

The Effects of Single Antimicrobial Interventions on Instrumental Color Characteristics When Used in a Ground Beef Patty Production System

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Story in Brief

Prior to grinding, beef trimmings (90/10) were left untreated (CON), or were treated with either 3% potassium lactate (KL), 4% sodium metasilicate (NMS), 200 ppm of peroxyacetic acid (PAA) or 1,000 ppm acidified sodium chlorite (ASC) and utilized to evaluate antimicrobial chemical compound impact on instrumental color characteristics of ground beef patties. After antimicrobial application, the trimmings were ground, made into patties, packaged, and evaluated during simulated retail display for 7 days. Patties from the PAA treatment were lighter (L^* ; $P < 0.05$) than patties from CON whereas KL, NMS, and ASC patties were similar ($P > 0.05$) to CON patties. At day 0 of display, the KL, NMS and PAA patties were redder (a^* , $P < 0.05$) than those left untreated (CON). Estimated oxymyoglobin proportions (630/580 nm) were higher ($P < 0.05$) for all antimicrobial treatments when compared to the CON on day 0 of retail display. Furthermore, on day 1 of display patties from all other treatments were more yellow (b^* , $P < 0.05$) than the CON patties. Patties from all other treatments were more ($P < 0.05$) vivid in color (saturation index) than the CON patties on day 1 of display. Application of NMS, KL, PAA or ASC antimicrobials to beef trimmings prior to grinding suggests a minimum deleterious impact on color characteristics by allowing similar or improved quality over the untreated patties.

Introduction

As the ground beef patty producers satisfy the great demand from worldwide fast food chains, restaurants, hospitals, and further processing plants in the fabrication of beef patties, various approaches to increase safety have been utilized. Beef carcass hot water washing, alkaline compounds spraying, steam pasteurization, and organic acid rinses, among other decontaminating methods, have been employed. Antimicrobial intervention on beef trimmings prior to grinding has been reported to potentially improve safety characteristics by reducing pathogenic bacteria log counts (Pohlman et al., 2002a; 2002b). There are several techniques to reduce bacterial counts and various types of antimicrobials that can be utilized to protect the product from these pathogenic strains and increase its safety. Some of these antimicrobials have been tested on beef carcasses or in pork and chicken further processed products such as sausages or comminuted chicken patties. However, the impact on quality characteristics of ground beef patties has received limited attention. Furthermore, regarding instrumental color attributes, investigations of the effects of antimicrobial agent intervention on beef trimmings prior to grinding with the purpose of fabricating patties is also limited to studies such as the ones from Jimenez-Villareal et al. (2002a; 2002b). Therefore, the objective of this study was to investigate the instrumental color characteristics of ground beef patties after the application of four antimicrobial compounds onto beef trimmings destined for the grinding and processing of patties, relative to untreated sample patties.

Experimental Procedures

Antimicrobial treatment and processing technique of the patties. The treatments included 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; Inspexx-200®, Ecolab, St Paul, Minn.), and an untreated control (CON). As per the manufacturers' instructions, 0.1% ASC and 0.2% PAA were prepared just before the experimental run in order to use the solutions in an active decontaminating state. For antimicrobial application, 12-lb batches of meat were placed into a meat tumbler. The selected volume of antimicrobial agent was added and tumbled at 60 rpm for 3 min. The volume of antimicrobial solution used in tumbling was 500 ml except for PAA (1,500 ml). As per manufacturer's instructions, ASC treatment was tumbled only for 30 sec. Following antimicrobial application, beef trimmings were ground 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. Polyvinyl chloride film was used to over wrap, and the patties were stored under simulated retail conditions (39°F; deluxe warm white fluorescent lighting) for 7 days.

Instrumental color. Instrumental color readings of patties were measured on days 0, 1, 2, 3 and 7 of simulated retail display using a Hunter-Lab Miniscan XE Spectrocolorimeter. The samples were evaluated using illuminant A/10° observer for the Commission Internationale de l'Eclairage (CIE) lightness (L^*), redness (a^*) and yellowness (b^*) color values. Reflectance values at 580 and 630 nm were also taken to determine a ratio of 630/580 nm to estimate the proportion of oxymyoglobin of the myoglobin pigment (Hunt et al., 1991). The spectrocolorimeter was standardized using a white tile and a black tile and a working standard. The shift from red to yellow of the ground beef patties, known as the hue angle, was calculated [$\tan^{-1}(b^*/a^*)$]. Also the saturation index [$(a^{*2} + b^{*2})^{0.5}$]

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which describes the brightness or vividness of color was determined (Hunt et al., 1991). Five measurements were taken of each sample and averaged for statistical analysis.

