Final Report

Mississippi Center for Food Safety and Post-Harvest Technology

Title: "Improving the Safety and Quality of Raw Tuna Fillets by X-ray Irradiation"

(Award #015770-006)

Award year: 2013-2015

PI: Dr. Barakat Mahmoud

Co-PI: None

Collaborator: None

1. Objectives.

   Objective 1-Determine the efficacy (specific doses) of X-ray irradiation on the inactivation of *Salmonella enterica* on raw tuna fillets.
   Objective 2-Determine the effects of X-ray treatments on the shelf life of raw tuna fillets during storage at 5^{o}C, 10^{o}C, and 25^{o}C.
   Objective 3-Determine the effects of X-ray treatments on the quality (color and texture) of raw tuna fillets during storage at different temperatures (5^{o}C, 10^{o}C, and 25^{o}C).

2. New Accomplishments toward objectives. Please indicate if all objectives listed were completed.
   All objectives listed were completed.

3. Objectives not accomplished and impediments to meeting objectives.
   None

4. If continuing project, when will new and/or long term objectives be completed?
   N/A

5. Students supported: **None**

   a. PhDs (% FTE and name)
   b. M.S. (% FTE and name)
   c. Undergraduate (number of students)

6. Leveraged Funds: External Competitive Funding Applied and Awarded based on findings from this project.
   a. Applied for:

      i. Funding agency; Related proposals were submitted to USDA-AFRI
      ii. Program: Improving The Food Quality
      iii. Funding request ($$): 150,000

   b. Awarded: Pending
      i. Funding agency
      ii. Program
      iii. Funding awarded ($$)

7. Outputs – In addition to the above, please populate the following sections to be included in a report to be compiled in a FSI Research Accomplishment Booklet. The project report will also be posted in a FSI website to be developed.

Project Summary (Issue/Response)

In recent years, consumers are eating more of raw and/or minimally processed foods include raw fish products such as Sushi and Sashimi, etc. However, raw or minimally processed foods can serve as vehicles for many foodborne pathogenic microorganisms. The fish products can be contaminated from the environments and/or through processing steps. Furthermore, inadequate storage conditions (temperature abuse) may allow pathogens to grow and reach the infective dose. Recently (in 2012), tainted tuna slices (the product was not sold to customers directly but sold to restaurants and grocery store chains around the country) caused a 28-state outbreak of *Salmonella* infections. A total of 425 persons infected with the outbreak strains of *Salmonella* were reported from 28 states and the District of Columbia; Alabama (5), Arkansas (1), California (8), Colorado (1), Connecticut (11), District of Columbia (3), Florida (1), Georgia (22), Illinois (30) Indiana (1), Kansas (1), Louisiana (6), Massachusetts (36), Maryland (40), Missouri (4), Mississippi (2), Nebraska (2), New Hampshire (2), New Jersey (42), New York (68), North Carolina (12), Pennsylvania (37), Rhode Island (6), South Carolina (6), Tennessee (4), Texas (15), Virginia (34), Vermont (1), and Wisconsin (25). 55 ill persons were hospitalized, and no deaths were reported. *Salmonella* is an important cause of human illness in the United States. People with a *Salmonella* infection develop diarrhea, fever and abdominal cramps in 72 hours of exposure. The infection typically lasts four to seven days and most people will recover without treatment. However if the infection spreads from the gut into the bloodstream, it could spread throughout the body and cause hospitalization or death. Infants, the elderly and pregnant women are especially at risk. Several treatment agents include quaternary ammonium, iodine bromine and chlorine compounds used in seafood processing operations to reduce the number of spoilage and pathogenic microorganisms. These treatments have shown negative effects on the quality of treated food products and/or low log reductions. Therefore, to improve the safety and quality of raw tuna fillets a highly effective non-thermal sanitation technology needed to be developed.

Project Results/Outcomes

Effect of X-ray on *Salmonella* in raw tuna fillets: In this study, raw tuna fillets (25 g) samples were inoculated by immersing in 0.1 peptone water that contained 10^{8-9} CFU ml^{-1} of a three-strain mixture of *Salmonella enterica* for 1 min in a biosafety cabinet. The samples were then air dried at 22^{o}C for 30 min (to allow bacterial attachment) in the biosafety cabinet prior to X-ray treatments (0.0, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6 kGy). The surviving *Salmonella* populations on raw tuna fillets samples were evaluated using a nonselective medium (tryptic soy agar) for 6 h with xylose lysine desoxycholate (XLD) (Difco, Becton Dickinson) selective medium overlay. The plates were then incubated for an additional 18 h at 37°C. Finally, the colonies were counted and the results were expressed as log CFU g-1.

