

Quality and Sensory Characteristics of Ground Beef Patties Processed from Beef Trimmings Treated with Potassium Lactate, Sodium Metasilicate, Peroxyacetic Acid, or Acidified Sodium Chlorite

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Story in Brief

Beef trimmings were treated with 3% potassium lactate (KL), 4% sodium metasilicate (NMS), 200 ppm peroxyacetic acid (PAA), 1,000 ppm acidified sodium chlorite (ASC), or left untreated (CON). Trimmings were ground and pattied. Grinding and patty forming abilities were evaluated during processing. Under simulated retail display, sensory characteristics, lipid oxidation, pH, and Lee-Kramer shear force were measured to evaluate the impact of the treatments. Panelists found patties from all treatments to have a brighter ($P < 0.05$) red overall color than the CON on day 0 of display. Panelists also found KL, NMS, PAA, and ASC patties to have less ($P < 0.05$) or similar ($P > 0.05$) off odor to CON on days 0 to 3. The NMS and PAA treated patties had lower ($P < 0.05$) lipid oxidation values than the CON at days 0, 3, and 7 of display. Patties from the NMS treatment had the highest ($P < 0.05$) pH of the treatments. Panelists did not find any difference ($P < 0.05$) in beef flavor or off flavor between the CON and the rest of the treatments. Therefore, KL, NMS, PAA and ASC treatments on ground beef trimmings before grinding improves or maintains the quality attributes in a patty production system.

Introduction

Ground beef patty safety became an issue of serious concern after the *E. coli* O157:H7 “Jack in the Box” outbreak in 1993. This case triggered federal safety agencies and meat scientists to develop research that would positively impact the safety of meat products. Most of this research also needed to include educational programs for the consumer regarding hamburger cooking methods; however, scientists needed to reduce pathogenic incidence at the beginning of processing before contamination could exponentially become greater, rather than at later stages. Factors such as cross contamination from the cutting and handling of the meat pieces create a constant potential for inoculation of bacteria onto newly exposed meat surfaces. For this reason, the use of chemical compounds (Pohlman et al., 2005) at later stages of the process have been tested on beef trimmings with the purpose of evaluating single antimicrobial intervention before grinding and the impact that this intervention has on the processing and quality attributes of the formed patties (Jimenez-Villareal et al., 2003a; 2003b).

Therefore, the objective of this study was to evaluate the impact of applying potassium lactate, sodium metasilicate, peroxyacetic acid or acidified sodium chlorite and their effects on processing characteristics, sensory attributes, TBARS value (which determines the thiobarbituric acid reactive substances produced during lipid oxidation), and sensory taste and odor characteristics when used in a ground beef patty production system.

Experimental Procedures

Antimicrobial Treatment Application and Ground Beef Patty Processing Technique. The antimicrobial treatments for this study were 3%(v/v) potassium lactate (KL; Purasal®, Purac America Inc., Lincolnshire, Ill.), 4% (w/v) sodium metasilicate (NMS; Avgard®,

Rhodia Inc., Cranbury, N.J.), 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, Va), 0.2% (v/v) peroxyacetic acid (PAA; an equilibrium mixture of peroxyacetic acid, octanoic acid, acetic acid, hydrogen peroxide, and 1-hydroxyethylidene-1.1-diphosphonic acid; Inspexx 200®, Ecolab, St Paul, Minn.), and an untreated control (CON). The 0.1% ASC and 0.2% PAA treatments were prepared minutes before the application on the meat with the purpose of having the solutions in an active decontaminating state. For the antimicrobial treatments, 12 lb of beef trimmings (90% lean and 10% fat) were placed into a meat tumbler (Model 4Q; Lyco Inc. Janesville, Wis.) with 500 ml of the chosen chemical compound solution and tumbled with the meat for 3 min at 60 rpm, then removed and allowed to drip dry for 1 min. In the case of PAA, 1,500 ml were utilized to apply onto the meat batch. The ASC treatment was an exception, and it was tumbled only for 30 sec according to the manufacturer’s instructions.

