Evaluating a beef enhancement brine using 1% ammonium hydroxide as a replacement for sodium tripolyphosphate

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STORY IN BRIEF

Phosphates are a significant source of sodium in meat enhancements. Alternative ingredients that can serve as replacements are desirable. The objective of this research was to evaluate the effect of replacing sodium tripolyphosphate in meat enhancement solutions with a non-sodium based alkylating agent, ammonium hydroxide. Ten paired U.S. Select striploins (n = 20), were randomly chosen to be injected with either the control brine containing 4.5% sodium tripolyphosphate, 3.6% NaCl, and 1% Herbalox seasoning HT-S type or the AHT brine containing 1% ammonium hydroxide solution, 3.6% NaCl, and 1% Herbalox seasoning HT-S type. Steaks were MAP packaged, and stored at 4°C in dark storage for 4 d, then in a retail case under low UV, color-balanced lights for the remainder of the study. Steaks were selected randomly on d 0, 7, and 14 retail display to measure purge, cook yield, pH, L*a*b* color, shear force, aerobic plate counts, anaerobic plate counts, composition (moisture, fat, ash, and protein), TBARs, taste panel sensory evaluation, and visual color evaluation. There were no differences found between treatments in Warner Bratzler Shear Force or any of the taste panel quality attributes. Lipid oxidation (TBARs assay) was not found to differ between treatments except on d 19, where control steaks had more lipid oxidation present. Maximum purge measurements of AHT steaks were around 2.5%, however, purge was significantly lower (1-1.5%) for control steaks. Cookloss was also lower (21%) for control than AHT steaks (23%). Both aerobic and anaerobic plate counts were higher for the AHT steaks. Overall, AHT steaks did perform comparably with control steaks. However, performance of AHT steaks may be offset by gains achieved in sodium reduction, about 50% and AHT steaks had better color stability than control steaks. Ammonium hydroxide looks like a promising replacement for phosphates in meat enhancement solutions.

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

INTRODUCTION

As emphasized by many scientists, tenderness is considered the most important qualitative characteristic of meat (Destefanis et al., 2008). Unfortunately, tenderness is also a highly variable characteristic, depending on many intrinsic and extrinsic factors of the animal and on their interaction (Destefanis et al., 2008). This wide variability is a limiting factor for consumer product acceptability, besides being a reason for consumer dissatisfaction and reduction in beef consumption (Destefanis et al., 2008). The beef industry has made it a priority to address inconsistency in beef tenderness (Wheeler et al., 2004). The industry utilizes several different enhancement technologies to improve tenderness: postmortem aging, electrical stimulation, mechanical tenderization, and injection enhancement. Injection enhancement has been used extensively in pork processing for years and is becoming more common in beef processing with the advent of modified-atmosphere packaging (MAP) and case-ready merchandising (Knock et al., 2006). A variety of ingredients are used in injection-enhancement solutions including a type

of lactate, salt, phosphates, natural flavorings, and water (Miller, 1998). However, for a small segment of the public, products with added phosphates (e.g. those suffering from CKD or chronic kidney disease) are considered a health detriment (Kestenbaum et al., 2005). In addition, recent data from the U.S. Centers for Disease Control and Prevention (CDC) provides additional evidence that the majority of Americans over the age of 20 should limit the amount of sodium (salt) they consume daily to 1,500 mg to prevent and reduce high blood pressure (CDC, 2009). The CDC also shows that 69 % of adults are salt sensitive, so the need to reduce sodium has become an even higher priority in the U.S. (CDC, 2009). It is in the best interest in the meat industry to try and meet the needs of all consumers by providing products with minimal negative health impacts. This project attempts to address these concerns by looking at an alternative means to improve tenderness, juiciness, palatability and shelf-life in meat while minimizing additives that may have negative health implications for some consumers.

The objective of this study was to compare water holding capacity, tenderness attributes, sensory attributes, microbial growth, shelf-life, and proximate analysis of beef subprimal strip loins injected with an ammonium-based enhancement containing no phosphates to a commercially based phosphate enhancement solution. By removing phosphates entirely from the injection brine and replacing them with ammonium hydroxide, we see a reduction in the amount of sodium present and also elimination of phosphates that have been shown as a health detriment to some consumers.

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 4ºC.

Sample Enhancement. Strip loins were trimmed and 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 (AHT). Strip loins were injected with solution at 4ºC 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. 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 AHT brine was prepared using 1% food grade ammonium hydroxide, 3.6% sodium chloride, 94.4% 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 4 ºC. 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 79.15% O_2/15.28% CO_2/5.57% 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 AHT (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 AHT 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 oxidative 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 11.22% (SD = 0.17) and 11.15% (SD = 0.19) for the AHT.

Sample pH. The mean pH of striploins prior to injection was 5.67 (SD = 0.05). The pH of the brine solutions prior to injection was 7.18 for the control and 10.81 for the AHT brine. Control steaks (5.86 ± 0.01) had a significantly lower pH than AHT steaks (5.98 ± 0.01) for each day.

