CONTROL OF *CAMPYLOBACTER JEJUNI* IN CHICKEN BREAST MEAT BY IRRADIATION IN VACUUM OR HIGH CO_2 ATMOSPHERE

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Introduction

Campylobacter jejuni is one of the most frequently reported pathogens causing human foodborne illness in the U.S. through contaminated, undercooked meat and poultry, or cross contamination of ready-to-eat foods with raw meat and poultry (Mead and others 1999).Vacuum and high CO_2 modified atmosphere packaging (MAP) are common packaging methods used by the poultry industry for the control of spoilage bacteria. High CO_2 MAP also inhibits some foodborne pathogens in meat and poultry during storage (Rao & Sachindra 2002). However, Boysen et al. (2007) reported that *C. jejuni* survived in anaerobic packaging better than in aerobic packaging. Therefore, in order to maintain shelf life of fresh poultry products without compromising food safety in regard of *C. jejuni*, additional control measures may be necessary for reduction of this pathogen in poultry packaged in vacuum or high CO_2 MAP. Low dose irradiation (<0.5 kGy), for example, has been reported to reduce this pathogen effectively in meat and poultry products (Radomyski et al, 1994).

The objective of this study was to test the hypothesis that combining irradiation with high CO_2 MAP will be more effective than irradiation with vacuum packaging for eliminating *C. jejuni* from chicken breasts, and that CO_2 in MAP will further reduce pathogen survivors during refrigerated storage or during temperature abuse at 25 °C. Quality evaluations (meat color, pH, package purge and lipid oxidation) and sensory evaluation were also conducted to assess the overall feasibility of these combined hurdles.

Materials and Methods

A 5-strain cocktail of *C. jejuni* was used for the inoculation of chicken breasts (5 log cfu /gram of chicken). Chicken breasts were packaged in vacuum or MAP (99.6% CO_2 /0.4% CO). Electron beam irradiation was used to treat inoculated samples at doses of 0 (control), 0.25, 0.5 or 0.75 kGy. Enumeration was conducted following the methods of Luo et al. (2003) immediately after irradiation, 24 or 48 hours after irradiation, or once per week during 6 weeks of storage at 4 °C, or after 48 hours of temperature abuse following one week of refrigerated storage. Radiation sensitivity of the pathogen (D_{10}-value) was calculated as negative reciprocal of the slope of the regression line on the plot constructed with irradiation doses versus the counts of survivors (log cfu /g) (Clavero et al., 1994).

Uninoculated samples to be used for quality and sensory evaluations were irradiated at 1.0 or 1.5 kGy. CIE color values (L*, a* b*) of the surface color of the chicken breasts were measured with a Hunter Lab LabScan. The pH of the samples was measured with a FC 200B pH electrode at 25 ºC; the 2-thiobarbituric acid (TBA) value was measured for assessing lipid oxidation. Package purge was determined by measuring the difference of sample weights before and after packaging. Sensory evaluation was conducted with a trained 10-member panel to assess color, irradiated off-aroma, sour-like aroma, and raw chicken aroma for fresh product; irradiated off-aroma, sour-like aroma, chicken aroma, irradiated off-flavor, sourness, chicken flavor, firmness and juiciness for the cooked product.

Factorial designs were used for all treatments with three samples per treatment, and each experiment was repeated three times. A general linear model was used to evaluate the effects of irradiation dose, packaging types and storage time ($p < 0.05$). Post-hoc tests of differences with Tukey adjustment were used to analysis the significance of main and simple main effects.

Results and Discussion

Similar radiation sensitivity (D_{10}-value) was observed for *C. jejuni* in vacuum (0.31 ± 0.01 kGy) and in high CO_2 MAP (0.29 ± 0.03 kGy). Patterson (1995) reported that D_{10}-value of *Campylobacter* spp in

vacuum-packaged, sterilized, minced chicken meat ranged from 0.12 to 0.25 kGy, and suggested that the radiation sensitivity of *Campylobacter* spp was strain- and species-dependent. Nevertheless, this pathogen was very sensitive to irradiation in both vacuum and high CO_2 MAP, with the population reduced by 2.5 log cfu /g with the 0.75 kGy dose in the present study. There was no significant difference in reduction of the pathogen survivors between vacuum and high CO_2 MAP during 6 weeks of storage at 4 °C. This result is consistent with the observation of Boysen et al. (2007), who reported that *C. jejuni* in fresh chicken fillets packaged in low oxygen MAP (70% N_2 /30% CO_2) can survive more than 10 days at 5 °C. However, Blankenship and Craven (1982) reported that the population of *C. jejuni* on raw chicken drumsticks packaged in air or in CO_2 MAP was reduced 1.5 to 2 log when the product was stored at 4 °C for 21 days. In the present study, the survivors of *C. jejuni* did not grow, but remained viable at room temperature for 48 hours in all treatments. This observation differed from that reported by Hanninen et al. (1984) where the population of *Campylobacter* on beef declined 0.5 to 1.0 log after the product was exposed to 20 °C for 24 or 48 hours.

Irradiation increased the redness of chicken breasts. Nam & Ahn (2002) suggested that the irradiation-induced pink (red) color in poultry was due to the formation of CO- heme pigment complexes under a reduced condition (vacuum). In the present study, chicken breasts in high CO_2 MAP with CO also increased in redness due to the addition of 0.4% of CO. There was no pH change or lipid oxidation observed due to packaging or irradiation. There was irradiated off-odor in irradiated fresh chicken breasts due to volatiles produced by irradiation (Kim et al., 2002), however, the off-odor was mitigated by cooking. Chicken breasts from high CO_2 MAP packages had sour-like aroma. Further, chicken breasts from high CO_2 MAP were firmer and less juicy than the product from vacuum packages.

Conclusion:

Low dose irradiation was effective for improving control of *C. jejuni* in chicken breast meat packaged in vacuum or high CO_2 MAP. However, MAP with high CO_2 and low CO was not superior to vacuum packaging for further eliminating the pathogen during refrigerated storage or temperature abuse. Since irradiation increased the redness, it is not necessary to use CO in high MAP packaging when poultry products are treated with irradiation. The present study showed that irradiated off-odor in fresh poultry is still likely to be a significant challenge to be overcome.

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