-6 ratio of all the species studied ranged from 4.86 to 8.12. Results of this study indicate that all these fish species are highly recommended as a source of low calorie food that can meet the n-3 fatty acid dietary requirements of the Panamanian population.

1. Introduction

According to the Food and Agriculture Organization (FAO), it is estimated that 3 billion people around the world consume fish and other marine organisms as a source of proteins (Tveteras et al., 2012). In addition to providing people with high-quality proteins, fish consumption satisfies nutritional requirements for essential n-3 fatty acids, primarily eicosapentaenoic (EPA; 20:5 n-3) and docosahexaenoic (DHA; 22:6 n-3) acids, which are two long chain polyunsaturated fatty acids (LC-PUFAs) mainly present in fish (Connor, 2000). Surveys aimed at establishing the influence of n-3 fatty acids on various health conditions have shown their positive effects, both in disease prevention and health status improvement.

The human brain consists of 60% lipids, of which 33% are n-3 fatty acids (Bourre and Dumont, 1991). These fatty acids mediate the function of neuronal cells by regulating receptors and enzymes (Yehuda et al., 1994). DHA is essential for normal fetal brain and cognitive development as the formation of neuron synapses in the brain depends strongly on the integration of this fatty acid into growing neurons (Jensen, 2006). Research trials conducted on infants have suggested that it is necessary to incorporate an adequate quantity of DHA into their diets for correct maturation of the visual cortex and retina (Uauy et al., 2003).

Clinical studies indicated a direct relationship between a decline in cognitive function and memory loss with a deficiency in dietary n-3 fatty acids (Bourre, 2004; Fontani et al., 2005; Yurko-Mauro et al., 2010). Human studies and experimental models suggest that ingestion of n-3 fatty acids prevents and ameliorates Alzheimer's disease by inhibition of inflammatory cytokine secretion, downregulation of proapoptotic proteins, and upregulation of anti-apoptotic proteins secretion (Uauy and Dangour, 2006; Calviello et al., 2008; Boudrault et al., 2009). Gu et al. (2012) reported an association between a higher intake of n-3 PUFAs and lower levels of β-amyloid peptide in plasma, which is associated with a reduced risk of Alzheimer's disease. Mamalakis et al. (2002, 2006) found negative relationships between adipose tissue n-3 fatty acids and depression in adolescents, adults and the elderly, which may be due to the suppression on the production of cytokines, interleukin (IL) 2, IL-6 and tumor necrosis factor alpha (TNF-α) by monocytes.

Increasing n-3 fatty acids intake significantly reduces the incidence of cardiovascular disease. They reduce total cholesterol,

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Table 1
Taxonomic information, feeding habits, environment, common name and total lipid content of the fishes investigated.

Genus	Species	Family	Feeding	Environment	Common name	Lipid content
Caranx	*caballus*	Carangidae	Carnivore	Pelagic	Green jack/Cojinua	3.74 ± 0.41
Cynoscion	*phoxocephalus*	Sciaenidae	Carnivore	Demersal	Cachema weakfish/Corvina	2.75 ± 0.35
Lutjanus	*guttatus*	Lutjanidae	Carnivore	Reef associated	Spotted rose snapper/Pargo de la mancha	1.81 ± 0.12
Scomberomorus	*sierra*	Scombridae	Carnivore	Pelagic	Pacific sierra/Sierra	3.09 ± 0.23

Values are expressed as g/100 g wet weight and are means ± SD ($n = 50$).

and thus minimize significantly the risk of myocardial infarction (Lox, 1990; Zyriax and Windler, 2000). Furthermore, n-3 fatty acids reduce serum triglycerides level (Dasgupta and Bhattacharyya, 2007), lower blood pressure in hypertensive persons (Ueshima et al., 2007), and diminish the occurrence of sudden cardiac death (Villa et al., 2002). n-3 PUFAs, especially EPA and DHA, have proven to be beneficial in autoimmune diseases such as Crohn's disease, multiple sclerosis, lupus erythematosus and psoriasis (Simopoulos, 2002a). These n-3 fatty acids have been reported to have a lower risk and suppressing effects in prostate (Demark-Wahnefried et al., 2001) and colorectal cancers (Theodoratou et al., 2007).

