

Project Summary

Evaluating Quality and Palatability Characteristics of Beef Carcasses Treated with Low-Dose Surface Irradiation

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Background

Each year, food safety issues arise in the media due to medical severity and subsequent economic losses. The meat industry is constantly searching for interventions or processing aids to help reduce the probability of an outbreak. Foodborne outbreaks result in great illness and substantial economic losses. It is estimated that each year approximately 48 million Americans get sick, 128,000 are hospitalized, and 3,000 die of foodborne diseases (Centers for Disease Control and Prevention, 2011). Food safety issues among the beef industry are frequent, affect the health of numerous individuals, and cost the United States billions of dollars.

In an attempt to reduce the number of outbreaks, the beef industry continues to encourage USDA's Food Safety and Inspection Service to approve low-dose carcass surface irradiation. When approved, it is expected that many harvest facilities will implement this technology to improve the safety of beef products. The subprimals and trimmings produced from the carcasses treated with low-dose irradiation may have different quality characteristics than non-irradiated products. It is extremely important to determine the impact of low-dose irradiation on quality and palatability characteristics of subprimals and trimmings (lean and fat). The irradiation may cause oxidation of the tissue, and could have an impact on quality, especially if the surface trim is used in the production of ground beef.

The objectives of this project were to:

1. To determine the impact of low-dose carcass irradiation on the quality characteristics (color, TBA, and shelf-life) on beef subprimals and trimmings (fat & lean).
2. To determine the impact of low-dose carcass irradiation on palatability characteristics of steaks and ground beef produced from treated subprimals and trimmings.

Methodology

Beef inside rounds (IMPS #168, n=10), bottom round flats (IMPS #171B, n=10), and knuckles (IMPS #167A, n=18) were collected from a commercial meat packing facility on the same day. Subprimals then were shipped to Texas A&M University and stored for two days under refrigerated conditions (2-4°C). When the subprimals were collected, both sides of the same carcass were removed and randomly divided into a control group (non-irradiated) and a treated group (irradiated). The irradiated group was treated with low-dose irradiation at the National Center for Electron Beam Research at Texas A&M University. During the irradiation process, three Kodak BioMax alanine dosimeter strips were placed on the surface of each subprimal at a level that was considered to be thick, thin, and intermediate. After irradiation, the subprimals (irradiated and non-irradiated) were fabricated into three equal parts to randomly assign to an aging day (0, 14, or 21). The inside rounds were cut into thirds to produce cranial, intermediate, and caudal portions. The bottom round flats were cut into thirds to generate proximal, intermediate, and distal portions; and the knuckles were fabricated into thirds to produce lateral, intermediate, and medial portions. Next, the subprimal pieces that were not designated for day 0 were vacuum packaged and randomly assigned to one of the two remaining aging days. The subprimal pieces were stored for either 14 or 21 days under refrigerated conditions (2-4 °C). Following the designated storage times, the subprimal pieces were trimmed of all external fat, trimmings were produced by removing approximately 1.27 cm of

exposed lean, and 2.54 cm steaks were cut. After the appropriate numbers of steaks were cut, the remaining lean portion was combined with the lean trim. The trimmings were coarse ground through a 2.54 cm plate and hand mixed, fine ground through a 0.3175 cm plate and hand mixed, and formed into 0.113 kg ground beef patties. The steaks and patties were placed in foam trays and PVC overwrapped. Following packaging, the steaks and patties were placed under continuous fluorescent lighting for two or four days to simulate retail display.

Following storage, the steaks and patties were evaluated for sensory and shelf-life characteristics. Meat descriptive-sensory evaluation was conducted at the Texas A&M University sensory testing facility using an expert, trained meat descriptive-attribute panel. For sensory determinations, steaks were cooked to an internal temperature of 70 °C and patties were cooked to an internal temperature of 75 °C on a Hamilton Beach Portafolio Indoor/Outdoor Grill (Hamilton Beach/Proctor-Silex, Inc., Southern Pines, NC). Internal temperatures were monitored by a copper-constantan thermocouple (Omega Engineering, Stamford, CT) inserted into the geometric center of each steak or patty. Once the internal temperature reached 35°C for steaks and 37 °C for patties, they were flipped and cooked until the final temperature was reached. Following cooking, the steaks were cut into 1.27 cm cubes and the patties were cut into 1/8 patty wedges and served warm (within 5 minutes post cooking) to each of the five trained meat descriptive attribute sensory panelists.

The panel was trained as defined by AMSA (1995) and Meilgaard et al. (2007). Flavor, basic taste, mouthfeel, after-taste, and texture attributes were determined during ballot development sessions. Panelists were provided samples of beef from treatments during training and ballot-development sessions. The panel previously evaluated irradiated ground beef and steaks for other research projects. After attributes for the ballot were defined, training sessions were conducted. During training sessions, panelists were provided samples similar to those for the study. Following training, the study was initiated after panelists could consistently and accurately identify sensory attributes (AMSA, 1995). Each panelist was seated in individual booths equipped with red theater gel lights. Samples were served in a random order and identified using three-digit codes. Unsalted saltine crackers, fat-free ricotta cheese, and double distilled, deionized water was served to the panelists between samples to cleanse the palate. The panelists evaluated each sample using a 15-point universal scale with 0 = none and 15 = extremely intense for attributes defined from the ballot development sessions (Meilgaard, Civille, & Carr, 2007). Two sessions were conducted with eight samples evaluated per session where samples were represented across treatments. A break was given between sessions and samples were served a minimum of four minutes apart.