Beef trimmings were ground twice using a Hobart grinder with a 3.2-mm plate. Between the applications of each treatment, the grinder was washed with commercial sanitizer and bleach and was well rinsed. Patties of 220 g were fabricated using a Hollymatic® patty machine, and placed on foam trays with absorbent diapers. Trays were over wrapped with polyvinyl chloride film and stored under simulated retail conditions (39°F; deluxe warm white fluorescent lighting) for 7 days of simulated retail display. Ground beef was sampled on days 0, 3 and 7 of display for thiobarbituric acid reactive substances (TBARS) evaluation which measures lipid oxidation. The pH from patties of each treatment was determined on days 0, 1, 2, 3, and 7 of display by homogenizing 1.8 g of ground beef in 18 ml of distilled water and measured with an Ultra Basic Portable pH/mv meter. Sensory panel, cook loss percentage and Lee-Kramer shear force characteristics were analyzed using patties at day 2 of display.

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Processing Properties. The processing abilities refer to the behavior of ground beef and ground beef patties in the presence or in the absence of the antimicrobial compounds. Sensory analysis was conducted using a 4-member sensory panel to evaluate those processing abilities. Sensory panelists evaluated smearing during the grinding process (6 = extreme smearing; 1 = extreme cut – grind) and patty forming ability (6 = extremely fragile; 1 = extremely cohesive) for each treatment.

Sensory Color and Odor. To evaluate sensory color and odor characteristics of ground beef patties through simulated retail display, a 10-member trained sensory panel was selected and trained according to AMSA (1991). Ground beef patty packages were evaluated for worst point color, overall color and percentage of discoloration (5 = bright purplish red, bright purplish red, 7 = no discoloration (0 to 4%); 1 = brown/gray, brown/gray, total discoloration (96 to 100%)) on days 0, 1, 2, 3 and 7 of display. Ground beef patty packages were then taken to a static pressure room, opened, and evaluated for beef odor and off odor attributes. Panelists evaluated beef odor and off odor (8 = extremely beef like, 5 = no off odor; 1 = extremely non-beef like, extreme off odor) at the same display days.

TBARS Characteristics. A TBARS analysis was performed as described by Tarladgis et al. (1960) to evaluate the lipid oxidation of the treated and untreated patties.

Sensory Taste Evaluation. Sensory evaluation was carried out on day 2 of simulated retail display. An 11-member panel was selected and trained according to AMSA (1995). Patties were removed from their foam trays prior to the sensory session and cooked for evaluation using a Blodgett forced air convection oven to an internal temperature of 162°F (AMSA, 1995). Internal patty temperature was continuously monitored during cooking. Immediately after cooking, patties were sectioned into pieces and held in a food warmer at 158°F prior to sensory evaluation and during the evaluation process. Samples were randomly presented to the panelists using a complete design, where all panelists received all treatments during the evaluation session. Panelists evaluated bind, juiciness, and beef flavor (1 = extremely fragile, dry, no beef flavor; 8 = extreme bind, extremely juicy, intense beef flavor), and off flavor intensity on a 5 point scale (1 = extreme off flavor; 5 = no off flavor). Tests were conducted with individual booths and under low pressure sodium color neutralizing light to avoid bias.

Lee – Kramer Shear Force and Cooking Yield. Ground beef patties were cooked as described in the sensory taste evaluation section and then were cooled to room temperature (25°C) and sectioned (6 x 6 cm) for Lee – Kramer analysis. Shear force with a Lee – Kramer shear device attachment using an Instron Universal Testing Machine was analyzed.

