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Packaging atmospheres alter beef tenderness, fresh color stability, and internal cooked color

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PACKAGING ATMOSPHERES ALTER BEEF TENDERNESS, FRESH COLOR STABILITY, AND INTERNAL COOKED COLOR[1]

J. P. Grobbel, M. E. Dikeman, M. C. Hunt, and G. A. Milliken[2]

Introduction

Several meat quality traits affect consumers' overall purchase decisions and satisfaction with meat products, but color is the major factor affecting purchasing decisions. According to some researchers, tenderness is the most important palatability attribute in consumers' overall eating experience. Case-ready packaging in the meat industry is growing at a rapid rate and generally includes modified atmosphere packaging (MAP) with specific gases. Advantages of MAP include use of a centralized location, improved sanitation control, more consistent products, and increased marketing flexibility. Packaging beef in high-oxygen (HiO_2) MAP results in a desirable bright red lean color but can have detrimental effects on other quality traits, including increased off-flavors and decreased tenderness. Use of carbon monoxide (CO) has been approved by USDA and the Food and Drug Administration for use at levels up to 0.4% in retail MAP. Products in MAP that include CO have improved beef color stability and extended display time.

Premature browning, originally discovered in ground beef, results when meat is cooked to temperatures lower than what is necessary to kill harmful pathogens but appears well done internally. This phenomenon is also found in whole muscle steaks and can be attributed to packaging environments, including HiO_2 MAP. Therefore, objectives of our study were to evaluate the effects of different gas compositions in different MAP systems vs. vacuum packaging on grain finished beef tenderness, display color stability, and internal cooked color.

Experimental Procedures

Strip loins (n=14 pairs) from USDA Select, A-maturity carcasses were assigned to either 14 day tenderness measurement or to display and then 18 or 28 day tenderness measurement. Loins were fabricated on day 7 postmortem into 1-inch-thick steaks. Seven steaks from the anterior end of the strip loin were cut and assigned to one of six packaging treatments or to initial tenderness measurement. Steaks 8-10 were cut posterior to the first seven steaks, cut in half and assigned to a packaging treatment, and used for internal cooked color determination. One full steak was used for initial tenderness. Packaging treatments were: vacuum packaging (VP); 80% O_2/20% CO_2 (HiO_2); 0.4% CO/35% CO_2/64.6%N_2 (ULO_2CO); 0.4% CO/99.6% CO_2 (ULO_2COCO_2); 0.4% CO/99.6% N_2 (ULO_2CON_2); or 0.4% CO/99.6% Ar (ULO_2COAr). Steaks packaged in HiO_2 MAP were held in dark storage at 35.6°F for 4 days,

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and all other steaks were held in the dark at 35.6°F for 14 days. Steaks were then displayed under fluorescent lighting for 7 days with instrumental color measured on day 0 and 7 of display. Ten trained color panelists assigned color scores. Instrumental tenderness was measured using Warner-Bratzler shear force (WBSF). Steaks for WBSF and cooked color were cooked to 158°F.

Results and Discussion

There was a packaging treatment × day interaction (P<0.01) for WBSF (Figure 1). Warner-Bratzler shear force values from strip loin steaks indicate that, as a system, HiO_2 MAP at day 18 postmortem resulted in steaks being less tender than those packaged in ULO_2 with CO MAP or VP at day 28 postmortem. On day 14 postmortem, WBSF was similar (P>0.05), and all treatments were more tender (*P*<0.01) on day 14 postmortem than on day 7 postmortem. Conversely, steaks packaged in HiO_2 MAP were less tender (*P*<0.05) than other treatments at the end of display, likely due to 10 days less aging time (18 vs. 28 days postmortem) resulting from a shorter dark storage period (4 days) for HiO_2 MAP than for ULO_2CO MAP and VP treatments (14 days). Steaks packaged in all packaging treatments used for 14 days postmortem WBSF were held for 7 days in the dark and then cooked for WBSF measurement. Dark storage times for HiO_2 and ULO_2 atmospheres were designed to replicate industry practice.

There was a packaging treatment × day interaction (P<0.001) for display visual color (Figure 2). Display color scores indicated that steaks from all treatments became darker (P<0.05) as day of display increased, as was expected. Steaks packaged in HiO_2 MAP were slightly brighter (*P*<0.05) according to display color scores than steaks packaged in ULO_2COAr or ULO_2CO MAP on day 0 of display. Vacuum-packaged steaks had the most consistent display color throughout the 7 days of display and changed only from bright purplish red or pink to dull purplish red or pink during the entire display period. Steaks in VP were expected to be stable in color and not change much throughout the 7 days of display; however, many consumers find the purplish red color of VP meat undesirable regardless of the consistent display color. Steaks packaged in HiO_2 MAP were an undesirable reddish tan by day 7 of display, whereas steaks packaged in the ULO_2CO MAP treatments were either dull red or slightly dark red by day 7 of display.

There was a packaging treatment × day interaction (P<0.001) for discoloration scores (Figure 3). Steaks packaged in VP or the four ULO_2 MAP blends with CO had little or no surface discoloration over the 7 days of display. Steaks packaged in HiO_2 MAP discolored faster (P<0.05) and to a greater extent (P<0.05) than those packaged in any of the ULO_2 MAP or VP treatments. Steaks packaged in HiO_2 MAP discolored (P<0.05) by day 4 of display and had 56% more (P<0.05) metmyoglobin discoloration than steaks packaged in any other packaging treatment. Including O_2 in the package allowed for oxidation of myoglobin and thus resulted in a reddish tan color by day 7 of display. Excluding O_2 from the package, as with VP or ULO_2CO MAP treatments, allows myoglobin to remain in a more stable form (red) longer and delays the onset of metmyoglobin (tan/brown) color formed through oxidation of myoglobin.

