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PALATABILITY, COLOR, AND PRODUCT LIFE OF LOW-DOSE IRRADIATED RAW GROUND BEEF PATTIES

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BACKGROUND AND OBJECTIVE

Recent events involving foodborne infections in meat products have increased consumer awareness of possible food contamination by pathogens, especially *Escherichia coli* O157:H7. Of surveyed consumers, 43% were very concerned with food safety (AMIF, 1993). One possible method to increase meat safety is the use of irradiation. The World Health Organization (WHO) stated that no toxicological hazard resulted from consuming food irradiated up to 10 kGy (WHO, 1981). Clavero et al. (1994) and Monk et al. (1994) summarized that treatment of ground beef with 2.5 kGy of gamma irradiation would reduce *Escherichia coli* O157:H7 by 8.1 $\log_{10}$, salmonellae 3.1 $\log_{10}$, *Campylobacter jejuni* 10.6 $\log_{10}$, *Listeria monocytogenes* 4.1 $\log_{10}$, and *Staphylococcus aureus* 5.12 $\log_{10}$. Irradiation has considerable potential for the meat industry when combined with Good Manufacturing Practices. Historically, consumers have rejected irradiation. After educational intervention, the percentage of consumers purchasing irradiated ground beef increased from 51.5% to 70.9% (AMIF, 1993). Little is known about the effects of low-dose irradiation on meat quality; thus on consumer acceptance. The objective of this study was to determine flavor, aroma, color and product life of raw ground beef patties of two fat levels (10 and 22%) and two packaging systems (aerobic and vacuum) exposed to three dose levels (0, 2, and 3.5 kGy) of non-radioactive irradiation.

METHODS

Beef knuckles from a commercial processor trimmed of external and seam fat for each of three replications and beef fat trim from Kansas State University (KSU) Meat Laboratory were coarse ground separately through a 0.95 cm plate, mixed to obtain fat levels of 10% and 22% as determined by Foss-Let Fat Analyzer, then ground twice through a 0.32 cm plate. Twelve patties (114 ±1 g; 10.8cm X 1.2cm) per treatment were made using a hand press. Patties were stacked individually on metal trays and crust frozen in a blast freezer (-40°C) for 20 min. Patties were either vacuum-packaged in B-630 bags (O_2 transmission of 3-6 cc/m^2/24 hrs at 4.4°C and 0% relative humidity, Cryovac Corporation, Duncan, SC) or sealed in oxygen-permeable bags (polyethylene, 0.65μm) and frozen (-20 ± 3°C). Patties were freezer stored for about 60 hrs, then removed, boxed, and shipped under dry ice with arrival within 6 hrs to Iowa State University's (ISU) irradiation facility. After stabilizing the product temperature (-27 ± 1°C) overnight, patties were treated with either 0, 2.0 or 3.5 kGy of non-radioactive X-rays (5 MeV energy level; 12 kW power level). After irradiation, the product was shipped back to KSU and stored at -19 ± 1°C overnight.

Eight frozen patties per treatment per replication were broiled to 74°C internally, as measured with a 21-gauge hypodermic probe-type thermocouple attached to a hand-held thermometer (Omega Engineering, Inc., Stamford, CT). Fifteen texture/flavor attributes: toughness (TOU), juiciness (JUI), meat identity (MID), browned/roasted (BR), bloody (BL), fat-like (FL), metallic (MET), liver-like (LL), burnt (BT), rancid (RAN), animal-hair (AH), chemical (CHM), sweet (SW), sour (SR), and bitter (BI) were assessed by five professional flavor profile panelists using a 15-point scale (0=none to 15=very intense). Each panelist received one patty per treatment. Beef aroma and off-odor were evaluated on broiled patties. Cooking loss percentage, Warner-Bratzler Shear (WBS) Force (Universal Testing Machine, Model 4201, Instron Corp., Canton, MA) and cooked internal color using Illuminant A CIE L*a*b*, hue angle, saturation index, and a*/b* and 630/580 reflectance ratios (2.5 cm diameter aperture, UltraScan Sphere Spectrocolorimeter, Hunter Associates Laboratory, Inc., Reston, VA) were evaluated.