Additionally, cooking loss % was calculated by weight differences for patties before and after cooking. The following formula was used for the calculation of the cooking loss:

$$\text{Cooking loss (\%)} = \frac{(\text{Fresh Patty wt.} - \text{Cooked Patty wt.})}{\text{Fresh Patty wt.}} \times 100$$

Statistical Analysis. The experiment was arranged in a complete randomized 5 x 5 factorial design. The experiment was analyzed using the GLM procedure of SAS (SAS Inst., Inc., Cary, N.C.). The model included main effects of antimicrobial treatment, day of display, and treatment by day interactions. For sensory panel data, a panelist term was added to the model to account for sensory panelist variation. For variables involved in an interaction, interaction means were generated and then separated using the PDIF option

of GLM. Least-squares means for all other variables not confounded by interaction were generated and separated using PDIF.

Results and Discussion

Processing Properties. Some of the limited research on the processing abilities of ground beef after being treated with antimicrobial agents includes studies of Jimenez-Villareal et al. (2003a; 2003b). Similarly, during this study KL, PAA, and ASC patties had much less ($P < 0.05$) particle definition than the CON, whereas NMS patties were similar ($P > 0.05$) to CON for grinding ability. Moreover, panelists found all treatments to be more ($P < 0.05$) fragile than the CON for patty forming ability (Table 1).

pH. The slightly acidic nature of KL, PAA, and ASC treated patties (pH = 5.8, pH = 5.2, and 5.1, respectively) was similar ($P > 0.05$) to CON across 7 days of display (Fig. 1A) although it may have contributed to the color differences. However, the NMS treatment had higher ($P < 0.05$) pH values than the CON and the rest of the treatments on days 0, 1, 2, and 3. This may be an explanation for the high redness (a^*) values of this treatment since high pH of the antimicrobial could potentially increase the pH of the meat proteins. A high pH further from the isoelectric point of meat results in more oxymyoglobin retention and brightness of its red color.

TBARS Values. Lipid oxidation among treatments is shown in Figure 1B. On day 0 of display the NMS, PAA, and ASC treated patties had lower ($P < 0.05$) TBARS values than the CON treatment, whereas KL was similar ($P > 0.05$) to CON. However, on day 3 of display the NMS-treated patties had less ($P < 0.05$) lipid oxidation than patties on the other treatments and CON which had the highest ($P < 0.05$) lipid oxidation compared with all the treatments. By day 7 of display, both the KL and the ASC were similar ($P > 0.05$) to CON but had higher ($P < 0.05$) TBARS values than NMS. Likewise, PAA had lower ($P < 0.05$) lipid oxidation than CON by day 7 of display, but it was similar ($P > 0.05$) to the rest of the treatments.

Sensory Color and Odor Evaluation. The day of display by antimicrobial treatment interaction effects for overall color, worst point color, percentage discoloration, and off odor are shown in Figures 2A, 2B, 3A, and 3B respectively. Panelists found all treatments to have a higher ($P < 0.05$) red color than the CON treated patties on day 0 of display for the overall color attribute (Fig. 2A). On day 1, 2 and 3 of display NMS had a brighter red color ($P < 0.05$) than the rest of the treatments. The high brightness in overall red color for KL and NMS was detected by the panelists in day 7 of display and they were considered redder ($P < 0.05$) than the CON. Sensory panelists detected that all treatments had a brighter ($P < 0.05$) red worst point color than the CON patties on day 0 and 1 of simulated retail display (Fig. 2B). The NMS treatment was clearly the highest ($P < 0.05$) at d 0, 1, 2, and 3 whereas PAA values were not as high as NMS but higher ($P < 0.05$) than CON until d 3 of display. Panelists were unable to find any difference in worst point color ($P > 0.05$) between the CON, KL, NMS, PAA, and ASC treatments on day 7 of retail display.

All treatments had slightly less ($P < 0.05$) discoloration than the CON patties on day 0 and 1 of display (Fig. 3A). On day 7 of display, the KL and NMS treated patties had slightly less ($P < 0.05$) discoloration than the CON, PAA, and ASC treated patties. These results can explain the brighter red in overall and worst point color of KL, NMS, and PAA and also the reduced percentage of discoloration of KL and NMS treatment when compared to the CON,

whereas ASC treated patties maintained relatively similar sensory color characteristics to the CON.

