

Project Summary

Effect of Ammonium Hydroxide and Carbon Monoxide on Palatability and Color of Beef Chuck and Round Muscles

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Background

Tenderness is one of the major factors affecting consumer acceptability of beef steaks. Due to the large tenderness inconsistencies between carcasses, muscles, and locations within a muscle, enhancement procedures have been developed to create a more consistent product. A new enhancement procedure adjusts the pH in beef by injecting a solution comprised of water, salt, ammonium hydroxide, and carbon monoxide (patent pending technology).

The objectives of this project were to:

1. Evaluate levels of pump for muscles from the beef chuck and round.
2. Evaluate the interaction of aging and pH-adjustment.
3. Determine the sensory and tenderness differences between controls and treated beef.
4. Explore the shelf stability of the product treated with ammonium hydroxide and carbon monoxide.

Methodology

Phase I

This study examined 4 pump levels (0%, 15%, 22.5%, and 30%) on 3 muscles from the beef chuck and round (*triceps brachii*, *biceps femoris*, *rectus femoris*). Beef clod hearts, sirloin caps, and knuckles (n = 60 each) were randomly assigned to each treatment and one of three replications. Subprimals were injected with a solution containing water, salt, ammonium hydroxide and carbon monoxide (patent pending technology). Three steaks were cut from each subprimal to a thickness of 2.54 cm, trimmed of excess fat and muscles, vacuum packaged in trays and frozen. These steaks were used for determination of Warner-Bratzler shear force, pH and trained taste panel ratings. Thaw-loss, cook-loss and cook time were also recorded when steaks were cooked for shear force and trained taste panels. A trained taste panel evaluated steaks for tenderness, connective tissue, juiciness and off-flavor on 8-point scales.

Phase II

This study examined the effects of aging on enhanced and non-enhanced (control) beef chuck and round muscles (*triceps brachii*, *biceps femoris*, *rectus femoris*). Beef subprimals (clod hearts, sirloin caps, and knuckles; n = 72 each) were randomly assigned to each treatment (enhanced or control), aging period (1, 7 14 d), and one of three replications. Enhanced subprimals were injected with a solution containing water, salt, ammonium hydroxide and carbon monoxide (patent pending technology) to a 20% target pump level. Three steaks were cut from each subprimal to a thickness of 2.54 cm, trimmed of excess fat and muscles and packaged in a modified atmosphere package (80% oxygen, 20% carbon monoxide). At the end of each aging period, steaks were removed from the modified atmosphere package, vacuum packaged and frozen. Steaks were then used for determination of Warner-Bratzler shear force and consumer taste panel ratings. Thaw-loss, cook-loss and cook time were also recorded when steaks were cooked to 70°C for Warner-Bratzler shear force and consumer taste panels. Consumer taste panels evaluated steaks for desirability of tenderness, connective tissue, juiciness, flavor and overall acceptability on an 8-point scale.

Phase III

This study examined the shelf stability of enhanced and non-enhanced (control) beef chuck and round muscles (*triceps brachii*, *biceps femoris*, *rectus femoris*). Beef subprimals (clod hearts, sirloin caps, and knuckles; n = 72 each) were randomly assigned to each treatment (enhanced or control), dark storage period (1, 2 or 3 weeks) and one of three replications. Enhanced subprimals were injected with a solution containing water, salt, ammonium hydroxide and carbon monoxide (patent pending technology) to a 20% target pump level. Three steaks from the clod hearts were cut from each subprimal to a thickness of 2.54 cm, trimmed of excess fat and muscles and packaged in a modified atmosphere package (80% oxygen, 20% carbon monoxide). Three steaks from the sirloin caps and knuckles were cut from each subprimal to a thickness of 2.54 cm, trimmed of excess fat and muscles and packaged in a modified atmosphere package (100% carbon dioxide). At the end of each dark storage period, steaks were placed in simulated retail display conditions for 7 days. Objective and subjective color measurements were obtained during the retail display period, as was retail purge. In addition, thiobarbituric acid (TBA) values were determined following the retail display conditions. Retail purge and was determined from steaks 1 (day 0 retail display), steaks 2 (day 4 retail display) and steaks 3 (day 7 retail display). TBA values were determine from steaks 1 (day 0 retail display) and steaks 3 (day 7 retail display).

Findings

Phase I

For all muscles, shear force decreased as the target pump level increased. Also, steaks pumped to 30% had the lowest shear force. As percentage pump increased, pH increased. Steaks pumped to 30% had the highest pH and there were no significant pH differences between the 15% and 22.5% pump levels. Ultimate pH was strongly related to shear force. Trained taste panel ratings revealed an increase in tenderness, decrease in connective tissue and an increase in juiciness as pump level increased for all muscles. In all cases but one (juiciness of the *rectus femoris*), the control had the least desirable ratings and shear force values. Muscles pumped to 30% tended to have an uncharacteristic soft and mushy texture. For this reason, a 20% target pump level was determined to be the optimum pump level since there were no major differences between the 15% and 22.5% pump levels.

