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The impact of single antimicrobial intervention treatment with potassium lactate, sodium metasilicate, peroxyacetic acid, and acidified sodium chlorite on non-inoculated ground beef lipid, instrumental color, and sensory characteristics

S.A. Quilo [a], F.W. Pohlman [a,*], P.N. Dias-Morse [a], A.H. Brown [a], P.G. Crandall [b], R.T. Baublits [c], J.L. Aparicio [d]

[a] Department of Animal Science, University of Arkansas, Fayetteville, AR 72701, USA
[b] Department of Food Science, University of Arkansas, Fayetteville, AR 72701, USA
[c] Tyson Foods, Inc., Springdale, AR 72765, USA
[d] John Brown University, Siloam Springs, AR 72761, USA

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ABSTRACT

The effect of using potassium lactate, sodium metasilicate, acidified sodium chlorite, or peroxyacetic acid as a single antimicrobial intervention on ground beef instrumental color, sensory color and odor characteristics, and lipid oxidation was evaluated. Prior to grinding, beef trimmings (90/10) were treated with 3% potassium lactate (KL), 4% sodium metasilicate (NMS), 200-ppm peroxyacetic acid (PAA), 1000-ppm acidified sodium chlorite (ASC), or left untreated (CON). Ground beef under simulated retail display was measured at 0, 1, 2, 3, and 7 of display for instrumental color, sensory characteristics, TBARS values, and pH to evaluate the impact of the treatments. The KL, NMS, PAA, and ASC were redder (a^*; $P < 0.05$) than CON. All treatments were scored by sensory panelists to have a brighter ($P < 0.05$) red color than CON during days 1–3 of display. All treatments had less ($P < 0.05$) lipid oxidation than CON on days 0, 3, and 7 of display. These results suggest that the use of these antimicrobial compounds on beef trimmings prior to grinding may not adversely affect, and may improve bulk packaged ground beef quality characteristics.

1. Introduction

Constant efforts have been made to create effective and new technologies for the decontamination of carcasses and meat products (Huffman, 2002). Some techniques have been demonstrated to be more effective, accurate and economically reasonably priced than others. However, several of these proven interventions have not been yet incorporated into a commercial meat processing system for reasons such as cost, practicability, or even perception of the final consumer. Consumers are now more conscious about the importance of food safety, the zero tolerance of pathogens during food manufacturing practices, and microbiological standards (Todd, 2003). For this reason it is important to grant the consumer these demands, whether it is retail, food service or restaurants. Ground beef production is an area where one or several intervention technologies must be present due to the high risk of pathogenic bacteria potentially contaminating the product. Since freshly cut surfaces of beef trimmings can facilitate contamination and further spreading of bacteria, decontamination steps prior to grinding can be beneficial to reduce the microbiological loads in ground beef. Studies have shown that decontamination of beef trimmings prior to grinding with antimicrobial agents would be advantageous to improve the microbiological quality of ground beef. According to Stivarius, Pohlman, McElyea, and Apple (2002b), treating beef trimmings with 1% ozonated water for 15 min or with 10% chlorine dioxide can reduce microbial pathogens in ground beef by almost 1 log CFU/g. Stivarius, Pohlman, McElyea, and Waldroup (2002c) also suggested that the application of 5% lactic acid solutions to beef trimmings prior to grinding can improve the microbial quality of ground beef. In addition, the decontamination of beef trimmings with 5% acetic acid or with 5% gluconic acid prior to grinding has been shown to be effective in reducing bacterial counts in ground beef (Stivarius, Pohlman, McElyea, & Apple, 2002a). Furthermore, Pohlman, Stivarius, McElyea, and Waldroup (2002) reported that use of 0.5% cetylpyridinium chloride and/or 10% trisodium phosphate as antimicrobial agents in ground beef production could significantly reduce coliforms and aerobic plate counts by 0.58–0.71- and 0.61–0.77-log CFU/g, respectively.

