Effect of different types of heat processing on chemical changes in tuna

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Abstract The chemical changes in skipjack tuna (Katsuwonus pelamis) subjected to cooking, frying, canning and microwave heating were studied. Raw tuna contained an unusual fatty acid C16:3 in high proportion (29.3%) followed by C18:2, C16:0 and C18:3. Health beneficial fatty acids, eicosapentaenoic acid (EPA) (1.67%) and docosahexaenoic acid (DHA) (2.50%), were quite low with ω-3/ω-6 ratio 0.28. The total saturated fatty acids suffered major loss in fried (70%) and canned tuna (40%) due to loss of C16:0, C14:0 and C22:0. The monounsaturated fatty acids content increased (38%) in cooked and microwave heated tuna due to C24:1. The polyunsaturated fatty acids content increased in fried (50%) and canned (25%) tuna due to the uptake of frying and filling oil, respectively during processing. The loss of health beneficial ω-3 fatty acids, EPA and DHA were minimum in cooked tuna followed by microwave heated tuna. Canning totally destroyed these fatty acids. In fried tuna, the losses of EPA and DHA were 70 and 85%, respectively. Thiobarbituric acid – reactive substances values increased in heat processed tuna. Cholesterol increased in canned and microwave heated tuna but not in cooked tuna. Reduction of cholesterol in fried tuna was due to its migration into frying oil. This study indicated that cooking and microwave heating are the better processing methods to retain the health beneficial ω-3 fatty acids in comparison to frying and canning.

Keywords Tuna · Katsuwonus pelamis · ω-3 Fatty acids · Thiobarbituric acid · Cholesterol · Thermal processing

Introduction

Fish lipids have gained more importance because of the presence of health beneficial omega-3 polyunsaturated fatty acids (ω-3 PUFA). These PUFA viz. eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) play a crucial role in the prevention of atherosclerosis, heart attack, depression, stroke, diabetes, obesity, premature ageing, hypertension, cancer and to improve the vision power and memory (Sanders 1993, Chin and Dart 1995). Recognizing the health benefits of ω-3-fatty acids and the serious consequences of their deficiency, the US National Institute recommended a daily intake of 650 mg of ω-3 fatty acids in the form of fish (Venugopal 2004). Information about PUFA content is mainly available only for raw fish. But, fish is normally consumed after different methods of processing. There were very few studies on the effect of processing on the stability of ω-3 PUFA fatty acids in fish (Aro et al. 2000, Garcia- Arias et al. 2003). Canned fish are products of economic importance in many countries. Canned fishery products are formally canned in vegetable oils and now available in water packs. The use of microwave for heating foods has increased considerably during the past few decades (Sumnu 2001). Fish is also consumed normally in cooked and fried forms. Data on the stability of ω-3 fatty acids of processed fish based on Indian cooking and frying methods are sparse.

Tuna is one of the most important and popular commercial fish and is mainly eaten after cooking and frying. Canned tuna is one of the chief fishery products with good export market. Microwave heating is also important in fast food restaurants. This work was therefore undertaken to examine the stability of ω-3 fatty acids in tuna subjected to different heat processing treatments.
Materials and methods

Skipjack tuna (*Katsuwonus pelamis*) procured from Tuticorin fish-landing centre of Tamilnadu, India, situated within 1 km from the laboratory was immediately brought to the laboratory in iced condition. The average length and weight of tuna were 74 cm and 6 kg, respectively. The fish was beheaded, eviscerated and made into steaks and washed in potable chlorinated water (5 ppm). The average dressing yield of tuna was calculated. Steaks weighing 100–150 g were divided into 5 lots. First lot was treated as control (raw) and designated as R. Second lot was subjected to cooking in a boiling water bath (100°C) for 10, 20 and 30 min and were designated as C1, C2 and C3, respectively. Third lot was subjected to shallow frying at 180°C using double refined sunflower oil on a frying pan for 5, 7.5 and 10 min and were designated as F1, F2 and F3, respectively. Fourth lot was subjected to canning using standard canning procedure (Saralaya 1978) in 8 oz cans at 110, 115 and 121°C for 90, 70 and 40 min, respectively and were designated as N1, N2 and N3, respectively. Canning was performed to achieve 12-D process at 3 different temperatures to examine the temperature effect. Fifth lot was subjected to microwave heating by placing the samples in a microwave oven (IFB, Kochi, India) operating at 2450 MHz (Gall et al. 1983) for 10, 15 and 20 sec and were designated as O1, O2 and O3, respectively. The processing yield of tuna after each heat treatment was calculated. Samples were analyzed for fatty acid composition and other chemical parameters in triplicates from each treatment.

