SENSORY TRAITS, COLOR, AND SHELF LIFE OF LOW-DOSE IRRADIATED BEEF STEAKS

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Summary

Irradiation had minimal effects on flavor and texture of frozen or chilled vacuum-packaged boneless beef steaks. A dose level of 3.5 kilograys (kGy) reduced beef aroma in chilled steaks. Irradiation did not influence internal or external cooked color, most raw color traits, cooking loss, pH, oxidative rancidity, or Warner-Bratzler shear force in chilled or frozen boneless steaks. PVC-wrapped controls were less red than irradiated steaks after 5 days of display. Exposure to oxygen by repackaging into oxygen-permeable film increased oxidative rancidity after display. Vacuum-packaging, in combination with irradiation, enables boneless beef steaks to be stored and/or displayed up to 28 days with minimal effects on color, oxidative rancidity, and bacterial counts.

(Key Words: Irradiation, Beef Steaks, Sensory, Color.)

Introduction

Consumers are concerned about food-borne infections, and irradiation of meat produced under a program of good manufacturing processes can reduce this problem. Although consumers previously have rejected irradiation, they are increasingly recognizing its benefits. Our objective was to determine flavor, aroma, color, and shelf life of boneless beef steaks in one of two packaging systems (vacuum and/or PVC film) and exposed to two dose levels (2 and 3.5 kGy) of nonradioactive irradiation or not irradiated.

Experimental Procedures

Twelve steaks per treatment were cut 1.0 in. thick from boneless beef strip loins (NAMP #180A) for each of three replications. Steaks were vacuum packaged in oxygen-barrier bags and either stored frozen at 4 °F or chilled at 36°F. Steaks were stored for about 60 hr, then removed, boxed, and shipped either under dry ice or chilled to arrive within 6 hr at Iowa State University s irradiation facility. After stabilizing product temperature to either 4 °F or 36°F overnight, steaks were treated with either 2.0 or 3.5 kilograys (kGy) of nonradioactive X-rays or not irradiated, then shipped back to KSU. The frozen steaks were thawed at 36 °F overnight (frozen/thawed treatment). Chilled steaks were stored at 30°F for 14 days. After 14 days, one-half of the chilled steaks were placed onto styrofoam trays, covered with oxygen-permeable PVC film, and allowed to bloom overnight at 30°F.

Eight steaks per treatment per replication were broiled to 158°F internally. Eighteen texture/flavor attributes (animal hair-fat, animal hair-lean, beef identity, bitter, bloody, browned/roasted, burnt, chemical-fat, chemical-lean, fat-like, juiciness, liver-like, metallic, rancid-fat, rancid-lean, sour, sweet, and toughness) were assessed by five professional flavor-profile panelists using a 15-point structured scale (0 = none to 15 = very intense; 0.5 intervals). Each panelist received one steak per treatment. Off-odors in the package (frozen/thawed steaks) and beef aroma and off-odors after broiling (frozen/thawed and chilled steaks) were evaluated. Cooking loss percentage, Warner-Bratzler shear force, and cooked

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internal and external color traits also were evaluated.

Two steaks were displayed at 36 °F under 150 foot candles of Deluxe Warm White fluorescent lighting and instrumentally evaluated for reflectance color at days 0, 7, and 14 for frozen/thawed steaks. For chilled steaks, PVC-packaged (PVC) steaks were evaluated at 0, 2 and 5 days only, and vacuum-packaged (VP) steaks were evaluated at 0, 2, 5, 7, and 14 days. Two additional steaks (chilled or frozen/thawed) per treatment per replication were tested before display for purge and pH and before and after display for total microbial plate count (TPC) using standard procedures. Rancidity was measured with a modified 2-thiobarbituric acid (TBA) analysis, before and after display.

Data were analyzed as a split plot design using the maximum likelihood mixed model analysis of the Statistical Analysis System. Least square means were determined, and the statistical significance level was set at $P<.05$.

Results and Discussion

Frozen/Thawed Steaks. Irradiation had minimal effects on the sensory quality of frozen, vacuum-packaged, boneless, beef steaks. Dose level did not affect beef identity, bitter, bloody, browned/roasted, fat-like, juiciness, liver-like, metallic, sour, sweet, and toughness flavor/textural attributes, or beef aroma (Table 1). Animal hair-fat, animal hair-lean, burnt, chemical-fat, chemical-lean, and rancid-fat flavor intensities were inconsistent, but less than 1 on the sensory scale, too low to be detected by most consumers. No rancid-lean or cooked off-odors were detected. In the package, off-odors were greater for irradiated steaks than for controls (Table 1). However, most of those aromatics came from the packaging film, because when samples were removed from the bag and exposed to air for 2 to 3 min, those aromas diminished or were not perceptible.

Color lightness and yellowness values were stable throughout display. Redness increased as irradiation increased from 2.0 to 3.5 kGy and as display time increased from 7 to 14 days.

