The Effects of Low Dose Irradiation and Storage Time on Aroma of Fresh Beef Patties in Anaerobic Packaging

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J. L. Montgomery, research assistant
F. C. Parrish, Jr., professor of animal science and food science and human nutrition
D. G. Olson, professor of animal science and food science and human nutrition

Summary

The effects of electron beam irradiation, anaerobic packaging, and storage times on the aroma of raw ground beef patties were investigated. Patties were coarse ground at three days postmortem, and then fine ground and packaged at three, six, and nine days postmortem. Patties were irradiated immediately after packaging, or three days after packaging at 2 kGy, and then stored at 2.5 °C ±1.5 °C for four days. Non-irradiated controls were held under similar conditions. After four days of storage for each postmortem time (three, six, and nine days), sensory aroma evaluations were performed on all samples. Irradiated and non-irradiated patties with the shortest postmortem storage times had the most desirable aroma scores. Controls had significantly ($p \leq .05$) more desirable aroma scores than irradiated patties.

Introduction

Recent events with food-borne illnesses involving the meat industry have increased industry, governmental and consumer awareness of possible contaminants and pathogens such *as Escherichia coli* 0157:H7, *Salmonella spp*, and *Staphylococcus aureus*. Concerns with the safety of fresh meats have reemphasized the importance of technologies useful in prevention or reduction of pathogenic bacteria (Bruhn, 1995). Although not a new technology, irradiation has proven in recent studies to be effective in reducing pathogenic bacteria and gram-negative microorganisms while extending shelf life (Ehioba et al., 1988; Monk et al., 1995; Radomyski et al., 1994; Thayer and Boyd, 1993).

Several researchers have shown that D-values (the required dose to kill 90% of the microorganisms present on the product) of one kGy and less eliminated pathogenic bacteria and gram negative spoilage microorganisms (Clavero et al., 1994; Lefebvre, et al., 1992; Mattison et al., 1986; and Tarkowski et al., 1984). Thayer and Boyd (1993) concluded that a dose of 1.5 kGy eliminated *E. coli* 0157:H7 in meat challenged with $10^{4.8}$ CFU/g. at 0 ^{0}C following 20 hours of temperature abuse at 35 ^{0}C. Thus, by using low dose irradiation a substantial protection against *E. coli* 0157:H7 and other pathogens can be offered to the consumer.

Various packaging films have been shown to suppress spoilage microorganisms and extend shelf life (Lee et al., 1995; Farber, 1991; and Radomyski et al., 1994). Packaging of fresh meats in plastic films also prevents recontamination. Consequently, the combination of irradiation and barrier packaging films could be an effective and valuable technology in providing safer, and more wholesome and palatable meat, while alleviating consumer concerns about meat safety.

Radiolytic compounds are produced from free radicals that are formed when meat products are irradiated. In 1981, the World Health Organization's (WHO) Expert Committee on the Wholesomeness of Irradiated Food found there was no toxicological hazards from foods irradiated with a maximum dose of ten kGy (WHO, 1981). Radiolytic compounds, however, have been found to cause off odors and discoloration of fresh meat (Lambert et al., 1992; Lee et al., 1995; and Lefebvre et al., 1994). Consumers perceive desirable fresh meat quality to be a combination of appearance, color, and aroma when the package is opened (Lambert et al., 1992). Irradiation-caused radiolytic compounds are important because the higher the dose the more radiolytic compounds are formed resulting in stronger off-odors and discoloration.

Factors requiring further research before commercial application can occur involve the effects of postmortem age of fresh meats prior to irradiation, and the storage time prior to irradiation on the quality characteristics of fresh meats, especially beef patties. The objective of this study was to determine the effects of postmortem storage time, the time interval between packaging and irradiation, anaerobic packaging and electron beam irradiation on the aroma of fresh beef patties.

Materials and Methods

Sample Preparation and Storage

Fresh beef shank meat from a commercial packing plant at three days postmortem for each of three replications was coarse ground through a .95 cm plate, and mixed at the Iowa State University Meat Lab. For each of the replications the batch of mixed coarse ground beef was split into three equal amounts and placed in plastic lugs. Two lugs were then placed in the cooler and maintained at approximately 0 ^{0}C until postmortem days six and nine, respectively. The three-day-postmortem coarse ground beef was finely ground through a .32 cm plate, and pattied (114 g on average) using a patty machine. The three-day-postmortem

patties were next packaged anaerobically in Cryovac B620 barrier bags. Half of the three-day-postmortem patties were placed back into plastic lugs and stored at 0 ^{0}C for three more days. The other half were further grouped into 50% control patties, and 50% treated patties. The control patties were maintained between 1 ^{0}C and 4 ^{0}C, under fluorescent light. The treated patties were irradiated (2 kGy) at the Iowa State University Linear Accelerator facility. The treated patties were then stored with the controls. The other half of the three-day-postmortem patties were treated in the same manner, split in two equal groups three days after packaging. The six-and nine-day-postmortem coarse ground meat batches were treated in the same manner as the three-day-postmortem ground beef on day six and nine postmortem, respectively.

