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Changes in the lipid fraction of king mackerel pan fried in coconut oil and cooked in coconut milk

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ABSTRACT

The influence of cooking on the nutritional value of king mackerel when cooked in coconut milk or pan fried in coconut oil was verified from the alterations in the fatty acid content; formation of cholesterol oxides and the nutritional quality indices of the lipids. Cooking in coconut milk caused an 11.6% reduction in the protein content and 28.3% reduction in the ash content. The lipid content increased after cooking (253%) and frying (198%) causing an increase in the caloric value. The total saturated and monounsaturated fatty acids of the cooked king mackerel increased 462% and 248%, respectively, whereas these increases were 418% and 130%, respectively, for the fried king mackerel. There were reductions of 21% and 38% in the total EPA + DHA of the pan fried and cooked samples, respectively, as compared to the fresh king mackerel. The heat treatment did not cause alterations in cholesterol content.

1. Introduction

Fish are traditionally considered as a fundamental part of a balanced diet in order to have a healthy life, and the consumption of two 140 g portions of fish per week is recommended (Ruxton, 2011). This recommendation is based on the fact that fish are a source of polyunsaturated fatty acids of the n-3 and n-6, of which docosahexaenoic (DHA) and eicosapentaenoic (EPA) acids stand out (Figueirêdo, Bragagnolo, Skibsted, & Orlien, 2015; Saldanha & Bragagnolo, 2010) and also of high biological value proteins. Polyunsaturated fatty acids act in various physiological and metabolic processes, and are considered primordial in the maintenance of cell membranes, the retina, the reproductive system, the cerebral cortex and nerve tissues. They present an anti-inflammatory action and reduce the risks of coronary diseases, moderate high blood pressure and the incidence of diabetes, as well as playing a role in the prevention of various types of cancer (Harris et al., 2009; Ruxton, 2011).

The compositions of these nutrients undergo changes according to the cooking method to which the food is submitted. The different types of heat treatment can cause changes in the chemical, physical and structural characteristics of the fresh food, resulting in moisture losses which cause a concentration of the nutrients, incorporation of substances present in the cooking medium and nutrient losses into the medium (Ansorena, Guembe, Mendizábal, & Astiasarán, 2010; Baggio & Bragagnolo, 2005; Figueirêdo et al., 2015; Saldanha & Bragagnolo, 2010). Frying is a well-accepted cooking method, making the foods more attractive for consumption, since it confers agreeable sensory characteristics on the product. However, the use of elevated temperatures can cause degradation reactions in the food which can modify the functional and nutritional qualities of the fresh food (Warner, 2002). Since fish contain cholesterol and a high content of polyunsaturated fatty acids, they are highly susceptible to lipid oxidation, generating adverse compounds with respect to human health such as cholesterol oxides, which are associated with cytotoxic, atherogenic, mutagenic and cancerous processes (Alemany, Laparra, Barberá, & Alegría, 2012; Otaegui-Arrazola, Menéndez-Carreño, Ansorena, & Astiasarán, 2010).

Virgin coconut oil was much used for frying in the past, being substituted by industrialized vegetable oils and hydrogenated fats for culinary purposes. Having been stigmatized since its consumption was considered harmful to one's health, due to the fact that it contains > 50% of triacylglycerides formed from caprylic (8:0), lauric (12:0) and myristic (14:0) acids, it was almost forgotten. The saturated fatty acids are considered to be hypercholesterolemic, since they raise the levels of low density lipoproteins. On the other hand, low molecular weight saturated fatty acids are rapidly absorbed by the intestinal tract and

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hence they show therapeutic actions (Rioux, Lemarchal, & Legrand, 2000). In addition, some studies have reported that virgin coconut oil may have protective effects, such as antioxidant, cardio-protective, hepato-protective, anti-thrombosis, antibacterial, antiviral, antifungal and anti-cancer (Babu, Veluswany, Arena, Guazzi, & Lavie, 2014; Law et al., 2014).

Coconut milk is an opaque white liquid obtained by pressing the grated or ground coconut endosperm with or without the addition of water. It is an important ingredient of recipes in various parts of the world due to its original taste and other desirable sensory characteristics. It has been estimated that 25% of world's coconut production is consumed as coconut milk and the main constituents of coconut milk are water (76–84%), lipids (11–18%), proteins (0.3–0.9%), carbohydrates (3.5–8.1%) and minerals (0.4–0.7%) such as phosphorus, calcium and potassium (Seow & Gwee, 1997).

The salt water fish king mackerel is one of the most commercialized fish species in the state of Alagoas, Brazil. As virgin coconut oil has a lot of saturated fatty acids, it is more resistant to oxidation and more stable to heat, becoming an interesting option for cooking, such as cooking and frying. Due to a complete lack of data in the literature concerning the effects of cooking mackerel in coconut oil or milk, the present work studied the influence of cooking on the nutritional value of king mackerel (*Scomberomorus cavalla* Cuvier, 1829) when pan fried in coconut (*Cocos nucifera* L) oil or cooked in coconut milk. For this purpose, the proximate composition and the fatty acid, cholesterol and cholesterol oxide contents were determined before and after cooking. The quality of the lipid fraction was also evaluated as from the atherogenic index (AI), thrombogenic index (TI) and the ratio between the hypocholesterolemic and hypercholesterolemic acids (H/H).

