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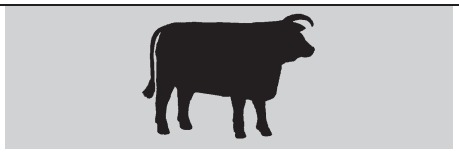

Single or multiple decontamination interventions involving lauric arginate on beef trimmings to enhance microbial safety of ground beef

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ABSTRACT

Inoculated (Escherichia coli O157:H7 and 6 non-O157 Shiga toxin-producing E. coli strains and Salmonella Typhimurium definitive type 104 and Salmonella Newport multidrug-resistant AmpC; 10^5 cfu/mL) beef trimmings (1.6 kg/treatment per replicate) were treated with lauric arginate (LA; 5%) alone or followed by 0.4% cetylpyridinum chloride (LAC), 4% sodium metasilicate (LAN), 0.02% peroxyacetic acid (LAP), 10% trisodium phosphate (LAT), or sterile water (LAW). Uninoculated (CON) and inoculated untreated (INCON) control trimmings along with treated trimmings were individually ground and 200-g samples were overwrap-packaged and stored under simulated retail conditions (4°C) until sampled on d 0, 1, 2, and 3 of display for microbiological analysis and CIE L, a*, and b* measurements (n = 3/sample). All treatments had lower (P < 0.05) coliform, E. coli, and Salmonella counts compared with INCON from d 1 to 3 of display. The LAC, LAN, LAP, and LAT treatments surpassed others in controlling Salmonella, with up to 2 log reductions on d 1 through 3 of display. The LA, LAN, LAT, and LAW treated ground beef had similar (P > 0.05) L* to CON. Lauric arginate alone (LA) or followed by water (LAW) surpassed (P < 0.05) other treatments for a* of ground beef. However, LAC, LAN, LAP, and LAT treated samples maintained similar (P > 0.05) a* to CON and INCON samples. The results suggest that LA alone or followed by selected antimicrobials on beef trimmings may provide successful decontamination interventions to enhance microbial quality of consequent ground beef without adverse effects on ground beef color.*

Key words: lauric arginate, *Escherichia coli*, *Salmonella*, ground beef, instrumental color

INTRODUCTION

Even with numerous decontamination efforts implemented by beef processors, safety of ground beef through the processing chain remains a concern. *Escherichia coli* O157:H7 has been recognized as a food-borne pathogen as early as 1982 (Padhye and Doyle, 1992). According to Scallan et al. (2011), about 63,153 cases of *E. coli* O157:H7 infections occur in the United States annually. Although *Escherichia coli* O157:H7 is the most commonly known Shiga toxin-producing strain (**STEC**) of *E. coli* responsible for food-borne outbreaks in the United States, 6 non-O157:H7 STEC serogroups (O26, O45, O103, O111, O121, and O145) are gaining public health concern as they have the potential to cause human illnesses, resulting in bloody diarrhea and hemolytic-uremic syndrome (Brooks et al., 2005; Kasper et al., 2010; Fratamico et al., 2011). Given the recent declaration of 6 non-O157 STEC as adulterants in raw, nonintact beef products, the Food Safety Inspection Service of the USDA highlights the need to reassess established hazard analysis and critical control points to address controlling measures for non-O157 STEC (FSIS, 2012). Besides the food safety threats caused by *E. coli* species, over 2,500 serotypes of *Salmonella enterica* have been identified (Schmidt et al., 2012); serotypes Typhimurium definitive type (**DT**) 104 and *Salmonella enterica* serotype

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Newport multidrug-resistant (**MDR**) AmpC pose food safety hazards, as well as MDR risks in the US beef industry. According to Talbot et al. (2006), although an overall decrease in human MDR isolates has been noted, *Salmonella* Newport MDR AmpC and *Salmonella* Typhimurium DT 104 account for several recent large outbreaks of human infection. Even though specific interventions to combat non-O157 STEC or MDR *Salmonella* are currently not available, existing scientific evidence indicates that interventions to control *E. coli* O157:H7 also may effectively control the non-O157 STEC and *Salmonella* species (FSIS, 2012).

