Project Summary

Extending Shelf-Life of Beef Cuts Utilizing Low Level Carbon Monoxide in Modified Atmosphere Packaging Systems

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Background

The cutting and packaging of beef at retail has undergone many changes, from whole carcasses fabricated in retail backrooms, to tray-ready and now to case-ready beef. Currently, the majority of beef sold at retail is centrally packaged into primal and subprimal cuts, vacuum packaged and shipped as "boxed beef." Retailers can purchase based on local preferences and buy the mix of beef cuts that fit specific consumer buying habits by store. Case-ready beef takes this one step further by packaging specific grinds of hamburger, steak and roast cuts at a central location ready for sale at the retail level. There are many options available for case-ready packaging systems; from over-wrapped trays that mimic in-store packaging to modified atmosphere sealed trays that contain differing levels of oxygen, carbon dioxide and/or nitrogen.

High-oxygen packaging systems help impart the bright red color of fresh beef. However, these systems also accelerate the extent to which the red color is converted to brown. Low oxygen systems do not impart a bright red color, but they should sustain the color in the retail case. Carbon monoxide modified atmosphere packaging (MAP) has been used in the Norwegian meat industry for many years. The U.S. Food and Drug Administration (FDA) approved carbon monoxide (CO) as a substance that is "Generally Recognized as Safe" (GRAS) in 2001. The FDA-approved level of CO in MAP is 0.4%, with carbon dioxide at 30% and nitrogen of 69.6%.

The main objectives of this study were to: 1) assess the impact of low-oxygen packaging systems containing CO on shelf-life; 2) determine the effect of CO MAP on sensory ratings; 3) compare the effectiveness of CO versus current packaging systems on microbial profile; and 4) examine if CO retards the formation of metmyoglobin ("browning") and oxidative rancidity properties in case-ready packaged beef cuts.

Methodology

Boxed beef subprimals, short loins (IMPS # 174) and top sirloin butts (IMPS # 184), were obtained from National Beef Co. in Liberal, KS and allowed to age refrigerated for 14 days at 37°F. After aging, samples were over-night mailed to Cryovac Sealed Air Corporation in Duncan, SC for further processing. Each short loin (n = 14) was fabricated into 12 one-inch thick steaks. One steak was randomly removed from each subprimal and cut in half for thiobarbituric acid analysis (TBA) and total plate count (TPC) determination, respectively. A second steak was removed and identified for day 0 sensory panel and a third was obtained for an estimation of day 0 cooked lean color panel. The day 0 TBA, TPC, sensory, and cooked lean color were considered an overall control or baseline measurement for analysis. The remaining steaks (n = 9) of each subprimal were individually placed in foam meat trays randomly assigned into one of three MAP treatments: 80% O_2/20% CO_2 (High-Oxygen); 70% N_2/ 30% CO_2 (Nitrogen); or 69.6% N_2/ 30% CO_2/ 0.4% CO (CO) and sealed.

Each top sirloin butt (n = 14) was fabricated into 6 one-inch thick steaks, and then cut in half (n=12). One steak was removed and cut in half again for TBA and TPC analyses. A second steak was removed for day 0 sensory panel measurement and a third steak was removed for day 0

cooked lean color measurement. The day 0 TBA, TPC, sensory, and cooked lean color were considered an overall control or baseline measurement for analysis. The remaining 9 steaks were placed into foam meat trays and randomly assigned to one of three MAP treatments (High-Oxygen, Nitrogen or CO).

Chubs of 80% lean coarse ground beef (10 pounds each) were obtained from the National Beef Case-Ready facility (Moultrie, GA), ground again, blended, and formed into quarter-pound patties. Six patties were randomly selected from each treatment and divided in half for TBA and TPC measurements. Six trays (n = 2 patties/tray) per treatment were used for day 0 cooked color ratings and another 6 trays (n = 2 patties/tray) per treatment were used for day 0 sensory panel ratings. A total of 50 packages (n=2 patties/tray) per treatment were used for color score analysis. Patties were randomly assigned to one of three MAP treatments (High-Oxygen, Nitrogen or CO).

Storage and Display

Steak and ground beef packages were placed in dark, refrigerated storage (37°F) for 0, 7, or 14 days. After the designated storage time, individual packages from each treatment group were randomly placed in simulated commercial retail display conditions for 7 days at approximately 36-39°F. Packages were rotated randomly every two days. Samples were then removed and randomly divided into three equal groups for TBA, TPC, cooked color lean analysis, and sensory panel testing. This methodology was repeated for each storage time.

Lean Color Assessment

Ground beef patties, top sirloin butt steaks, and T-bone steaks were visually evaluated by a six member trained panel once daily for lean color, fat color, percent lean discoloration, and overall acceptability. Additionally, bone discoloration was evaluated for T-bone steaks. Both the *longissimus dorsi* (strip) and the *psoas major* (tenderloin) muscles within the T-bone steaks were individually assessed. Overall acceptability represented the combined effects of lean color, fat color, and percent discoloration and was utilized as an indicator of acceptability of the retail products.