2. Material and methods

2.1. Material

Ten fresh king mackerel (*Scomberomorus cavalla* Cuvier, 1829) slabs, each weighing an average of 900 g, having been fished in the summer (December 2010 to January 2011), on the maritime coast of Alagoas, Brazil, between the geographical coordinates of 8°8′12″ S and 10°29′12″ S, where the highest temperature is above 20 °C and the salinity is high and constant (Correia & Sovierzoset, 2005). In each batch of fish (total 10), the samples were stored in plastic bags in a styrofoam box containing ice and taken immediately to the laboratory. The coconut oil and coconut milk used to cook were acquired in the local market in Maceió, AL, Brazil.

2.2. Sample preparation

Each sample (900 g) was divided into three portions (300 g each), designated as group I, group II and group III. The samples in group I were maintained raw, the samples in group II were submitted to pan frying in 30 mL of coconut oil for 15 min at 150 °C, and the samples in group III were cooked in pan with 200 mL of coconut milk for 20 min at 100 °C. For the frying process, a frying pan of 4 cm high and 19 cm diameter wide was used. Fresh king mackerel were baked in a pan of 7 cm high and 22 cm wide diameter. After pan frying, the coconut oil was discarded and the same was done with coconut milk. The coconut oil and the coconut milk were kept in a transparent glass vessel which were wrapped with foil and held at 5 °C throughout the experiment. The fish bones and skin were removed after cooking. The preparation conditions were standardized in preliminary tests based on the sensory characteristics of the food. In addition, three samples each of extra virgin coconut oil and coconut milk were submitted to an analysis of their fatty acid content.

2.3. Methods

The moisture, protein and ash contents were determined using AOAC (1990) methodologies. Total lipid was extracted by Folch, Lees, and Stanley (1957) and the lipid content was gravimetrically determined. The caloric value was calculated from the caloric coefficients corresponding to the proteins and lipids (Livesey, 1990).

2.3.1. Cholesterol and cholesterol oxides

The samples were submitted to cold, direct saponification according to Mariutti, Nogueira, and Bragagnolo (2008). The extracts obtained were dissolved in the mobile phase, filtered through a 0.45 μm Millipore membrane and injected into a high performance liquid chromatograph (HPLC) using the chromatographic conditions established by Saldanha, Sawaya, Eberlin, and Bragagnolo (2006).

A Shimadzu liquid chromatograph was used equipped with UV–visible (SPD-10 AVvp) and refractive index (RID- 10 A) detectors, connected in series and a Nova Pack HP (300 mm × 3.9 mm × 4 μm, Waters) analytical column with a 20 μL manual injector loop, maintained at a controlled temperature of 32 °C. The mobile phase was a mixture of hexane (minimum of 63% n-hexane) and 2-propanol (97:3 v/v) with a flow rate of 1 mL/min, the analysis time being 50 min and the solvents of chromatographic grade, filtered and degassed.

The cholesterol oxides were identified by a comparison of the retention times of the peaks obtained from the mackerel samples with the peaks of the following authentic standards (20α-hydroxycholesterol, 22*R*-hydroxycholesterol, 22*S*-hydroxycholesterol, 25-hydroxycholesterol, 5,6α-epoxycholesterol, 5,6β-epoxycholesterol, 7-ketocholesterol, 7α-hydroxycholesterol and 7β-hydroxycholesterol acquired from Sigma-Aldrich and Steraloids). Cholesterol and the cholesterol oxides were quantified by external standardization, constructing six-point standard curves with concentrations varying from 0.5 to 100 μg/mL for cholesterol oxides and from 0.05 to 4 mg/mL for cholesterol.

2.3.2. The content of fatty acids

Aliquots of the lipid extracts obtained according to Folch et al. (1957) were submitted to saponification and the fatty acids converted into methyl esters (Joseph & Ackman, 1992). The methyl esters were identified by comparison of the retention times of the peaks with those of authentic methyl ester standards (FAME Mix C4-C24, Supelco, Bellefonte, Pennsylvania, USA) and quantified by internal standardization with the methyl ester undecanoic acid (Sigma-Aldrich Chemie, Steinheim, Germany), added before sample injection. A Shimadzu gas chromatograph (model GC2010, Kyoto, Japan) was used equipped with split injection (1/100) at 260 °C, with a fused silica capillary column (length 100 m, i.d. 0.25 mm and a stationary phase thickness of 0.20 μm, CP-SIL 88, Chromopack, Middleburg, Holland); flame ionization detector at 260 °C and workstation (GCSolution, SHIMADZU, Kyoto, Japan). The temperature was programmed according to Costa and Bragagnolo (2017). The stripping gas was hydrogen with a linear velocity of 20 cm/s and the make-up gas was nitrogen at 30 mL/min. The volume injected was 1 μL using the hot needle technique for 5 s.

2.3.3. Nutritional indexes of the lipids

The nutritional quality of the lipid fraction was evaluated as from the data for the fatty acid composition, using the following three indices: atherogenic index (AI), the thrombogenic index (TI) (Ulbricht & Southgate, 1991) and the hypocholesterolemic to hypercholesterolemic fatty acid ratio (H/H) (Santos-Silva, Bessa, & Santos-Silva, 2002). The AI corresponds to the ratio between the sum of saturated fatty acids 12, 14 and 16, as pro-atherogenic by the sum of n3 and n6 polyunsaturated fatty acids, oleic acid and other monounsaturated acids as anti-atherogenic (Ulbricht & Southgate, 1991). On the other hand, the TI correlates the ratio between the sum of saturated fatty acids 14, 16 and 18 by the sum of n3 and n6 polyunsaturated fatty