Instrumental color properties of ground beef processed from beef trims pre-treated with hydrochloric/citric acid based decontamination interventions

P. N. Dias-Morse¹, F. W. Pohlman¹, L. N. Mehall¹, J. A. McDaniel¹, R. D. Guidry¹, T. L. Devine¹, K. L. Beers¹ and A. Mohan¹

Introduction

Despite advanced decontamination technologies employed in meat processing, ground beef safety concerns continue with frequent safety recalls related to possible contamination with pathogenic bacteria. Single and multiple antimicrobial interventions have shown promising results in decontaminating meat products; however, any intervention that has a negative impact on meat color characteristics leads to severe economic losses. Application of cetylpirinidium chloride (CPC) and trisodium phosphate (TSP) as an antimicrobial intervention, as reported by Pohlman et al. (2002) and Jimenez-Villarreal et al. (2003), may enhance redness ($a^*$) and oxymyoglobin stability (630 nm/580 nm) without affecting the odor characteristics in ground beef. A novel hydrochloric/citric acid blend has showed promise as a potential decontamination technique to enhance microbial quality of meat products. However, impact of such intervention on ground beef color properties is under-investigated.

Jimenez-Villarreal et al. (2003) and Pohlman et al. (2009) found out the use of CPC, TSP and sodium metasilicate (NMS) may not adversely affect the color characteristics when used in a ground beef system. Therefore, the objective of this study was to evaluate the impact of hydrochloric/citric acid blend alone or followed by CPC, TSP, NMS or water when used as a pre-grinding intervention on instrumental color properties of ground beef.

Materials and Methods

**Antimicrobial Treatment and Processing.** The treatments involved 15% hydrochloric/citric acid blend (Citrilow™ Safe Foods Corporation, Little Rock Ark.; CIT) alone or CIT followed by 4% sodium metasilicate (Avguard®, Rhodia Inc., Cranbury, N.J.; CITNMS), 0.4% cetylpirinidium chloride (CECURE™ Safe Foods Corporation; CITCPC), 10% trisodium phosphate (Trisodium phosphate anhydrous (FG), ICL performance products, St. Louis, Mo.; CITTSP) or water (CITW). For treatment application, 5 lb batches of beef trims were placed into a meat tumbler (Model 4Q, Lyco Inc. Janesville, Wis.) and 500 ml of hydrochloric/citric acid blend was added and tumbled at 60 rpm for 2 min. The CIT-treated trims designated for secondary antimicrobial treatment were allowed to drip for 30 min prior to vacuum tumbling for 2 min at 60 rpm with (1) sodium metasilicate (CITNMS), trisodium phosphate (CITTSP), cetylpirinidium chloride (CITCPC) or water (CITW). Each antimicrobial treatment was repeated three times. Next, pre-treated trims as well as untreated un-inoculated (CON) and inoculated (INCON) control trims were ground twice. Samples of 200 g of ground beef processed from each treatment (n = 5 per treatment per replicate) were placed on styrofoam trays with absorbent pads and overwrapped with polyvinyl chloride film with an oxygen transmission rate of 14,020 cm³O2/m²/24 h/atm -6 (Koch Supplies, Inc., Kansas City, Mo.). The ground beef samples were stored under simulated retail conditions (4C; deluxe warm white fluorescent lighting, 1630 lux, Phillips Inc., Somerset, N.J.).

**Instrumental Color.** Instrumental color measurements of ground beef processed from treated and untreated beef trim were taken on days 0, 1, 2, 3, 4 and 5 of simulated display using a Hunter-Lab MiniScan XE Spectrocolorimeter, Model 4500L (Hunter Associates Laboratory, Reston, W.Va.). The samples were assessed for CIE ($L^*$, $a^*$, and $b^*$) color values, hue angle ($tan^{-1}(b^*/a^*)$), which describes the hue or color of ground beef, and saturation index ($a^*+b^*$)/2, which describes the brightness or vividness of color (Hunt et al., 1991). Reflectance measurements were also taken in the visible spectrum from 580 to 630 nm and reflectance factor (630/580 nm) was calculated to estimate the oxymyoglobin proportion of the myoglobin pigment (Hunt et al., 1991). Each sample was measured three times using Illuminant A/10° observer and the spectrophotometer was standardized using white tile, black tile and working standards before used in measurements.