Two patties per treatment per replication were tested for purge, pH, total plate count (TPC) using standard procedures (APHA, 1992), and a modified 2-thiobarbituric acid analysis (TBA) (Witte et al., 1970). Two additional patties were displayed at -19 ± 1°C under 1614 lux light intensity (Philips, 40W Deluxe Warm White) and evaluated instrumentally (5 cm diameter aperture, LabScan 6000 Spectrocolorimeter, Hunter Associates Laboratory, Inc.) as mentioned above at days 0, 7, 14, and 21. After the final day of display, TBA was determined.

Data were analyzed as a strip-split plot design using the maximum likely-hood mixed model analysis of the Statistical Analysis System (SAS Institute, 1994). Least square means were determined and separated at P<0.05.

RESULTS AND DISCUSSION

Sensory: Dose level, package type, and fat percentage did not affect TOU, JUI, LL, BT, CHM, SW, and SR flavor attributes or beef aroma (Table 1). However, stronger MET notes were observed on vacuum-packaged (VP) patties than aerobically-packaged (AP) counterparts. Fat level of 22% resulted in higher BR impressions than 10%. Intensity levels for BT, CHM, SW, RAN, and AH were < 1 in the sensory scale for all treatments, except AH for 10% fat, 3.5 kGy VP (mean=1.53) was greater than control or 2 kGy samples. Bitterness notes decreased for 22% fat, 3.5 kGy VP (1.44) patties when compared to 22% fat, 3.5 kGy AP (2.02) and 10% fat, 3.5 kGy VP patties (2.06). Within a fat by packaging combination, BI was not influenced by dose. Fat-like notes were lower for 22% fat, 3.5 kGy VP patties (4.43) than for 22% fat, 3.5 kGy AP patties (5.43). The reverse was observed for 10% fat, 3.5 kGy counterparts (4.18 and 3.29). Dose of 2 kGy increased FL intensity for 22% fat AP patties. Bloody notes were lower (P<0.05) for 10% fat AP controls (2.78) when compared to 10% fat VP controls (3.44). Dose levels of 2 kGy decreased BL intensity for 10% fat VP patties compared to 0 kGy. No off-odors were detected for either raw or cooked.

Raw color: Vacuum-packaged patties were darker than AP counterparts at day 0, 7, 14 and 21. Control patties had higher (P<0.05) L* values than irradiated patties at day 0, but were not different at 7, 14, and 21d. VP patties (0, 2 and 3.5kGy) had greater a* values (redder) than AP at 7, 14 and 21 days display, except for day 7 controls. Also, at day 0, control VP patties had higher a* values than AP patties. Within VP patties, redness decreased from 0 to 2 kGy at day 0, increased from 0 to 2 kGy at day 7, and no differences were observed at 14 and 21 d. Within AP patties, redness decreased from 0 to 2 kGy at 0, 7, and 14 d, with no difference at day 21. Dose levels did not affect b* values at 7, 14, and 21 d. Day 0 control patties had higher b* values than irradiated counterparts with no difference at 7, 14 and 21 d. Greater hue angles were observed at 7, 14 and 21 d in 0, 2 and 3.5 kGy AP patties compared to VP, except for 7d controls. The a*/b* ratio data showed an opposite effect to hue angle data, but had no differences for day 0 controls. Saturation index was greater for 0, 2 and 3.5 kGy at 0, 14 and 21 d and for 3.5 kGy day 7 VP patties compared to AP counterparts. Opposite results were obtained for control and 2 kGy day 7 samples. Saturation index decreased from 0 to 2 kGy in AP patties at 0 and 7 d and in VP patties at day 0. A greater reflectance ratio was observed for 14 and 21 d VP patties compared to AP. Reflectance ratios were lower for irradiated day 0 samples than control samples.

