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Antimicrobial Interventions and Application Time Effects on Ground Beef Quality

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Summary with Implications

Small business meat processors can use organic acid antimicrobial interventions to control Shiga toxin-producing E. coli (STEC) when producing ground beef; however, many small producers are concerned about the impact on ground beef quality. The effects of two commonly used organic acids, lactic acid and peroxyacetic acid, were evaluated at short (15 seconds) or extended (3 minutes) raw material dip times on ground beef quality parameters. Beef trim dipped in lactic acid for 3 minutes had a reduction in total aerobic bacteria plate count, but also increased ground beef discoloration and lipid oxidation during retail display. Use of a shorter dip time showed minimal differences in ground beef quality compared to untreated controls. In addition, dipping lean trim in peroxyacetic acid for 3 minutes slowed ground beef discoloration during display. Therefore, processors should consider either type of organic acid, and the length of lean trim exposure to organic acid during dipping, to optimize shelf life quality attributes.

Introduction

Organic acid antimicrobial interventions are used to reduce Shiga toxin-producing *E. coli* (STEC) in ground beef, however, the use of organic acids can impact ground beef quality during retail display. One application method is dipping pieces of meat into organic acids for a set length of time. With dipping, processors that do not follow correct operating procedures for interventions may impact ground beef quality. The purpose of this study was to compare an abusive dipping time versus a recommended time, using concentrations of acid near maximum concentrations, to determine the effects on ground beef quality during retail display.

Procedures

Study Design

Two organic acids, lactic acid and peroxyacetic acid, were used to dip beef shoulder clod pieces (approximately 62 in^2 surface area). Five beef shoulder clods were fabricated into smaller pieces (approximately 2.5 lbs). Shoulder clod pieces (lean trim) were randomly assigned to one of 5 treatments with a target of 12 pounds per treatment. Four treatments used shoulder clod pieces dipped for either 15 seconds (15s) or 3 minutes (3m) using either 4.5% lactic acid (LA) or 380 ppm peroxyacetic acid (PA) at 72°F. The fifth treatment (negative control; CON) used shoulder clod pieces not dipped in an organic acid. Shoulder clod pieces from each treatment were ground (0.5 in coarse, 0.25 in fine) and formed into one-pound blocks using a Colosimo press. The ground beef blocks were overwrapped with an oxygen permeable film and placed in retail display (approximately 36.8°F) for 7 days. On days 0, 1, 3, 5, and 7, ground beef samples were collected for each treatment group to determine total aerobic plate count (TPC), pH, and lipid oxidation (TBARS). The ground beef percentage discoloration (% discoloration) and L*, a*, and b* color was evaluated daily during retail display. Six replications were conducted.

Quality Characteristic Analysis

Total aerobic bacteria plate count was determined using standard procedures for Aerobic Count Plate Petrifilms™. Ground beef pH was measured with a pH meter using 10g of powdered ground beef combined with 90mL deionized water. Lipid oxidation analysis used procedures for the determination of malonaldehyde content. Percentage discoloration was determined daily with a subjective color panel. Ground beef color L*, a*, and b*, was measured daily by reflectance with a Konica-Minolta colorimeter.

Statistical Analysis

Data were analyzed using SAS 9.2 PROC GLIMMIX procedures with the model statement including treatment, retail display day, and the interaction between them. Tukey's adjustment for LSmeans separation with $P< 0.05$ was applied.

Results

Ground beef quality measures of TPC, lipid oxidation, pH, and percent discoloration had a significant interaction between treatment and day of display ($P<0.001$), therefore LSmeans were separated across treatments and days of display.

On days 0 and 1, all treatments were similar for TPC (total colony forming units/gram (CFU/g). However, on days 3, 5, and 7 of display, the ground beef TPC (CFU/g) for LA3m was lower ($P< 0.05$) than CON and PA15s (Table 1). In addition, ground beef lipid oxidation (mg malonaldehyde/kg tissue) was higher ($P< 0.05$) for LA3m than both PA15s and PA3m on day 3, and was also higher ($P< 0.05$) than CON on day 5, as well as PA15s and PA3m on day 5 and 7 (Table 2). Perhaps TPC and lipid oxidation were impacted by ground beef pH as the meat pH from LA3m was lower ($P< 0.05$) than ground beef control treatments on days 0, 1, and 3 (pH=5.25 vs 5.81; 5.32 vs 5.76; 5.21 vs 5.58; respectively for LA3m vs CON on d 0, 1, and 3).