Cooked Color Analysis

Top sirloin butt and T-bone steaks were placed in dark, refrigerated storage (36°F) for 0, 7, or 14 days. After storage, steaks were placed in simulated commercial retail display conditions and evaluated for lean color stability for 7 days. After retail display, one-third of each retail cut was designated for cooked lean color analysis. Steaks were broiled on an impingement oven to two degrees of final doneness (149°F and 167°F). The ground beef patties were handled according to the same described procedures prior to cooking; however, patties were cooked on a George Foreman Grill for 7, 8 or 9 minutes depending on predetermined endpoint degree of doneness: 9 minutes for well-done, 8 minutes for medium, and 7 minutes for rare.

Following cooking, steaks and ground beef patties were allowed to cool for approximately 3 minutes and cut in half exposing the geometric center. A trained panel evaluated the center of each cooked lean split surface of the steaks and ground beef patties for subjective cooked color analysis according to the Beef Steak Color Guide-Degree of Doneness chart. Objective color

measurements (L*, a*, and b* values) were recorded for each sample using a Hunter Labs Colorimeter.

Drip Loss

Drip loss was evaluated for one-third of the steaks at the end of each retail display period. To assess drip loss, the entire package (i.e., the steak, tray and film) was weighed. Next, the meat sample and any purge were removed from the package making sure to wipe the entire package surface clean. Finally, the meat sample was placed back into its package, with film, and re-weighed. The weight of the package absent of purge was subtracted from the package with purge, and then a percentage was obtained. Drip loss was not determined for ground beef patties.

Sensory Panel

Sensory panelists were trained for sensory analysis following AMSA (1995) guidelines. Trained panelists were subjected to smelling dilute hexanal to identify and establish flavors associated with rancidity. Steaks and patties were removed from their MAP treatment after their respective storage and display periods, and were placed in vacuum packages and stored at 28°F until further analysis. Meat cuts were defrosted for 24 hours at 39°F, and then broiled on an impingement oven to an internal temperature of 158°F (medium degree of doneness). Six sessions, consisting of six-trained panelist/treatment were performed. In the first two sessions, fourteen ground beef samples were evaluated per panelists; in the second two sessions, eleven top sirloin butt samples were evaluated per panelists; and in the final two sessions eleven T-bone samples each were evaluated per panelist. Panelists were served 2 portions per sample and instructed to record the average of the two portions. Samples were evaluated on tenderness, juiciness, cooked beef flavor, off flavor, and overall acceptability.

Total Plate Count

All samples were packaged in whirl-paks and transported overnight to Food Safety Net Services (San Antonio, TX) for standard total plate counts. Food Safety Net followed standard plating methodology outlined by FDA's Bacteriological Analytical Method (BAM).

Odor Panel

Following storage and retail display periods, two packages per treatment were selected for the odor panel. The barrier film was cut with a knife, and the panel immediately evaluated the odor of the sample.

Thiobarbituric Acid Analysis

On the initial day (day 0) of the study and the final day (day 7) of each of retail display period, samples were removed from the retail display case, packaged in whirl-paks and frozen at –4°F until Thiobarbituric acid (TBA) analysis could be performed.

Findings

T-Bone steaks, top sirloin steaks and ground beef patties in 4% CO modified atmosphere packaging (MAP) exhibited acceptable color ratings for longer periods of retail display than the other two (High-Oxygen and Nitrogen) packaging systems. Specifically:

- Two cuts, tenderloin (*psoas major*) and top sirloin, appear to benefit the most from CO MAP. Previous research has shown that these two cuts tend to have shorter shelf-life during retail display.
    - Top sirloin steaks that were stored for 14 days maintained lean color acceptability for the entire 7-day retail display period.
    - For 7- and 14-day storage times, less discoloration was observed on the surface of the tenderloin of the CO packaged T-bone steaks.
- CO MAP prolonged the acceptable bone color in T-bone steaks during retail display.
- CO MAP reduced lipid oxidation (TBAR values) over the storage and retail display periods.
- Sensory panelists could not distinguish CO MAP products from Nitrogen MAP samples, and found them more acceptable than High-Oxygen MAP samples.
- CO MAP did not appear to have an effect on fat discoloration, odor characteristics, or drip loss.
- CO MAP causes "persistent pinking" or "hard-to-cook" phenomenon in ground beef patties.

Implications

Color of fresh beef during retail display is an important factor used by consumers to judge freshness and make their purchase decision. A bright, cherry-red muscle tissue color is desired. Recession of the cherry-red color during product display, and the appearance of brown hues, is a natural process in beef, and occur prior to microbial spoilage. Beef products that are in the early stages of discoloration may be discounted to encourage quick sale to more price-conscious consumers, seasoned or marinated into products for which fresh meat color is not pertinent, or converted to ground beef. Products with advanced discoloration are likely to be discarded. Each of these options contributes to losses in value and sales of beef at retail. U.S. retailers fail to capture at least one billion dollars of revenue annually from fresh beef sales, due to product discoloration.

The findings of this study suggest that CO MAP could contribute to longer shelf life for T-bone steaks, sirloin steaks and ground beef patties. This packaging system also appears to reduce oxidation over storage and retail display time versus the other two packaging systems, and sensory panelists found the cuts packaged in CO more acceptable than the High-Oxygen MAP cuts. This is important to the Beef Industry in that longer shelf life can contribute more to the bottom line of the retailer and consistent eating experiences by the consumer contribute to customer satisfaction and continued willingness to purchase. The findings of this study suggest that different packaging systems may impact how specific beef cuts perform under retail conditions and much more study is needed in order to delineate "best practices" for case-ready packaging at retail.

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