Guidelines for MAFMA Final Report

Final Reports due 3 months after completion of project
(4-5 pages)

Project Title Modeling the Microbiological Effect of Low-Energy X-ray Irradiation on Ground Beef Patties

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Please complete all questions below and attached form

1. Objective Summary (1-2 sentence summary)

The overall purpose of this project was to test the efficacy of low-energy x-ray irradiation technology for application to ground beef patties, and to develop the data and tools needed to scale-up the technology to a commercial system applicable to the processing line of Omaha Steaks.

2. Objective Accomplishments

As the first step of the project, the dose-lethality relationships were determined for *E. coli* O157:H7 and total plate count (TPC) on ground beef. The D_{10}-value for *E.coli* O157:H7 and TPC ranged from 76.8 to 118 Gy (Fig. 1), depending on the measurement methods; these result suggest that this type of irradiation is more effective than gamma irradiation at inactivating the target organisms, based on typical D_{10}-values reported in the literature for gamma irradiation (240~270 Gy). Based on this analysis, low-energy x-ray appears to have great potential to achieve 5 log reductions for *E. coli* O157:H7 and general spoilage microorganisms at production speeds for ground beef patties.

A dose penetration test was also conducted with beef patties constructed with the same thicknesses of the Omaha Steaks 4 oz and 8 oz patties (Fig. 2), but with a smaller diameter (due to the geometric constraints of the prototype unit). The results showed that the prototype machine could achieve a 5 log reduction without any adverse effects on the visual quality of the patties. In addition, CT images of the actual 4 oz and 8 oz patty were acquired and were processed to construct 3-D density maps that are necessary for developing a predictive model (Fig. 3). The next step is to couple the biological model (dose-lethality model) with a physical model (dose-distribution model), which will be developed using an X-ray beam simulation package (MCNPX 2.6.0,Radiation Safety Information Computational Center, Oak Ridge, TN). The software package was obtained, and initial development of the modeling method has been initiated. However, due to an unexpected delay in production of the commercial-scale low-energy X-ray irradiator by Rayfresh Foods Inc. (one of the project partners), comprehensive validation tests could not be conducted yet. This impediment is expected to be resolved in the near future, and the validation tests will be conducted via leveraging funding.

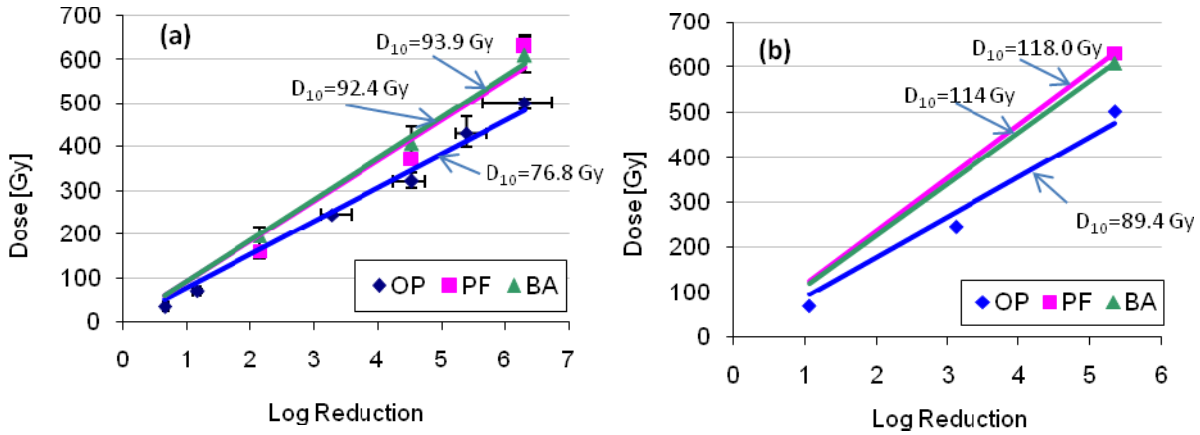
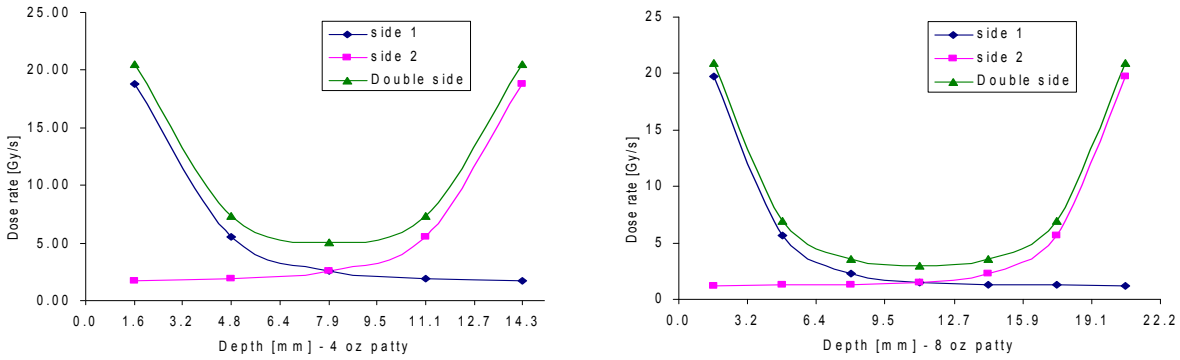


Figure1. Low-energy x-ray inactivation results for (a) E. coli *O157:H7 and (b) total aerobic plate count (TPC). OP: original package; PF: plastic film; BA: without package.*



(a) (b)

Figure 2. Dose rate vs. depth of the small diameter beef patty under x-ray irradiation in the prototype machine (distance from the source was 1.25 in). (a) Dose rate for 4 oz patty thickness and (b) Dose rate for 8 oz patty thickness.

