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Evaluation of peroxyacetic acid as a post-chilling intervention for control of *Escherichia coli* O157:H7 and *Salmonella* Typhimurium on beef carcass surfaces

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Abstract

Four experiments were conducted to test the efficacy of peroxyacetic acid as a microbial intervention on beef carcass surfaces. In these experiments, beef carcass surfaces were inoculated with fecal material (no pathogens) or fecal material containing rifampicin-resistant *Escherichia coli* O157:H7 and *Salmonella* Typhimurium. Inoculated surfaces were subjected to a simulated carcass wash with and without 2% L-lactic acid treatment before chilling. In Experiments 1 and 2, the chilled carcass surfaces were sprayed with peroxyacetic acid (200 ppm; 43°) for 15 s. Peroxyacetic acid had no effect on microbial counts of any organism measured on these carcass surfaces. However, lactic acid reduced counts of *E. coli* Type I (1.9 $\log_{10}$ CFU/cm^2), coliforms (3.0 $\log_{10}$ CFU/cm^2), *E. coli* O157:H7 (2.7 $\log_{10}$ CFU/cm^2), and *S.* Typhimurium (2.8 $\log_{10}$ CFU/cm^2) entering the chilling cooler and prevented growth during the chilling period. In Experiment 3, peroxyacetic acid at different concentrations (200, 600, and 1000 ppm) and application temperatures (45 and 55 °C) were used to investigate its effectiveness in killing *E. coli* O157:H7 and *S.* Typhimurium compared to 4% L-lactic acid (55 °C). Application temperature did not affect the counts of either microorganism. Peroxyacetic acid concentrations up to 600 ppm had no effect on these microorganisms. Concentrations of 1000 ppm reduced *E. coli* O157:H7 and *S.* Typhimurium by up to 1.7 and 1.3 $\log_{10}$ CFU/cm^2, respectively. However, 4% lactic acid reduced these organisms by 2.7 and 3.4 $\log_{10}$ CFU/cm^2, respectively. In Experiment 4, peroxyacetic acid (200 ppm; 43 °C) was applied to hot carcass surfaces. This treatment caused a 0.7 $\log_{10}$ CFU/cm^2 reduction in both *E. coli* O157:H7 and *S.* Typhimurium. The collective results from these experiments indicate that peroxyacetic acid was not an effective intervention when applied to chilled inoculated carcass piece surfaces.

Keywords: Beef; *E. coli*; Interventions; Pathogens; *Salmonella*

1. Introduction

Interventions applied to hot carcasses are commonly used to reduce pathogen contamination on beef carcasses entering the chilling cooler. Of the available interventions, spraying carcass surfaces with organic acids or hot water has been found to be effective in reducing microbial contamination (Castillo, Lucia, Goodson, Savell, & Acuff, 1998; Dickson, 1992; Hardin, Acuff, Lucia, Oman, & Savell, 1995). Hardin et al. (1995) reported that organic acid treatments were more effective in removing *S.* Typhimurium and *Escherichia coli* O157:H7 than trimming or washing alone.

Recently, interest has been expressed in identifying post-chilling interventions to be applied before fabrication to further reduce microbial numbers in beef products. Acuff et al. (1987) applied organic acid treatments to beef strip loins after fabrication and found no difference in the aerobic plate counts between treated and control loins after various time periods of storage

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and retail display. In contrast, Castillo et al. (2001b) found that 2% lactic acid spray reduced the counts of *S.* Typhimurium and *E. coli* O157:H7 on chilled carcass surfaces that had been inoculated. These findings were supported by those of Castillo, Lucia, Mercado, and Acuff (2001a) who reported that spraying chilled carcasses with 4% lactic acid in a commercial setting caused a 3-log cycle reduction in aerobic plate counts. In addition, the lactic acid rinse consistently reduced coliforms and *E. coli* Type I to non-detectable levels.

Peroxyacetic acid is an antimicrobial compound that has been used as a sanitizer on food contact surfaces (Rossoni & Gaylarde, 2000) and fruit (Wisniewsky, Glatz, Gleason, & Reitmeier, 2000). Peroxyacetic acid caused a 2.5-log cycle reduction in *E. coli* O157:H7 when used to sanitize the auger from a grinder that had been used to grind inoculated beef (Farrel, Ronner, & Lee Wong, 1998). Additionally, Farrell et al. (1998) found that peroxyacetic acid reduced the percentage of samples that tested positive for pathogenic *E. coli* from 34% to 7% compared to non-sanitized samples. These findings indicate that peroxyacetic acid is effective against *E. coli* O157:H7.

