Lowering sodium tripolyphosphate usage in beef enhancement brines with 1% ammonium hydroxide

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STORY IN BRIEF

The objective of this research was to reduce phosphate usage in beef enhancement brines in order to minimize additives having negative health implications for some consumers, while maintaining high quality meat palatability standards. Ten paired U. S. Select striploins, (n=20) were randomly chosen and injected with either a control brine containing 4.5% sodium tripolyphosphate, 3.6% NaCl, and 1% Herbalox HT-S or a treatment brine containing 1% ammonium hydroxide solution, 1% sodium tripolyphosphate, 3.6% NaCl, and 1% Herbalox HT-S. Steaks after 4 d storage in dark at 4°C were selected randomly on d 0, 7,and 14 of retail storage to measure purge, cook yield, pH, L*a*b* color, shear force, aerobic plate counts, anaerobic plate counts, composition, TBARs (oxidative rancidity assay), sensory taste panel, and visual color evaluation. There was not a significant difference between steaks injected with the control or AHP brine in the following measurements: pH, purge, and shear force. There was no significant difference between steaks injected with the control or AHP in any of the sensory taste panel attributes: initial juiciness, sustained juiciness, initial tenderness, connective tissue, overall tenderness, beef flavor, salty flavor, pepper flavor, or ammonia intensity. Differences in cook loss were not seen until d 19. In the overall lean color score, the control was more desirable than the treatment from d 7 retail until the end of the study. The control had lower microbial counts than the treatment in both the aerobic and anaerobic plate counts. Differences between treatment and control steaks were comparable, except after d 7 significant differences in color started to emerge with the control performing better. The study demonstrates that the phosphate level used in meat enhancements can be significantly reduced (>75%) with the aid of ammonium hydroxide as an alkaline processing aide.

Key Words: ammonium hydroxide, beef Select striploins, injection enhancement

INTRODUCTION

The current study was conducted as a follow up to previous research done at Oklahoma State University in order to find successful alternatives to phosphate usage in commercial brine injections used in the enhancement of Select beef striploins. In 2007 OSU scientists, Vann and Mireles DeWitt compared a phosphate-based solution (4.5% phosphate, 3.6% sodium chloride, 90.9% water, and 1% Herbalox seasoning Type HT-W) and an aqueous solution of solubilized protein (3.6% sodium chloride, 1% Herbalox seasoning Type HT-W). They found that phosphate-enhanced steaks performed better than protein-enhanced steaks (Vann and Mireles DeWitt, 2007). In another OSU directed investigation, Cerruto-Noya et al. (2009) compared Select beef striploins injected with the same phosphate-based solution as Vann and Mireles DeWitt (2007) to an alkaline-based injection enhancement (0.1% ammonium hydroxide, 3.6% sodium chloride, and 1% Herbalox Type HT-W). Their results showed that the alkaline-enhancement brine was not as effective as the phosphate-based brine, but suggested that a higher concentration of ammonium hydroxide in brine may raise final meat pH sufficiently to be more

competitive with the phosphate-based brine in terms of color stability, water holding capacity, and tenderness (Cerruto-Noya et al., 2009). Previous to the current study, we used the same phosphate-based brine to inject Select beef striploins and compared it to striploins enhanced with an AHP brine containing 1% ammonium hydroxide, 3.6% sodium chloride, 1% Herbalox Type HT-S, and 94.4% water. Results showed that the phosphate-based steaks and the AHT steaks performed comparably, with the exception of the phosphate-based steaks having lower aerobic and anaerobic plate counts. AHT steaks did achieve nearly a 50% reduction in total sodium content as well as produced steaks that had better color stability.
The objective of this study was to determine if a significant reduction in the amount of phosphate from the ammonium hydroxide-based injection brine by >75% would perform better than the no phosphate ammonium hydroxide brines.