Much research on the fatty acid composition of fish from different marine ecosystems has been conducted, e.g., fish from the Mediterranean Sea, the northeastern coast of Australia, the Adriatic Sea, Malaysian and Turkish waters (Belling et al., 1997; Osman et al., 2001; Zlatanos and Laskaridis, 2007; Pacetti et al., 2010; Chuang et al., 2012), but information concerning the nutritional value of certain fish species is still scarce. There is a lack of data on the n-3 fatty acid composition of fishes from the eastern central Pacific region, which is one of the major fishing areas of the FAO and includes part of the Pacific coast of the United States and the Central American Pacific coastline from Mexico to Panama. Fish is the main source of EPA and DHA for the population in this area. Our current research on Alzheimer's disease involves the study of the molecular mechanisms by which compounds present in food, such as the n-3 PUFAs fatty acids, in particular EPA and DHA, can prevent and/or mitigate the effect of the disease.

We therefore aimed to investigate the lipid content, fatty acid composition, and amount of essential n-3 fatty acids in four fish species of important commercial value that are highly consumed by the local population of Central America. Seasonal variations in the lipid content and n-3 fatty acid composition were also studied. Uncovering trustworthy information on these topics is required for designing health-related policies and programs intended for improving the nutritional status and health conditions of local inhabitants, not only from Panama, but from the rest of the Central American region. Furthermore, these data are of significant interest to the fishing and nutraceutical industries and for the establishment of conservation strategies to support the sustainable development of these marine species.

2. Materials and methods

2.1. Materials

Analytical grade hexane, chloroform, and methanol were purchased from Merck (Darmstadt, Germany). Butylated hydroxytoluene (BHT) was obtained from Sigma–Aldrich (St. Louis, MO, USA). Menhaden fish oil and fatty acid methyl esters (FAME) mixture (analytical standard) were purchased from Supelco (Bellefonte, PA, USA). All other reagents were of analytical grade.

2.2. Fish samples and lipid extraction

Fresh samples of 4 fish species (*Caranx caballus*, *Cynoscion phoxocephalus*, *Lutjanus guttatus*, and *Scomberomorus sierra*), were collected from the Pacific coast of Panama, Panama City, in February, April, June, September and November of 2011. Ten individuals from each species were sampled. Specimens on crushed ice were brought to the laboratory, and subjected to lipid extraction immediately. Each fish was beheaded and eviscerated, and the muscle below the dorsal fin, including the skin, was subsequently analyzed. A sample of 25 g of muscle was homogenized, and lipids were extracted according to the method of Folch et al. (1957) using a chloroform/methanol mixture (2:1, v/v) containing 0.01% butylated hydroxytoluene (BHT) to prevent oxidation. The lipid content was determined gravimetrically.

Table 1 provides taxonomic and environmental information about the fish species. The English and local names of the fishes are also provided.

2.3. Determination of fatty acid compositions

Aliquots of the lipids extracted were used to prepare the FAME according to the procedure described by Christie (1993). In brief, the sample was mixed with acidic-methanol solution (5% anhydrous hydrogen chloride in methanol), heated at 70 °C for 1 h, cooled and extracted with hexane. FAMEs were separated and identified on an Agilent/HP 6890 gas chromatograph with flame ionization detector (FID) equipped with an HP-Innowax capillary column (25 m × 0.20 mm i.d., 0.20 μm film thickness) (Agilent, Palo Alto, USA), using helium as the carrier gas at a flow rate of 1.2 mL min^{-1}. The oven temperature was initially set at 170 °C for 3 min, and then increased to 230 °C at 4 °C/min with a final hold time of 3 min. The injector and detector temperatures were set at 230 °C and 270 °C, respectively. The FAME chromatographic peaks were identified by comparison of their retention times with those from a known FAME standard mixture, and characterized menhaden fish oil sample. The results are expressed as the percentage of total area of identified fatty acids, or as the amount of fatty acids in mg/100 g wet weight of the edible part of the fish by transforming each percentage to mg/100 g of wet tissue, using the fish conversion factor proposed by Exler, Kinsella and Watt (Greenfield and Southgate, 2003).

2.4. Statistical analysis

The results of the analyses are presented as mean values ± standard deviation (SD). The data were subjected to a one-way analysis of variance (ANOVA) to determine the differences between the fatty acid contents and the n-3 to n-6 fatty acid ratio among the samples studied. Fisher's least significant difference test was applied to discriminate among the means. Differences were accepted as statistically significant at a probability of $p < 0.05$. Statistical evaluations were carried out with the Statgraphics Centurion system (Warrenton, VA, USA).

3. Results and discussion

Although plants and plant-derived food products, such as seeds, nuts, soybeans and vegetable oils, provide humans with essential linolenic acid (18:3 n-3), fish is the principal source of other n-3