Project Summary

Accelerated Chilling and Packaging Effects on Enhanced Beef Round Muscles

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Study Completed
June 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 beef based on local preferences and buy a mix of 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.

Modified atmosphere packaging (MAP) has been around for a long time. Recent innovations in packaging films and equipment technology have expanded packaging options for whole muscles. Each system has its own advantages and disadvantages which necessitates careful consideration of all features when a packaging option is selected for a given beef product.

Recently, there has been a strong interest in the marketplace for enhanced beef products. In most cases, beef is pumped with a variety of compounds designed to enhance shelf life, texture, flavor, and consistency. The ingredients typically include salt, phosphate, sodium lactate, antioxidants/seasonings that protect both color and flavor stability. In turn, performance of enhanced products in modified atmosphere packages should be evaluated.

The objectives of this study were to: (1) Accelerate the postmortem chill rate of beef round muscles by hot boning the knuckle (*quadriceps*) early postmortem; (2) evaluate the effects of hot boning the knuckle on color, color stability, color uniformity, and other chemical, physical, and sensory attributes of enhanced steaks from the round; (3) determine the effects of high- and ultra-low oxygen modified atmosphere packaging on chemical, physical, and sensory properties of enhanced steaks from the beef round; (4) make directional comparisons between 6 and 10% enhancement levels; and (5) determine the effects of MAP on premature browning in enhanced beef round steaks when cooked to a medium degree of doneness.

Methodology

Fourteen beef carcasses (steers; A-maturity; quality grades select to choice; yield grades 2 and 3; weighing 750 to 850 pounds) were selected randomly from a commercial slaughter plant. Carcass sides were electrically stimulated and one side from each carcass was assigned randomly to a hot boning technique performed 60 to 90 min after stunning, and the other side remained intact until 48 hours postmortem. Postmortem temperature decline was monitored for 24 hours at various locations in each carcass.

Fabrication and processing

At 48-h postmortem, the *semimembranosus* (SM), *biceps femoris* (BF), and the whole knuckle were removed from both intact and hot-boned (HB) sides, trimmed to 0.1 inch of fat, weighed,

and vacuum packaged. Muscles were injected (approximately 5 days postmortem) using a multi-needle injector with a solution containing water, salt, phosphate, and natural flavorings containing rosemary. Sets of muscles (SM, BF, and knuckles) representing paired carcass sides (HB and chilled intact) were injected at 6% (n=7) in experiment 1 or 10% (n=7) of injected weight in experiment 2. Enhanced muscles were sliced into 1 inch thick steaks. Six knuckle steaks, consisting of both the *vastus lateralis* (VL) and RF muscles, were collected for packaging. Five steaks from sliced BF and SM were collected for packaging. Steaks from each muscle were assigned randomly for packaging in either high-oxygen modified atmosphere packaging (HiOx MAP, 80% O_2 / 20% CO_2), ultra-low oxygen modified atmosphere packaging (LoOx MAP, 80% N_2 / 20% CO_2), or vacuum packaging.

Packaging

Steaks were packaged for use as follows: (1) Vacuum packaged and aged for 14 days and used for shear force testing; (2) vacuum packaged and stored for 1 day and used for chemical analysis; (3) packaged in HiOx MAP or LoOx MAP and used for chemical analysis, color analysis and odor analysis; and (4) packaged in HiOx MAP or LoOx MAP and used for trained sensory panel evaluation.

Display

Steaks packaged in HiOx and LoOx MAP were displayed under simulated retail conditions. Steaks were evaluated for color at the beginning, middle and end of display and for odor at the end of display. Steaks packaged in HiOx MAP were displayed 5 days, and those used for sensory panel were displayed 2 days. Steaks packaged in LoOx MAP were displayed 3 d, and those used for sensory panel were displayed 1 day.

