Project Summary

Survey of and Strategies for Variation in Functional Properties of Chuck and Round Muscles from Fed and Cow Beef

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Background

Ultimate pH and overall maturity in beef are known to affect palatability and overall appearance of end products. Postmortem glycolysis and muscle pH decline during normal chilling but low levels of glycogen at the time of harvest (a result of stress) can cause natural postmortem glycolysis to cease leaving pH levels too high. This results in darker-than-normal colored lean that is considered unfavorable by consumers.

The objectives of this project were to:

1. Survey the variability in color and pH of muscles from fed and cow beef.
2. Propose strategies for optimal muscle utilization for further processing of pH-challenged cuts based on individual small-scale studies.

Methodology

Phase I

Beef carcasses (n=2,324) were evaluated from two fed beef packing plants and two cow beef packing plants three times in one year. Muscle pH and muscle color was determined post-harvest along with yield grade and quality grade.

Phase II

Four beef subprimals were obtained from four types of beef: normal (pH 5.3 to 5.7) fed beef carcasses (n=6); dark cutting (pH>6.0) fed beef carcasses (n=6); normal (pH 5.3 to 5.7) cow carcasses (n=6); and dark cutting (pH>6.0) cow carcasses (n=6). These subprimals taken from both sides of each carcass were beef inside rounds (IMPS#138), striploins (IMPS#180), outside rounds (IMPS#171B) and chucks.

<u>Striploins</u>

Preliminary studies were conducted to determine non-meat, food grade ingredients to be used to lower the pH and lighten color of high pH beef. It was determined that acetic acid was the most effective food grade ingredient to lower beef muscle pH. Three treatment solutions (0.5% acetic acid; 0.25% Keltol© + 0.5% acetic acid; and 0.125% Konjac flour + 0.5% acetic acid) were prepared within 48 hours of each processing day (n=3).

Striploins were trimmed and cut into 2 equal sections perpendicular to the length of the Longissimus muscle, resulting in 4 equal sections from each carcass. Each section was randomly assigned to one of the three treatments mentioned above and initial pH and color spare values were determined prior to injection.

Treatment solutions were injected at a 12% pump level and striploins were allowed to equilibrate before being cut into 3 equal sections. These sections were randomly assigned to 0, 14, or 28 days of storage. Within each storage day, 3- 1 inch thick strip loin steaks were cut and randomly assigned for trained sensory panel evaluation, chemical determination or Warner-Bratzler shear (WBS) force analysis for tenderness determination.

Bottom Rounds

Beef bottom rounds were trimmed and cut into 2 equal section perpendicular to the length of the *biceps femoris* muscle, resulting in 4 equal sections from each carcass. Each section was randomly assigned to one of the three treatments described above and initial pH and color measurements were taken.

Treatment solutions were injected into each bottom round section at a 12% pump level and sections were allowed to equilibrate before they were vacuum packaged in cook-in bags and placed in a smokehouse for cooking. Then, roasts were removed from bags and cook yield was determined before roasts were cut into 3 equal sections and randomly assigned to 0, 14 or 28days of storage.

On each storage day, roasts were removed from packaging and a 5 mm slice was removed for chemical analysis before color and pH was measured on the cut roast surface. On each storage day, two separate, 5-member trained descriptive attribute sensory panels evaluated each sample. Remaining roasts were utilized for WBS analysis.

Chuck Ground Beef Patties

Ground beef patties were prepared from chucks derived from all four types of carcasses. The ground chuck was divided into 4 equal parts and randomly assigned to one of the treatments described above plus a control. Standard foodservice patties were made from each treatment and cooked and held for 4 hours on an aluminum tray. Patties were evaluated for external pink color and color space values every 30 minutes of hold time and internal pink color and color space values every 2 hours of hold time. Cooking yield and myoglobin concentration was also determined.

Inside Round Beef Jerky

Inside round were obtained from each of the 4 carcass categories and trimmed before initial pH evaluation. Inside rounds were frozen for two weeks and then sliced frozen to generate 0.25 cm thick slices. Slices were placed in a vacuum bag and a commercial jerky brine solution was added at 15% of raw weight. Bagged jerky treatments were tumbled and thermally processed in a smokehouse. After removal from the smokehouse, slices were analyzed for cooked color, water activity, pH, cooked moisture and protein content, moisture:protein ratio and cook yields.

Findings

Phase I

Overall muscle pH averaged 5.6 throughout all carcasses surveyed but the range was 2.5 to 7.4. Overall marbling averaged Slight, but the range extended from practically devoid to moderately abundant. For fed carcasses, muscle pH averaged 5.5 and ranged from 2.5 to 6.6. Average L* (lightness), a*(redness) and b* (yellowness) values were 39.64, 27.95 and 12.84, respectively while lean maturity score mean was equivalent to "A" maturity. For cow carcasses, mean muscle pH averaged 5.8 and ranged from 2.9 to 7.4. Cow carcasses had a slightly higher mean pH than fed carcasses. Mean cow carcass lean maturity scores were equivalent to "B" maturity.

In terms of pH, the majority of all carcasses evaluated fell within a range of 5.6 to 5.9 while 6% of the whole population had a pH of 6.0. Ninety-four percent of fed carcasses fell within a pH range of 5.3 to 5.9 while 1% had pH values of 6.0 or higher. Sixty-two percent of cow carcasses fell within 5.6 to 5.9 while 38% of pH values were 6.0 or higher.

