

# A Comparison of Five Different Modified Atmosphere Package Methods for Retail Display-Ready Ground Beef

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## SUMMARY

Modified atmosphere packaging was evaluated for retail display caselife attributes after refrigerated storage for 5, 7, 9, 11, 17, or 25 d post-processing. Five differing types of case-ready retail packaging, consisting of two high oxygen and three low oxygen packaging methods, were evaluated. Color was evaluated every twelve hours using the average measurements obtained with three HunterLab MiniScans™ during retail display. After 11 d of storage, all ground beef packaged using high oxygen techniques were unacceptable in lean color, and evaluation was discontinued. Low oxygen treatments displayed acceptable color after 25 d of storage, however maintenance during retail display of cherry-red color decreased as the days of simulated retail display increased for each treatment tested. Therefore, 11 d of storage was determined to be the most ideal length of storage time for all low oxygen case-ready packaging treatments when 48 h of retail case display was desired after storage.

**Key Words:** Modified Atmosphere Packaging, Ground Beef, and Color.

## INTRODUCTION

Consumers view color as one of the most important attributes of fresh beef when making a decision to purchase retail product. Color, therefore, determines appeal of the product in the retail case and consumer acceptability. Consumers associate a quality ground beef product with a bright cherry-red color. This characteristic of ground beef results from oxygenation of the primary pigment in muscle, myoglobin, to form oxymyoglobin. However, extended retail case display time or refrigerator storage can cause oxymyoglobin to

further oxidize and form metmyoglobin, which has an undesirable brown color.

Because visual appearance of ground beef is important to the consumer when making the decision to purchase, retailers discount or discard product that is not acceptable in color, resulting in a substantial economic loss for the retailer. Thus, various strategies have evolved to minimize the oxidation of oxymyoglobin to metmyoglobin, including (but not limited to) use of strategic packaging methods that allow central processing and packaging of ground beef to maximize control of bacteriological quality of the product and, at the same time, maximize case-life characteristics. This study was designed to evaluate five different modified atmosphere ground beef packaging methods.

## MATERIALS AND METHODS

**Raw Materials.** Boneless, vacuum-packaged subprimal cuts of fresh beef were obtained from ConAgra in Greeley, Colorado, including: (1) Bottom Rounds; (2) Beef Briskets; (3) Rib Lifter Meat; (4) Chuck Rolls; (5) Clods; and (6) Knuckles. Subprimal cuts were collected randomly from several different carcasses and transported to the Colorado State University Meat Science Laboratory.

After two days of storage at 4°C, subprimals were trimmed to remove excess fat, sectioned and mixed to achieve, visually, approximate lean percentage formulations desired for the finished product, and ground through a 1/2 inch plate. Carbon dioxide snow was applied to the coarsely ground product during blending to maintain product temperatures of <34°F, following which the coarse ground beef was ground a second time through a 1/8 inch plate. Finely ground beef was portioned into one-pound bricks using a Vemag stuffer and a Reiser portioner and placed in white, barrier Styrofoam trays. Similar barrier trays (only differing in depth) were used for all treatments. Product was formulated and blended to target two different percent lean content final blends (83% and 94% lean). After samples were collected, they were shipped via overnight service to a private laboratory (Food Safety Net Services, LTD., San Antonio, TX) for analysis of fat content using ether extractions. It was determined that the

two divergent formulations differed in fat content by 11%. One-pound packages (n=400) of 94% lean ground beef were packaged, followed by one-pound packages (n=370) of 83% lean ground beef.

**Packaging Treatments.** Each of the two resulting lean-content blends of ground beef were packaged in a manner that allowed a comparison of five different retail-ready modified atmosphere packaging (MAP) treatments. Two of the MAP treatments were characterized as “high oxygen” treatments with a modified atmosphere consisting of 80% O<sub>2</sub>, while the remaining three treatments were characterized as “low oxygen” packages. For the low oxygen packages, O<sub>2</sub> was removed from the package and replaced with either N<sub>2</sub> or CO<sub>2</sub>. Each packaging method was coded to aid in collecting subsequent display caselife data. The “HOX” prefix indicated that it was a high oxygen treatment, whereas the “LOX” prefix indicated a low oxygen environment. Packaging treatments are further described in Table 1.