Figure 3B shows the day by treatment interaction effect of off odor. The NMS treated patties had slightly less ($P < 0.05$) off odor than the CON and the PAA patties but were similar ($P > 0.05$) to KL and ASC at d 0. However, on day 1 and 3 of display, the KL, NMS, PAA, and ASC treated patties had less ($P < 0.05$) off odor than the CON. On day 7 of display the NMS, PAA, and ASC had similar ($P > 0.05$) off odor when compared to the untreated patties (CON).

Sensory Taste, Shear Force and Cook Loss Percentage. Sensory panelists were unable to detect any difference in beef flavor among treatments (Table 2). Likewise, KL, NMS, PAA, and ASC patties were similar ($P > 0.05$) in off flavor to the CON. The NMS treatment was scored juicier ($P < 0.05$) than the CON. The KL and NMS treatments were found to have similar ($P > 0.05$) bind compared to the CON.

Ground beef patties from the NMS and PAA treatment produced the lowest ($P < 0.05$) peak force to shear (kg) compared with the rest of the treatments (Table 2). Cook loss (%) was also affected by treatment where the CON, KL, and ASC patties were similar ($P > 0.05$), but the NMS had the least ($P < 0.05$) loss during cooking. High pH treatments such as the NMS treatment have greater juiciness and require less peak force to shear (Table 2). The latter can be explained as high water holding capacity of the meat proteins, which is typical at high pH values.

Implications

The use of potassium lactate, sodium metasilicate, peroxyacetic acid and acidified sodium chlorite on beef trimmings before grinding could improve or maintain the same sensory color, odor and taste, lipid oxidation, shear characteristics, and cooking characteristics as traditionally processed ground beef patties. Therefore,

the application of these antimicrobial treatments can be used effectively to potentially improve ground beef safety without adversely affecting ground beef quality.

Acknowledgments

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Table 1. Effect of antimicrobial treatments applied to beef trimmings on the least-squares means for processing abilities and beef odor of raw ground beef patties.

Attributes	Treatment ^a					SE
	CON	KL	NMS	PAA	ASC	
<i>Processing abilities</i>						
Grinding ability ^b	1.00z	3.33y	1.50z	4.16x	3.58yx	0.22
Patty forming ^c	1.91z	3.75x	2.91y	5.00w	4.58w	0.16

^a CON = Control, KL = 3% potassium lactate, NMS = 4% sodium metasilicate, PAA = 200 ppm peroxyacetic acid, ASC = 1000 ppm acidified sodium chlorite.

^b Grinding ability score: 6 = extreme smearing; 1 = extreme cut – grind.

^c Patty forming ability score: 6 = extremely fragile; 1 = extremely cohesive.

^{wxyz}Least-squares means within a row with no letter in common differ ($P < 0.05$).

Table 2. Effect of antimicrobial treatments applied to beef trimming on the least squares means for beef flavor, off flavor, juiciness, bind, odor characteristics, shear force and cook loss % of raw ground beef patties.

Attribute	Treatment ^a					SE
	CON	KL	NMS	PAA	ASC	
<i>Sensory properties</i>						
Beef flavor ^b	7.4z	7.2z	7.2z	6.9z	7.4z	1.20
Off flavor ^c	4.6z	4.7z	4.7z	4.6z	4.8z	0.53
Juiciness ^d	5.8y	4.7z	6.5x	6.1xy	6.3xy	1.12
Bind ^e	6.0x	6.0x	6.0x	4.2z	4.8y	1.22
Beef odor ^f	7.56y	6.86z	7.23yz	7.23yz	7.32yz	0.23
<i>Physical properties</i>						
Shear force (kg)	3.50x	3.17xy	2.60z	3.00yz	3.25xy	0.15
Cook loss % ^g	23.22xy	22.48y	17.82z	25.80x	22.68xy	1.01

^a CON = Control, KL = 3% potassium lactate, NMS = 4% sodium metasilicate, PAA = 200 ppm peroxyacetic acid, ASC = 1000 ppm acidified sodium chlorite.

