THE EFFECTS OF IRRADIATION, STORAGE TIME, AND HIGH AND LOW OXYGEN TRANSMISSION ANAEROBIC PACKAGING ON RAW AND COOKED SENSORY ATTRIBUTES AND COLOR OF GROUND BEEF PATTIES

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Abstract

The effects of electron beam irradiation, high and low oxygen transmission anaerobic packaging, and storage time on the raw lean color, raw odor, and cooked sensory attributes of ground beef patties were investigated. Beef trim was coarse ground and split into two groups on day one. Group one was fine ground, pattied and packaged immediately; group two was treated likewise as a seven-day sample. Patties were held either as controls or irradiated with a 2 kGy dose one day following packaging and stored at 0°C. Sensory evaluations of controls and treated patties were conducted four days after irradiation. Irradiated beef patties had greater ($P < 0.05$) raw aroma intensities, raw off-odors, and off-flavors, lower ($P < 0.05$) Hunter CIE L*, a* and b* values, and were darker red ($P < 0.05$). Seven-day raw beef patties had greater aroma intensities ($P < 0.05$), higher b* values and were less juicy ($P < 0.05$) than raw one-day beef patties. Irradiated patties had greater ($P < 0.05$) off-odors than controls for both one-day and seven-day beef patties. Hunter b* values were also lower ($P < 0.05$) for irradiated patties than controls for both one-day and seven-day beef patties. Therefore, only the freshest beef should be irradiated, and the detrimental sensory effects of irradiation were minimized by cooking.

Introduction

Ground beef is highly perishable and its shelf-life is limited by the growth of aerobic and psychrotrophic strains of bacteria under refrigerated aerobic storage. The combination of vacuum packaging and irradiation have been shown to reduce or eliminate pathogenic and spoilage organisms (Mon et al., 1995). Several researchers however have reported irradiation causes discoloration, off-odors, and off-flavors of fresh meats (Lefebvre et al., 1994; and Sudarmadji and Urbain, 1972). The objective of this study was to determine the effects of storage time of raw beef, high and low oxygen transmission vacuum plastic packaging, and irradiation on color, and the raw and cooked sensory attributes of ground beef patties.

Materials and Methods

Preparation of samples. Two piece boneless chucks were used for each of the 3 replications, and fabricated into 85% beef trim. The batch of beef trim was coarse ground through a 1.27 cm plate and mixed for three minutes. Half of each replication of coarse ground beef was fine ground through a .32 cm plate, and formed into patties (114 g). The ground beef patties were further split into two packaging groups consisting of either a high oxygen permeability vacuum bag (Cryovac 37 cc/m^2/24 hr.) or a low oxygen permeability vacuum bag (Cryovac 10 cc/m^2/24 hr.). Day-one storage patties consisted of patties from this group. The other half of each replication was stored in covered plastic lugs at 0°C±1°C for 6 days. After 6 days of storage the second half of each replication coarse ground beef was fine ground and packaged in the same manner as the first half of each replication.

Irradiation and storage. The control and treated patties were maintained at 0°C±1°C. The treated patties were irradiated the day after patties were formed, and packaged with an average dose of 2.14 ± .16 kGy. After irradiation the treated patties were once again stored with the controls at 0°C±1°C for another four days. The second half of the 3 replications were handled in the same manner.

Sensory evaluation. Sensory evaluations of the treated and control patties (Cross et al., 1978) of both package types were conducted 4 days after the treated patties were irradiated. Fourteen panelist had been previously trained in experiments in which they were required to detect irradiation off-odors and off-flavors as well as to determine color differences of raw meat and other cooked meat attributes. After allowing the color to develop the panelists evaluated the patties for lean color. The beef patty aroma intensity scale was an 8 point scale where 8 was extremely strong. The off-odor (irradiation) scale was a 5 point scale where 5 was extremely off-odor, and 1 was no off-odor. The color scale was also an 8 point scale.

Patties were cooked on a griddle from a thawed state to 71°C and evaluated by a sensory panel (AMSA, 1995). The scales for off-odors and off-flavors (irradiation) were 5 point scales, 5 being extremely off-odor or extremely off-flavor. Cooked aroma intensity, juiciness, tenderness, and flavor intensity were all 8 point scales with 8 being extremely strong, juicy, tender, and intense, respectively.

Color analysis. Two patties for each of the treatment groups were analyzed for CIE L*, a*, and b* values (Illuminat A/108) by a Hunter Labscan Spectrocolorimiter (4.4 cm diameter aperture). Each patty was removed from the vacuum bag and allowed to bloom over a 15 minute period. Three measurements were made on both patties.