The Food Safety and Inspection Service (FSIS) is placing renewed emphasis on the justification for the interventions included in HACCP programs. Therefore, a need exists for independent, third-party studies validating intervention strategies. Peroxyacetic acid is currently being used for decontamination of chilled beef carcass surfaces in the industry. However, limited published data are available to evaluate its effectiveness when used to decontaminate chilled beef carcass surfaces.

A series of experiments was conducted to evaluate peroxyacetic acid as an intervention on chilled carcass surfaces. In the first two experiments, our objective was to measure the effectiveness of a commercially available preparation containing peroxyacetic acid when applied to chilled carcass surfaces without previous interventions or following lactic acid being applied to the hot carcass surfaces. The final two experiments were conducted to identify parameters under which peroxyacetic acid would be most effective.

2. Materials and methods

2.1. Inoculation, sampling, and microbiological analysis

2.1.1. Preparation of inoculum

Rifampicin-resistant *S.* Typhimurium and rifampicin-resistant *E. coli* O157:H7 were cultured and incorporated into an inoculum according to the procedure of Castillo, Lucia, Kemp, and Acuff (1999). The inoculum contained 5.8 and 5.9 $\log_{10}$ CFU/ml *E.* coli O157:H7 and *S.* Typhimurium, respectively. Fresh, bovine fecal material was collected and homogenized. The fecal material was weighed into 10 g portions, and inoculated with 9 mL of an inoculum containing the rifampicin-resistant *S.* Typhimurium and rifampicin-resistant *E. coli* O157:H7. Separate non-inoculated fecal samples were prepared to measure the reduction in coliforms and *E. coli* Type I.

2.1.2. Preparation and inoculation of carcass surfaces

For each experiment, animals were harvested in the Texas A&M University Rosenthal Meat Science and Technology Center according to established procedures (Savell & Smith, 2000). No carcass washes or microbial interventions were applied to carcasses before removing carcass pieces for these experiments. After removal, the pieces were wrapped in cotton shrouds to prevent dehydration, placed in insulated containers, and transported to the microbiology laboratory located in the adjacent Kleberg Center.

Fecal material (containing rifampicin-resistant pathogens or containing no pathogens; 10 g) was prepared as described above and spread over a 400 cm^2 area on the surface of the carcass piece. The pre-existing counts present on carcass piece surfaces before inoculation of *E. coli* Type I and coliforms were 0.6 $\log_{10}$ CFU/cm^2 for each organism. The concentrations of *E. coli* O157:H7 and *S.* Typhimurium were initially below the detectable limit. The initial inoculation concentrations of coliforms, *E. coli* Type I, *E. coli* O157:H7, and *S.* Typhimurium are shown in Table 1. Following the application of fecal material, each carcass piece was placed in a wash cabinet designed by Chad Company (Lenexa, KS). Gross fecal material was removed with water (1.5 L at 35 °C and 50 kPa) applied with a hand-held non-corrosive, polyethylene compressed air sprayer (Universal-Gershwin, Saranac, MI) for 90 s. Cuts then were washed with a high pressure automatic wash system designed by Chad Company. The automatic system applied water (approximately 35 °C) at 1.72 MPa for 4 s and gradually increased to 2.76 MPa within 2 s. This pressure was maintained for 3 s for a total wash time of 9 s, during which approximately

Table 1
Simple means and standard deviations for initial $\log_{10}$ CFU/cm^2 concentrations of *Escherichia coli* Type I and coliforms on carcass surfaces that had fecal material with out added pathogens applied and *E. coli* O157:H7 and *Salmonella* Typhimurium on carcass surfaces that had fecal material with rifampicin-resistant pathogens added applied

Organism	Mean	SD
Fecal material, without added pathogens applied to carcass surfaces		
E. coli Type I	4.3	0.4
Coliforms	4.5	0.5
Fecal material, with rifampicin-resistant pathogens applied to carcass surfaces		
E. coli O157:H7	4.7	0.2
S. Typhimurium	4.6	0.2