

Project Summary

Effects of Packaging Atmospheres and Injection Enhancement on Beef Instrumental Tenderness, Sensory Traits and Display Color

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Background

Case-ready beef provides several benefits to processors due to centralized packaging, greater microbial control, extended shelf-life and quality control. The use of injection enhancement has been proven to improve beef tenderness and juiciness and is often used in conjunction with case-ready modified atmosphere packaging (MAP). Moreover, different packaging environments may cause different effects on tenderness and sensory characteristics for injection-enhanced product compared to non-enhanced product. Therefore, the objectives of this project were to determine the effects of different packaging atmospheres on beef instrumental tenderness and display color (Experiment 1) and determine the effect of different packaging atmospheres and injection enhancement on beef instrumental tenderness, sensory traits and display color (Experiment 2).

Methodology

Experiment 1

Paired beef loins (*longissimus* muscles) (n=14) from USDA Select, A maturity carcasses were obtained following a 48 hour chill and stored at 2°C until 7 days postmortem. Loins from different sides were assigned to either 14-day tenderness evaluation or display and then 18 or 28 day tenderness evaluation. Loins were fabricated into seven, 2.54-cm thick steaks and assigned to initial tenderness evaluation or one of 5 packaging treatments including vacuum packaging, ultra-low oxygen modified atmosphere packaging (MAP) with carbon monoxide (CO), high-oxygen MAP, 99% carbon dioxide (CO₂) & 0.4% CO, and 99.6% nitrogen (N₂) & 0.4% CO.

An additional 3 steaks were cut posterior to the first 7 steaks, randomly assigned to a packaging treatment, stored at 2°C in dark storage until 14 days postmortem and used for cooked internal color evaluation. High-oxygen MAP was held in dark storage for 4 days and then put into simulated retail display and removed on day 18. All packaging treatments without oxygen were held in dark storage for 14 days and then were put into simulated retail display and removed on day 28 postmortem. An activated oxygen scavenger was included in each of the ultra-low oxygen packages to eliminate any residual oxygen.

One steak from each loin was vacuum packaged and used for initial Warner-Bratzler shear force (WBSF) evaluation on day 4 postmortem. Steaks packaged in all packaging treatments used for 14-day postmortem WBSF were held for 7 days in the dark and then cooked for WBSF measurement. Steak pH was measured on day 14 postmortem. Trained visual color panelists evaluated initial color on day 0 of display and display color and surface discoloration on day 0 to 7 of display once each day. For all steaks, discoloration was considered as a percentage of surface metmyoglobin. Instrumental color (L^* , a^* , b^*) was also measured on days 3 and 7 of display for all treatments. In addition, cooked internal color was evaluated on day 14.

Experiment 2

In the first experiment, there was not much differentiation in color or tenderness data between the four ultra-low oxygen CO MAP treatments. Thus, three packaging treatments were chosen to use in the second experiment. Paired *longissimus* (n=12), *semitendinosus* (n=12) and *triceps brachii* (n=24) were obtained from the same USDA Select, A-maturity carcasses following a 48-hour chill. On day 7

postmortem, each muscle from one side was enhanced (typical beef broth, phosphate & rosemary natural flavoring solution used in industry) and the muscles from the opposite side were fabricated into 2.54-cm thick steaks and used as non-enhanced samples. Muscles were segmented into treatments of high-oxygen MAP, ultra-low oxygen CO MAP, or vacuum packaged and assigned to either 14 day WBSF tenderness evaluation or retail display followed by 18 or 28 day WBSF evaluation.

Storage, packaging, display, visual color, and WBSF were conducted similarly to Experiment 1. Cook loss was also calculated and one steak from each muscle and each packaging atmosphere was removed from MAP and vacuum packages on day 18 for sensory analysis. Trained panelists evaluated samples for myofibrillar tenderness, juiciness, beef flavor intensity, amount of connective tissue, overall tenderness, and off-flavor using an eight-point scale. Desmin degradation was used as a measure of postmortem proteolysis. Extraction, electrophoresis, Western blotting and quantification of desmin were measured on days 7 and 14 postmortem.

Findings

Experiment 1

WBSF values for *longissimus* steaks indicate that, as a system, high-oxygen MAP results in steaks being less tender than those packaged in ultra-low oxygen CO MAP or in vacuum. Steaks packaged in high-oxygen MAP were less tender than other treatments at the end of the display period but had 10 days less aging time because of a shorter dark storage period versus ultra-low oxygen CO MAP and vacuum packaged treatments (mimicking industry practices). There was a trend for steaks packaged in vacuum to be more tender than steaks packaged in ultra-low oxygen CO MAP on day 28 postmortem. However, there were no differences in pH for *longissimus* steaks in different packaging treatments.

