Effect of Potassium Lactate, Sodium Metasilicate, Peroxyacetic Acid or Acidified Sodium Chlorite as Single Antimicrobial Interventions on Un-inoculated Beef Trimmings Prior to Grinding on Ground Beef Sensory Characteristics

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Story in Brief

The effects of antimicrobial treatments on beef trimmings prior to grinding on ground beef sensory color characteristics through simulated retail display were evaluated and compared to an untreated control (CON). Beef trimmings (90/10) were treated with 3% potassium lactate (KL), 4% sodium metasilicate (NMS), 0.1% acidified sodium chlorite (ASC) or 0.02% peroxyacetic acid (PAA) prior to grinding. The ground beef was packaged and sampled at 0, 1, 2, 3, and 7 d of simulated retail display. Sensory panelists found ground beef from all treatments to be similar ($P > 0.05$) to the CON in beef odor and similar ($P > 0.05$) or improved ($P < 0.05$) off odor characteristics throughout retail display. All treatments were brighter ($P < 0.05$) in red color on days 1 to 3 for worst point color and overall color attributes. Similarly, on those days the percentage discoloration was less ($P < 0.05$) for all treatments when compared with the CON. However, on day 7 of display, only the NMS treatment was different ($P < 0.05$) from the CON for the percentage discoloration. These findings indicated that use of antimicrobial agents does not adversely affect the sensory odor and color characteristics and can potentially improve color during retail display.

Introduction

Previous studies have shown that decontamination of beef trimmings prior to grinding by utilizing different antimicrobial agents would reduce microbial counts in ground beef (Pohlman et al., 2002; Stivarius et al., 2002a; 2002b). Results from Ellebracht et al. (2005) suggested that dipping beef trimmings into 200 ppm peroxyacetic acid solutions reduced *E. 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 logs CFU/cm^2, respectively. A product known as SANOVA® (a combination of sodium chlorite and citric acid in aqueous solution) was also found to be effective in reducing bacteria on beef carcasses and on beef cuts and trimmings. For the potential use of sodium metasilicate as an antimicrobial agent in beef decontamination, sufficient information is not available for its effect on meat quality traits. Potassium and sodium lactates, commercially available as neutral pH aqueous solution (60%), are recommended for extending shelf life in cured and uncured meat and poultry products. However, little work on their antimicrobial effects and resulting product quality has been published. 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 un-inoculated beef trimmings prior to grinding on sensory color and odor characteristics of ground beef.

Experimental Procedures

Antimicrobial Treatment and Processing. The antimicrobial 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), 0.02% peroxyacetic acid (PAA; Inspexx-200®, Ecolab, St Paul, Minn.), and an untreated control (CON).

To perform each antimicrobial agent application, 12 lb batches of meat were placed into a meat tumbler. The selected volume of antimicrobial agents was added and tumbled at 60 rpm for 3 min. The volume of antimicrobial solution used for tumbling was 500 ml except for PAA (1,500 ml). As per manufacturer's instructions, ASC treatment was tumbled only for 30 sec. Following the complete antimicrobial application, beef trimmings were ground twice using a Hobart grinder with a 3.2 mm plate. Between each treatment the grinder was washed, sanitized, and rinsed to avoid cross contamination. Then, ground beef samples of 1 lb were placed on styrofoam trays with absorbent pads and over wrapped with polyvinyl chloride film and stored under simulated retail conditions (39°F; deluxe warm white fluorescent lighting). The pH of the treated ground beef was determined by homogenizing ground beef with distilled water in a 1:10 ratio. An ultra basic portable pH-mv meter was used to measure the pH.

Processing Properties. The processing abilities refer to the behavior of ground beef in the presence or 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 on a 6-point scale (6 = extreme smearing; 1 = extreme cut – grind) for each treatment.

Sensory Evaluation. Eight trained panelists (Hunt et al., 1991) were selected for the sensory panel. Sensory evaluation of ground beef treated with antimicrobial agents prior to grinding was carried out on 0, 1, 2, 3, and 7 d of simulated retail display. The panelists evaluated overall color and worst point color using a modified scale of Hunt et al. (1991) 5 = bright purplish red; 1 = brown. Percentage surface discoloration was evaluated on a 1 to 7 scale (7 = no discoloration (0%), 6 = slight discoloration (1 to 20%), 5 = small discoloration (20 to 39%), 4 = modest discoloration (40 to59%), 3 =

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moderate discoloration (60 to 79%), 2 = extensive discoloration (80 to 95%), 1 = total discoloration (96 to100%).