MATERIALS AND METHODS

Sample Collection. Ten paired, U.S. Select beef carcasses were tagged at a beef fabrication facility. The tagged strip loins were collected on the fabrication floor and placed into plastic vacuum package bags. Strip loins were transported to the Robert M. Kerr Food and Agricultural Product Center (FAPC) where they were subsequently vacuum-packaged and stored overnight at 4 ºC.

Sample Enhancement. Strip loins were trimmed of excess fatand an initial weight of each strip loin was recorded. The paired strip loins (left and right sides) were then randomly selected to be injected with either the control (phosphate based) brine, or the ammonium hydroxide based brine (AHP). Strip loins were injected with solution at 4 ºC using a 20 single needle automatic pickle injector (Fomaco, Model FGM 20/20S, Copenhagen, Denmark) calibrated to inject at 110% of the recorded initial weight.

Injection Brines. The control brine was prepared with 4.5% sodium tripolyphosphate (Brifisol®85 Instant; BK Giulini Corporation, Simi Valley, CA), 3.6% sodium chloride, 90.9% water, and 1% Herbalox seasoning type HT-S (Kalsec, Kalamazoo, Mich., U.S.A.). The AHP brine was prepared using 1% food grade ammonium hydroxide, 1% sodium tripolyphosphate (Brifisol®85 Instant; BK Giulini Corporation, Simi Valley, CA), 3.6% sodium chloride, 93.4% water, and 1% Herbalox seasoning type HT-S (Kalsec, Kalamazoo, Mich., U.S.A.).

Slicing of Strip Loins into Steaks. After injection, strip loins were allowed to rest for 30 min at 4ºC. The weight of the strip loins was recorded prior to slicing them into 2.54 cm steaks using a standard 13 in manual slicer (Model 3600P, Globe Food Equipment Co., Ohio, U.S.A.). Steaks were then weighed individually and placed into 5.08 cm deep prepadded trays (Cryovac CS978 Duncan,SC). Trays were then filled with a 75.9% O_2/15.2% CO_2 /8.9% N modified atmosphere and sealed with an oxygen barrier film (G. Mondini CV/VG-S Brescia, Italy). Packaged steaks were placed into dark storage at 4ºC for 4 d in order to simulate transportation to retail stores. After 4 d in dark storage, steaks were placed into a retail display case at 4ºC under 40 watt Rapid Start T12 Fluorescent Platinum lights (Promolux, B.C., Canada; 1600 to 1900 lux) for the remainder of the study, 14 d.

Steak Sampling (Day 5 to 19). Once steaks were placed in retail display, one steak from each strip loin of both the control and AHP (n = 20 total steaks) were color scored each day in the morning (a.m) and evening (p.m) until d 19, a.m. Three steaks from each loin (n = 30 total steaks/ treatment) were randomly selected from both the control and AHP on d 5 (d 0 retail display), 12, and 19. On each of the days, one of the three steaks collected from each loin was used to measure purge, HunterLab color, cook loss, and shear force; the second steak was used to measure purge HunterLab color, cook loss, and sensory analysis (on d 5 and 12 only); the third steak was used for aerobic plate count (APC), anaerobic plate count, proximate analysis, and 2-thiobarbituric acid reactive substances (TBARs) analysis, as an indicator of rancidity.

Subjective Color Score. Steaks in the retail case were color scored (d 5 to 19) by a trained panel (n = 6) according to the Guidelines for Meat Color Evaluation (AMSA, 1991).

Purge Analysis. Purge was reported as % purge and was calculated by the following formula:

$$\% \text{ purge} = \frac{(\text{steak weight prior to package}) - (\text{steak weight after storage})}{(\text{steak weight prior to package})} \times 100$$

Objective Color Score. Objective evaluation of color was measured using a MiniScan™ XE Plus (HunterLab, Reston, VA).