Phase II

<u>Striploins</u>

High pH cow striploins were darker in color and had higher pH than loins from normal pH cow carcasses and normal pH fed carcasses. High pH cow loins had higher yellow and red color space values than high pH fed loins. Normal pH cow loins were darker initially but caught up during storage. Additionally, normal pH fed loins were more yellow and red than normal pH cow loins.

High pH striploins had higher cook yields than normal pH loins. Steaks from cow carcasses, regardless of pH level, were tougher and had more sensory connective tissue than steaks from young, fed beef carcasses but were not appreciably tough. Steaks from striploins that had normal pH tended to be higher in cooked beef lean flavor and sour basic tastes while lower in cooked beef fat, livery and cowy flavor aromatics and steaks from normal pH fed carcass had higher salty basic taste.

The addition of acetic acid decreased pH and increased initial yellow and red color of steaks; however, with storage, the addition of non-meat ingredients resulted in lighter and slightly more yellow and red steaks. The addition of non-meat ingredients also increased drip loss and cook yield, resulted in lighter cooked color and increased overall flavor intensity.

As storage time increased, steaks were more tender. Steaks were juicier after 0 and 14 days of storage than steaks stored for 28 days. Steaks stored for 28 days had higher cooked beef fat, sour, bitter, metallic and acid flavor attributes than steaks stored for 0 days.

<u>Bottom Rounds</u>

High pH cow bottom rounds had the highest pH. Raw and cooked bottom rounds from the older animals were darker and tougher than raw and cooked bottom rounds from young animals. Interestingly, high pH cow bottom rounds were less red and yellow in raw color than bottom rounds from other carcass types. Cooked bottom round roasts from younger animals had less connective tissue and were more tender than cooked bottom round roasts from older animals.

Addition of non-meat ingredients to beef bottom rounds decreased cooked meat pH during storage with the greatest effect reported in bottom rounds containing acetic acid. All treated bottom round roasts were less red than control bottom round roasts. In general, bottom round roasts containing Konjac flour + acetic acid had the most desirable color. The addition of non-meat ingredients, while not affecting sensory, had positive effects on pH and color of cooked bottom round roasts.

With increased storage, cooked beef bottom round roasts changed in descriptive sensory flavor attributes associated with increased lipid oxidation and increased storage. However, the addition of non-meat ingredients and animal type did not impact these attributes.

<u>Chuck Ground Beef Patties</u>

High pH cow meat resulted in ground beef patties that were the most yellow, most red, had the least denaturation of myoglobin and the lowest external lightness and were the most pink. Normal pH fed beef had the lowest pH, the lightest internal appearance, lowest redness and yellowness, highest degree of doneness and highest myoglobin denaturation. The use of non-meat ingredients was induced to minimize the differences due to animal type.

Non-meat ingredients added to patties reduced pH. The addition of acetic acid resulted in low cook yields, however, combining acetic acid with Keltol© improved cook yields. Externally, the addition of non-meat ingredients increased the lightness, yellowness, redness and chroma compared with the control. Redness and yellowness values increased with the addition of treatments in all animal types except the normal pH fed type. The addition of Keltol© + acetic acid to patties increased cook yields but did not help with internal color. Acetic acid and acetic acid + Konjac flour treatments helped decrease yellowness and redness and increase degree of doneness and myoglobin denaturation; however, these treatments did not improve external color.

Patties held in a dry environment had lower cook yields, were less yellow and red, had less total color pigment and appeared to have a higher degree of internal doneness. This environment also produced patties that and darker and more yellow exteriors with lower external visual pink color. This effect varied due to animal type. Patties made from normal pH cow and fed beef and held in a dry environment resulted in lower internal redness and yellowness values and higher degree of doneness scores than those in moist environments. Dry cooking, regardless of holding method, had reduced external pink color; however, this effect was more pronounced when its holding method was wet.

With increased holding time, patty cook yield decreased and the patties tended to get darker externally, be less yellow and red, have less overall pigment, be les yellow and red, and have more myoglobin denaturation. At time 0, color values were similar, but in the dry holding environment, there was a greater decrease in external lightness and redness as well as overall pigment.

<u>Inside Round Beef Jerky</u>
Inside rounds varied in weight, thickness and overall dimensions between fed and cow carcass classes. Jerky manufactured from fed inside rounds exhibited a greater yield (approximately 3.5%) compared to jerky manufactured from cow inside rounds. High pH jerky retained more water during thermal processing resulting in a decrease in percent water and a higher moisture:protein ratio. The ability of muscle proteins to retain more water during drying because of a higher pH also resulted in a 23% higher water activity value for high pH versus normal pH jerky.

The most pronounced differences among jerky from both pH types were pH values, percent moisture, percent protein, moisture:protein ration, and water activity. Color values also varied greatly among jerky slices from each carcass class and pH type. pH variability among raw materials contributed to the wide range of values observed from each specific analysis conducted.

Implications
Large variation existed between fed beef and cow carcasses, as well as within cow carcasses and between individual cow plants. The use of buffer treatments tended to decrease some of the negative effects of this variation without impacting shelf-life in the beef striploins and bottom rounds evaluated. In ground beef, acetic acid and Konjac flour + acetic acid treatments resulted in reduced redness internally and holding method and time both improved color. Results indicate that the implementation of pH in a quality control program may be useful to sort raw materials into normal and high pH types for more effective utilization in further processing.

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