Visual percent discoloration increased for all treatments (from 0% to 100%) during retail display, with a rapid change from day 3 to day 5 of display. On days 3, 4, and 5, percent discoloration scores of ground beef from LA3m treatments were higher ($P< 0.05$) as compared to scores for ground beef from PA3m (Table 3). In addition, ground beef percent discoloration for the PA3m treatment on days 3 and 4 was different

Table 1. Total aerobic bacteria plate counts (CFU/g) of all treatments and days of retail display.[1]

Treatment[2]	Day of display				
	0	1	3	5	7
PA15s	3.02^{g}	3.24^{fg}	3.98^{abc}	4.13^{ab}	4.27^{ab}
PA3m	3.02^{fg}	3.21^{fg}	3.86^{abcde}	4.22^{ab}	4.39^{a}
LA15s	3.14^{fg}	3.19^{fg}	3.85^{bcde}	4.00^{abc}	3.95^{abcd}
LA3m	3.30^{fg}	3.06^{fg}	3.43^{defg}	3.56^{cdef}	3.43^{defg}
Control	3.10^{fg}	3.38^{efg}	4.17^{ab}	4.17^{ab}	4.26^{ab}

[1] LSmeans with different superscripts (a-g) are significantly different (P < 0.05).
[2]PA15s=peroxyacetic acid 380ppm, 15 s dip; PA3m=peroxyacetic acid 380ppm, 3 m dip; LA3m=lactic acid 4.5%, 15 s dip; LA3m=-lactic acid 4.5%, 3 m dip; Control = no organic acid treatment. Standard error for LA15s, PA15s, LA3m and control is 0.14 while PA3m standard error is 0.15.

Table 2. Lipid oxidation (mg malonaldehyde/kg tissue) for all treatments and days of retail display.[1]

Treatment[2]	Day of display				
	0	1	3	5	7
PA15s	0.96^{gh}	1.47^{efgh}	1.80^{defgh}	2.46^{bcdefgh}	2.86^{bcde}
PA3m	1.82^{defgh}	1.06^{fgh}	1.52^{defgh}	2.15^{cdefgh}	2.62^{bcdefg}
LA15s	1.15^{efgh}	1.78^{defgh}	2.69^{bcdef}	3.87^{ab}	4.65^{a}
LA3m	1.34^{efgh}	1.71^{defgh}	3.62^{abc}	4.75^{a}	4.58^{a}
Control	0.82^{h}	1.17^{efgh}	2.00^{cdefgh}	2.68^{bcdefg}	3.22^{abcd}

[1] LSmeans with different superscripts (a-h) are significantly different (P < 0.05).
[2]PA15s=peroxyacetic acid 380ppm, 15 s dip; PA3m=peroxyacetic acid 380ppm, 3 m dip; LA15s=lactic acid 4.5%, 15 s dip; LA3m=-lactic acid 4.5%, 3 m dip; Control = no organic acid treatment. Standard error for all treatments is 0.46.

Table 3. Percentage of discoloration for all treatments and days of retail display.[1]

Treatment[2]	Day of display							
	0	1	2	3	4	5	6	7
PA15s	1.87^{i}	-0.66^{i}	3.62^{i}	12.58^{hi}	43.97^{ef}	77.01^{bcd}	93.80^{ab}	100.15^{a}
PA3m	1.87^{i}	1.94^{i}	8.27^{i}	8.55^{i}	35.85^{fg}	68.31^{cd}	92.40^{ab}	100.07^{a}
LA15s	1.89^{i}	2.13^{i}	8.30^{i}	12.37^{hi}	46.13^{ef}	79.31^{abcd}	95.89^{ab}	100.10^{a}
LA3m	0.16^{i}	-0.35^{i}	2.67^{i}	32.18^{fgh}	63.69^{de}	90.98^{ab}	98.20^{ab}	96.34^{ab}
Control	1.87^{i}	2.01^{i}	5.99^{i}	16.17^{ghi}	63.47^{de}	89.13^{abc}	98.57^{ab}	100.17^{a}

[1] LSmeans with different superscripts (a-i) are significantly different (P < 0.05).
[2]PA15s=peroxyacetic acid 380ppm, 15 s dip; PA3m=peroxyacetic acid 380ppm, 3 m dip; LA15s=lactic acid 4.5%, 15 s dip; LA3m=-lactic acid 4.5%, 3 m dip; Control = no organic acid treatment. Standard error for range is 3.43–5.60.

from the ground beef discoloration percent for the CON treatment (Table 3). LA15s and PA15s were similar to controls on each day of display. Comparing objective color measurements, ground beef L* values were higher (P< 0.05) for LA3m (51.38) than ground beef L* for CON (48.66) and PA15s (49.55). This is in agreement with the change in discoloration percent as brown colors of beef are usually lighter in color. Ground beef a* for both PA15s (14.66) and PA3m (15.08) were more red (P< 0.05) than ground beef a* for the control (14.08). The increase in a* may indicate a positive quality attribute for the use of peroxyacetic acid as the percent discoloration on day 4 of display was less than the percent discoloration of the control. For b* values, the average mean was 11.36 for LA3m, which was higher (P< 0.05) than 10.86 measured for CON.

Conclusions

Ground beef treated with lactic acid for extended times produced undesirable effects on ground beef quality. It appears prolonged treatment of lean trim with lactic acid will reduce shelf life due to ground beef discoloration and increased oxidation during retail display, especially after 2 days of retail display. The quality reduction occurred even though total plate counts were reduced throughout shelf life by the lactic acid treatments with an extended application time. However, treatment of grinding materials with peroxyacetic acid for 3 minutes slowed discoloration during display and increased the redness color. Therefore, antimicrobial intervention organic acid type and length of exposure time used to control Shiga toxin-producing *E. coli* can impact ground beef shelf life and quality.

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