During retail refrigerated storage, color measurements were taken on PVC-packaged steaks and patties on days 0, 2, and 4. After steaks and patties were cooked for sensory analysis, cooked steak and patty slices were analyzed for cooked color measurements. Color was measured using a Minolta Colorimeter (CR-300, Minolta Co., Ramsey, NJ) which was calibrated daily to insure consistency among days. Each reading consisted of L^* , a^* , and b^* color space values. For raw measurements, three different readings were randomly taken from the surface of each patty and steak. For cooked color analysis, three color measurements were taken from the internal portion of three random cubes from the steaks and three random wedges from the patties.

Lipid oxidation was evaluated using a modified TBA (2-thiobarbituric acid) method defined by Wang et al. (2002). Standards were produced by combining different concentrations (0, 2, 4, 6, 8, 10, 20, and 30 mg/kg) of TEP (tetraethoxypropane) solution and TCA (trichloroacetic acid) extraction solution. After the standards were made, samples were prepared for extraction. Samples

were minced and weighed out 5 g of each sample were placed in a 50 mL centrifuge tube and 15 mL TCA extraction solution was added. The samples were homogenized for 20-30 seconds using a Polytron homogenizer (PT 10-35 GT, Kinematica, Bohemia, NY). Following homogenization, tubes were placed in a Jouan centrifuge (C 412, Jouan Inc., Winchester, VA) and centrifuged at 1,500 g for 15 min. The samples were filtered through No. 4 Whatman paper and 125 μ L of the resulting extract was loaded in triplicate into a 96-well microplate. After the samples were loaded, 125 μ L of TBA solution was dispensed into each well of the microplate using a pipette. The loaded microplate was then incubated for 130 min at 40°C. After incubation, absorbance was read at 532 nm on a microplate reader (Epoch Microplate Spectrophotometer, BioTek, Winooski, VT).

Findings

Raw color differences were seen between treated and control samples on day 0, but minimal differences were exhibited from day 2 to day 4. Differences in TBA values were seen, but were too erratic to attribute to a certain variable.

When comparing means between irradiated and non-irradiated cuts, it is apparent that some differences do exist. Overall, the TBA values are lower for steaks in comparison to the matching patties. Additionally, as the age day increases, the TBA values elevated. Although it is not consistent, some irradiated products produced elevated TBA values in comparison to the controls.

TBA values generally increased between shelf day two and shelf day four. Additionally, the patty TBA values were higher than their steak counterparts. This would be expected due to the added fat component of the ground beef. Also, the surface area of the lean and fat would increase with the grinding process and would allow for a greater amount of oxygen to interact with the product.

Implications

If the application of low-dose carcass irradiation is approved and beef processors decide to use it, these data can be used to develop educational or outreach materials to minimize or control the impact of low-dose irradiation on quality and palatability factors. This will help ensure the beef industry benefits from the safety aspects of the low-dose irradiation without creating quality problems that could result in economic losses to the industry. Although the impact on food safety has been demonstrated, it is crucial to the industry that we fully understand the quality implications of this technology.

Table 5. LS means for raw a* color space values for shelf-life day*treatment for all cuts and subprimals.

	Shelf day 0		Shelf day 2		Shelf day 4	
	Treated	Control	Treated	Control	Treated	Control
Bottom Round						
Steak	20.77b ¹	22.42a	17.60c	17.99c	13.97d	13.59d
Patty	20.83b	24.15a	14.92c	14.13c	9.23d	9.24d
Knuckle						
Steak	20.21b	21.98a	17.12d	18.51c	13.02f	15.60e
Patty	21.85b	24.22a	15.88c	15.58c	10.90d	10.39d
Top Round						
Steak	22.72b	24.12a	18.16c	19.12c	14.36d	15.41d
Patty	22.41b	25.32a	16.69c	16.49c	9.80e	11.29d

¹Means lacking a common letter within a row differ ($P < 0.05$).

Table 6. LS means for raw b* color space values for shelf-life day*treatment for all cuts and subprimals.

	Shelf day 0		Shelf day 2		Shelf day 4	
	Treated	Control	Treated	Control	Treated	Control
Bottom Round						
Steak	7.60c ¹	8.97a	8.06cb	8.24b	7.93cb	8.19cb
Patty	8.28c	10.82a	8.19c	8.28c	9.07b	8.85b
Knuckle						
Steak	7.15d	8.59a	7.83bc	8.17ab	7.27cd	7.55bcd
Patty	8.67b	10.46a	8.11c	8.06c	8.29bc	7.80c
Top Round						
Steak	8.71bc	10.13a	8.77bc	9.12b	8.52c	8.71bc
Patty	9.14b	11.30a	8.46cd	8.51cd	8.75c	8.23d

¹Means lacking a common letter within a row differ ($P < 0.05$).



Alanine dosimeters placed on the surface of each cut



Retail display and raw color assessment

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