Sensory Evaluation

Sensory evaluations of ground beef patties were made four days after being irradiated and placed in the display cooler under fluorescent lighting. Sensory evaluations for non-irradiated control patties were done at the same time as their counterpart irradiated patties. Patties were evaluated by an eight member trained panel for aroma. Each panelist received one patty from each of the treatment and control groups and was asked to evaluate each for initial aroma immediately after removal of the patties from the packaging. The same patties were also evaluated for aroma scoring 30 minutes later. The aroma scores were judged on an eight point scale, one being extremely undesirable, and eight being extremely desirable.

Statistical Analysis

A split-plot design was used by the Statistical Analysis System (SAS) to analyze the data. SAS~GLM was used in determining means, standard errors of the means, and the analysis of variance. Least significant differences (LSD) were calculated to separate means. An alpha level of $p \leq .05$ was used to determine significance. The experiment was replicated three times.

Results and Discussion

Ground beef patties packaged at a postmortem storage time of three days were found to have significantly more desirable initial and 30-minute aromas scores than those at six- and nine-day-postmortem storage times (see Table 1).

Table 1. Means[e] showing the effects of storage times, postmortem age of the meat and irradiation on the aroma of fresh beef patties packaged anaerobically in Cryovac B620 bags

		Treatments	
		Anaerobic Initial Aroma	Anaerobic 30 Minute Aroma
Postmortem Storage Time (days)[f]	3	4.78[a]	5.35[a]
	6	3.94[b]	4.76[b]
	9	3.91[b]	4.54[b]
	SEM	0.23	0.19
Irradiation Day After Packaging[f]	0	4.34	4.86
	3	4.08	4.91
	SEM	0.19	0.16
Dose (kGy)	0	5.28[c]	5.65[c]
	2	3.14[d]	4.11[d]
	SEM	0.19	0.16

a-d Superscripts indicate significant differences within columns ($P < .05$).

e Scores were based on an eight point scale, 1 being extremely undesirable and 8 being extremely desirable.

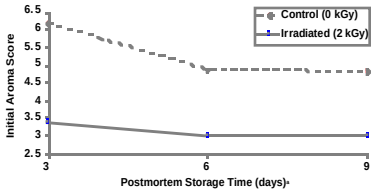
f Postmortem storage time and the irradiation day after packaging are combinations of control and irradiated patties.

Batzer et al. (1959) reported sensory qualities never increased, only deteriorated as postmortem age increased prior to irradiation. Non-irradiated controls were found to have significantly more desirable aromas than irradiated patties (see Table 1). Lambert et al. (1992) reported similar results in which irradiated (0.5 and 1 kGy) fresh pork received lower or less desirable odor scores from panelists than the controls.

Aroma scores for non-irradiated control patties decreased from moderately desirable on postmortem storage day three to slightly desirable on postmortem storage days six and nine (see Figure 1). Lefebvre et al. (1994) also found that lean ground beef packaged in polyethylene bags had less pleasurable odors when irradiated with one, 2.5, and five kGy than non-irradiated controls. Irradiated patties had less desirable aroma scores than controls and this trend remained consistent over postmortem storage times (see Figure 1). Irradiated patties received moderately undesirable aroma scores over all postmortem storage times (see Figure 1).

Figure 1. Initial aroma scores for anaerobic packaged patties at different postmortem storage times and doses. Thirty minute aroma scores followed similar paterns.

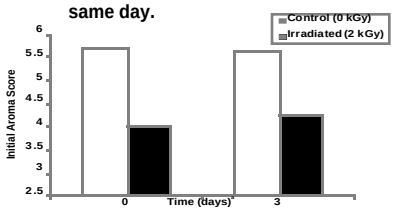
a Postmortem storage time reflects the age of the beef when first processed into patties.



Aroma scores for control patties were higher (more desirable) than irradiated patties that were irradiated days zero and three after packaging (see Figure 2). Mattison et al. (1986) noted that panelists could detect irradiation off-odors in vacuum packaged pork loins irradiated with one kGy at storage day seven but not after storage day 14. The control and irradiated aroma scores for ground beef patties remained consistent on day zero and day three of irradiation after packaging (see Figure 2).

Figure 2. Initial aroma scores for anaerobic packaged patties irradiated 0 or 3 days after packaging. Thirty minute aroma scores followed similar paterns.

a Patties were processed into patties and packaged on the same day.



Non-irradiated controls and irradiated patties had higher (more desirable) 30-minute aroma scores than initial aroma scores over all postmortem storage times and days of irradiation after packaging. This indicates that when packages are first opened, panelists find disagreeable odors for all irradiated patties, but after 30 minutes irradiated patties become more desirable in aroma. Dempster et al (1985) also reported off-odors improved in irradiated (1.03 to 1.54 kGy) vacuum packaged samples when opened and exposed to the air. Lee et al. (1995) observed irradiation may result in more off-odors when fresh meat is packaged with oxygen rather than vacuum packaged.

Implications

Coarse ground beef at three, six, and nine days postmortem and then finely ground and irradiated with two kGy had slight off-odors. Nevertheless, electron beam irradiation proved effective in extending the microbial shelf life of ground beef. The irradiated and control beef patties with the shortest postmortem storage time (day three) had significantly more desirable aroma scores than longer stored product (six- and nine-day). Control beef patties were found to have significantly more desirable initial and 30-minute aromas than irradiated beef patties. Aroma scores for all beef patties were scored higher 30 minutes after being opened than initially.

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