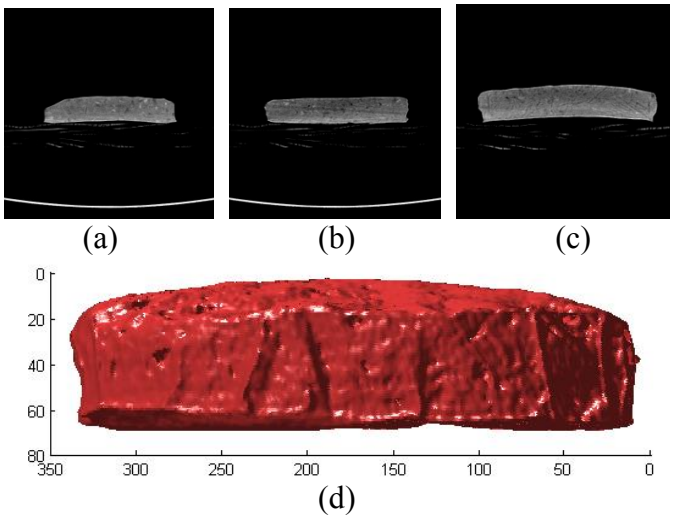


Figure 3. CT scan and cross-sectional slice image of 4, 5, and 8 oz beef patties and re-constructed 3-D image, where (a) 4 oz patty; (b) 5 oz patty; (c) 8 oz patty; (d) 3-D image.

3. Unexpected findings, if any

none

4. Practical impacts of research efforts.

a. Short Term Impacts

The initial outcome of this research (quantified efficacy of low-energy X-ray on E. coli *O157:H7 in ground beef) provided the necessary decision-making information for Omaha Steaks to place an order to purchase the first commercial scale low-energy X-ray food irradiator manufactured by Rayfresh Foods Inc.*

b. Long Term Impacts

The success of delivering the first commercial scale low-energy X-ray food irradiator will have lateral impact not just on ground beef processors, but other industry sectors having food safety issues, such as fresh produce processors. In particular, the advantage that the system can be installed as a continuous unit in an existing process line is a critical factor that will affect potential future expansion of applications. Therefore, the commercial impact of this research work may be enormous.

c. Further Pursuits

The PIs have pursued, and continue to pursue, additional funding to expand this research to other pathogens and food products, as follows:

Grant Proposals Submitted:

- National Research Initiative Competitive Grant Program (USDA). Cold Pasteurization of Raw Nuts Using Low-Energy X-ray Technology. S. Jeong, B.P. Marks, and E.T. Ryser. $388,802 (09/2007~08/2010) – Not Funded.

- Fresh Express Produce Safety Research Initiative. Efficacy of Low-energy X-ray Irradiation for Reduction of E. coli O157:H7 on Fresh Leafy Greens. S. Jeong, B.P. Marks, and E.T. Ryser. $129,768 (05/2007~04/2008) – Not Funded.
- National Integrated Food Safety Initiatives (USDA & CSREES). (Cross contamination, Long-wave X-ray Intervention, Risk Assessment Methodology: sub-award of "A Systems Approach to Minimize Escherichia coli O157:H7 Food Safety Hazards Associated with Fresh- and Fresh-cut Leafy Greens". E.T. Ryser, B.P. Marks, E. Todd, S. Jeong, and Z. Yan. $600,000 (MSU portion out of $2.5 million total) (10/2007~9/2011).- **Funded**.
- National Research Initiative Competitive Grant Program (USDA). Cold Pasteurization of Raw Nuts Using Low-Energy X-ray Technology. S. Jeong, B.P. Marks, and E.T. Ryser. $396,178 (06/2008~05/2011)-Resubmission – Not Funded.
- International Life Science Institute-North America (ILSI-NA). Inactivation of Salmonella on Raw Nuts Using Low-Energy X-ray. S. Jeong, B.P. Marks, and E.T. Ryser. Pending $78,857 (2009) –**Funded**.

5. If you are also making reports to other funding agencies in the course of this research work, please include a copy of that report.

N/A

6. a. Publications

Conference:

- Jeong, S., B.P. Marks, E.T. Ryser, and A.M. Booren. 2007. Efficacy of low-energy x-ray for elimination of *Escherichia coli* O157:H7 in ground beef. IFT Abstract 189-50. Presented at the Institute of Food Technologists Annual Meeting. Chicago, IL. July, 2007.
- Jeong, S., B.P. Marks, E.T. Ryser. 2008. Inactivation of *Salmonella* Enteritidis PT30 by Low-Energy X-ray Irradiation on Almonds at Different Water Activity. IAFP Abstract P1-31. Presented at the International Association for Food Protection Annual Meeting. Columbus, OH. August, 2008.

6. b. Patents (pending or granted) resulting from the research

N/A