^b Beef flavor score: 8 = extremely intense beef flavor; 1 = no beef flavor.

^c Off flavor score: 5 = no off flavor; 1 = extreme off flavor.

^d Juiciness score: 8 = extremely juicy; 1 = extremely dry.

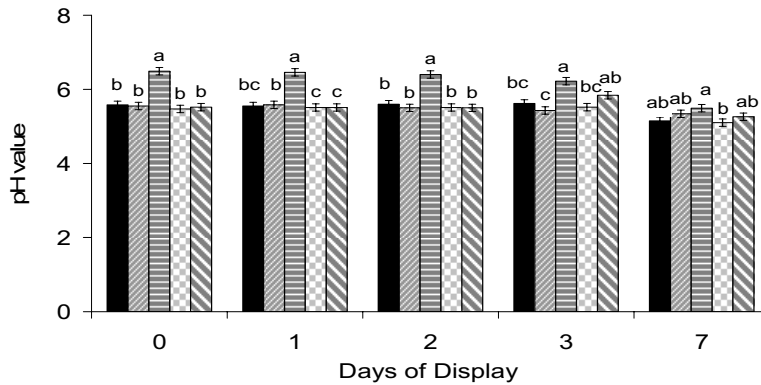
^e Bind score: 8 = extreme bind; 1 = extremely fragile.

^f Beef odor score: 1 = extremely non – beef like; 8 = extremely beef like.

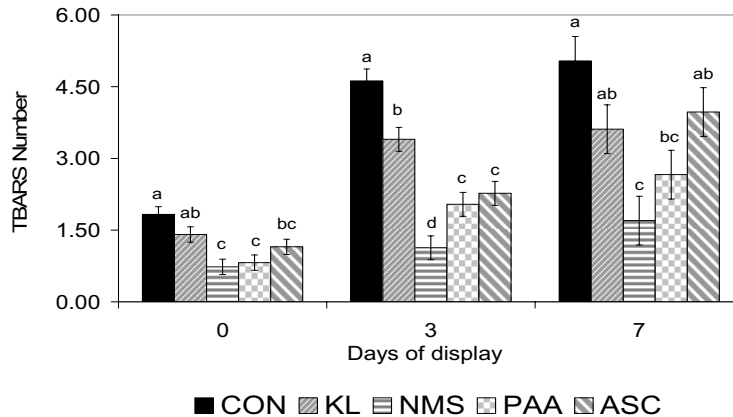
^g Calculated as [(fresh patty weight - cooked patty weight)/fresh patty weight × 100].

^{xyz} Least-squares means within a row with no letter in common differ (P < 0.05).

(A)

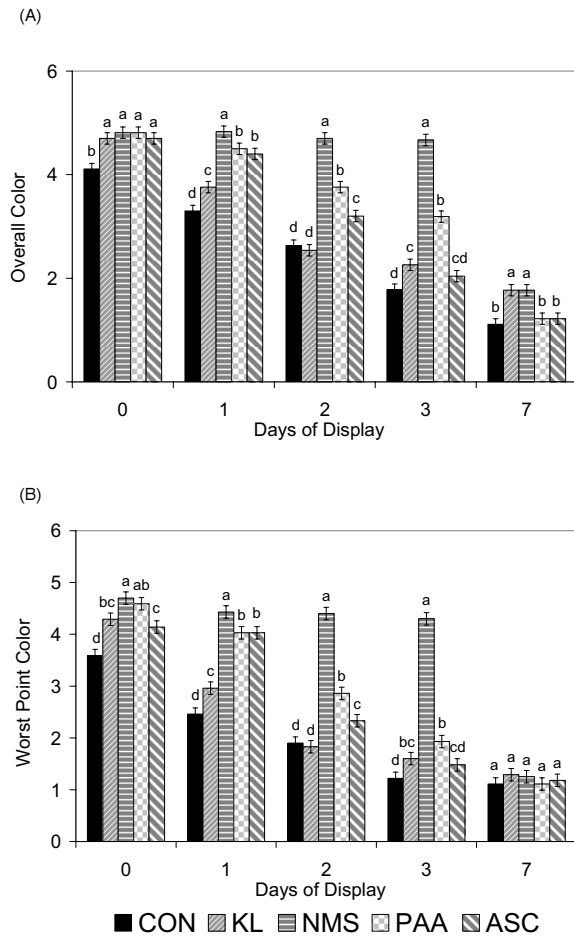


(B)