The odor characteristics of ground beef were evaluated as beef odor (8 = extremely beef like; 1 = extremely non - beef like) and off odor (5 = no off odor; 1 = extreme off odor) as described by Hunt et al. (1991).

Analysis of Data. The data were analyzed in a complete 5 x 5 factorial design and replicated three times. Treatments were analyzed for the main effects of antimicrobial treatment, day of display, and treatment by day interactions using the GLM procedure of SAS (SAS Inst., Inc., Cary, N.C.). A panelist term was added to the model to account for sensory panelist variation. Means were generated using LSMEANS and separated with the PDIFF option of GLM.

Results and Discussion

Processing Abilities. During this study KL, PAA, and ASC patties had much less ($P < 0.05$) particle definition than the CON, whereas NMS bulk ground beef was similar ($P > 0.05$) to CON for grinding ability (Table 1).

Treatment Main Effect on Ground Beef Odor and Off Odor. The effect of antimicrobial treatments on the least-squares means for ground beef odor characteristics is summarized in Table 1. Sensory panelists did not find a difference ($P > 0.05$) in beef odor between CON and the other treatments. The NMS and KL treatments had similar ($P > 0.05$) off odor to the control (CON). Although off odor intensities of PAA and ASC were different ($P < 0.05$) with the CON they were similar ($P > 0.05$) to KL and NMS. The overall numerical values for the off odor, regardless of their statistical difference ($P < 0.05$) indicate that there were no abnormal odors other than the beef like odor (Table 1).

Days of Display Main Effect on Ground Beef Odor and Off Odor Characteristics. No differences ($P > 0.05$) were found in beef odor on day 0 to day 2 of display (Table 2). The beef odor decreased ($P < 0.05$) at day 3 and day 7 of display. The off odor intensities also decreased ($P < 0.05$) slightly towards the end of the display days. The panelists did not detect any off odors on day 1 of display, whereas the off odor intensity on day 0 was similar ($P > 0.05$) to d 2 and d 3 of display. However, samples had more ($P < 0.05$) off odor intensities and less ($P < 0.05$) beef odor intensities on d 7 compared to d 1, 2, and 3.

Worst Point Color. The display days of antimicrobial treated beef on sensory worst point color characteristics are summarized in Table 3. The KL, NMS and ASC treatments had a similar ($P > 0.05$) worst point color on day 0 of display, whereas PAA treated ground beef had a brighter red color than the CON and the rest of the treatments. Nevertheless, worst point color values were higher ($P < 0.05$) for all the treatments when compared with the CON on days 1 to 3. No differences ($P > 0.05$) were detected for worst point color between any treatment and the CON at day 7 of display.

Overall Color. The days of display by antimicrobial treatment interaction effect on sensory overall color characteristics are summarized in Table 3. Sensory panelists were unable to detect differences ($P > 0.05$) in overall color between the CON and the rest of the treatments on day 0 of display. All treatments were redder ($P < 0.05$) in overall color attributes when compared with the CON on days 1 to 3 of display. However, on day 7 of display the ASC treated ground beef was similar ($P > 0.05$) to the CON. All other treatments were slightly brighter in red overall color, however their numerical values were low as is it would normally be expected at the last day of display.

Percent Discoloration. The days of display by antimicrobial treatment interaction effect on sensory percent discoloration characteristics are summarized in Table 3. All treatments were slightly less ($P < 0.05$) discolored than the CON on day 0 of display. However, on days 1 to 3 of display all treatments contained small ($P < 0.05$) or modest ($P < 0.05$) discoloration compared with the CON. In addition, at day 7 of display, the KL, NMS, and PAA had an extensive discoloration as expected, however, only NMS differed ($P < 0.05$) with the CON. The CON and ASC were also similar ($P > 0.05$) revealing a total discoloration of their surface.

Implications

These results indicate that all treated ground beef samples were performing similar or better compared to the control ground beef sample for sensory color attributes especially from day 0 to day 3 of display. The NMS treatment demonstrated a better performance against discoloration of the meat surface and brighter red color at its worst point and overall color at late stages of display. Also, all treatments demonstrated non residual off odors.

