

Project Summary

Biochemical, Raw and Cooked Color Characteristics of Individual Bovine Muscles in Oxygen Permeable and Modified Atmosphere Packaging

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**Study Completed
July 2003**



Funded by The Beef Checkoff

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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 and/or nitrogen.

High-oxygen packaging systems help impart a bright red color of fresh beef. Research has shown that the most important considerations for consumers in choosing fresh beef are the color of the meat and the expiration data. NCBA has been promoting “Beef Value Cuts” utilizing specific whole muscles from the chuck and the round. However, research that quantifies how these different muscles maintain their color in the retail meat case is lacking. The main objective of this study was to determine the extent to which different types of packaging and retail display time affect the color stability of specific beef muscles.

Methodology

Phase 1: Biochemical Characterization of Color Stability of Beef Muscles

USDA Select beef subprimals were purchased from a commercial packing facility and shipped to the Rosenthal Meat Science and Technology Center at Texas A&M University. Subprimals were stored at 36°F until they reached 14 days of age. The subprimals and muscles utilized in this study were as follows:

Subprimals Utilized	Individual Muscles from Subprimal
NAMP 114C Beef Chuck, Shoulder Clod, trimmed	M. Infraspinatus (IF)
	M. Triceps brachii (TB)
	M. Teres major (TM)
NAMP 167A Beef Round, Knuckle, peeled	M. Rectus femoris (RF)
	M. Vastus lateralis (VL)
NAMP 169A Beef Round, Top (Inside), Cap off	M. Semimembranosus (SM)
NAMP 170A Beef Round, Bottom (Gooseneck), Heel Out	M. Biceps femoris (BF)
	M. Semitendinosus (ST)
NAMP 180 Beef Loin, Strip Loin, Boneless	M. Longissimus lumborum (LL)
NAMP 184 Beef Loin, Top Sirloin Butt, Boneless	M. Gluteus medius (GM)
NAMP 189A Beef Loin, Tenderloin, Full, side muscle on	M. Psoas major (PM)

After aging, subprimals were separated into individual muscles and cut into 1 inch thick steaks by cutting perpendicular to the muscle fiber orientation. Steaks were assigned randomly to one of four packaging systems:

- Polyvinyl Chloride (PVC)-Overwrap – 5 days lighted retail display;
- High-Oxygen MAP (80% O₂, 20% CO₂) – 4 days dark storage, 5 days lighted retail display;
- Low-Oxygen MAP (80% Nitrogen, 20% CO₂) – 4 days dark storage, 5 days lighted retail display;
- Low-Oxygen MAP (80% Nitrogen, 20% CO₂) – 9 days dark storage; and
- One of six display days (0-, 1-, 2-, 3-, 4-, and 5-days).

Steaks were assigned to PVC packaging and placed immediately into retail meat cases. Steaks packaged in High-Oxygen MAP and Low-Oxygen MAP were stored in boxes for 4 days at 36°F. After 4 days, MAP packages were placed into the retail meat case. Retail meat cases were stored in a 36°F cooler to maintain a more constant temperature and minimize the effects of temperature fluctuations on meat color characteristics. Steaks were then analyzed for color and chemical composition.

Phase II: Cooked Color Evaluation

After the allotted number of retail display days, steaks were removed and evaluated for cooked color analysis. Evaluation of raw color was conducted using a three-member panel of trained color evaluators. For cooked color analysis, steaks were cooked to an internal temperature of 140°F, allowed to rest for 5 minutes and cut in half. The degree of doneness was determined by trained personnel using the cooked meat color guide as a reference. Additionally, a Hunter MiniScan was used to objectively measure internal color characteristics of each steak.

Findings

pH, TBARS, Oxygen Penetration Depth, Metmyoglobin Reductase Activity, Myoglobin Content, Hunter L*a*b scores and Oxygen consumption rate

There were no significant differences in pH among the different muscles. The IF, TM, RF, and BF had TBARS (measure of rancidity) values in the latter storage days of the high-oxygen packaging that were rancid. This trend continued with the VL, TB, ST, SM and the GM, most likely due to the high-oxygen packaging. Oxygen penetration depth was greater for all storage days of the high-oxygen treatment in both the TB and LL. Myoglobin content was higher in the low-oxygen dark and low-oxygen light packaging treatment as compared to the high-oxygen treatment for most retail storage days in the TM, BF, ST, VL and RF. There were also observed differences in redness between the high-oxygen environment and the low-oxygen packaged steaks.

Discoloration

Discoloration significantly increased as storage day increased in the high-oxygen and PVC packages for the TB, SM, VL, BF, IF, GM, PM, and TM. Numerical increases (following the trends of the other muscles) in discoloration were seen in the RF but were not significant. These results were expected as steaks will discolor as length of retail display increases. Low-oxygen light and low-oxygen dark packaging treatments on a whole were not affected by length of retail display.

Degree of Doneness

There were observed differences between the high-oxygen MAP and the low-oxygen MAP. The PM, TB and SM displayed a higher degree of doneness when compared to the low-oxygen light and low-oxygen dark packaging treatments. There were observed differences in all the other muscles, but the differences were not statistically significant ($p < .05$). These findings are consistent with other studies that show that high-oxygen MAP is a contributor to premature browning.

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 high-oxygen MAP and PVC overwrapped (which is oxygen permeable) are contributors to discoloration during retail display and also contribute to premature browning when steaks are cooked. On the other hand, steaks packaged in low-oxygen MAP had lower levels of discoloration during retail display and did not exhibit the premature browning effect.

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