Results and Discussion

Raw aroma intensity was found to be significantly ($P < 0.05$) higher in irradiated samples than non-irradiated control beef patties (Table 1). The raw aroma intensity was also ($P < 0.05$) higher for the seven-day beef samples than the one-day samples (Table 1). The increased aroma intensity of the 7-day samples is most likely explained by the higher levels of micro-organisms being present in those samples (data not shown). Microbial degradation of meat has been reported by Fu et al. (1995) leading to increased off-odors of irradiated samples. Consequently, microbial off-odors of meat may have lead to the increased aroma intensity of the raw beef patties in the older samples. Raw off-odors of the irradiated samples were found to be higher ($P < 0.05$) than non-irradiated control beef patties (Table 1). Lefebvre et al. (1994) also reported odors of lean ground beef to be less pleasant in irradiated than non-irradiated samples. Because panelists found the irradiated beef patties to have higher off-odor than controls, the increased aroma intensity of the irradiated samples may most likely be due to irradiation off-odors. The interaction of dose and storage time of the coarse ground beef was also found to be significant ($P < 0.05$) for irradiation off-odors of raw beef patties.

The panel found the color of the raw irradiated beef patties to be significantly ($P < 0.05$) darker red than the control patties, which were more cherry-red color (see Table 1). Control patties were also found to have higher ($P < 0.05$) Hunter CIE L*, a*, and b* values (see Table 1). Fu et al. (1995) reported raw L*, a*, and b* values of ground beef patties were initially lowered by irradiation. Thus, irradiation has the ability to alter the structure of meat pigments, and the state of the heme iron (Clarke and Richards, 1971). Day-one beef patties had lower ($P < 0.05$) b* values than aged seven-day-old beef patties (see Table 1). The interaction of storage time and irradiation for b* values was also significant ($P < 0.05$). Day one ground beef patties, were significantly ($P < 0.05$) juicier, or less dry than the seven-day beef patties (Table 2). Irradiated cooked beef patties had greater ($P < 0.05$) off-flavors than the non-irradiated controls (Table 2). The volatiles and radiolytic compounds which are formed from irradiation of raw meat also lead to off-flavors. Sudarmadji and Urbain (1972) reported beef had a threshold dose of 2.5 kGy before irradiation off-flavors developed.

Conclusions

An objective of our study was to determine if there was a significant difference between the high and low oxygen transmission vacuum packaging in reducing irradiation off-odors and off-flavors. Package type used in this study was not a significant influence on any of the main factors measured. Thus, a larger difference in oxygen transmission of vacuum packagesmay be necessary to release radiolytic gases which seemingly cause the irradiation odor and flavor of irradiated meats.

Accordingly, irradiation had its largest impact on raw factors of the beef patties. Once patties were cooked, only a small increase in off-flavors was detected by the trained panel were small. Also, irradiated patties having greater off-odors for both one-day and seven-day samples than controls may be partially explained in that irradiation off-odors may be compounded with spoilage off-odors. While irradiation will lower microbial counts, once meat has high microbial counts the meat will continue to have reduced quality factors after irradiation. Thus, the irradiation of high microbial count meat will produce off-odors as well as other negative sensory qualities, which could be combinations of irradiation and microbial off-odors.

References
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Table 1. Means of the effects of dose, package type, and storage time of ground beef on aroma intensity, off-odors, color and the Hunter Labscan CIE values of raw beef.

		EVALUATIONS			HUNTER LABSCAN CIE SCORES		
		RAW BEEF AROMA INTENSITY	RAW BEEF OFF-ODORS (IRRADIATION)	RAW BEEF COLOR	CIE L* VALUE	CIE a* VALUE	CIE b* VALUE
DOSE	Control	4.3[a]	1.5[a]	5.5[a]	45.3[a]	30.8[a]	25.6[a]
	Irradiated (2 kGy)	4.9[b]	2.5[b]	4.0[b]	43.4[b]	27.0[b]	22.4[b]
PACKAGE TYPE	High O_2 Transmission	4.8	2.1	4.6	44.3	28.8	24.1
	Low O_2 Transmission	4.5	1.9	4.8	44.4	28.9	24.0
STORAGE TIME	Day 1	4.4[c]	2.0	4.6	44.1	29.0	23.7[c]
	Day 7	4.8[d]	2.0	4.8	44.5	28.7	24.4[d]
	SEM's	0.14	0.09	0.14	0.19	0.18	0.11

a-d Superscripts indicate significant differences within columns ($P < 0.05$).

Table 2. Means of the effects of dose, package type, and storage time of ground beef, on cooked beef aroma intensity, cooked beef off-odors, overall-juiciness overall-tenderness, cooked flavor intensity, and cooked off-flavors of cooked beef patties.

		EVALUATIONS					
		AROMA INTENSITY	OFF-ODORS (IRRADIATION)	OVERALL JUICINESS	OVERALL TENDERNESS	COOKED BEEF FLAVOR INTENSITY	COOKED BEEF OFF-FLAVORS IRRADIATION
DOSE	Control	5.3	1.4	4.9	6.0	5.2	1.8[a]
	Irradiated (2 kGy)	5.3	1.5	5.0	5.9	5.4	2.2[b]
PACKAGE TYPE	High O_2 Transmission	5.3	1.4	5.0	6.0	5.3	1.9
	Low O_2 Transmission	5.3	1.4	4.9	5.9	5.3	2.1
STORAGE TIME	Day 1	5.3	1.4	5.4[a]	6.0	5.4	2.0
	Day 7	5.2	1.4	4.5[b]	5.8	5.2	2.0
	SEM's	0.12	0.06	0.21	0.15	0.11	0.08

a-b Superscripts indicate significant differences within columns ($P < 0.05$).