Although the use of antimicrobials has been found to be effective for improving microbiological quality of ground beef, attention should focus on their effects on product color and sensory attributes. It is well established that meat color is an important factor that primarily determines the purchasing decision of the

* Corresponding author. Address: Department of Animal Science, University of Arkansas, AFLS Building, West Maple, Fayetteville, AR 72701, USA. Tel.: +1 479 575 5634; fax: +1 479 575 7294.
E-mail address: fpohlma@uark.edu (F.W. Pohlman).

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consumer (Hunt et al., 1991). Stivarius et al. (2002a) reported that acetic acid tended to result in a decreased redness of ground beef. Acetic acid treated ground beef exhibited less beef-like odor and more off odor during simulated retail display. Similarly, decontamination of beef trimmings with 5% lactic acid and hot water (82 °C; Stivarius et al., 2002c), 1% ozonated water, or 200-ppm chlorine dioxide (Stivarius et al., 2002b) resulted in a lighter (L^*, $P < 0.05$) ground beef color; however, there was no difference ($P > 0.05$) in beef aroma or off odor. Nevertheless, Jimenez-Villarreal, Pohlman, Johnson, Brown, and Baublits (2003a) concluded that the application of 10% trisodium phosphate and 0.5% cetylpyridinium chloride on beef trimmings resulted in a redder and more stable color, improved sensory characteristics, and reduced lipid oxidation of ground beef. In the same study, the application of 5% lactic acid and 200-ppm chlorine dioxide on beef trimmings resulted in a similar ($P > 0.05$) color, sensory characteristics, and lipid oxidation compared to untreated ground beef. These findings support the possibility that different antimicrobial agents may have different impacts on sensory characteristics and color of the meat product. Therefore, despite the fact that a wide variety of antimicrobial solutions have been introduced and utilized, the beef industry constantly seeks for potential and efficient antimicrobial agents that will reduce the pathogenic microorganisms in meat, while not adversely altering the sensory and color properties of the meat products. Pohlman et al. (unpublished) found over 2 log reductions of bacteria when applying potassium lactate, sodium metasilicate, peroxyacetic acid, and acidified sodium chlorite prior to the grinding of inoculated beef trimmings.

Recent studies have shown that the peroxyacetic acid is an effective oxidant that provides bactericidal effects. Results from Ellebracht et al. (2005) suggested that dipping beef trimmings into 200 ppm peroxyacetic acid solutions reduced *Escherichia coli* O157:H7 and *Salmonella* Typhimurium by 1.01 log CFU/cm^2. King et al. (2005) reported that spraying carcass surfaces with 1000-ppm peroxyacetic acid for 15 s reduced counts of *E. coli* and *Salmonella* Typhimurium by 1.7- and 1.3-log CFU/cm^2, respectively. However, they also found that peroxyacetic acid was not effective for reducing bacterial counts in chilled carcasses even by increasing concentrations. Acidified sodium chlorite in concentrations of 200–1200-ppm through a product known as SANOVA® (a combination of sodium chlorite and citric acid in aqueous solution) was found to be effective in reducing bacteria on beef carcasses (Castillo, Lucia, Kemp, & Acuff, 1999; Gill & Badoni, 2004; Hajmeer, Marsde, Fung, & Kemp, 2004) and on beef cuts and trimmings (Ransom et al., 2003). A study by Stopforth et al. (2005) reported the potential use of sodium metasilicate as an antimicrobial agent in beef decontamination; however, sufficient information is not available on its effect on meat quality attributes. Potassium and sodium lactates are commercially available as pH neutral aqueous solutions (60%), recommended for extending shelf-life in cured and uncured meat and poultry products (FSIS, 2000). However, limited work on the impact on sensory attributes has been studied, particularly for ground beef. Therefore, the objective of this study was to evaluate and compare the effects of using potassium lactate, sodium metasilicate, acidified sodium chlorite, or peroxyacetic acid on beef trimmings prior to grinding on instrumental color, sensory color and odor characteristics, and lipid oxidation.

