

## **Project Summary**

### **Improving Quality of Beef Round Muscles Packaged in High-Oxygen Modified Atmosphere through Early Postmortem Calcium Lactate Enhancement**

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# Improving Quality of Beef Round Muscles Packaged in High-Oxygen Modified Atmosphere through Early Postmortem Calcium Lactate Enhancement

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### Background

There is an urgent need to enhance the quality of underutilized beef round cuts. Reducing the incidence of product defects such as inadequate tenderness, discoloration and off-flavor of these cuts will add significant value to each carcass. This study combines two approaches to meet this need: Modified atmosphere packaging (MAP) system and enhancement with calcium lactate. MAP systems with a high oxygen (80%) level are widely used in retail meat markets because the bright red color of meat in this packaging system attracts consumers. However, published studies have shown that high oxygen levels are likely to increase incidence of oxidative changes in the meat and consequently accelerate surface discoloration and decrease desirable flavors of the meat. Oxidizing conditions inhibits calpains, calcium-activated proteases, which results in decrease in tenderness during normal postmortem aging of beef. Other studies have determined that myosin, the most abundant protein in muscle tissue, is susceptible to oxidation resulting in intermolecular cross-linking and aggregation of the protein, which subsequently decreases tenderness of meat packaged in high oxygen MAP. This is quite troubling as high oxygen MAP packaging systems have a lot to offer the industry. Lactate injection is commonly used in fresh meat (typically injected between 7 to 14 d of postmortem), because it increases juiciness, flavor, tenderness, and color stability. However, the effects on meat quality of applying calcium lactate to early postmortem (within 24 hrs of exsanguination) muscle has never been investigated. Early activation of the calpain system by calcium inclusion, namely  $\text{CaCl}_2$  has a dramatic effect on meat tenderness. However, inclusion of  $\text{CaCl}_2$  also results in increasing oxidative deterioration of meat. Since calcium lactate has a strong antioxidant capacity, it was proposed that calcium lactate addition to early postmortem muscle can not only activate calpain, but prevent early postmortem oxidative inactivation of  $\mu$ -calpain in high-oxygen MAP systems, consequently increasing meat tenderness, and may also enhance meat flavor by decreasing lipid oxidation.

### Methodology

Ten market weight beef cattle were harvested at the Iowa State University Meat Laboratory. The *semimembranosus* (SM), *semitendinosus* (ST), and *adductor* (AD) muscles from each round and the *longissimus dorsi* (LD) were removed from each carcass within 24 hours after slaughter. The LD was used as a reference sample. Two different packaging types (HiOx-MAP or vacuum) were randomly assigned to each side of the carcasses. Each round muscle (SM, ST, and AD) was divided into three sections of equal dimensions, and three enhancement treatments [control (CON), 0.3% sodium tripolyphosphate (STP), 0.2 M calcium lactate with 0.3% phosphate (CAL)] were randomly assigned to each sub-divided piece. The AD muscle was divided to two sections, which were assigned to either STP or CAL, due to its size limitation. The pH of each of the muscles was measured using a glass tipped pH electrode prior to the injection enhancement. The pH of enhancement solutions containing one or more of the following was measured: distilled water, calcium L-lactate (PURACAL; PURAC America, Inc., Lincolnshire, IL), and sodium tripolyphosphate (Brifisol<sup>®</sup> 512; BK Giulini Corp; Simi Valley, CA). Sequential injections of calcium lactate followed by phosphate were applied (Kim and others, 2008) at 12% of raw weight since

