

Project Summary

**Does Pressurized Pre-Treatment with Carbon Monoxide (Co)
Improve Fresh Beef Shelf-Life Characteristics in Case-Ready
Packaging Systems?**

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Background

The Food and Drug Administration approved carbon monoxide (CO) as a substance that is Generally Recognized as Safe (GRAS) in 2001 at a level of 0.4% in modified atmosphere packaging (MAP). The objectives of this project were to assess the impact of low-oxygen packaging systems containing CO on shelf-life of beef cuts; determine if sensory ratings are altered by a case-ready packaging system containing CO; compare effectiveness of CO versus current packaging systems on microbiological profile; and examine if CO retards the formation of metmyoglobin (“browning”) and oxidative rancidity properties in case-ready packaged beef cuts.

Methodology

Three beef subprimal strip loins (IMPS #180), inside rounds (IMPS #169A) and top sirloins (IMPS #181A) were randomly selected from USDA Select carcasses and vacuum packaged before storage at 4°C for subsequent analysis. Subprimals were fabricated within 7 days postmortem into one inch steaks using a band saw. During fabrication, steaks were randomly assigned to one of three packaging treatments: 1) case-ready as a control with MAP (80% O₂ / 20% CO₂); individual steaks were packaged in a rigid tray (Cryovac CS977 Duncan, SC) with an absorbent pad (Cryovac DRI-LOC AC 50 Duncan, SC) and were sealed with oxygen barrier film (Cryovac Lid 1050/550 Lidstock Duncan, SC) using a MAP machine (G. Mondini CV/VGS Brescia, Italy); 2) CO pre-treated and vacuum skin packaged steaks were pre-treated with CO using a Vivotec Master Depot (md003); following pre-treatment the steaks were packaged with a Sealed Air Intact (model number RM571) vacuum skin machine; 3) steaks were pre-treated with CO and packaged in top-forming modified atmosphere (30% CO₂ / 70% N) pre-treatment procedure. Treatment 3) was identical to pre-treatment procedure 2) but packaged in an APT tray with MAPtech barrier film using a Prototype Map-Tech machine (Gas Master; Hilton Head Island, SC).

Following a three-day period to simulate transportation and distribution, all steaks were displayed in a commercial retail display case for 19 days under cool-white fluorescent light at 4°C. Samples were evaluated every twelve hours by a trained panel (n=3) for lean color, fat color, percent discoloration and overall appearance. Sensory analysis was conducted by a trained panel.

Following cooking, steaks were cut through their horizontal center exposing the geometric center. A trained panel (n=3) evaluated the center of each cooked lean split surface of the steaks for a subjective color analysis. On days 1, 7, 14 and 21 of the study, sample were removed from the retail display case, packaged in Whirl-Pak bags and frozen at -20°C until further analysis for thiobarbituric acid reactive substance (TBARS).

Odor of uncooked steaks was performed by two groups of two trained panelists on a percentage of packages from each treatment evenly representing all packaging systems and treatment groups. Packaging systems were individually opened with a knife and the panel immediately evaluated the odor of the package. Steaks from the odor analysis were then cooked for Warner-Bratzler (WBSF) measures. Purge analysis was conducted by measuring the amount of moisture lost during the shelf-life of the steak. After it was removed from the retail case, the weight of the steak was subtracted

from the initial weight of the steak at day zero of the study and then divided by the initial weight of the steak and multiplied by 100 to get the percent purge of the steak. Analysis was conducted on days 7, 14 and 21.

All samples were packaged in Whirl-Pak bags for total plate counts following standard plating methodology as outlined by FDA's Bacteriological Analytical Method (BAM). Five samples of each treatment from each subprimal were removed from the retail to expose during five days to higher temperatures and mishandling. The abused packages were also tested for total plate counts.

Findings

Striploin steaks

Based on lean color scores, CO increased consumer acceptability compared to the untreated group. When the addition of CO was compared between VAC and MAP packaging, results demonstrated that the combination of CO/VAC increased consumer acceptability of the striploin in comparison to the remaining experimental treatments. Fat color rating showed that CO improved the perception of the striploin when used in vacuum packages because the fat color remained white for a longer period of time compared to CON packages. Percent discoloration showed CO pre-treatment maintained the color of striploin steaks, especially when used in VAC compared to CON packages. Additionally, acceptable lean color discoloration was maintained for both CO-treated packaging systems throughout the entire retail simulation time. Overall acceptability, for the purposes of this study, was the average of all attributes including lean color, fat color and percent lean discoloration. The overall acceptability of striploin steaks treated with CO was higher than CON counterparts.