**Fatty acid composition:** The lipid was extracted by the method described by Folch et al. (1957). Fish (25 g) after homogenization was extracted twice with chloroform: methanol at the ratio of 2:1. The chloroform extract was washed with 0.75% KCl solution and again extracted with chloroform, methanol and water at the ratio 3:48:47. The lower chloroform layer was evaporated to dryness in a rotary flash evaporator (Superfit, India) under the stream of nitrogen. The extracted lipid was then quantified.

The lipid fraction (250 mg) was weighed and esterified into fatty acid methyl esters using 5 ml of BF₃ methanol (AOAC 1990). Fatty acid composition was determined by gas chromatography as per the method of Candela et al. (1996) with slight modifications. Perkin-Elmer Autosystem XL gas chromatograph, USA, fitted with a flame ionization detector and a fused silica capillary column (PE-225, 0.25 mm ID, 30 m length) was used for the separation and identification of fatty acids. The operating conditions were injector temperature 250°C and detector temperature 300°C. A temperature gradient programme was followed with initial oven temperature set at 70°C for 1 min, which was then increased to 180°C at the rate of 3°C/min and then to 220°C at the rate of 10°C/min. The carrier gas used was nitrogen at 20 psi pressure. Peaks were identified by comparison of their retention times with those of authentic fatty acid standard mixtures (Sigma Chemicals Co., Product No. 189-19, St. Louis, USA, 99% purity specific for gas chromatography). The ratio of ω-3 to ω-6 fatty acids as well as of PUFA to saturated fatty acids (SFA) (P:S) were calculated.

**Other chemical parameters:** Moisture fat and cholesterol contents of fish were determined by AOAC (1995) methods. Thiobarbituric acid reactive substances (TBARS) were determined by the spectrophotometric method (Ke et al. 1984) by measuring absorbance of coloured fraction at 538 nm against a blank in an UV-vis spectrophotometer (Jasco V 530, Japan).

**Statistical analysis:** The least significant differences tests for triplicate results were carried out to examine the effect of different heat processing treatments on the changes in the omega-3-PUFA fish using SPSS 10.0 statistical package.

Results and discussion

**Fatty acid profile of raw tuna:** The SFA, MUFA and PUFA contents of raw tuna were 15.5%, 18.3% and 57.9%, respectively (Table 1). The major SFA were palmitic (C16:0), stearic (C18:0) and behenic (C22:0) acids. The C16:0 has been reported as the major fatty acid in marine fish followed by C18:0 by many authors (Gopakumar and Nair 1972, Bhuiyan et al. 1986, Beltran and Moral 1990, Sanchez-Muniz et al. 1992, Bandarra et al. 1997). Presence of C14:0, C15:0 and C17:0 fatty acids were also noticed. The major MUFA’s were myristoleic (C14:1), cis-10-pentadecenoic (C15:1) and oleic (C18:1) acids in raw tuna. Although high levels of C18:1 was reported in marine fish by many workers (Ackman et al. 1982, Bandarra et al. 1997), their occurrence was lower (1.38%) in tuna. Another major MUFA noticed in our study was nervonic acid, C24:1 (10.9%). The major PUFA identified in raw tuna were entirely different from other marine fishes. Presence of hexadecatrienoic (C16:3) in very high proportion (29.3%) in addition to linoleic (C18:3), γ linolenic (C18:3) and hexadecatetraenoic (C16:4) acids were noticed. The fatty acids, C16:3 and C16:4, have been identified as the major fatty acids of green algae belonging to Chlorophyta (Johns et al. 1979; Khotimchenko 1993; Li et al. 2002, Sanina et al. 2004). These fatty acids could have been assimilated in tuna muscle through the food chain. Fatty acid composition of fish lipid is highly dependent on the fish diets (Fowler et al. 1994, Sathivel et al. 2002, Sengor et al. 2003), fish species and their growth conditions (Hedayatifard and Moeini, 2007). The EPA (C20:5) and DHA (C22:6) were the dominant ω-3 PUFA as also reported by Bandarra et al. (1997).

The proportion of ω-3 fatty acids was quite low (5.3%), although high proportions (80%) were reported in fish species of Pacific coast (19.0%). The P:S ratio was 3.74 and the ω3/ω6 ratio was quite low (0.28).

**Fatty acid profiles of cooked tuna:** The SFA contents varied from 17.4 to 11.0% with an increase in the duration of cooking (Table 1). Slightly higher values were noticed