Cook Loss. Steaks were cooked to an internal temperature of 70ºC (medium degree of doneness; measured with a Atkins AccuTuff™ 340 Type K thermocouple temperature probe) using an impingement oven (Lincoln Model 1022, Lincoln Food Service Product Ind., Fort Wayne, Ind., U.S.A.). Cook loss was calculated by the following formula:

$$\text{Cook loss} = \frac{(\text{steak weight prior to cook}) - (\text{steak weight after cook})}{(\text{steak weight prior to cook})} \times 100$$

Shear Force. Steaks selected for shear force were cooked as explained in the cook loss section (n = 10 per treatment per day). After cooking, steaks were allowed to cool to room temperature (21ºC) and then shear force was measured according to the Research Guidelines for Cookery, Sensory Evaluation, and Instrumental Tenderness Measurements of Fresh Meat (AMSA, 1995).

Sensory Panel. Research Guidelines for Cookery, Sensory Evaluation, and Instrumental Tenderness Measurements of Fresh Meat (AMSA, 1995) methodology was used to conduct sensory evaluation.

Microbial Analysis. Samples for microbial analysis were first used to take a sample for aerobic and anaerobic plate counts (n = 10 per treatment per day). Analysis was conducted following the pour plate method (Morton 2001) with Plate Count Agar (BD Difco™, Sparks, MD, U.S.A.) and 2,3,5-Triphenyl tetrazolium chloride (TTC) (BioChemika, Sigma-Aldrich, St. Louis, MO, U.S.A). Aerobic plates were incubated at 35°C for 48 h. Anaerobic plates were placed in an anaerobic jar containing GasPak Plus with Palladium Catalyst (BD BBL™, Sparks, MD, U.S.A.) and were incubated for 48 h at 35°C.

Lipid Oxidation. Steak samples were stored at 4°C the evening prior to analysis to allow them to thaw slightly. The next morning, a 10 g sample was taken from the surface of the steak (approximately 2 mm deep, from entire surface of steak) and analyzed according to a modified method based on Buege and Aust (1978).

Proximate Analysis. Immediately after a sample had been collected for lipid oxidation analysis, each steak was frozen using liquid nitrogen and powdered in a frozen Waring blender in a 0°C fabrication room. Powdered samples were then used for moisture, crude fat, ash, and protein analysis (AOAC 950, 960.39, 920.153, and 928.08, respectively; AOAC, 2003).

Statistical Analysis. Data were analyzed using SAS version 9.1 (SAS Inst. Inc., Cary, N.C., U.S.A.). The two treatment levels were evaluated in a RCBD with animal as the random block. Repeated measures covariance structures were modeled using either SAS/MIXED or SAS/GLIMMIX procedures. Appropriate pair-wise comparisons of least squares means were performed for the treatment, time or treatment/time combinations using unadjusted t-tests. All tests were done at the 0.05 level of significance.

RESULTS

Enhancement. The actual mean percent pump value for the subprimals enhanced with the control brine was 11.16% (SD = 0.14) and 11.24% (SD = 0.12) for the AHP.

Sample pH. The mean pH for the subprimals prior to injection was 5.52 (SD = 0.04). The pH prior to injection was 7.48 for the control brine and 10.73 for the AHP brine. There were no significant differences between the AHP pH of 6.13 ± 0.01 or the control pH of 6.12 ± 0.01 for the steaks after enhancement on d 5, 12, and 19.

Purge Analysis. There was no significant difference between the percent purge mean of the AHP (1.43 ± 0.09 g) or the control steaks (1.27 ± 0.09 g). There was a significant day effect with the steaks having an increase in percent purge each day.

Cook Loss. The mean cook loss for each day decreased, except for d 19 when the AHP steaks (21.88 ± 0.62) had significantly more cook loss than the control (19.0 ± 0.62).

Proximate Analysis. AHP steaks had a higher percent moisture (75.42 ± 0.41) than the control steaks (74.44 ± 0.41). No significant effects were seen in the percent fat measures. The percent fat mean and standard errors for control and AHP steaks were 4.86% ± 0.43% and 4.23% ± 0.43% respectively. There was only a significant treatment effect with respect to ash content, with the control steaks (1.81% ± 0.04%) having a higher ash percentage than the AHP steaks (1.51% ± 0.04%). There was not a significant difference in percent protein between control (20.83 ± 0.19) or AHP steaks (20.64 ± 0.19). However, there was a day effect with d 5 (20.5 ± 0.22) being significantly lower than d 19 (21.08 ± 0.22 %).