Display color scores indicated that steaks from all treatments became darker as day of display increased. Steaks packaged in high-oxygen MAP were slightly brighter than steaks packaged in ultra-low oxygen MAP on day 0 of display according to display color score. Vacuum packaged steaks were the most consistent in display color throughout the 7 day period; however, many consumers find the purplish-red color of vacuum packaged beef. Steaks packaged in high-oxygen MAP were reddish tan by day 7 of display, whereas steaks packaged in the ultra-low oxygen CO MAP treatments were either dull red or slightly dark red by day 7 of display.

Steaks packaged in vacuum or the ultra-low oxygen MAP blends with CO had little or no surface discoloration. Steaks packaged in high-oxygen MAP discolored faster and to a greater extent than those packaged in any of the ultra-low oxygen MAP or vacuum packaged treatments. Steaks packaged in high-oxygen MAP discolored by day 4 of display and discolored 56% more than those packaged in any other treatment.

Steaks packaged in the ultra-low oxygen CO MAP treatments had higher L^* (lightness) values than steaks packaged in high-oxygen MAP or vacuum packages. Steaks packed in ultra-low oxygen CO and ultra-low oxygen nitrogen and CO MAPs were redder (higher b^* values) than steaks packaged in high-oxygen MAP on day 0 of display. Moreover, steaks packaged in high-oxygen MAP had drastically lower a^* (yellowness) values on day 7 of display compared to day 0. Steaks packaged in high-oxygen MAP had a dramatic decrease in saturation index from day 0 to day 7 of display and was much lower than the ultra-low oxygen treatments by day 7 of display. In general, instrumental color agreed with display color results found by trained panelists.

Experiment 2

As found in Experiment 1, steaks packaged in high oxygen MAP were less tender at the end of their display period (18 days) than steaks packaged in vacuum or ultra-low oxygen CO MAP at the end of their display period (28 days). Enhanced *longissimus* steaks were more tender than non-enhanced steaks on day 7 postmortem (day 0 of packaging), indicating that injection-enhancement has an immediate effect on tenderness. The *longissimus* had the least amount of cook loss followed by the *triceps brachii* and the *semitendinosus*. Enhanced steaks had less cook loss than non-enhanced steaks. Steaks packaged in high oxygen MAP had the least amount of cook loss and steaks packaged in ultra-low oxygen CO MAP had the most.

According to sensory panelists, non-enhanced steaks packaged in high oxygen MAP were less tender, had less beef flavor, and more off-flavors than ultra-low oxygen CO MAP and vacuum packaging. The *longissimus* and *triceps brachii* were more tender according to myofibrillar tenderness than the *semitendinosus*. Enhanced steaks were juicier than non-enhanced steaks and steaks from the *longissimus* and *triceps brachii* were juicier than those from the *semitendinosus*. Steaks packaged in high oxygen MAP were less juicy than steaks packaged in ultra-low oxygen CO MAP. The most common off-flavors associated with steaks packaged in high oxygen MAP were oxidative and rancid. Moreover, enhanced steaks all had more off-flavors than non-enhanced steaks.

Longissimus steaks had more degradation of desmin at day 14 than the *semitendinosus* or *triceps brachii*, regardless of enhancement treatment. Enhanced steaks had a higher pH than non-enhanced steaks, regardless of packaging treatment. Enhanced steaks were darker initially than non-enhanced steaks. Non-enhanced triceps brachii steaks were darker than non-enhanced longissimus or *semitendinosus* steaks. Enhanced *semitendinosus* steaks were lighter than enhanced *longissimus* steaks, which were lighter than enhanced *triceps brachii* steaks. Steaks became darker throughout the 7 days of display, but in general, steaks packaged in vacuum or ultra-low oxygen CO MAP remained more stable than steaks packaged in high oxygen MAP. Steaks packaged in high-oxygen MAP discolored at a relatively faster rate and to a greater extent than steaks packaged in vacuum or ultra-low oxygen CO MAP. Steaks packaged in vacuum or ultra-low oxygen CO MAP had no discoloration throughout the 7 day display period.

Implications

In general, more off-flavors were associated with enhanced steaks than non-enhanced steaks. Steaks packaged in high oxygen MAP were less tender and had more off-flavors than either ultra-low oxygen CO MAP or vacuum packaging. In general, steaks packaged in vacuum or ultra-low oxygen CO MAP had more display color stability than steaks packaged in high oxygen MAP. Although steaks packaged in vacuum did not discolor throughout display, they have a purplish-red color that is not commonly acceptable to most consumers.

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