Reprinted from *J. Food Sci.*
61(4): 729–733

Chemical Changes After Irradiation and Post-Irradiation Storage in Tilapia and Spanish Mackerel

HASSAN A. AL-KAHTANI, HAMZA M. ABU-TARBOUSH, ADNAN S. BAJABER, MOHAMED ATIA, ATIF A. ABOU-ARAB, and MOHAMED A. EL-MOJADDIDI

ABSTRACT

Influence of gamma irradiation (1.5–10 kGy) and post-irradiation storage up to 20 days at 2 ± 2°C on some chemical criteria of tilapia and Spanish mackerel were studied. Total volatile basic nitrogen formation was lower in irradiated fish than in the unirradiated. Irradiation also caused a larger increase in thiobarbituric acid values which continued gradually during storage. Some fatty acids decreased by irradiation treatments at all doses. Thiamin loss was more severe at higher doses (≥4.5 kGy), whereas riboflavin was not affected. Alpha and gamma tocopherols of tilapia and alpha, beta, gamma, and delta tocopherols, in Spanish mackerel, decreased with increased dose and continued to decrease during 20-day post-irradiation storage.

Key Words: irradiation, TBA, tilapia, Spanish mackerel, volatile nitrogen

INTRODUCTION

GAMMA IRRADIATION has long been used as a method of food preservation (Urakami et al., 1959, 1961; Richardson et al., 1960; Diehl, 1973; Taub et al., 1976). Research on food irradiation over many years and has covered chemical and physical changes along with effects on safety, nutritional quality and acceptability (Josephson and Peterson, 1982; Josephson, 1983). Nutrient losses and formation of radiolysis products are among concerns raised about food irradiation. The effects of irradiation on several nutrients, including thiamin, tocopherols and fatty acids, and on thiobarbituric acid (TBA) number were investigated by several researchers (Hafez et al., 1985; Jenkins et al., 1989; Ramarathnam et al., 1989; Fox et al., 1994).

Our objective was to determine the effects of gamma irradiation and post-irradiation storage at 2 ± 2°C on total volatile basic-nitrogen, TBA number, fatty acids, thiamin, riboflavin, and tocopherols of tilapia and Spanish mackerel.

MATERIALS & METHODS

Preparation and irradiation of fish

Tilapia samples (*Tilapia nilotica* × *T. aurea*) were purchased from an aquatic farm in Al-Kharg (80 km south of Riyadh) and transported alive to the Meat Laboratory in the Food Science Department, King Saud University. The fish were then killed, gutted, and washed. The gutted fish and fillets were placed in isolated boxes (Rubbermaid, Medina, OH; dimensions: l 96.25 cm × w 42.5 cm × h 42.25 cm).

Spanish mackerel fish (*Scomberomorus commerson*) (≈ 160 kg) were obtained from the Qatif fish market in the Eastern province of Saudi Arabia. The fish had been caught off the Eastern coast (Arabian Gulf) of Dammam and purchased 3 hr after catching in the late evening. The fish were iced and arranged in plastic isolated boxes (25 kg capacity) and transported (4 hr driving) directly in an air-conditioned van to the university in Riyadh. Immediately on receiving, the fish were washed, gutted, beheaded, sliced and washed again.

All samples were completely covered with ice during sampling and transportation to the semi-commercial Gamma Irradiator at King Faisal Specialist Hospital and Research Center (KFSHRC). The boxes containing fish and ice were irradiated with a Co^{60} source (Nutronic) at 1.5, 3.0, 4.5, 6.0 and 10 kGy for exposure times of 96, 192, 288, 384, and 640 min, respectively. The dose rate was 1562.3 rads/min (0.94 kGy/hr). The Fricke ferrous sulfate dosimetry (ANSI, 1972) and the polymer perspex dosimeters (4034 Z red, range 5-50 kGy or 3042 A amber, range 1-3 kGy; Whittaker, 1970) were used for verification of the methods of dose of irradiated fish inside the icebox. The spectrophotometric measurements were made at 305 nm and 640 nm for ferric ion and polymer perspex, respectively. The procedure outlined in the Standard Test Method for Absorbed Gamma Radiation Dose in the Fricke Dosimeter was used (ANSI, 1972).

The maximum elapsed time from purchasing fish, preparation for irradiation and return to the laboratory was <15 hr. In the meat laboratory, fish boxes were opened and stored in the chill room (2 ± 2°C), the ice to fish weight ratio in the box was nearly 3:1. Samples were then taken for chemical analysis.

Chemical analysis and thiobarbituric acid (TBA)

Total volatile basic-nitrogen (TVB-N). Steam distillation as described by Antonacopoulus (1973) was used. The TVB-N was released by boiling the flesh directly with 2g magnesium oxide and received in boric acid (2%). TVBN was then titrated with 0.1N HCl and Taschiro indicator. Results were expressed as mg N/100g. TBA was determined according to the method described by Pearson (1976).

Fatty acids. Fat was extracted according to the method of Bligh and Dyer (1959). Fatty acid methyl esters (FAMEs) were prepared (Metcalfe et al., 1966) and identified on a 5840 Hewlett Packard (HP) gas chromatograph with a flame ionization detector (FID) and a 190 cm × 0.2 cm column packed with 5% diethyleneglycol succinate (DEGS) on 80-100 mesh chromosorb W, operated at a column temperature of 185°C, injection port and FID temperatures of 250°C, and with a nitrogen flow rate of 60 mL/min. The peak area and relative percentage of FAMEs were determined with a HP integrator.Peaks were identified by comparison with those of authentic methyl ester standards.

Thiamin and riboflavin. The procedure described by Fellman et al. (1982) using HPLC was followed with some modifications. Optimum HPLC conditions were as follows: the mobile phase (37% methanol in 0.01M phosphate buffer, pH 7.0) was introduced into μ Bandapak C_{18} column at 1.5 mL/min. Injected volume and running time were 50 μL and 10 min, respectively. Detection was at 360 nm excitation and 405 nm emission for thiamin, and at 450 nm excitation and 530 nm emission for riboflavin.

Tocopherols. The procedures of Carpenter (1979) and Speek et al. (1985) were adopted for separation and quantification of tocopherols in extracted fat samples. The extraction procedure was that of Bligh and Dyer (1959). The HPLC separation was performed on a 0.78 × 30 cm μ-porasil column (Waters Modular System, Milford, MA). The mobile phase (15% isopropyl alcohol in hexane) was introduced by a solvent delivery pump (Waters model M-45) at 1 mL/min. The system was attached to the injector (model U6K) and the absorption maximum for tocopherols was obtained at 295 nm on a LC-481 spectrophotometer (Shimadzu, Kyoto, Japan). The peak areas for calibration curves and for calculation of tocopherol amounts in the oil samples were measured by a data module Model 730 integrator. The chart speed was 1 cm/min and the sensitivity was 0.05.

Statistical analysis. Data were analyzed using analysis of variance (Steel and Torrie, 1980) and SAS programs (SAS, 1985).

RESULTS & DISCUSSION

Total volatile basic-nitrogen (TVB-N)

The accumulation of certain metabolites related to fish spoilage are generally used as evidence of shelf-life of chilled fish.

Authors Al-Kahtani, Abu-Tarboush, Bajaber, Atia, and Abou-Arab are with the Dept. of Food Science, King Saud Univ., College of Agriculture, P.O. Box 2460 Riyadh, 11451 , Saudi Arabia. Author El-Mojaddidi is with King Faisal Specialist Hospital & Research Centre, Riyadh, Saudi Arabia.