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SENSORY ANALYSIS AND CONSUMER ACCEPTANCE OF LOW-DOSE IRRADIATED BONELESS PORK CHOPS

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BACKGROUND AND OBJECTIVE

Recent events involving food borne infections in meat products have increased consumer awareness of possible food contamination with pathogens, especially *Escherichia coli* O157:H7. Of surveyed consumers, 43% were very concerned with food safety (AMIF, 1993). Irradiation is one possible method to increase meat safety, especially when combined with Good Manufacturing Practices. The World Health Organization stated that no toxicological hazard resulted from consuming food irradiated up to 10 kGy (WHO, 1981). Theoretically, an applied dose of 2.5 kGy would reduce five major pathogens by 4 to 10 log_{10} in ground beef (Clavero et al., 1994; Monk et al., 1994). Historically, consumers have rejected irradiation, but several studies indicate that consumer attitudes toward irradiation are changing (Bruhn, 1995; Resurreccion et al., 1995). After educational intervention, the percentage of consumers purchasing irradiated ground beef increased from 51.5 to 70.9 % (AMIF, 1993). Even though the effects of irradiation on the survival of microorganisms in food has been well studied, little is known about the effects of low-dose irradiation on meat quality, and meat quality will ultimately determine consumer acceptance.

The objective of this study was to determine flavor and aroma characteristics of boneless center-cut pork chops in one of two packaging systems (vacuum and aerobic), at one of two irradiation/storage temperatures (-17 ± 3 and 3 ± 2°C), with exposure to one of three dose levels (0, 1.5, and 2.5 kGy for chilled and 0, 2.5, and 3.85 kGy for frozen) of one of two irradiation sources (Co^{60} and electron beam). This study also determined consumer acceptance of chilled, vacuum-packaged boneless pork chops exposed to two Co^{60} dose levels (0 and 2.5 kGy).

METHODS

Flavor/Aroma Profile: Bone-in pork loins were obtained from a commercial processor for each of three replications. Five *Longissimus thoracis/lumborum* center-cut boneless chops per treatment were cut 3.18 cm thick from boneless pork loins (NAMP #412B). Loins were separated by temperature treatment and further divided by package type. Loin identification was tracked throughout the study. Only chops with color, firmness/wetness, and marbling scores of 2, 3, or 4 (NPPC, 1991), loin eye of 4.5 to 6.5 in^2, and Minolta L* value of 40 to 58 were used. Chops were either vacuum-packaged (VP) in Perflex 51 bags (O_2 transmission of 32.55 cc/m^2/24 hrs at 1 atm, Viskase Corp., Chicago, IL) or sealed in oxygen-permeable (AP) bags (Perflex S, O_2 transmission of 5037 cc/m^2/24 hrs 1 atm, Viskase Corp.). After packaging, chops were boxed and stored either frozen at -17 ± 3°C or chilled at 3 ± 2°C. Boxed product was stored for about 60 hrs and shipped with arrival within 24 hrs at either Iowa State University's Linear Accelerator Facility (electron beam (EB), ISU, Ames, IA) or FOOD TECHnology Service, Inc. (Co^{60}, FTS, Mulberry, FL). After stabilizing product temperature overnight to either -17 or 3°C, chops were treated with either 0, 1.5 or 2.5 kGy (chilled) or 0, 2.5, or 3.85 kGy (frozen) of either non-radioactive EB (10 MeV energy level; 7.1 to 10 kW power level) or radioactive Co^{60}. After irradiation, product was stored overnight, returned to Kansas State University (KSU) and stored either at -17 ± 3 or 3 ± 2°C for about 60 hrs. Prior to broiling, frozen chops were thawed at 1 ± 1°C overnight.

