Control of *Listeria monocytogenes* on pre-cooked pork chops by irradiation combined with modified atmosphere packaging

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Abstract

The efficacy of controlling *Listeria monocytogenes* in pre-cooked pork chops by irradiation combined with high CO_2 (100%) modified atmosphere packaging (MAP) was investigated in this study. Enhanced pork loins (injected with water, salt, phosphate and potassium lactate) were purchased from a local manufacturer, cooked to internal temperature 72 ºC, and sliced to 1.5 cm thick chops. Chops were inoculated with a five strain cocktail of *L. monocytogenes* at a concentration of 5 log /gram. Chops were packaged individually with vacuum or MAP, and irradiated at 0 (control), 1.0, 1.5 or 2.0 kGy. The radiation sensitivity of this microorganism was observed to be similar in vacuum or MAP packaging. The D10-value was 0.59 ± 0.02 kGy in vacuum and 0.57 ± 0.02 kGy in MAP packaging. During temperature abuse (at room temperature for 48 hours), the population of this bacterium increased significantly on both irradiated or non-irradiated pork chops in vacuum packages, but only on non-irradiated chops in MAP packages. The lag phase of *L. monocytogenes* was 7-9 weeks in vacuum packaging, and at least 12 weeks in MAP packaging. Very little lipid oxidation was detected in the irradiated product from either vacuum or MAP packages. Neither irradiation nor packaging affected the pH of the product. Irradiation-induced redness was observed in precooked pork chops in vacuum packages, but not in MAP packages. Pre-cooked pork chops from MAP packages were less firm and juicier than from vacuum packages. Irradiated off-odor was detected in the product from both vacuum and MAP packages.

Introduction

Product recalls of ready-to-eat (RTE) meat products due to contamination with *L. monocytgenes* have not only caused tremendous economic loss in the meat industry, but also indicate that this foodborne pathogen is still a potential risk for public health. While progress has been made, additional control measures are needed to eliminate this pathogen from RTE meats. Irradiation and modified atmosphere packaging (MAP) have been used for the control of pathogenic bacteria in many food meat products (Olson, 1995; Rao & Sachindra, 2002). Many reports have shown that MAP with high CO_2 (60-100%) is more effective than low CO_2 (20-30%) for control of spoilage bacteria in fresh meats, and meat shelf life was longer in MAP with high CO_2 (Tewari et al., 1999). MAP with high CO_2 also has the advantage of excluding oxygen from packages and preventing lipid oxidation when meat product was treated with irradiation (Grant and Patterson, 1991). Few studies have been done on the radiation sensitivity of *L. monocytogenes* on RTE meat products packaged in high CO_2 MAP, or on the survival and recovery of this foodborne pathogen in high CO_2 MAP at refrigeration temperature, or with temperature abuse following irradiation treatments.

Objective

The objective of this study was to test the hypothesis that irradiation combined with high CO_2 MAP (100% CO_2) is more effective than irradiation with vacuum packaging for reducing *L. monocytogenes* on pre-cooked pork chops, and for inhibiting the growth of survivors at 2-4 ºC or with temperature abuse. Quality and sensory evaluations were also included to assess the quality implications of the combined treatments.

Materials and Methods

- ► Preparation of bacterial cultures
  - Five strains of *L. monocytogenes*
  - Medium: TSB+YE
  - Incubation: 35 ºC for 24 hr
- ► Inoculation and packaging
  - Inoculum: combined five strains in 0.1% peptone water (7 log cfu /ml)
  - Pork chops: 1.5 cm thick slices, 100 grams
  - Inoculation concentration: 5 log cfu /g
  - Packaging: vacuum or high CO_2 MAP for single chops
- ► Irradiation
  - Electron beam (linear accelerator)
  - Target doses for inoculated samples: 0 (control), 1.0, 1.5, 2.0 kGy
  - Target doses for uninoculated samples: 0 (control), 1.5, 2.0 kGy
- ► Enumeration:
  - Medium for plating: MOX, incubated at 35 ºC for 48 hr
  - Radiation sensitivity (D10-values): plating immediately after irradiation
  - Storage: 12 weeks at 2-4 ºC, plating once a week
  - Temperature abuse: 48 hr at room temperature following 2 weeks at 2-4 ºC
- ► Quality evaluation:
  - •CIE color values (L* b* a*), oxidative rancidity (TBA), pH and purge
- ► Sensory evaluation:
  - Ten trained panelists; 15 unit numerical line
    - Unheated samples: color and aroma
    - Heated samples: aroma, texture and flavor