Acknowledgments

Sincere appreciation is expressed to J. Stephenson, S. McCord and J.L. Aparicio for their assistance in conducting this study. The authors would also like to thank Purac America Inc., Lincolnshire, Ill.; Rhodia Inc., Cranbury, N.J.; and Ecolab, St Paul, Minn., for their material and technical support.

Literature Cited

Ellebracht, J.W., et. al. 2005. Meat Sci. 70:197.
Hunt, M.C., et al. 1991. Proceedings 44th Annual Reciprocal Meat Conference, 3:170.
King, D.A., et al. 2005. Meat Sci. 69:401.
Pohlman, F.W., et al. 2002. Meat Sci. 60: 349
Stivarius, M.R., et al. 2002a. Meat Sci. 60: 245.
Stivarius, M.R., et al. 2002b. Meat Sci. 60: 299.

Table 1. Effect of antimicrobial treatments applied to beef trimmings on the least-squares means for beef odor and off odor intensities of bulk ground beef through simulated retail display.

Attribute	Treatment[a]					
	CON	KL	NMS	PAA	ASC	SE
Processing Abilities						
Grinding ability[b]	1.00yz	3.33x	1.50y	4.16w	3.58wx	0.22
Sensory Properties						
Beef odor[c]	7.29wx	7.19x	7.27wx	7.42w	7.19x	0.07
Off odor[d]	4.48x	4.60wx	4.62wx	4.73w	4.67w	0.05

[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] Beef odor score: 1 = extremely non – beef like and 8 = extremely beef like.
[d] Off odor score: 1 = extreme off odor and 5 = no off odor.
[wxyz] Least-squares means within a row bearing different letters are different (P < 0.05).

Table 2. Effect of duration of display on the least-squares means for beef odor and off odor characteristics of ground beef.

Attribute	Days of display					
	0	1	2	3	7	SE
Beef odor[a]	7.60x	7.43xy	7.49xy	7.38y	6.45z	0.07
Off odor[b]	4.64y	5.00x	4.74y	4.62y	4.11z	0.05

[a] Beef odor score: 1 = extremely non –beef like and 8 = extremely beef like.
[b] Off odor score: 1 = extreme off odor and 5 = no off odor.
[xyz] Least-squares means within a row bearing different letters are different (P < 0.05).

Table 3. Effects of days of display by antimicrobial treatment interaction effect on the least-squares means for worst point color, overall color and percent discoloration of ground beef through simulated retail display.

Attribute	Treatment[a]	Days of display				
		0	1	2	3	7
Worst Point Color[b]						
	CON	3.88y	2.86z	1.76y	1.37z	1.07w
	KL	4.03xy	3.26y	2.70x	2.00y	1.18w
	NMS	4.33x	4.46w	3.73w	4.14w	1.22w
	PAA	4.81w	3.86x	3.90w	3.51x	1.22w
	ASC	4.33x	4.03x	3.63w	3.59x	1.11w
	SE	0.13	0.12	0.14	0.15	0.07
Overall Color[b]						
	CON	4.74w	3.66y	3.16y	2.51z	1.14y
	KL	4.74w	4.23x	3.66x	3.37y	1.85x
	NMS	4.81w	4.76w	4.63w	4.70w	2.33w
	PAA	4.88w	4.36x	4.56w	4.25x	2.03wx
	ASC	4.74w	4.46wx	4.40w	4.29x	1.40y
	SE	0.07	0.10	0.10	0.10	0.13
% Discoloration[c]						
	CON	6.22y	5.46y	4.43y	3.59y	1.85xy
	KL	6.62x	6.06x	5.40x	5.07x	2.33wx
	NMS	6.70wx	6.76w	6.43w	6.44w	2.70w
	PAA	7.00w	6.63w	6.40w	6.33w	2.33wx
	ASC	6.59x	6.50w	6.16w	6.48w	1.44y
	SE	0.10	0.11	0.16	0.17	0.25

[a] CON = Control, KL = 3% potassium lactate, NMS = 4% sodium metasilicate, PAA = 200 ppm peroxyacetic acid, ASC = 1000 ppm acidified sodium chlorite.
[b] Color score: 1 = brown and 5 = bright purple red.
[c] Percentage discoloration: 1= total discoloration (96 to100%) and 7 = no discoloration (0 to4%).
[wxyz] Least–squares means within a column and attribute bearing different letters are different (P < 0.05).