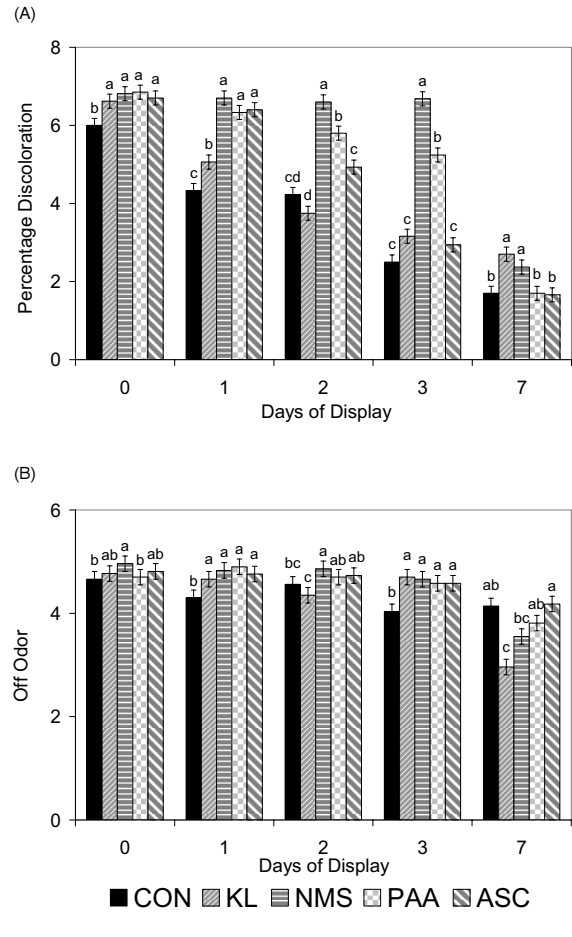
abcd Least squares means within a day with no letter in common differ (P < 0.05).
 Treatments: CON = control; KL = 3% potassium lactate; NMS = 4% sodium metasilicate; PAA = 200 ppm peroxyacetic acid; iASC = 1000 ppm acidified sodium chlorite.

Fig. 1. Day of display by antimicrobial treatment interaction effect on the least squares means (±SE) of pH values and (B) TBARS (thiobarbituric acid reactive substances) values of ground beef patties through simulated retail display.



abcd Least squares means within a day with no letter in common differ ($P < 0.05$).
 Treatments: CON = control; KL = 3% potassium lactate; NMS = 4% sodium metasilicate; PAA = 200 ppm peroxyacetic acid; ASC = 1000 ppm acidified sodium chlorite.

Fig. 2. Day of display by antimicrobial treatment interaction effect on the least squares means (\pm SE) for sensory evaluated (A) overall color score (1 = brown; 5 = bright purple red) and (B) worst point color of ground beef patties through simulated retail display.



abcd Least squares means within a day with no letter in common differ ($P < 0.05$).
 Treatments: CON = control; KL = 3% potassium lactate; NMS = 4% sodium metasilicate; PAA = 200 ppm peroxyacetic acid; ASC = 1000 ppm acidified sodium chlorite.

Fig. 3. Day of display by antimicrobial treatment interaction effect on the least squares means (\pm SE) for sensory evaluated (A) percentage discoloration (1 = total discoloration (96 to 100%); 7 = no discoloration (0 to 4 %)) and (B) off odor score (1 = extreme off odor; 5 = no off odor) of ground beef patties through simulated retail display.