Chops were broiled to 74°C internally, as measured by type-T thermocouples attached to a Doric temperature recorder (Model 205, Beckman Instruments, Schaumburg, IL). Eighteen texture/flavor attributes: bitterness (BIT), bloody (BLD), browned/roasted (BR), burnt (BUR), fat-animal hair (FAH), fat-chemical (FCH), fat-like (FL), fat-rancid (FR), juiciness (JUI), lean-animal hair (LAH), lean-chemical (LCH), lean-rancid (LR), liver-like (LL), metallic (MET), pork identity (PID), sour (SR), sweet (SW), and toughness (TOU) were assessed by five professional flavor profile panelists using a 15-point scale (0 = none to 15 = very intense). To avoid animal differences, each panelist evaluated treatment samples from the same loin. Each panelist received one chop per treatment. Pork identity aromas and off-odors were evaluated on raw and cooked chops by two professional aroma profile panelists using a 15-point scale. Off-odors also were evaluated during broiling.

Consumer Acceptance: Twenty-eight chops per treatment were prepared as previously described. Chops were vacuum-packaged in Perflex 51 bags. After packaging, chops were boxed and stored chilled at 3 ± 2°C. Boxed product was handled and shipped to FOOD TECHnology Service, Inc. as described above. After stabilizing product temperature overnight to 3°C, chops were treated with 0 or 2.5 kGy of radioactive Co^{60}. After irradiation, product was stored overnight, returned to KSU and stored at 3 ± 2°C for about 84 hrs.

Consumers (n=108) were chosen from a database of 500. Panelists included only those consumers that ate red meat at least three times per week. Chops were prepared as described above. To avoid animal differences, each panelist evaluated treatment samples from the same loin. Each chop was sliced into quarters and then sliced in half again for two bites per sample. Each chop was tested by four panelists. Overall acceptance, meatiness, freshness, tenderness, and juiciness were evaluated using an 9-point scale (1=dislike or to 9=like extremely).

Statistical Analysis: 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 to separate means at P<0.05.

RESULTS AND DISCUSSION

Chilled Boneless Pork Chops: Dose level, package type, and irradiation source did not affect BUR, FL, FR, JUI, LL, LR, MET, and TOU flavor attributes (Table 1). BLD increased from 1.5 to 2.5 kGy. ISU VP chops had stronger SR notes than FTS VP samples. BIT increased in AP samples from 1.5 to 2.5 kGy and was greater in 2.5 kGy AP than in 2.5 kGy VP chops. PID was lower for ISU VP 2.5 kGy than ISU VP 1.5 kGy, ISU AP 2.5 kGy and FTS VP 2.5 kGy samples. BR increased in ISU AP from control to 2.5 kGy samples, but FTS AP and VP samples were not affected by dose. FTS VP and ISU AP controls had more BR than ISU VP controls. SW notes were lower in FTS AP 2.5 kGy than ISU AP 2.5 kGy samples. BUR, FR, LL and LR intensity levels were <1, and FAH, FCH, LAH and LCH were <1.7 in the sensory scale for all treatments.

Frozen Boneless Pork Chops: Dose level, package type, and irradiation source did not affect BIT, BUR, FAH, FL, LR, PID, SR, and SW flavor attributes (Table 1). BLD was greater in VP chops then in AP. MET was lower in controls than irradiated samples. TOU increased from AP control to 3.85 kGy AP samples, but VP samples were not influenced by dose. BR was lower in ISU 3.85 kGy than either ISU 2.5 kGy or FTS 3.85 kGy samples, and ISU VP was lower for BR than ISU AP chops. JUI was lower for FTS VP 2.5 kGy samples than for FTS AP 2.5 kGy. BUR, FAH, FCH, FR, LAH, LCH, LL, and LR intensity levels were <1 in the sensory scale for all treatments.

Aroma: Raw and cooked pork attributes were not influenced by dose level, package type, or irradiation source at either storage temperature. No off-odors were detected in the raw or cooked state or during broiling on chilled chops. In frozen chops, no off-odors were detected during broiling or in cooked chops, but raw off-odor did not satisfy the assumption of continuous response.

Consumer Acceptance: Approximately 84% of the panelists were between the ages of 26 and 55, and over 50 % had at least some college experience. No differences were observed between irradiated and control samples for overall acceptance or any other attribute tested (Table 2).

Table 2: Mean and standard errors (SE) for triats evaluated by consumers on irradiated boneless pork chops.