Phase II

For every muscle, enhanced steaks were always more desirable than control steaks in terms of tenderness, juiciness, off-flavor and overall acceptability. These data indicate aging does not decrease the benefits (tenderness, juiciness and flavor) of enhancement. At day 1 of age, enhanced steaks were rated 1.31, 1.63 and 1.67 points higher than control for the *triceps brachii*, *biceps femoris* and *rectus femoris*, respectively. At day 7 of age, enhanced steaks were rated 0.91, 1.28 and 1.28 points higher than control steaks for the respective muscles listed above. After 14 days of aging, enhanced steaks were rated 1.30, 1.93 and 1.40 points higher than control steaks for the respective muscles listed above. For all muscles, enhanced steaks had lower shear force values than the controls at every aging period.

After aging for 1 day, shear forces from control steaks were 0.97, 1.03 and 1.38 kg higher than enhanced steaks for the *triceps brachii*, *biceps femoris* and *rectus femoris*, respectively. At day 7 of aging, shear forces for control steaks were 0.56, 1.05 and 1.41 kg higher than enhanced steaks (*triceps brachii*, *biceps femoris* and *rectus femoris*, respectively). After 14 days of aging, shear forces values for control steaks were 0.75, 0.82 and 0.75 kg higher than enhanced steaks for the respective muscles listed above.

Phase III

TBA values were higher for control *triceps brachii* steaks than enhanced steaks at both 0 and 7 days of retail display. Also, TBA values increased as dark storage time increased and as retail display time increased. *Biceps femoris* steaks had higher TBA values in the controls than the enhanced. TBA values also increased as retail display time increased. TBA values for control *rectus femoris* steaks were always higher than enhanced steaks at every dark storage time and at both 0 and 7 days of retail display. In addition, values were higher at day 7 of retail display than at day 0 for every dark storage period.

Retail purge for *triceps brachii* steaks tended to increase as dark storage time increased and as retail display time increased. Also, enhanced steaks had more purge than controls. Retail purge for *biceps femoris* steaks was lower for the enhanced steaks only at day 0 of retail display, but was higher at days 4 and 7. As dark storage time increased, purge also increased. At every retail display time and at every dark storage period, control *rectus femoris* steaks had less purge than enhanced steaks.

L* values changed for both enhanced and control *triceps brachii* steaks as retail display time increased. For all treatments, values decreased from day 0 to day 3 of retail display and then tended to increase again. Control steaks with 3 weeks of dark storage prior to retail display had higher L* values throughout. A* values decreased for all treatments as retail display time increased. Enhanced steaks that had 2 weeks of dark storage prior to retail display had higher a* values throughout. Discoloration of *triceps brachii* steaks increased as retail display time increased. Steaks with only 1 week of dark storage prior to retail display took a longer time to discolor than those steaks that were stored longer. Control steaks always had higher discoloration scores than the enhanced steaks for each dark storage period. This suggests enhanced steaks had better color stability.

L* values for *biceps femoris* steaks increased as retail display time increased. Control steaks had lower values than enhanced steaks until day 5 when values were similar. Values increased for all 3 dark storage periods as retail display time increased. A* values decreased for all treatments as retail display time increased. Control steaks had more discoloration than enhanced steaks. For all treatments, day 0 of retail display had less discoloration than the other days. Discoloration was minimal for all steaks.

L* values for *rectus femoris* steaks were variable for each dark storage period. Week 1 steaks were the most variable from day 1 to day 6 of retail display. Day 7 values were similar to those values recorded on day 0. Week 2 steaks decreased from day 0 to day 1 and then increased slightly up to day 7. Week 3 steaks increase slightly over time. A* values decreased slightly for all steaks from day 0 to day 6 and then increased on day 7. Enhanced steaks always had higher a* values than the control for every dark storage period. Week 1 controls had the lowest a* values throughout. Discoloration scores were not able to be tabulated due to the fact that during one of the trials one of the retail display cases broke down.

Implications

Steaks enhanced with a water, salt, ammonium hydroxide and carbon monoxide solution (patent pending technology) were more tender, juicier and had less connective tissue and off-flavors than non-enhanced steaks. Shear force decreased as pump levels increased. Since muscles pumped to 30% tended to have an uncharacteristic soft and mushy texture, 20% was determined to be the optimum pump level for the *triceps brachii*, *biceps femoris* and *rectus femoris*. A consumer taste panel

found enhanced steaks to be more desirable than non-enhanced steaks at all aging periods (1, 7, 14 d). However, shear force tended to increase with an increase in aging. In simulated retail display conditions, enhanced steaks had lower TBA values and better color stability, but more retail purge. Data suggests enhancement with this technology has potential. Enhanced steaks were more tender, more desirable and had better color stability than non-enhanced steaks.

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