**Simulated Storage and Retail Case Display.** Resulting retail-ready packages of ground beef were placed in boxes and transported to the Colorado State University meat plant for storage at 34°F. Packages were not exposed to light during storage. Packages were stored under refrigerated conditions until reaching 5, 7, 9, 11, 17 or 25 days of storage. Two retired deli cases were installed courtesy of Safeway to represent the retail cases in their stores. These cases were set up at the Colorado State University meat plant and were maintained at approximately 32°F (four 15 min defrost cycles per day) to maintain displayed ground beef at approximately 38°F. Lighting, measured in lux, was simulated to reflect Safeway and AMSA Guidelines for Meat Color Evaluation (National Livestock and Meat Board, 1991). After storage, packages were randomly placed in the retail case as follows: 28 HOXA (94% and 83% lean), 6 HOXB (94% and 83% lean), 6 LOXC (94% and 83% lean), 6 LOXD (94% and 83% lean), and 6 LOXE (94% and 83% lean). One package from each treatment was sacrificed after 12 h of retail case display to evaluate microbiological quality. Treatment

HOXA required a deeper tray (allowing extra head space, thus making objective color evaluation with spectrophotometers difficult without opening the package); therefore, 5 packages were sacrificed every 12 h for color analysis. The retail case was filled with extra packages during observation to help stabilize case temperature. Every 12 h, retail ground beef package placement within the retail case was rotated to minimize exposure to different temperatures and lighting conditions within each case. Temperature, light and package gas content was monitored for the duration of the study to assure consistency.

#### ***Simulated Home Refrigerator***

**Storage.** After 48 h of retail display time, the treatment packages were transported via a personal cooler to the Colorado State University Meat Laboratory on campus. Here, they were placed in a refrigerated, dark environment and stored for an additional 48 hours at 40°F to simulate conditions typical after purchase.

**Color Evaluation.** Ground beef color during retail display and home refrigerator storage for each package of ground beef was objectively measured (6,837 observations) using three HunterLab MiniScan™ XE portable spectrophotometers (Hunter Associates Laboratory, Inc., Reston, Virginia) to determine values for L\* (brightness; 0=dark, 100=light), a\* (positive values=red, negative values=green), and b\* (positive values=yellow, negative values=blue). Each package was scanned three times at three random locations every 12 h, with each of the three spectrometers, through the retail package overwrap film. Averages of the color readings for each instrument and for each package of ground beef were recorded and analyzed.

## **RESULTS AND DISCUSSION**

**Color Analysis.** Because samples were not evaluated visually in this study, a method to effectively determine at what point “color” of ground beef became unacceptable to consumers was

necessary. Sixteen packages of ground beef, varying metmyoglobin formation, were evaluated by three retail company corporate meat buying professionals on October 31, 2000. They were asked to indicate whether they would discard, discount or accept the packages based on visual appearance. Then each package was scanned with the MiniScan spectrometers to determine L\*, a\* and b\* color values. The values were averaged over the three machines. From these data, it was determined that it was not just a certain a\* or b\* value that determined whether a package was discounted or discarded, but, rather, an interaction between the two values. An a\*b\* of >200 was determined to be acceptable by the corporate representatives without discount, a value between 200 and 125 was discounted, and any a\*b\* value below 125 was discarded.

Mean HunterLab MiniScan™ a\*b\* values are presented in Figures 1 and 2. Each graph plots the mean a\*b\* for the packages of ground beef by packaging treatment and by lean content. The standards determined by personnel of Safeway are indicated on each graph. Overall, the low oxygen treatments all followed the same pattern. High oxygen packaging treatments resulted in more rapid discoloration of the ground beef (by 7 days of storage, 100% were considered discarded) than the low oxygen packaging treatments. Because of these findings and additional visual observations, it was decided on October 31, 2000 (Day 13 of storage) by the sponsors of the study not to continue collecting caselife data from high oxygen packaging treatments. Data also indicated that the 83% lean ground beef discolored less rapidly during retail display than 94% lean ground beef, especially in the low oxygen packaging environments.

#### ***Additional Visual Observations.***

Throughout the study, several visual observations were made relative to differences in color attributes. These differences seemed to reflect retail packaging treatment effects during simulated retail display. After 11 days

of storage, it was noticed that in the last 24 hours of retail display, ground beef packaged using the LOXC treatment developed spots that appeared to be bleached-out in appearance; this occurred where the ground beef came into direct contact with the overwrap film. This bleaching effect seemed to disappear after the first 12 h of refrigerated display. Excessive purge development was observed in ground beef packaged using either the LOXD or LOXE treatments. Additionally, for ground beef packaged using the HOXB, LOXD, or LOXE treatments, an immediate browning occurred where the ground beef came into contact with the film overwrap. This was most evident around the edges of the packages. Both 83% and 94% lean ground beef packaged using the HOXA treatment displayed a dry appearance.