Cooked color: Fat and dose levels did not affect internal cooked L*a*b* values, hue angle, saturation index, or a*/b* and reflectance ratios. However, VP samples had higher ($P<0.05$) a* values, saturation indexes, a*/b* and reflectance ratios than AP counterparts.

Other: Shear force and pH were not affected by fat, dose level, or package type (Table 1). Fat and dose level did not influence cooking loss percentage. Cooking loss was less in VP than AP patties. A 1.62 $\log_{10}$ and 2.03 $\log_{10}$ TPC reduction from controls was observed for 2 and 3.5 kGy irradiated patties, respectively. Fat level and packaging type did not affect TPC. Percent purge was higher for VP patties than AP patties within a fat level. Higher TBA values were observed across all days for AP patties compared to VP. TBA values were larger than controls and above the threshold level (1.00) for 2 and 3.5 kGy AP patties at day 21.

CONCLUSIONS

Irradiation did not influence TOU, JUI, LL, BT, CHM, SW, SR, MET, MID, BR, BI and RAN flavor or beef aroma attributes, but did influence AH, FL and BL notes. Raw L*a*b* values were initially lowered by irradiation but stabilized during storage and were influenced by packaging type. Cooked internal color, shear force, and pH were not influenced by irradiation. Cooking loss percentage and TBA values were greater for aerobic than vacuum packaging.

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Table 1. Mean and standard error (SE) values for flavor/aroma sensory attributes*, shear force (WBS), total plate counts (TPC), cooking loss, and pH for ground beef patties as affected by fat percentage, package type and dose level.

	Fat (%)			Package			Dose (kGy)			
Trait	10	22	SE	Aerobic	Vacuum	SE	0	2	3.5	SE
Sensory										
Toughness (TOU)	6.40	5.97	0.27	6.11	6.26	0.26	6.16	6.20	6.20	0.28
Juiciness (JUI)	5.70	6.40	0.35	6.02	6.06	0.32	6.19	5.70	6.22	0.38
Browned/Roasted (BR)	7.81[b]	8.31[a]	0.29	8.05	8.07	0.29	8.05	8.06	8.07	0.30
Metallic (MET)	3.04	2.70	0.48	2.59[b]	3.16[a]	0.47	2.87	2.87	2.88	0.49
Liver-like (LL)	1.96	0.85	0.26	1.46	1.34	0.21	1.81	1.31	1.09	0.32
Burnt (BT)	0.30	0.36	0.14	0.34	0.31	0.12	0.22	0.38	0.39	0.15
Chemical (CHM)	0.40	0.24	0.17	0.31	0.33	0.14	0.09	0.35	0.52	0.18
Sweet (SW)	0.63	0.70	0.20	0.66	0.67	0.19	0.73	0.61	0.66	0.20
Sour (SR)	1.55	1.50	0.15	1.54	1.50	0.15	1.51	1.54	1.50	0.16
Beef aroma	10.17	10.00	0.28	10.08	10.08	0.25	9.96	10.25	10.04	0.35
WBS (kg)[d]	3.10	2.75	0.10	2.95	2.91	0.09	3.03	2.89	2.86	0.10
TPC[e]	3.20	3.23	0.39	3.16	3.27	0.38	4.43[a]	2.81[b]	2.40[c]	0.39
Cooking loss (%)	32.47	38.44	1.05	36.05[a]	34.85[b]	0.79	34.72	36.66	34.97	0.97
pH	5.79	5.82	0.06	5.80	5.80	0.06	5.80	5.80	5.81	0.06

abc Mean values within the same row within fat or dose level or package type bearing different superscript letters are different ($P<0.05$)

d Warner - Bratzler Shear

e Expressed as $\log_{10}$ CFU/cm^2.

* 15 point scale: 0= none to 15= very intense.