Sensory panel evaluations

After 2 days (HiOx MAP) or 1 day (LoOx MAP) of display, all steaks assigned for sensory panel evaluation were vacuum packaged, frozen, and stored at –4°F until evaluated. Steaks were thawed and cooked to an internal temperature of 160°F. A trained sensory panel (n=7) evaluated steaks on an 8-pont scale for tenderness, juiciness, beef flavor intensity, connective tissue amount, overall tenderness, and off-flavor. Panelists described off-flavors, if present, using either a provided list of potential descriptors or their own descriptors.

Findings

The postmortem chill rate within beef round muscles was accelerated by hot boning the knuckle (quadriceps) early postmortem.

- Chilling rate was accelerated in the *biceps femoris* (BF) and *rectus femoris* (RF) muscles.
- Chill rate also was accelerated in deep portions of the *semimembranosus* (SM) muscle allowing it to chill more similarly to superficial areas of the same muscle and to reduce the degree of two-toning, but the rate of chill was still not rapid enough to totally equalize color differences between the two regions.

Hot boning the knuckle improved color, color stability, color uniformity, and other chemical, physical, and sensory attributes of enhanced steaks from the round. Initial muscle color during display was darker for BF, VL, and RF muscles as result of a more rapid chill of these muscles.

- More rapid chill improved surface color uniformity in the BF.
- The RF was the muscle with the most improved color and color stability due to accelerated chilling for 6% injected cuts. For 10% injected cuts, the VL was most improved.
- Display yields were slightly higher (approximately 1%) for hot-boned BF and knuckle steaks than cold-boned counterparts.
- Hot boning the knuckle had minimal effect on sensory panel attributes and shear force with no conclusive trends evident.
- Hot boning did not impart cold toughening.

High- and ultra-low oxygen modified atmosphere packaging affected chemical, physical, and sensory properties of enhanced steaks from the beef round.

- Steaks in HiOx had more intense initial bloomed color, a brighter cherry red appearance, and improved color stability during display compared to steaks in LoOx.
- Oxidation of steaks in HiOx packaging was significantly higher than for LoOx.

Oxidation of 6% injected cuts in HiOx packaging resulted in an increase of rancid flavors and a decrease in beef flavor intensity.

- Tenderness was increased and the perception of connective tissue decreased in LoOx packaging, likely due to longer storage times that allowed for extended aging to occur.
- Steaks in HiOx prematurely browned, appearing well done (brown throughout) with no pink remaining when cooked to a medium degree of doneness.
- Steaks in LoOx had a cooked appearance that consumers would typically expect (slightly pink when cooked to a medium degree of doneness).

Other notable findings:

- Significant color differences were noted between VL and RF (in the knuckle steak) for all treatments. The VL was darker, redder, and more yellow and saturated than the RF. This could have negative implications on marketing because these muscles are typically merchandized together in a single steak.
- No treatments affected odor or microbiology counts; each were minimal for both 6% and 10% injected cuts, and did not negatively impact any results.
- The RF was the tenderest muscle in the study and had the least connective tissue.
- The BF was the least tender and had the highest perception of connective tissue.

Casual observations comparing 6 and 10% injection levels are:

- Steaks from muscles injected at 10% had darker initial beef color and visual color during display. Two-toned color and color stability were similar for the two injection levels.
- Display and cook yields for steaks injected at 10% were similar to steaks injected 6% indicating the muscles were able to retain the higher injection levels without creating excessive package purge and cook loss.
- Oxidation decreased and subsequently improved flavor and off-flavor scores in HiOx steaks injected at 10%, likely due to increased levels of antioxidant (rosemary).

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 hot boning the beef knuckle is a commercially feasible process that will improve the quality and performance of enhanced beef round muscles in modified atmosphere packaging. The technique could alleviate color issues with cuts from the round that confront the industry. Both the HiOx and LoOx systems worked in this study, however, while (HiOx) provides excellent color and color stability, (LoOx) allows for greater shelf life and improved sensory characteristics. One drawback to HiOx packaging is the effect of premature browning. Consumers may discriminate against products that do not yield the expected cooked color, and may undercook it in order to achieve the desired pink color.

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