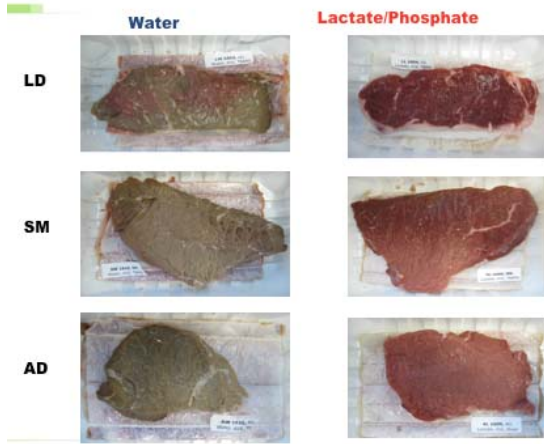
phosphates chelate calcium in solution if mixed together. After injection, subprimal cuts were sliced (2.54 cm thick steaks) into steaks for vacuum packaging (day 1). After nine days of the vacuum packaged (VAC) storage in a dark cold room (1°C), steaks assigned for MAP packaging were opened from the vacuum packages, re-packaged with the HiOx-MAP (80% O<sub>2</sub>/ 20% CO<sub>2</sub>), and then displayed for seven days at 1 °C under 2150 lux of fluorescent natural white light (until day 16). Steaks assigned for VAC packaging remained in the vacuum packaged bags for nine day storage and additional seven days display (day 16) at 1°C under the same display condition. Surface color (CIE *a*\* values) for initial (day 1; 48 hour of postmortem) and at the end of display (day 16) of each steak was measured using a HunterLab LabScan® XE Spectrophotometer (Illuminant A, 2.54 cm diameter aperture, 10° standard observer; Hunter Associates Laboratory, Inc., Reston, VA). Meat pH for each steak from day one and day 16 was measured by a penetration probe on three different locations of per steak. Lipid oxidation of steaks from day 16 was determined using the 2-thiobarbituric acid (TBA) distillation method described by Tarladgis et al. (1960). A trained sensory panel (n=6) evaluated sensory characteristics (Lonergan et al., 2007) of steaks from day 16. Sensory traits including tenderness, chewiness, juiciness, metallic flavor, beef flavor and off-flavor (rancidity) were evaluated using a 15-cm line scale (1 = not tender, chewy, juicy, low beef flavor; 0 = no off-flavor; 15 = very tender, chewy, juicy, high beef flavor, **high off-flavor**). The steaks were cooked on clamshell grills to an internal temperature of 71°C. Star probe analysis of steak samples from day one and day 16 was measured by following the procedure of Lonergan et al. (2007).

## **Findings**

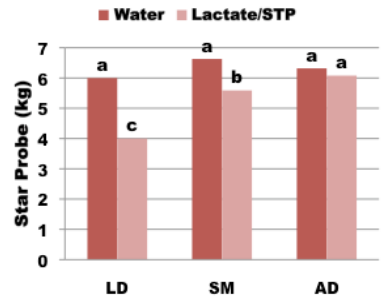
The results from the current study determined that high oxygen modified atmosphere packaging system can induce more oxidative conditions, which negatively influence myoglobin and lipid oxidation stability, tenderness and other sensory traits of beef cuts. However, the results also found that addition of calcium lactate with phosphate to early postmortem muscles significantly improved tenderness, chewiness and lipid oxidation stability of underutilized beef round cuts packaged in high-oxygen modified atmosphere packaging conditions. Further, the combination enhancement of calcium lactate and sodium tripolyphosphate had more synergistic effects on beef tenderness development and oxidation stability than the sodium tripolyphosphate only treatment under high oxygen modified atmosphere packaging conditions. Increased meat tenderness development under the oxidative condition could be related to early activation of calpain enzyme system and earlier tenderization by breaking down the structure of the muscle and/or inhibition of protein/lipid oxidation through calcium lactate addition to early postmortem beef muscles. In either case, the addition of calcium lactate and sodium tripolyphosphate appear to be beneficial in maintaining and improving the quality of beef round muscle in high oxygen modified atmosphere packaging systems

## **Implications**

Overall, early activation of calpain system and inhibition of protein/lipid oxidation through calcium lactate is expected to enhance muscle color, flavor and/or tenderness of underutilized beef rounds packaged in high oxygen MAP. Further, elucidation and manipulation of biochemical mechanisms regulating bovine muscle color, flavor and/or tenderness enable greater utilization of muscles. This will consequently increase the profitability of the fresh meat industry and offer consumers more consistent quality. It is important to note that this new knowledge will help the industry and research community have a better understanding of the biochemical processes that govern tenderness development. This new knowledge will contribute to solving a wide range of meat tenderness and color issues and will have long term implications to the industry.



**Lactate/phosphate enhancement improved tenderness values for LD and SM in HIOX-MAP**



<sup>abc</sup>Means having different letters are different ( $p < 0.05$ ).

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