Purge Analysis. Control steaks (1.31% ± 0.16%) had a lower percent purge than AHT steaks (2.07% ± 0.16%). There was a significant day effect with the steaks having an increase in percent purge each day.

Cook Loss. Control steaks (21.34% ± 0.40%) had a significantly lower percent cook loss than AHT steaks (23.27% ± 0.40%). D 5 (22.20% ± 0.39%) and 19 (21.49% ± 0.39%) had lower cook loss than d 12 (23.22% ± 0.39%).

Proximate Analysis. Control steaks had a higher percent moisture than the AHT steaks on d 5 and 12; on d 19, AHT steaks had a higher percent moisture (75.06% ± 0.67) than control steaks (73.92 ± 0.67). On d 5, control steaks (3.25% ± 0.57) had significantly less percent fat than AHT steaks (5.02 ± 0.57). However, on d 12 and 19 no treatment effect was evident. Control steaks (1.75 ± 0.05) had a higher ash percentage than the AHT steaks (1.28 ± 0.05). Control steaks (20.81 ± 0.22) had a higher percent protein than AHT steaks (21.52 ± 0.22).

Sensory Panel. There were no differences found in any of the taste panel quality attributes (initial/sustained juiciness, tenderness first impression, tenderness overall impression, and connective tissue). All steaks scored between slightly to moderately juicy, slightly to moderately tender, and had between traces to practically no connective tissue.
Panelists were also to evaluate taste/flavors, cooked beef flavor, salty flavor, soapy flavor, pepper flavor, and ammonia intensity. No significant treatment effects were found in the soapy flavor or ammonia intensity flavor. Control steaks had a stronger pepper (1.39 ± 0.12) and salty flavor (1.43 ± 0.15) than AHT steaks (1.19 ± 0.06 and 1.28 ± 0.10 respectively).

Microbial Analysis. In the aerobic plate count, control (2.46 ± 0.21 $\log_{10}$ cfu/g) and AHT steaks (2.2 ± 0.21 $\log_{10}$ cfu/g) were not significantly different on d 5. Microbial counts increased significantly each week, and these counts on AHT steaks increased more rapidly than on control steaks. In the anaerobic plate count, control and AHT steaks were not significantly different on d 5 and 12, but on d 19 the AHT steaks (6.61 ± 0.24 $\log_{10}$ cfu/g) had significantly higher microbial counts than the control steaks (4.23 ± 0.24 $\log_{10}$ cfu/g).

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

Lipid Oxidation. The control was not significantly different than the AHT steaks on d 5 and 12, but on d 19 the control steaks (2.94 ± 0.16 mg MDA/kg) showed higher lipid oxidation than the AHT steaks (1.78 ± 0.16).

Objective Color Score. There was a significant treatment*day interaction for L^* values. Steaks appeared darkest on d 5 and then became lighter on d 12 and d 19. The a^* values showed significant treatment*day effects. Control steaks (25.03 ± 0.23) appeared redder than AHT steaks (24.33 ± 0.23), on d 5 only. The b^* values also showed significant treatment*day interaction. AHT steaks (17.43 ± 0.22) had a more yellow appearance than control steaks (15.61 ± 0.22).

Subjective Color Score. Muscle color of steaks started at d 0 retail display with a slightly cherry-red to a red color and ended with a moderately dark red or brown, to a dark red or brown at the end of retail display. AHT steaks scored higher than control steaks beginning at d 6 p.m until the end of retail display. Steaks saw a significant increase in percent discoloration over 14 d of retail display. AHT steaks had significantly less discoloration than control steaks beginning at d 6 p.m. until the end of retail display. Steak fat color scores started between white and creamy white and finished at scores between creamy white and slightly yellow. No sustained treatment effects were evident in the study. For overall appearance, AHT steaks scored more desirably than control steaks.

DISCUSSION

Between the control and the AHT treated steaks there were no significant differences in Warner Bratzler Shear force or any of the sensory taste panel attributes: initial juiciness, sustained juiciness, initial tenderness, connective tissue, and overall tenderness. The control steaks had lower microbial counts than the AHT in both the aerobic and anaerobic plate counts. Control steaks also had slightly lower percent purge and cook loss than the AHT treated steaks. There

were no differences found between treatments in lipid oxidation, except for d 19 of the AHT trial, in which control steaks had a significantly larger TBARs value than AHT steaks. Differences between AHT and control steaks were comparable, except after d 6 significant differences in color started to emerge with the AHT performing better. Overall, AHT steaks did perform comparably with control steaks. In addition to performance of AHT steaks, there is also about a 50% reduction in the total sodium content. The study demonstrates that the phosphate level used in meat enhancements can be completely substituted with the aid of ammonium hydroxide as an alkaline processing aide.

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