¹ University of Arkansas System Division of Agriculture, Department of Animal Science, Fayetteville, Ark.
Analysis of Data. Lightness ($L^*$), redness ($a^*$), yellowness ($b^*$), hue angle, reflectance ratio and saturation index were arranged in a completely randomized $5 \times 5$ factorial design. The experiment was 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.). Means were generated using LSMEANS and separated with the PDIFF option of SAS.

**Results and Discussion**

The results (Figs. 1 and 2) indicate that CITTSP-treated ground beef was more red ($P < 0.05$) compared to all other treatments on day 0 of simulated display. Ground beef processed from CITTSP maintained a similar $a^*$ ($P > 0.05$) compared to INCON, respectively on days 1 through 5 of display. Similarly, CITNMS treatment showed similar $a^*$ ($P > 0.05$) compared to CON on day 1 through 5 of display. The hue angle value for CITTSP and CITNMS- treated ground beef was lower compared to other treatments on day 0 indicating more redness in color than the rest of the treatments. In addition CITTSP and CITNMS treatments continued to maintain lower hue angle compared to CIT, CITCPC, and CITW treatments on day 2 through 5 of display. Similarly, CITTSP and CITNMS treated samples had more ($P < 0.05$) vivid color compared to all the treatments on day 0 and had similar vivid color to CON and INCON on days 2, 3 and 4 of display. Additionally, the oxymyoglobin proportions ($630 \text{ nm}/580 \text{ nm}$ ratio) were highest ($P < 0.05$) in CITTSP compared to all the treatments on day 1 and 2 of display. The ground beef samples were lighter ($P < 0.05$) and more yellowish ($P < 0.05$) on day 0 compared to other days of display. There was no significant ($P > 0.05$) difference in $L^*$ during day 1 through 5 of display, however, the intensity of $b^*$ reduced ($P < 0.05$) with the time. These results were in agreement with Pohlman et al. (2009) and Jimenez-Villarreal et al. (2003) who reported TSP and NMS may enhance redness ($a^*$) and oxymyoglobin stability ($630 \text{ nm}/580 \text{ nm}$) when used as a pre-grinding treatment.

**Implications**

Findings from this study indicate that use of hydrochloric/citric acid blend along with trisodium phosphate or sodium metasilicate may improve the ground beef redness and extend shelf-life. Therefore, the antimicrobial properties of these agents may be used as potential multiple pre-grinding interventions to enhance ground beef safety without adverse effects on ground beef color.

**Literature Cited**


Effect of antimicrobial treatment and day of display interaction on redness ($a^*$), Hue angle$^1$, saturation index and oxymygolobin proportion$^2$ of the myoglobin pigment (630nm/580nm) values ground beef.

Fig. 1. Data sharing a common letter (a-c) within a day are significantly not different ($P > 0.05$). Estimates ($n = 3$/treatment/replicate) for redness ($a^*$), Hue angle, saturation index and oxymygolobin proportion of the myoglobin pigment (630nm/580nm) with ±SE represented on the vertical bars. CON- un-inoculated untreated control; INCON- inoculated untreated control; CITNMS-15% hydrochloric/citric acid followed by 4% sodium metasilicate, CITTSP-15% hydrochloric/citric acid followed by 10% trisodium phosphate; CITW-15% hydrochloric/citric acid followed by water; CIT-15% hydrochloric/citric acid alone; CITCPC-15% hydrochloric/citric acid followed by 0.4% cetylpyrinidium chloride. Hue angle$^1$ = $\tan^{-1}(b^*/a^*)$, saturation index$^2$ = $(a^*^2 + b^*^2)^{0.5}$.
Effect of antimicrobial treatment and day of display effects on lightness \((L^*)\) and effect of day of display on least squares means (± SE) yellowness \((b^*)\) values of ground beef

![Graph showing lightness \((L^*)\) and yellowness \((b^*)\) values for different treatments and days of display.](image)

**Fig. 2.** Data sharing a common letter \(\text{(a-d)}\) are significantly not different \((P > 0.05)\). Estimates \((n = 3/\text{treatment/replicate})\) for Lightness \((L^*)\) and yellowness \((b^*)\) with ± SE are represented on the vertical bars. CON- un-inoculated untreated control; INCON- inoculated untreated control; CITNMS-15% hydrochloric/citric acid followed by 4 % sodium metasilicate, CITTSP-15% hydrochloric/citric acid followed by 10% trisodium phosphate; CITW-15% hydrochloric/citric acid followed by water; CIT-15% hydrochloric/citric acid alone; CITCPC- 15% hydrochloric/citric acid followed by 0.4% cetylpyrinidium chloride.