Dose (kGy)	Overall Acceptance	Meatiness	Freshness	Tenderness	Juiciness
0	6.2	7.3	6.7	5.8	5.5
2.5	6.3	7.4	6.8	5.9	5.7
SE	0.2	0.1	0.2	0.2	0.2

(P>0.05)

SUMMARY

Irradiation did not influence BUR, FL, FR, JUI, LL, LR, MET, SR, TOU, and aroma attributes in chilled pork chops. Irradiation did not influence BIT, BLD, BUR, FAH, FL, LR, PID, SR, SW, and aroma attributes in frozen pork chops. Irradiation source and package type had varying affects on other flavor notes at either storage temperature. Acceptance of irradiated samples by consumers was not different from controls. Overall, there were few major differences between control and irradiated chops.

ACKNOWLEGDEMENTS

Research sponsors: National Live Stock and Meat Board; National Pork Producers Council. We thank Drs. D. Olson and G. Milliken, H. Everett, K. Chartier, J. Eilers, D. Woydziak, C. Cultra, and S. Hollinger for technical and/or statistical assistance.

PERTINENT LITERATURE

AMIF. 1993. Amer. Meat Inst. Found., Arlington, VA.
APHA. 1992. Amer. Public Health Assoc., Washington, D.C.
Bruhn, C.M. 1995. J. Food Prot. 58(2):175-181.
Clavero, M.R.S., J.D. Monk, L.R. Beuchat, M.P. Doyle, and R.E. Brackett. 1994. Appl. Environ. Micro. 60(6):2069-2775.
Monk, J.D., M.R.S. Clavero, L.R. Beuchat, M.P. Doyle, and R.E. Brackett. 1994. J. Food Prot. 57(11):969-974.
NPPC. 1991. Nat. Pork Producers Council, Des Moines, IA.
Resurreccion, A.V.A., F.C.F. Galvez, S.M. Fletcher, and S.K. Misra. 1995. J. Food Prot. 58(2):193-196.
SAS Institute. 1994. SAS User's Guide, Version 6 ed. SAS Institute Inc., Cary, N.C.
WHO. 1981. Report of a Joint FAO/IAEA/Who Expert Committee. World Health Org. Tech. Rpt. No. 659, Geneva, Switzerland.

Table 1: Means and standard errors (SE) for flavor attributes* for frozen and chilled pork chops as affected by irradiation source, package type and dose level.

	Irradiation Source			Package			Dose			
Trait	ISU	FTS	SE	Aerobic	Vacuum	SE	0	1.5/2.5	2.5/3.85	SE
Chilled										
Bloody (BLD)	1.7	1.5	0.3	1.5	1.7	0.3	1.6^{b}	1.4^{b}	1.9^{a}	0.3
Burnt (BUR)	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1
Fat-chemical (FCH)	0.8	0.8	0.2	1.1^{a}	0.5^{b}	0.2	0.5^{b}	0.9^{a}	1.0^{a}	0.2
Fat-like (FL)	1.3	1.4	0.3	1.3	1.3	0.3	1.3	1.5	1.3	0.3
Fat-rancid (FR)	0.4	0.4	0.1	0.6^{a}	0.2^{b}	0.1	0.2	0.5	0.5	0.1
Juiciness (JUI)	7.1	7.1	0.4	7.0	7.2	0.4	7.3	6.9	7.1	0.4
Lean-rancid (LR)	0.1	0.1	0.1	0.2^{a}	0.0^{b}	0.1	0.0	0.1	0.2	0.1
Liver-like (LL)	0.2	0.2	0.1	0.2	0.2	0.1	0.1	0.2	0.3	0.1
Metallic (MET)	1.7	1.8	0.4	1.7	1.8	0.4	1.7	1.6	1.9	0.4
Toughness (TOU)	6.7	6.8	0.4	6.9	6.7	0.4	6.6	6.8	6.8	0.4
Frozen										
Bitterness (BIT)	1.0	1.0	0.2	1.0	1.0	0.2	1.0	1.0	1.0	0.2
Bloody (BLD)	1.7	1.7	0.3	1.6^{b}	1.8^{a}	0.3	1.6	1.8	1.7	0.3
Burnt (BUR)	0.0	0.1	0.03	0.1	0.0	0.03	0.1	0.0	0.0	0.03
Fat-animal hair (FAH)	0.3	0.3	0.1	0.3	0.3	0.1	0.2	0.4	0.4	0.2
Fat-like (FL)	1.2	1.1	0.3	1.2	1.2	0.3	1.2	1.2	1.1	0.3
Lean-rancid (LR)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Metallic (MET)	1.8	1.8	0.4	1.7	1.8	1.4	1.6^{b}	1.9^{a}	1.9^{a}	0.4
Pork Identity (PID)	11.8	11.9	0.2	11.8	11.8	0.2	11.9	11.7	11.8	0.2
Sour (SR)	1.7	1.8	0.3	1.8	1.8	0.3	1.7	1.8	1.8	0.3
Sweet (SW)	1.2	1.2	0.1	1.2	1.2	0.1	1.2	1.2	1.2	0.1