Statistical analysis. The experiment was arranged in a randomized 5 x 5 factorial design. The experiment was analyzed using the GLM procedure of SAS (SAS Inst. Inc., Cary, N.C.). The treatments were analyzed for the main effects of antimicrobial treatment, day of display, and treatment by day interactions. For variables involved in an interaction, means were generated and then separated within day using the PDIF option of GLM in SAS. Least-squares means for variables not confounded by interaction were generated and separated using PDIF.

Results and Discussion

L^* . There was not a significant treatment x day interaction for L^* (lightness) values. Therefore, main effects of treatment and day are reported in Tables 1 and 2. In comparison to the CON, only the PAA ground beef patties were lighter ($P < 0.05$), but the KL, NMS, and ASC treatments and the CON did not differ ($P > 0.05$) in CIE L^* values. Ground beef patties became lighter ($P > 0.05$) in color across 7 days of display (Table 2).

a^* . The day of display by antimicrobial treatment interaction effect on CIE a^* value is summarized in Figure 1A. On day 0 of display, the KL, NMS and the ASC treatments were similar ($P > 0.05$) in redness, but only KL, NMS and PAA were redder ($P < 0.05$) than ground beef patties left untreated (CON). However, on day 1 of display all treatments were redder ($P < 0.05$) than the CON. On day 2 of display, NMS patties were redder ($P < 0.05$) than the rest of the treatments; KL, PAA, and ASC treatments were similar ($P > 0.05$) to the CON. Likewise, on day 3 of display NMS patties were redder ($P < 0.05$) than patties from the other treatments. However, PAA patties were redder ($P < 0.05$) than the CON patties which were similar ($P > 0.05$) to KL and ASC treated patties. No differences ($P > 0.05$) in redness intensity were found between any of the treatments on day 7 of display. Results from the addition of KL, NMS, PAA, and ASC treatments on non-inoculated beef trimmings before grinding and pattying agree with the previous results obtained by Jimenez-Villarreal et al. (2003a) who found an extension in patty redness through display after antimicrobial treatment in comparison with ground beef patties formed from untreated trimmings.

b^* . The CIE b^* value day of display by antimicrobial treatment interaction effect is shown in Figure 1B. On day 0 of display, PAA patties had the same ($P > 0.05$) intense yellow color as the KL and ASC treatments, whereas the NMS and ASC treated patties were similar ($P > 0.05$) to CON. However, on day 1 of display patties from all treatments were more ($P < 0.05$) yellow than CON patties. There was no difference ($P > 0.05$) between any of the treatments and CON for CIE b^* values on day 2 of display. On day 3 of display, the NMS treated patties were more ($P < 0.05$) yellow than the rest of the treatments. However, on day 7 of display patties from the NMS treatment were less yellow ($P < 0.05$) than those from KL and PAA treatments which were similar ($P > 0.05$) to patties from the CON and ASC treatments.

Hue Angle. The hue angle refers to the trueness of red. A lower value (excluding negative values) defines a redder intensity of the sample. Figure 2A, shows the day of display by treatment interaction effect on hue angle of ground beef through simulated retail display. On days 0, 2, and 3 of display, the NMS treatment was lower ($P < 0.05$) than the rest of the treatments. Likewise, on day 1 of

simulated retail display, NMS, PAA and ASC had a lower ($P < 0.05$) hue angle than the CON treated patties. Additionally, the NMS treatment had a lower ($P < 0.05$) hue angle than the CON on day 7 of display. An explanation of the slightly lower values in hue angle for the NMS treatment in comparison to the rest of the treatments are the higher a^* values on days 2 and 3 and lower b^* values on day 0 and 7 of display, which indicated an overall brighter color for this particular treatment. These findings agree with those of Jimenez-Villarreal et al. (2003a; 2003b) for hue angle values in antimicrobial treated patties.

Saturation Index. The vividness of the ground beef patties is determined by the intensity of its corresponding a^* values and b^* values and is expressed as the saturation index. High values of this trait demonstrate how vivid the overall color of the sample is. In Figure 2B, the saturation index day by treatment interaction effect is shown. On day 0 of display, the KL and PAA treatment had a more ($P < 0.05$) vivid color compared with the CON treated patties that were similar ($P > 0.05$) to the NMS and ASC treatment. All treatments were more ($P < 0.05$) vivid in color than the CON on day 1 of display. On day 2 of display, the NMS treatment and PAA were similar ($P > 0.05$), but only NMS was more ($P < 0.05$) vivid in color in comparison with the CON patties. Patties from NMS and PAA treatments presented more ($P < 0.05$) vividness than the other treatments on day 3 of display. No difference ($P > 0.05$) was observed between any treatment and the CON on day 7 of display.