Muscles of healthy animals are generally sterile (Anderson et al., 1977). However, various processes involved in ground beef production, such as mixing of surface meat from various animals, grinding, and subsequent increase in meat surface area, enhance the likelihood of pathogenic bacterial contamination and proliferation in ground beef (Kang et al., 2001). As summarized by Pohlman (2003), application of antimicrobial interventions on beef trimmings before grinding may reduce pathogenic bacterial populations in ground beef. Using more than 1 antimicrobial in multihurdle interventions on beef trimmings has resulted in significant reductions in *E. coli* and *Salmonella* populations (Pohlman and McElyea, 2003). However, some antimicrobial interventions can pose deleterious effects on ground beef quality and color attributes, creating unappealing products for meat consumers. Lauric arginate, a cationic surfactant derived from naturally occurring lauric acid, arginine, and ethanol, has gained importance as a valuable tool in advancing the progress of food safety and quality (Bakal and Diaz, 2005). The broad spectrum of antimicrobial efficacy along with activity over a wide pH range and low toxicity are particular features of lauric arginate to excel in decontamination interventions (Bakal and Diaz, 2005). Some studies have provided scientific evidence to conclude the efficacy of peroxyacetic acid (**PAA**; Quilo et al., 2010), cetylpyridinium chloride (**CPC**; Cutter et al., 2000; Pohlman et al., 2002a,b), and trisodium phosphate (**TSP**) (Pohlman et al., 2002a,b) for improving beef product safety. An added benefit in application of CPC and TSP antimicrobial interventions, as reported by Pohlman et al. (2002a,b) and Jimenez-Villarreal et al. (2003), is that these agents may enhance redness and oxymyoglobin stability (630/580 nm) without affecting the odor characteristics of ground beef.

The application of lauric arginate alone or followed by other antimicrobials as decontamination interventions in a ground beef-production system is still under investigated, and little or no information is available on its effect on ground beef quality and color properties. Therefore, the objective of the current study was to evaluate ground beef microbial and instrumental color properties when lauric arginate alone or followed by water, CPC, sodium metasilicate (**NMS**), TSP, or PAA were applied to decontaminate beef trimmings before grinding.

MATERIALS AND METHODS

Inoculation Process

Frozen cultures (−80°C) of *E. coli* O157:H7, non-O157:H7 strains O26, O103, O111, O121, O45, and O145, *Salmonella* Typhimurium DT 104, and *Salmonella* Newport MDR AmpC sourced from subcultures from the USDA Agricultural Research Service (Beltsville, MD) were thawed and 0.1 mL of each bacterial suspension was dispensed into separate 10-mL aliquots of brain heart infusion (Becton Dickinson and Company, Sparks, MD) broth. Following 18 h of incubation at 37°C (Beckman GS-6 series, Fullerton, CA), bacteria were harvested by centrifugation (3,500 × *g* for 20 min at 25°C; Beckman GS-6 series), and resuspended in 0.1% buffered peptone water (Becton Dickinson and Company). The bacterial suspensions were mixed together to form a 9-strain cocktail mixture consisting of equal volumes of each strain and further diluted with buffered peptone water to achieve 10^5 cfu/mL of suspension. The cocktail mixture was stored at 4°C for 18 h until further use.

Meat Inoculation

All beef trimmings (80:20 lean-to-fat ratio; 40 kg; approximately 5 × 15 cm; from predominantly chuck, plate, rib, and loin trimmings) obtained from Cargill Meat Solutions (Plainview, TX) were submerged in the prepared cocktail mixture (10^5 cfu/mL; 4°C) in commercial thermally sterile bags (B2620 Barrier Bags for Boneless Beef, Cryovac Sealed Air, Duncan, SC). Then the inoculated trimmings were separated into 21 batches (1.6 kg) and left overnight at 4°C for bacterial attachment.

Antimicrobial Treatment Application

The inoculated beef trimmings (1.6 kg/treatment per replicate) were arranged in a single layer on stainless steel trays (35.6 × 45.7 cm). Each side of the beef trimmings were spray treated with conventional spray (~0.1 mL/g) applications of 5% (vol/vol) lauric arginate (**LA**; A & B Ingredients, Fair Field, NJ) alone or followed by 0.4% (vol/vol) CPC (**LAC**; Safe Foods Cooperation, Little Rock, AR.), 4% (wt/vol) NMS (**LAN**; PQ Corporation, Valley Forage, PA), 0.02% (vol/vol) PAA (**LAP**; FMC Corporation, Philadelphia, PA), 10% (wt/vol) TSP (**LAT**; ICL Performance Products, St Louis, MO), or high purity water (**LAW**; Nerl Diagnostics LLC, Thermo Scientific Inc., East Providence, RI). The LA samples were allowed to drip for 3 min before and after the assigned second antimicrobial application (3 replicates/treatment). An untreated, inoculated control (**INCON**; no antimicrobial or water) served as a control to compare antimicrobial treatment effectiveness.

Sample Processing

All treated and untreated INCON beef trimmings were ground [Ameri-