Project Summary

Can Beef Lean Color Originating from Dark-Cutting Carcasses be Improved by "Super-Saturation" Oxygen Packaging?

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Background

The beef quality defect known as "dark cutting" occurs when animal stress causes glycogen supplies in the lean tissue to dip abnormally low prior to harvest leading to an abnormally high ultimate muscle pH post-harvest. The dark cutting condition results in lean color that is too dark and unacceptable to consumers with less consistency, less desirable sensory characteristics and decreased shelf-life compared to "normal" beef. Dark cutting results in reduced carcass value and reduced quality grade. USDA graders can discount the quality grades for dark cutters by 1/3 of a grade for a carcass classified as 1/3 dark, 2/3 for a carcass classified as 2/3 dark and a full grade for a carcass classified as fully dark. While research is underway to determine how to prevent the dark cutting condition by mitigating animal stress pre-harvest, limited research has been done post-harvest to improve the quality of dark-cutting beef.

Therefore, the objectives of this project were to:

- Investigate if a unique enhancement solution can be used to lower muscle pH and improve lean color from meat samples from dark cutting carcass items.
- Determine if a high oxygen packaging system improves dark cutting lean color ratings through oxygen "super-saturation" of myoglobin.
- Determine if sensory ratings of dark cutting beef samples are altered by a case-ready modified atmosphere packaging (MAP) system containing high oxygen.

Methodology

Phase 1

Twelve pairs of strip loins were selected and consisted of three pairs each of 1/3 dark cutters, 2/3 dark cutters, full dark cutters and normal A-maturity beef. Strip loins from the left side were designated for a 7-day aging period while strip loins from the right side were designated for a 14-day aging period. On day 6 of the 7 day aging period, one-inch steaks were cut from the left-side strip loins and subjected to 240 psi of pure oxygen in a chamber for 12 hours. The remaining uncut portions of the strip loins were repackaged. On day 7, one-inch steaks were cut from the remaining halves of the left loins and the oxygenated steaks were removed from the chamber resulting in two treatments: oxygenated and non-oxygenated. Steak 1 from each treatment was used for day 1 oxidative rancidity testing (TBARS), objective color scores ($L^*a^*b^*$), pH, drip loss and oxygen penetration. Steaks 2 through 6 were packaged in a high oxygen MAP system and then steaks 2 through 5 were subjected to simulated retail display for 7 days. Steak 2 was used for day 7 TBARS, $L^*a^*b^*$, pH and headspace. Steak 3 was used for a subjective cooked color panel, cooked $L^*a^*b^*$, cooked pH and a subjective odor panel. Steaks 4 through 5 were used for sensory panel and slice shear force. Steak 6 was left in simulated retail storage for an additional 7 days. During the 14-day period, a subjective panel evaluated the steaks daily for lean color, fat color, percent discoloration and overall acceptability. Steaks were pulled after 14 days and used for day 14 TBARS, $L^*a^*b^*$, pH and headspace evaluation. On day 13 of the 14 day postmortem aging period for right side loins, the above-mentioned process was repeated beginning with oxygenation of half of the samples.

Phase 2
Thirty-two paired strip loins were selected and consisted of four pairs each of 1/3 dark cutters, 2/3 dark cutters, full dark cutters and normal A-maturity beef. Two pairs from each group were designated for a 7-day postmortem aging period and the remaining two pairs were designated for a 14-day aging period. On day 6 of the 7-day aging period, one strip loin from each pair was randomly selected and pumped to 110% of its original weight with a brine solution containing 91.7% water, 4.2% acidic phosphate blend, 3% sodium chloride and 1.2% Herbalox™ antioxidant (final brine pH = 4.92). Strip loins were allowed to equilibrate and one-inch steaks were cut from the remaining portions of both enhanced and non-enhanced loins from each pair. These steaks were then subjected to the oxygenation treatment mentioned above and the remaining uncut portions of the loins were repackaged. On day 7, one-inch steaks were pulled from the oxygen chamber resulting in four treatments: oxygenated/enhanced, oxygenated/non-enhanced, non-oxygenated/enhanced and non-oxygenated/non-enhanced. Steaks 1 through 6 were used in the same manner for the same analysis as described for *Phase 1*.