630/580 nm Ratio. The oxy-myoglobin to metmyoglobin ratio is an indicator of overall color in the samples. Higher values indicate brighter red color of the samples. Estimated oxy-myoglobin proportions (630/580 nm), summarized in Figure 3, were higher ($P < 0.05$) for all the treatments when compared with the CON on day 0 of retail display. On day 1 of display, the NMS, PAA and ASC treated patties had higher ($P < 0.05$) oxy-myoglobin values when compared with the CON. On day 2 of display the NMS treated patties had considerably higher ($P < 0.05$) oxy-myoglobin proportions than the rest of the treatments. Similarly, on day 3 of display, both NMS and PAA treatments were higher ($P < 0.05$) for this ratio than the CON treatment. Almost similar to day 2, on day 7 of display the NMS treatment had higher ($P < 0.05$) oxy-myoglobin proportions than the rest of the treatments with the exception of KL which was similar ($P < 0.05$) to NMS.

Implications

Relative to traditionally processed ground beef patties, patties treated with potassium lactate, sodium metasilicate, peroxyacetic acid or acidified sodium chlorite application exhibited similar or improved instrumental color characteristics over 7 days of display. However, sodium metasilicate demonstrated a better performance compared to the other treatments up to day 3 of display. Additionally, the oxy-myoglobin proportions of NMS were higher at day 7.

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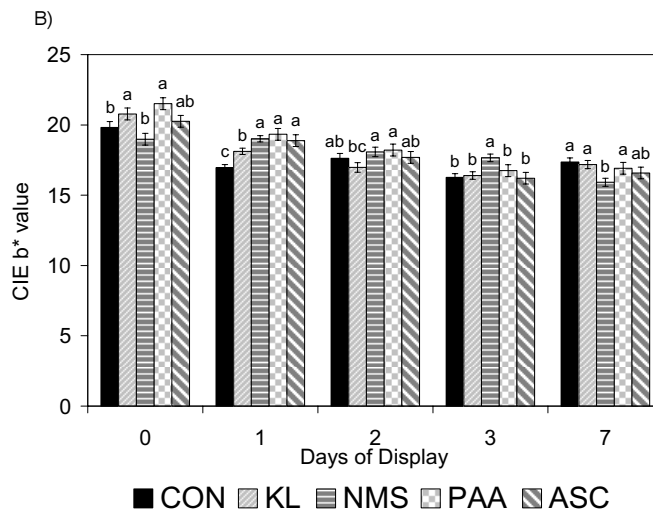
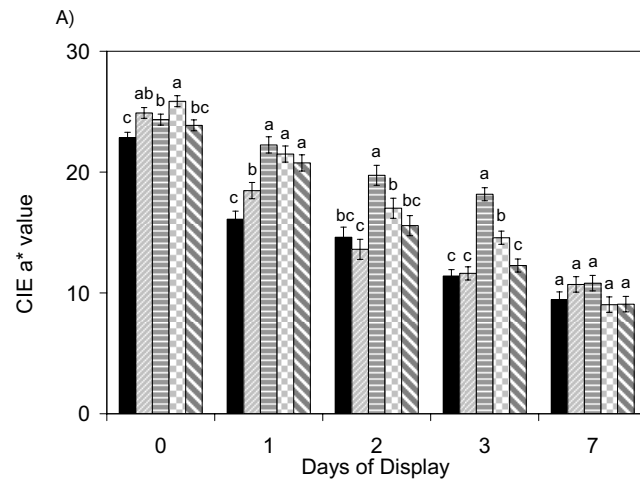
Jimenez-Villareal, J.R., et al. 2003b. Meat Sci 65:1055.

Table 1. Effect of antimicrobial treatments applied to beef trimmings on the least-squares mean for lightness (CIE L^*) values of raw ground beef patties.