[ab] Mean values within the same row within source, package type, or dose level bearing different superscripts are different (P<0.05).
* 15 point scale: 0=none to 15=very intense.

Aroma: raw and cooked pork attributes were not influenced by dose level, package type, or irradiation source at either storage temperature. No off-odors were detected in the raw or cooked state or during broiling of chilled chops. In frozen chops, no off-odors were detected during broiling or in cooked chops, but raw off-odor did not satisfy the assumption of continuous response.

Consumer Acceptance: Approximately 58% of the panelists were between the ages of 26 and 55, and over 50 % had at least some college experience. No differences were observed between irradiated and control samples for overall acceptance or any other attribute tested (Table 2).

Table 2: Mean and standard errors (SE) for traits evaluated by consumers on irradiated boneless pork chops

Dose (kGy)	Overall Acceptance	Moistness	Freshness	Tenderness	Juiciness
0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2.5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

(P<0.05)

SUMMARY

Irradiation did not influence BUR, FL, FR, JUI, LI, LR, MET, SR, TOU, and aroma attributes in chilled pork chops. Irradiation did not influence BIT, BLD, BUR, FAH, FL, LR, PID, SR, SW, and aroma attributes in frozen pork chops. Irradiation source and package type had varying effects on other flavor notes at either storage temperature. Acceptance of irradiated samples by consumers was not different from controls. Overall, there were few major differences between control and irradiated chops.

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PERTINENT LITERATURE

AMIF. 1993. Amer. Meat Inst. Found., Arlington, VA.

APHA. 1992. Amer. Public Health Assoc., Washington, D.C.

Bruhn, C.M. 1995. J. Food Prot. 58(2):175-181.

Clavero, M.R.S., J.D. Monk, L.R. Beuchat, M.P. Doyle, and R.E. Brackett. 1994. Appl. Environ. Micro. 60(6):2069-2075.

Monk, J.D., M.R.S. Clavero, L.R. Beuchat, M.P. Doyle, and R.E. Brackett. 1994. J. Food Prot. 57(11):969-974.

NPPC. 1991. Nat. Pork Producers Council, Des Moines, IA.

Resurreccion, A.V.A., F.C.F. Galvez, S.M. Fletcher, and S.K. Misra. 1995. J. Food Prot. 58(2):193-196.

SAS Institute. 1990. SAS User's Guide, Version 6 ed. SAS Institute Inc., Cary, N.C.

WHO. 1981. Report of a Joint FAO/IAEA/WHO Expert Committee. World Health Org. Tech. Rpt. No. 659, Geneva, Switzerland.

Table 1: Means and standard errors (SE) for flavor attributes* for frozen and chilled pork chops as affected by irradiation source, package type and dose level.

Trait	ISU	FTS	SE	Aerobic (AP)	Vacuum (VP)	SE	0	1.5/2.5	2.5/3.85	SE
Chilled										
Bloody (BLD)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Burnt (BUR)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fat-animal (FAH)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fat-like (FL)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fat-rancid (FR)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Juiciness (JUI)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lean-rancid (LR)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Liver-like (LI)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Metallic (MET)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Toughness (TOU)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Frozen										
Bitterness (BIT)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Bloody (BLD)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Burnt (BUR)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Fat-like (FL)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Lean-rancid (LR)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Pork identity (PID)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Sweet (SW)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ab Mean values within the same row within source, package type, or dose level bearing different superscripts are different (P<0.05).

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