## **CONCLUSION**

Color analysis of retail ground beef supported use of low oxygen treatments when a more appealing color is needed in the retail case after extended periods of storage (>N7d).

Color acceptability, according to the a\*b\* relationship, was not affected by the length of storage for the blooming of treatment LOXC. However, as the days of storage increased, the length of time the color was acceptable in the retail case decreased for all treatments.

Low oxygen treatments, specifically LOXC, would be best suited for obtaining acceptable color and microbiological safety when increased storage time is needed. Accordingly, the a\*b\* values suggested that LOXC can remain visually attractive for a maximum of 18 storage days, while still maintaining acceptable retail display color for at least 48 h.

## **REFERENCES**

- AMSA. 1991. Guidelines for Meat Color Evaluation. National Livestock and Meat Board, Chicago, IL. Proc. Recip. Meat Conference. 44:3-11.

Table 1. Treatment gas content and packaging descriptions.

Treatment	% O <sub>2</sub>	% CO <sub>2</sub>	Lidding/Overwrap	OTR
HOXA	75 <sup>a</sup>	20 <sup>a</sup>	LID550	2.58cc/m <sup>2</sup> /24hr@40F 75%RH
HOXB	74 <sup>a</sup>	24 <sup>a</sup>	SES520	12,000cc/m <sup>2</sup> /24hr@40F 100RH
LOXC	0.03 <sup>a</sup>	30 <sup>a</sup>	LID550P	0.23cc/m <sup>2</sup> /24hr@40F 75%RH
LOXD	0.50 <sup>a</sup>	38 <sup>a</sup>	SES520	12,000cc/m <sup>2</sup> /24hr@40F 100RH
LOXE	0.01	100	SES520	12,000cc/m <sup>2</sup> /24hr@40F 100RH

<sup>a</sup> Remaining gas content is Nitrogen.