Results

1. Radiation sensitivity:

Table 1—Mean of radiation D_{10}-values (kGy) of *L. monocytogenes* on pre-cooked pork chops packaged in vacuum or high CO_2 MAP

Product	Packaging	N	Mean D_{10}-value	Std. Deviation	SEM	p-value
Pre-cooked pork chops	Vacuum	27	0.59	0.09	0.02	0.137
	MAP	27	0.57	0.08	0.02	

2. Growth during storage:

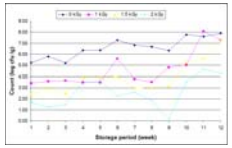

Fig. 1. The growth of *L. monocytogenes* on irradiated pork chops packaged in vacuum during refrigerated storage

Significant growth after 7-9 week (p<0.05)

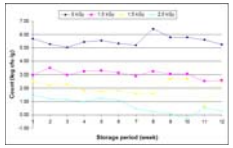

Fig. 2. The growth of *L. monocytogenes* on irradiated pork chops packaged in high CO_2 MAP during refrigerated storage

No significant growth during entire storage period

Results Cont.

3. The growth during temperature abuse

Table 2—Growth of *L. monocytogenes* (log cfu /gram) on irradiated cooked pork chops at 25ºC for 48 hours

Dose (kGy)	Count (log cfu /g) in vacuum packages				Count (log cfu /g) in MAP packages			
	Mean[1] (4 ºC)	SE[2]	Mean[1] (25ºC)	SE[2]	Mean[1] (4 ºC)	SE[2]	Mean[1] (25ºC)	SE[2]
0	6.36^{a}	0.13	8.68^{b}	0.11	5.29	0.04	5.91	0.07
1.0	2.90^{a}	0.48	5.48^{b}	0.17	3.47	0.06	3.18	0.20
1.5	2.10^{a}	0.03	4.69^{b}	1.01	2.24	0.20	2.13	0.25
2.0	0.72	0.33	1.85	0.10	1.07	0.17	1.16	0.20

[1] *Mean values within the same row of the same packaging type with different superscripts are statistically/significantly different (p <0.05).*
[2] *Standard error of means.*

4. Quality and sensory evaluation

Table 3—Red-green color value (a*) of cooked pork chops irradiated in vacuum and high CO_2 MAP packages

Dose (kGy)	Vacuum		MAP	
	Day 1	Day 7	Day 1	Day 7
0	$9.46^{a} \pm 0.14$	$8.83^{a} \pm 0.27$	$9.04^{a} \pm 0.34$	$8.97^{a} \pm 0.20$
1.5	$11.29^{b} \pm 0.22$	$9.60^{a,b} \pm 0.21$	$9.19^{a} \pm 0.38$	$8.32^{a} \pm 0.45$
2.0	$12.58^{b} \pm 0.39$	$9.81^{a} \pm 0.66$	$9.66^{a} \pm 0.21$	$8.27^{a} \pm 0.42$

Mean values within same row and same column with different superscripts are statistically significantly different (p <0.05) within the same replication.

Table 4 —LS means for sensory attributes of heated cooked pork chops packaged using different techniques

Packaging	Irradiated off-aroma	Sour-like aroma	Pork aroma	Firmness	Juiciness	Irradiated off-flavor	Sourness	Pork flavor
Vacuum	3.6	1.8	3.2	8.0^{a}	3.0^{a}	2.8	2.7^{a}	3.9
MAP	3.4	1.9	3.0	5.8^{b}	4.9^{b}	3.0	3.8^{b}	3.3
SEM	0.5	0.5	0.4	0.6	0.4	0.4	0.7	0.6

Mean values within same column with different superscripts are statistically significantly different (p <0.05)

Conclusion

The results of this study showed that irradiation combined with high CO_2 atmosphere packaging was similar to irradiation combined with vacuum packaging for elimination of *L. monocytogenes* on pre-cooked pork chops. Irradiation combined with high CO_2 MAP was more effective than vacuum packaging for control of the growth of this pathogen during refrigerated storage or temperature abuse. High CO_2 MAP did not result in the redness often induced by irradiation in pork. However, strategies are needed to mitigate irradiated off-odor that occurred in both packaging types, and sourness in high CO_2 MAP.

Literature Cited

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