Sensory Panel. There were no differences found in any of the taste panel quality attributes (initial/sustained juiciness, tenderness 1st impression, tenderness overall impression, and connective tissue). All steaks scored between slightly juicy/tender and moderately juicy/tender

for juiciness and tenderness and had traces to practically no connective tissue. No significant treatment effects were found in any of the flavors, with the exception of pepper flavor, where the AHP steaks (1.27 ± 0.27) were perceived as having a stronger pepper flavor than control steaks (1.20 ± 0.20).

Microbial Analysis. Control steaks had lower microbial counts (4.55 ± 0.13 $\log_{10}$ cfu/g) than AHP steaks (5.70 ± 0.13 $\log_{10}$ cfu/g), and microbial counts increased over time. Control steaks had lower microbial counts (4.02 ± 0.17 $\log_{10}$ cfu/g) than AHP steaks (5.45 ± 0.17 $\log_{10}$ cfu/g). The means for d 5, 12, and 19 were 2.20 ± 0.17 $\log_{10}$ cfu/g, 5.05 ± 0.16 $\log_{10}$ cfu/g, and 6.96 ± . 16 $\log_{10}$ cfu/g, respectively. Anaerobic plate counts increased over time.

Shear Force. There were no significant differences for shear force between days or treatments.

Lipid Oxidation. There was not a significant difference between the control or AHP steaks (0.71 ± 0.15 mg MDA/kg vs 0.75 ± 0.15 mg MDA/kg, respectively). There was a day effect with d 12 (0.81 ± 0.15 mg MDA/kg) and 19 (0.84 ± 0.15 mg MDA/kg) being significantly higher than d 5 (0.54 ± 0.15).

Objective Color Score. There was a significant treatment effect in L* values (lightness). Control mean scores (41.42 ± 0.71) were lower than the mean scores of AHP steaks (42.00 ± 0.71), and therefore control steaks appeared darker. The a* values (redness) had significant treatment and day effects. The control steaks (20.69 ± 0.52) appeared more red than the AHP steaks (18.93 ± 0.52), and a* values decreased (appeared less red and more green) each week. There was a significant treatment*day interaction for b* values. The b* values decreased each week (steaks appeared less yellow and more blue) with a significant difference between control (18.84 ± 0.25) and AHP steaks (19.4 ± 0.25) occurring only on d 5.

Subjective Color Score. Muscle color of steaks decreased significantly throughout the 14 d of retail display. Steaks' initial color score at d 0 a.m were scored between moderately bright cherry-red and slightly cherry-red. By the end of retail display, steaks scored between moderately dark red or brown and dark red or brown. Beginning at d 8 p.m. control steaks scored higher than AHP steaks until the end of retail display. All steaks began with no surface discoloration present, and finished on d 14 having 41to 60% surface discoloration and 61 to 80% surface discoloration. Control had less surface discoloration than AHP steaks starting at d 6 a.m. until the end of retail display. Steak fat color scores stayed between white and creamy white. For overall appearance, color scores of steaks decreased significantly over 14 d of retail display. Steak scores began between extremely desirable and desirable then by d 14 steak scores decreased to scores of slightly to extremely undesirable.

DISCUSSION

Control and AHP steaks performed comparably in Warner Bratzler Shear force, lipid oxidation, percent purge, percent cookloss (except on d 19; AHP > control) and in the sensory taste panel attributes. The control steaks, however, had lower microbial counts than the AHP in both the aerobic and anaerobic plate counts and by d 7 retail display had a more desirable color

appearance than AHP steaks. However, performance of AHP steaks may be offset by gains achieved in sodium reduction, about 38% and greater than 75% reduction in phosphates.

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