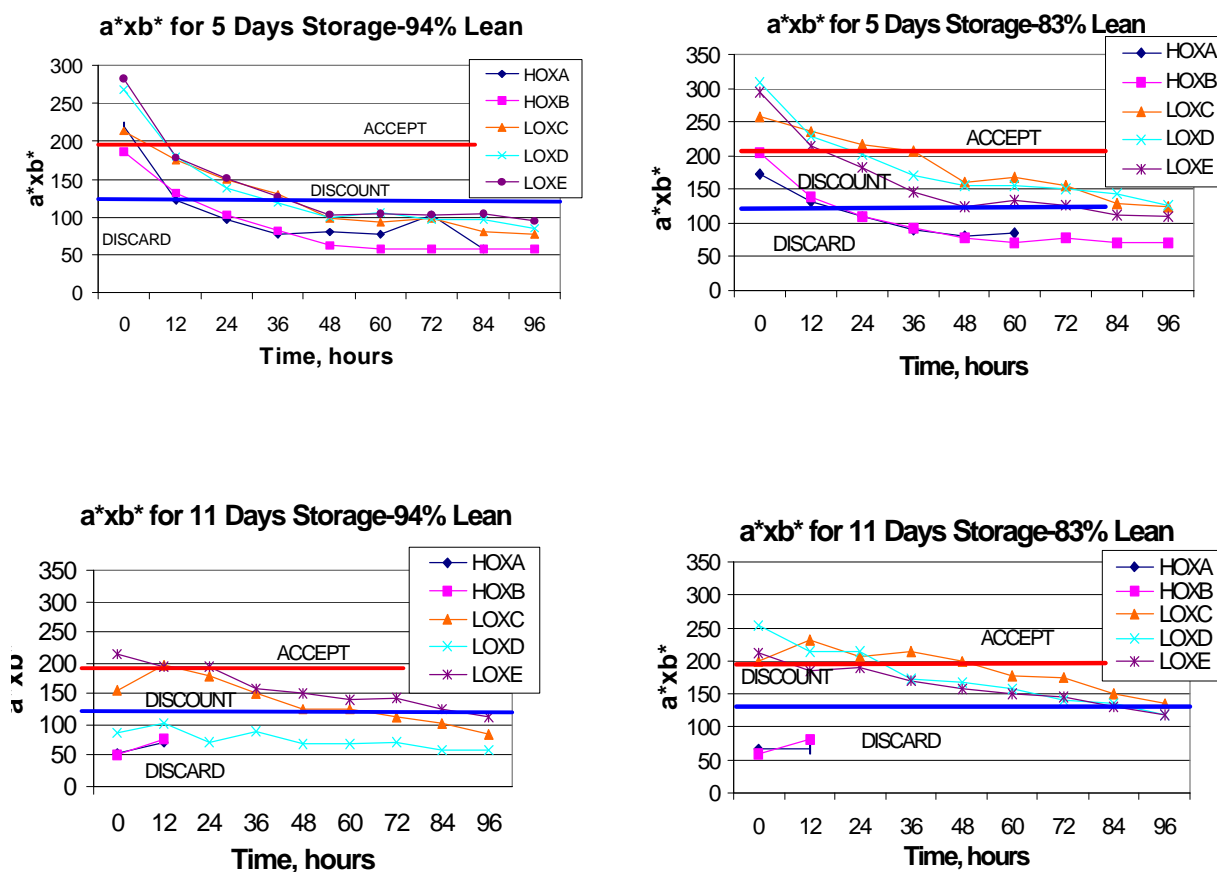


Figure 1. Two-way interaction (a\*xb\*) plots by product age for the prediction of hours of retail case-life and refrigeration storage.

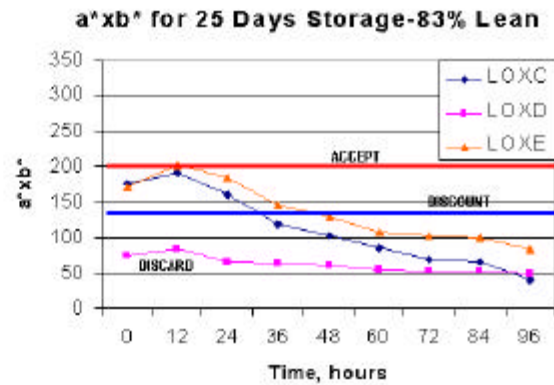
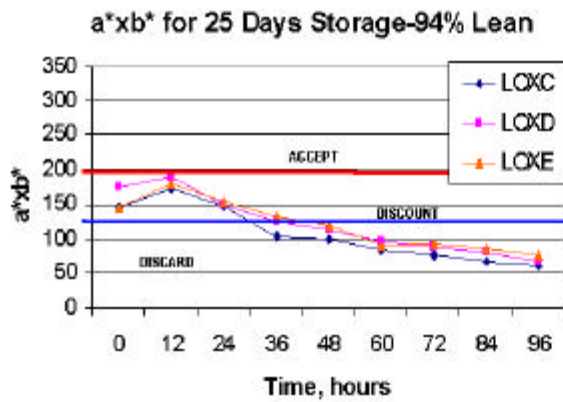
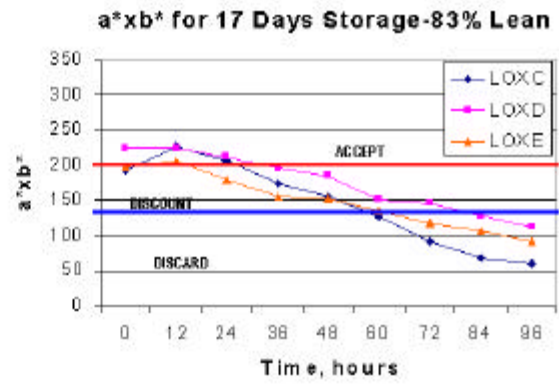
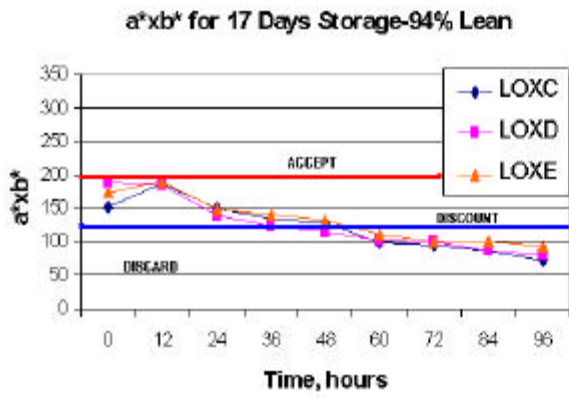


Figure 2. Two-way interaction ( $a \cdot x b^*$ ) plots by product age for the prediction of hours of retail case-life and refrigeration storage.