2. Material and methods

2.1. Antimicrobial treatment and processing

The antimicrobial treatments included 3% (v/v) potassium lactate (KL; Purasal®, Purac America Inc., Lincolnshire, Illinois, USA), 4% (w/v) sodium metasilicate (NMS; Avgard®, Rhodia Inc., Cranbury, New Jersey, USA), 0.1% (v/v) acidified sodium chlorite, (ASC; sodium chlorite supplemented with food grade citric acid in 1:1 ratio to obtain a solution of pH = 2.5; SANOVA®, Alcide Cooperation, Redmond, Virginia, USA), 0.2% (v/v) peroxyacetic acid (PAA; Inspexx-200®, Ecolab, St. Paul, Minnesota, USA), which is an even mixture of peroxyacetic acid, octanoic acid, acetic acid, hydrogen peroxide, and 1-hydroxyethylidine-1.1-diphosponic acid, and an untreated control (CON). The 0.1% ASC and 0.2% PAA treatments were prepared a few minutes before application on the meat with the purpose of having the solutions in an active decontaminating condition.

Antimicrobial application was carried out on 5.4 kg batches of meat (beef trimmings containing 90% lean and 10% fat) that were placed into a meat tumbler (Model 4Q, Lyco Inc., Janesville, Wisconsin, USA). The selected volumes of antimicrobial agents were added and vacuum tumbled at 60 rpm for 3 min. The volume of antimicrobial solution used in tumbling was 500 ml except for PAA (1500 ml). As per manufacturer's instruction, the ASC treatment was tumbled for 30 s only. Following the antimicrobial application, beef trimmings were ground twice using a Hobart grinder (Model 310, Hobart Inc., Troy, Ohio, USA) with a 3.2 mm plate. Then, 500 g ground beef samples were placed on plastic foam trays with absorbent pads and over wrapped with polyvinyl chloride film with an oxygen transmission rate of 14,000 cc/mm^2/24 h/1 atm (Koch Supplies, Inc., Kansas City, Missouri, USA) and stored under simulated retail conditions (4 °C; deluxe warm white fluorescent lighting, 1600 lux, Phillips Inc., Somerset, New Jersey, USA). Three replications of antimicrobial treatments ($n = 10$ samples/treatment/replicate) were conducted. The pH of treated ground beef was determined by homogenizing ground beef with distilled water in a 1:10 ratio. An Ultra Basic Portable pH/mv meter (Model Up-10, Denver Instruments Inc., Denver, Colorado, USA) was used to measure (three measurements/sample) the pH.

2.2. Processing properties

Analysis was conducted using a four-member trained sensory panel to evaluate the processing abilities. The processing abilities refer to the behavior of ground beef in the presence or in the absence of the antimicrobial compounds. Therefore, panelists evaluated smearing during the grinding process (6 = extreme smearing, 5 = moderated smearing, 4 = slight smearing, 3 = slight cut-grind, 2 = moderate cut–grind, 1 = extreme cut–grind) for all the treatments in three replications ($n = 15$).

2.3. Instrumental color

For instrumental color evaluations, ground beef was sampled on days 0, 1, 2, 3, and 7 of simulated retail display using a Hunter-Lab MiniScan XE Spectrocolorimeter; Model 4500L (Hunter Associates Laboratory, Reston, West Virginia, USA). The samples were evaluated for CIE (L^*, a^*, and b^*) color values and calculations were determined for hue angle ($\tan^{-1}(b^*/a^*)$), which describes the hue or color of ground beef and saturation index ($(a^{*2} + b^{*2})^{0.5}$, which describes the brightness or vividness of color (Hunt et al., 1991). In addition, reflectance measurements were taken in the visible spectrum from 580 to 630 nm and reflectance ratio (630/580 nm) was calculated to estimate the oxymyoglobin fraction of the myoglobin pigment (Hunt et al., 1991; Strange, Benedict, Gugger, Metzger, & Swift, 1974). All the values were determined from the mean of five measurements of each ground beef sample using Illuminant A/10° observer. The spectrocolorimeter was standardized using white tile, black tile, and working standards before use.