Instrumental color	Treatment ^a					SE
	CON	KL	NMS	PAA	ASC	
L^* ^b	48.03 ^z	47.73 ^z	47.75 ^z	50.49 ^y	47.68 ^z	0.48

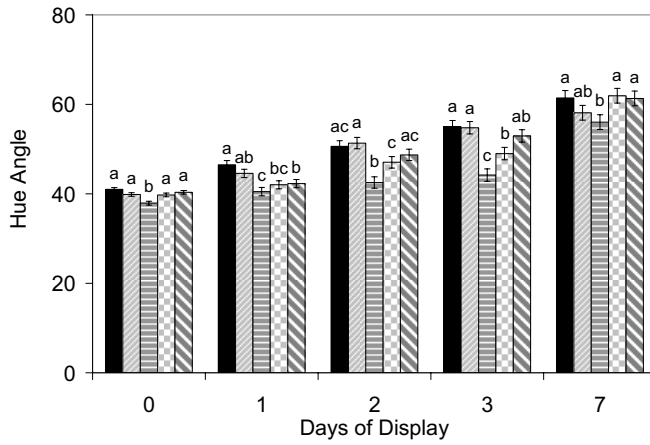
^a CON = Control, KL = 3% potassium lactate, NMS = 4% sodium metasilicate, PAA = 200 ppm peroxyacetic acid, ASC = 1000 ppm acidified sodium chlorite.^b L^* is a measure of lightness (0 = black and 100 = white).^{yz} Least-squares means within a row with no superscript in common differ ($P < 0.05$).**Table 2. Effect of duration of display on the least-squares mean for lightness (CIE L^*) of raw ground beef patties.**

Instrumental color	Days of display					SE
	0	1	2	3	7	
L^* ^a	46.82 ^z	48.31 ^{xy}	47.00 ^{yz}	49.57 ^{wx}	49.99 ^w	0.48

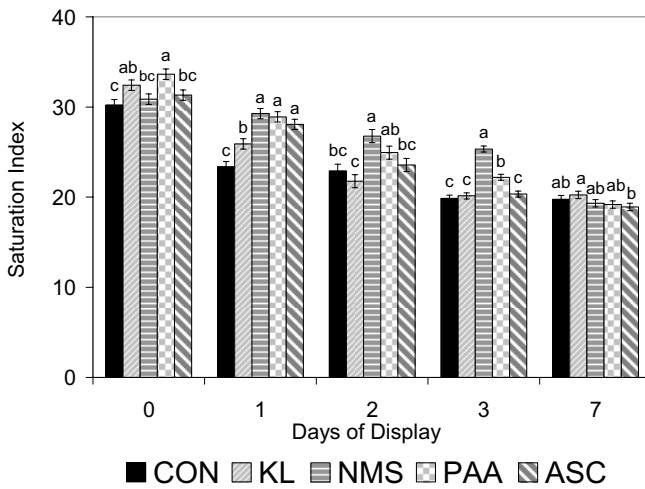
^a L^* is a measure of lightness (0 = black and 100 = white).^{wxyz} Least-squares means within a row bearing different superscripts are different ($P < 0.05$).

abc Least-squares means within a day with no letters 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. 1. Day of display by antimicrobial treatment interaction effect on the least squares means (\pm SE) (A) Commission Internationale de l'Eclairage (CIE) redness (a^* ; -60 = green and +60 = red) value and (B) CIE yellowness (b^* ; -60 = blue and +60 = yellow) value of ground beef patties through simulated retail display.

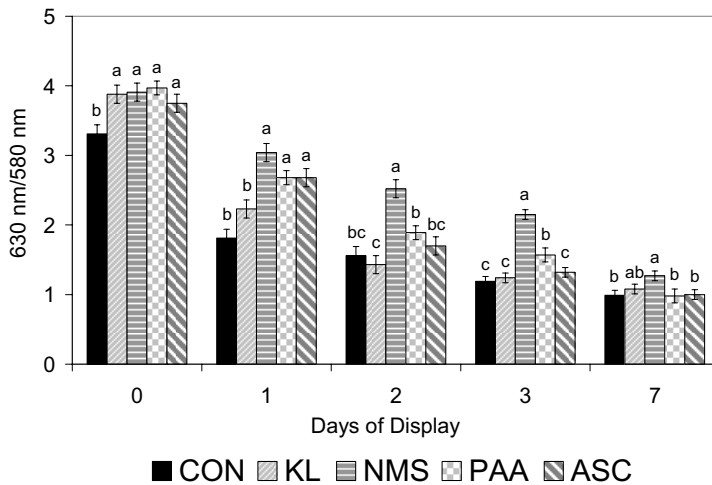


B)



abcLeast-squares means within a day with no letters 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) (A) hue angle (lower values indicate a redder color) and (B) saturation index (higher values indicate greater saturation of red) of ground beef patties through simulated retail display.



abcLeast-squares means within a day with no letters 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) of the 630nm reflectance/580nm reflectance ratio (higher values indicate greater oxymyoglobin proportions) of ground beef patties through simulated retail display.