Inside round steaks

For inside round steaks, the combination of CO/VAC increased lean color stability. CON-packaged inside round steaks were undesirable after only 4 days of retail display. For the entire retail duration, CO-treated samples discolored very little and the fat color remained creamy white. The control, high-oxygen packages displayed a linear lowering in fat color from brown to white. Percent discoloration values for CO pre-treatment groups were stable and the color of the inside round was maintained throughout the investigation. The CON samples discolored faster and were undesirable approximately 5 days following retail display. Overall acceptability of CO-packaged steaks displayed a small depression after 3 days of display; however, from days 4 through 19, inside round color stability remained constant.

Top sirloin steaks

The CO/VAC top sirloin steaks were rated highest in terms of lean color, and were followed closely by the other CO treated samples with the CON samples displaying the least, most undesirable lean color stability. Top sirloin steaks from CO/MAP-treated samples were rated as undesirable at the termination of retail simulation. After only two days of display, the CON top sirloin steaks began their downward trend in fat color stability. For both CO-treated packaging systems, fat color scores decreased over time but at a much slower pace than CON samples. Percent discoloration for top sirloin steaks responded differently because CO/VAC remained non-discolored throughout the entire retail display period. CO/MAP-packaged steaks exhibited a slow, intermediate decline in discoloration when compared to the rapid descent of the high-oxygen MAP control top sirloin steaks. The overall acceptability of top sirloin steaks with CO pre-treatment had higher acceptability when used in the CO/VAC packaging system.

Odor panel

For strip loin steaks, CON-packaged samples exhibited the highest, most objectionable odor rating following 7, 14 or 21 days of retail storage. The CO/VAC strip steaks had the lowest, most acceptable odor ratings regardless of retail storage time. For inside round steaks, CON- and CO/MAP-packaged product received similar odor scores to each other across the tested retail display times. The CO/VAC had the lowest, most non-detectable small of the tested packaging systems. Odor scores for top sirloin steaks were similar to those exhibited by inside round steaks in that CO/VAC steaks displayed the least odor compared to CON and CO/MAP packaged top sirloin steaks. After 14 days of retail display, CON- and CO/MAP-packaged top sirloin steaks were approaching odor scores that were described as being distinct and approaching being objectionable.

Total plate count

Initial counts on inside rounds were similar for all packaging types. For CON and CO/VAC samples, it was not until 21 days of retail display that counts were higher when compared to days 1, 7 and 14. For inside round steaks packaged in the CO/MAP, a linear increase in total plate count was observed as retail display time increased. In conclusion, it appears that incorporating CO into either MAP or VAC packaging samples does improve lean color stability while not influencing microbial counts.

Premature browning

Even though strip loin steaks were cooked to a “done” end point, the CO treated steaks remained pink in the center. CON steaks were completely brown throughout. These same results were noted for both inside round steaks and top sirloin steaks.

Lipid oxidation

The indicator of lipid oxidation is presence of thiobarbituric acid reactive substances (TBARS). For strip loin steaks, the CON samples exhibited an increase in lipid oxidation between all display days; however, the CO/VAC and CO/MAP samples were the same but significantly lower than CON samples. For inside round samples, the CON treatment was significantly different from the other two treatments marking an increase in oxidation from day 1 to day 7. After day 7, no significant difference existed. For top sirloin steaks, no significant difference existed between the different types of packaging or during days of display.

Purge loss

Samples which were VAC-packaged displayed the least amount of purge loss compared to other tested packaging systems. Both of the systems which included a modified atmosphere (CO/MAP and CON) exhibited a significant increase in purge loss during days of display compared to the CO/VAC samples. This elevated loss was increased as display time increased. Similar findings were observed for inside round and top sirloin steaks.

Sensory panel

Sensory panelists evaluated meat samples based on five categories: tenderness, juiciness, beef flavor, off-flavor and overall acceptance. There were no significant differences in main effects or interactions among any sensory categories for any of the strip loin, inside round or top sirloin steaks. In addition, CON samples showed the highest levels of oxidation, which was confirmed by sensory panelists detecting an off-flavor in those samples.

Temperature abuse

No significant differences were detected in total plate counts between abused versus normal treated striploin steaks. The CON samples displayed significantly higher microbial counts than the CO-treated striploin steaks. For inside round steaks, abused steaks tended to have higher total plate counted than their normal counterparts. This was especially true for the CON- and CO/MAP-packaged inside rounds.

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