Irradiation dose level did not influence any instrumental internal or external cooked color values. Cooking loss percentage, shear force, pH, and TBA values were not influenced by dose. Purge percentage was not consistent across dose level. Total microbial plate counts were not different across dose at day 0 (data not shown). At day 14, 3.1 $\log_{10}$ and 5.0 $\log_{10}$ TPC reductions (approximately 99.9 and 99.999%) from nonirradiated controls were observed for 2.0 and 3.5 kGy irradiated steaks, respectively (data not shown). Nonirradiated control and 2.0 kGy TPC values increased from day 0 to day 14, but TPC for 3.5 kGy did not increase.

Aged Chilled Steaks. Neither irradiation dose level nor package type affected bitter, fat-like, juiciness, metallic, or sweet flavor/textural attributes (Table 2). Animal hair-fat, animal hair-lean, burnt, chemical-fat, chemical-lean, rancid-fat, and rancid-lean flavor attributes and cooked off-odors results were inconsistent, but below 1 on the sensory scale.

The introduction of oxygen when steaks were repackaged in PVC increased some undesirable characteristics, such as toughness, sour and liver-like flavors, and decreased desirable flavors, such as beef aroma, browned/roasted, and beef identity. Intensity levels for undesirable attributes, such as bloody, liver-like, and sour, were at the lower end of the sensory scale and would not be detected by most consumers.

VP steaks were stable during display for most color traits. PVC-wrapped steaks (oxygen-permeable film) were lighter colored and yellower at 0, 2, and 5 days compared to VP. In addition, PVC steaks had lower red intensity. Redness decreased with longer display for PVC steaks for all dose levels. At day 5 of display, control steaks wereless red and more yellow than irradiated steaks. Rewrapping steaks into PVC degraded color and shortened display life when compared to steaks left in vacuum packaging. However, within PVC-wrapped steaks, irradiation slowed the decreasing redness and increasing yellowness, thus allowing a slightly longer retail display.

Irradiation dose level did not affect any instrumental internal or external cooked color values. Cooking loss percentage, pH, and Warner-Bratzler shear force were not affected by dose level or package type (Table 2). Greater purge percentage was observed for VP than for PVC steaks. Within PVC and VP steaks, TPC were higher for controls than irradiated samples at 0 and 5 days and 0 and 14 days, respectively. TPC at day 14 for 3.5 kGy VP were not different than day 0 counts, but TPC increased for controls and 2 .0 kGy samples during display.

Day 0 TBA values were slightly higher for PVC steaks than for VP counterparts. Day 5 TBA values for PVC were higher than day 0 counterparts and above the taste detection threshold level of 1.0. No increase in TBA values was observed in VP steaks during display. Exposing steaks to oxygen by repackaging in PVC film resulted in increased TBA values. Vacuum-packaging, in combination with irradiation, enables boneless beef steaks to be stored and(or) displayed up to 28 days with minimal effects on sensory attributes, color, oxidative rancidity and bacterial counts.

Table 1. Effect of Irradiation on Flavor/Aroma Sensory Attributes [a] for Cooked Frozen Boneless Beef Steaks

	Dose, kGy			
Attribute	0	2.0	3.5	SE
Beef identity	12.1	12.0	11.8	.3
Bitterness	1.5	1.8	1.8	.3
Bloody	4.8	6.2	6.1	.6
Browned/Roasted	8.6	8.0	8.1	.2
Fat-like	2.1	2.3	2.3	.3
Juiciness	9.9	9.3	9.4	.3
Liver-like	1.8	2.1	1.2	.5
Metallic	3.1	4.0	3.8	.3
Sour	1.7	1.9	1.8	.2
Sweet	.7	.5	.5	.2
Toughness	6.1	6.7	7.0	.7
Beef aroma	11.7	11.0	11.2	.4
Off-odor - In package	$.5^c$	3.5^b	3.5^b	.6
- Cooked	.0	.0	.0	.0

[a]15-point scale: 0 = none to 15 = very intense.
[bc]Mean values within the same row with different superscripts are different (P<.05).

Table 2. Flavor/Aroma Sensory Attributes [a] and Warner-Bratzler Shear Force (WBS) as Affected by Irradiation Dose and Package Type

	Dose, kGy				Package Type		
Attribute	0	2.0	3.5	SE	PVC	VAC	SE
After cooking							
Bitterness	1.5	1.7	1.8	.3	1.7	1.6	.3
Fat-like	2.5	2.5	2.6	.2	2.5	2.6	.2
Juiciness	8.8	8.6	8.5	.3	8.6	8.7	.3
Metallic	3.3	3.7	3.7	.4	3.5	3.6	.4
Sweet	1.0	.9	.8	.2	.9	.8	.2
Beef aroma	11.3^{c}	11.5^{c}	10.6^{d}	.2	10.8^{d}	11.5^{c}	.1
Off-odors	.3	.0	.5	.4	.6	.0	.3
WBS, kg[b]	3.20	3.25	3.23	.31	3.29	3.16	.25
Cooking loss, %	22.6	22.1	23.7	1.1	22.8	22.8	1.0
Purge, %	.30	.42	.49	.18	$.0^{d}$	$.8^{c}$	.16
pH	5.59	5.64	5.61	.04	5.63	5.59	.03

[a] 15-point scale: 0 = none to 15 = very intense.
[b] Six 1/2 in.-cores per steak.
[cd] Mean values within the same row within a variable with differe nt superscripts are different (P<.05).