Findings
Mean pH of raw *longissimus dorsi* muscle (strip loin) from non-dark cutting carcasses was 5.42 while 1/3 dark cutter mean pH was 5.92, 2/3 was 6.25 and full was 6.85. Non-oxygenated steaks had a lower mean pH value than oxygenated steaks; however, there was no effect on pH for enhancement treatment or aging period. Non-enhanced steaks exhibited higher pH values for both 2/3 and full dark cutters when compared to their enhanced counterparts. Relative to cooked strip loin steaks, enhanced steaks once again displayed lower pH vales than their non-enhanced counterparts. Full dark cutters were higher in pH than 2/3 dark cutters, which were higher than 1/3 dark cutters. However, no differences in pH were found between 1/3 dark cutters and normal beef.

As expected, L^* (lightness) values, a^* (redness) values and b^* (yellowness) values decrease as dark cutter score increases. Non-oxygenated steaks were darker than oxygenated steaks and steaks became darker for both enhanced and non-enhanced steaks as dark cutter score increased. Oxygenated steaks were more red than non-oxygenated steaks. Moreover, non-enhanced steaks had higher a^* values than enhanced steaks and steaks aged 7 days prior to treatment had higher a^* values than steaks aged 14 days prior to treatment.

When a cooked color panel evaluated these steaks, non-dark cutters were viewed as more brown or done than any dark cutter classification. Oxygenated steaks were viewed as more done than non-oxygenated and enhanced more done than non-enhanced. Steaks aged 14 days prior to treatment appeared more done than those aged only 7 days prior to treatment. In terms of retail shelf-life, steaks from 2/3 and full dark-cutting strip loins aged 14 days prior to oxygenation and enhancement treatments were considered less acceptable than steaks aged 7 days. Most steaks aged 14 days prior to treatment had a stronger odor than steaks aged only 7 days for all oxygenation/enhancement treatments. Enhanced steaks that were either oxygenated or non-oxygenated had higher odor scores than non-enhanced steaks (both oxygenated and non-oxygenated) for all dark cutter scores.

For all dark cutter scores, non-oxygenated steaks had more lipid oxidation than oxygenated steaks. As dark-cutter score increased, the amount of lipid oxidation decreased for all oxygenation, enhancement treatment combinations. Oxygenated steaks contained less oxidation for day 7 and day 14 than non-oxygenated steaks did. However, on day 1 of retail display the trend was opposite. Steaks aged 14 days prior to treatment had more oxidation than steaks aged 7 days prior to treatment. As retail display period decrease and dark cutter score increased, oxidation increased. As retail display period decreased and dark cutter score increased, oxidation levels decreased.

Panelists found the non-oxygenated steaks to be more tender than the oxygenated steaks. Panelists also found the enhanced steaks to be more tender, juicier and have less connective tissue than non-enhanced steaks. However, panelists found the enhanced steaks to have a moderately uncharacteristic flavor. Non-oxygenated steaks and non-enhanced steaks were found to be more acceptable than steaks that were oxygenated or enhanced. Steaks from the full dark cutters were found to be more acceptable overall than steaks from non-dark cutters, 1/3 dark cutters and 2/3 dark cutters. Researchers hypothesized that this could be attributed to the panelists finding these steaks juicier with the least uncharacteristic flavor. In terms of slice shear force, enhanced strip steaks were significantly more tender than non-enhanced strip steaks. Non-dark cutters and full dark cutters were significantly more tender than 1/3 and 2/3 dark cutters.

Implications

The inclusion of high-pressure oxygenation in strip steaks from dark cutting beef carcasses improves lean color characteristics. However, further research is needed to evaluate a lower oxygenation cycle to make this process more acceptable to the industry. Enhancement using an acidic phosphate had no effect on lean color characteristics and was detrimental on uncharacteristic flavors using a trained sensory panel. Continued research is also needed in lowering the pH of dark cutting beef muscle to improve shelf-life without impacting sensory attributes.

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