Effect of X-ray on the inherent microflora in raw tuna fillets: 25g of un-inoculated tuna samples were packaged separately in sterilized bags and exposed to the lowest and highest X-ray doses (0.0 and 6.0 kGy), then stored at 5°C, 10°C and 25°C for 25, 15 and 10 days, respectively. Samples were withdrawn at 0, 5, 10, 15, and 20 days, and microflora (psychrotrophic and mesophilic) counts were evaluated. Viable counts were expressed as log $CFUg^{-1}$
Effect of X-ray on the color and texture of tuna fillets: Tuna samples were treated with 0.0 and 0.6kGy X-ray at 22^{o}C and 55–60% relative humidity. Then stored at 5°C, 10°C and 25°C for 25, 15 and 10 days, respectively. At each examined period, samples were pulled from the storage for instrumentally quality analysis. The color was evaluated using the Hunter (*L**, *a**, and *b**) colorimeter values (LabScan XE Hunter Colorimeter; Hunter Associates Laboratory, Inc., Reston, VA). The texture was also measured by a puncture test using an Instron 4944 (Instron, Norwood, MA). The instrumental settings and operations were accomplished using the software Bluehill Materials

Testing Software (Bluehill 3, version 3.13, 2010; Instron). On the test day, tuna samples were punctured with a cylindrical probe (10mmdiameter). Crosshead speed was set at
50mm/min. Force-distance curves were obtained from the puncture tests and firmness was taken as the force (N) required puncturing the Tuna samples.
The results indicated that more than a 6 log CFU reduction of *Salmonella* population being achieved with 0.6 kGy X-ray treatment. Furthermore, treatment with X-ray significantly reduced the initial inherent microbiota on raw tuna fillets and inherent levels were significantly ($p < 0.05$) lower than the control samples throughout the shelf-life storage at 5, 10 and 25oC for 25, 15 and 5 days, respectively. There was a significant effect of X-ray treatment on tuna color after treatment (day 0). However, no significant differences ($p > 0.05$) in color or texture of control and treated samples were observed after (day 0).

Project Impacts/Benefits

The results of the study indicated that X-ray (a novel non-thermal technology) is an effective technology in reducing *Salmonella* and spoilage microflora in tuna fillets. Using X-ray, by the food industry, can save millions of dollars by avoiding recalls for their products; the company recalled approximately 60,000 pounds of raw yellowfin tuna product from the market. Also, using X-ray can ensure the safety of raw tuna and save hundreds of millions of dollars in future health expenses (to treat infected consumers)

Project Deliverables

Mahmoud, B.S.M. and Coker, R. 2014. Improving the Safety and Extending the Shelf life of Raw Tuna Fillets by X-ray Radiation. The IFT Annual Meeting. New Orleans, LA. June 21-24, 2014

Graphics

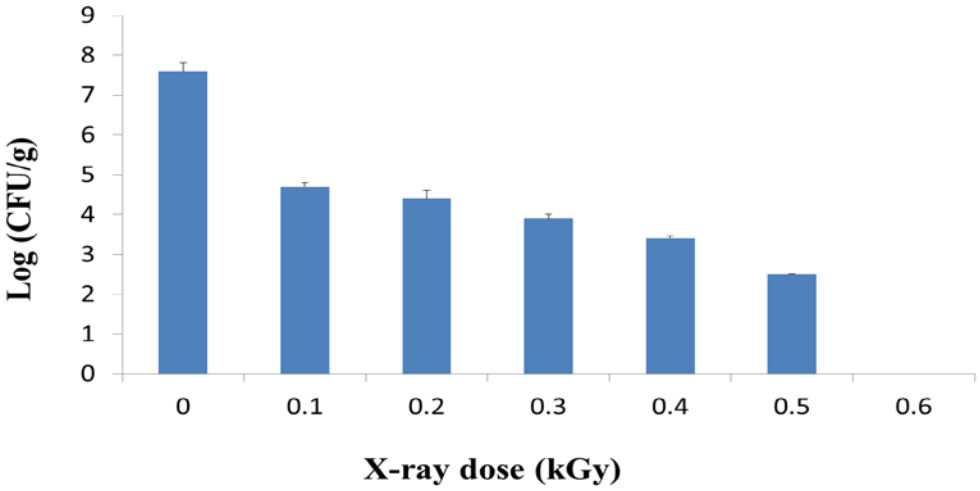

Fig. 1. Inactivation of inoculated *Salmonella enterica* on raw tuna fillets by X-ray

Table 1. Changes in the color (Hunter parameters) of treated tuna with X-ray during storage at 5°C for 25 days

Treatments / Storage time (days)	0.0 kGy			0.6 kGy		
	*L**	*a**	*b**	*L**	*a**	*b**
0	41.1±0.5[a]	10.2±0.3[a]	8.7±0.5[a]	43.4±1.0[b]	7.6±0.1[b]	7.1±0.0[b]
2	40.0±0.1[a]	9.4±0.3[a]	8.2±0.0[a]	41.1±0.7[a]	9.9±0.2[a]	9.0±0.0[a]
10	41.3±0.7[a]	8.3±1.0[a]	8.7±0.2[a]	40.6±0.7[a]	8.4±0.3[a]	8.8±0.1[a]
15	40.7±0.1[a]	9.9±0.3[a]	7.8±0.2[a]	38.9±1.3[b]	8.1±0.5[b]	9.4±0.0[b]
20	44.4±0.1[a]	8.2±0.7[a]	7.4±0.1[a]	42.2±0.2[b]	8.6±0.2[a]	8.3±0.1[a]
25	45.0±0.3[a]	6.0±0.7[a]	7.7±0.2[a]	43.8±0.1[a]	6.5±0.2[a]	8.1±0.2[a]

Attached Refereed Journal Publications in Separate Files

Journal article is in preparation.