There was a packaging treatment main effect (P<0.001) for internal cooked color as assessed by a* value and saturation index (Figure 4). Steaks packaged in HiO_2 had the lowest (P<0.05) a* values (brownest) for internal cooked color of all packaging treatments. Steaks packaged in ULO_2COCO_2 and in VP had intermediate a* values, and those packaged in ULO_2COAr, ULO_2CO, and ULO_2CON_2 had the highest (P<0.05) a* values (reddest). Premature browning is defined by internal cooked color of meat that is brown at temperatures where it should still appear red

in color and is related to the oxidative state of meat prior to cooking. Results indicated that steaks packaged in ULO_2COAr, ULO_2CO, and ULO_2CON_2 MAP had a redder ($P<0.05$) internal cooked color than steaks packaged in VP. Steaks were cooked to a medium degree of doneness (158°F), which should result in a pinkish internal color. Steaks packaged in HiO_2 MAP were brown inside at this temperature. This could pose a definite safety risk, especially if consumers cook intact steaks to an internal color and do not use a meat thermometer to determine a safe endpoint cook temperature.

In conclusion, results from this study indicated that steaks packaged in HiO_2 MAP have less display color stability than all other packaging treatments evaluated because they discolor faster and to a greater extent. Ultra-low oxygen + CO MAP and VP steaks had better fresh color stability and equal or better tenderness than steaks packaged in HiO_2 MAP. Packaging atmospheres altered internal cooked color, with steaks packaged in HiO_2 MAP exhibiting premature browning. Strip loin steaks packaged in the HiO_2 MAP system were less tender at the end of display than other packaging treatments, perhaps due to the shorter aging time associated with the HiO_2 MAP system.

Implications

Packaging beef in ULO_2CO MAP provides a bright red color with extended display color stability, allows for a longer aging time and increased tenderness, and results in an internal cooked color that is expected for a medium degree of doneness, all of which would are beneficial to the meat industry.

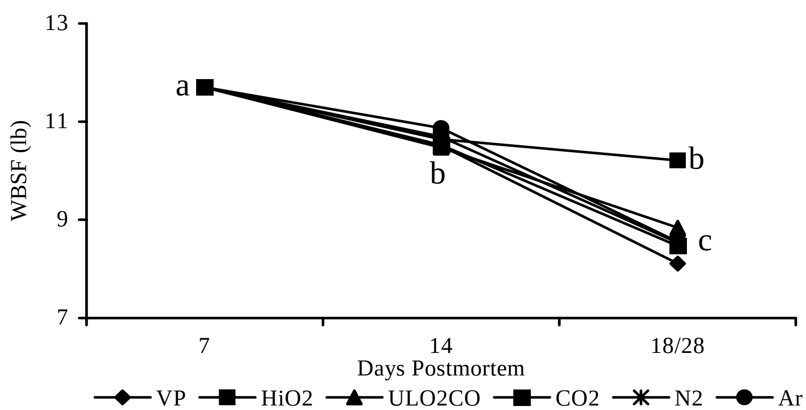

Figure 1. Packaging Treatment × Day Warner-Bratzler Shear Force Means for Strip Loin Steaks Packaged in Different Atmospheres.

[abc]Means without a common superscript letter differ ($P<0.05$).

VP = vacuum packaging; HiO_2 = 80%/O_2, 20%CO_2; ULO_2CO = 64% N_2, 35% CO_2, 0.4% CO; CO_2 = 99.6% CO_2, 0.4% CO; N_2 = 99.6% N_2, 0.4% CO; Ar = 99.6% Ar, 0.4% CO.

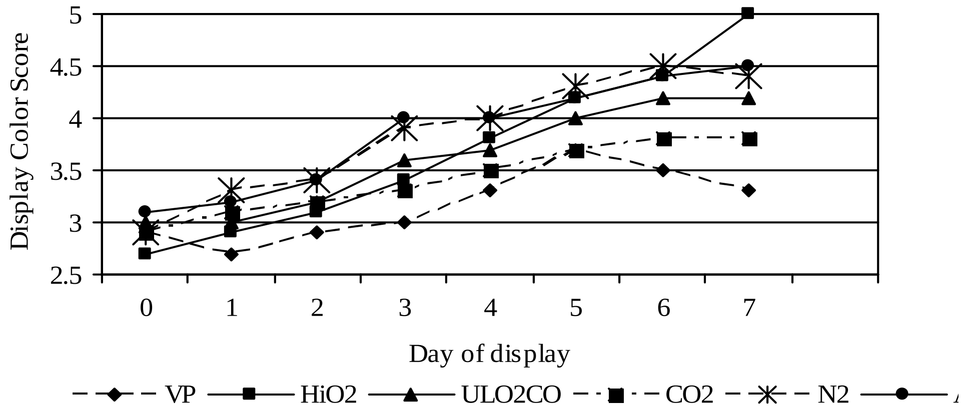

Figure 2. Display Color Score Means for Strip Loin Steaks Packaged in Different Atmospheres.

VP = vacuum packaging; HiO_2 = 80%/O_2, 20%CO_2; ULO_2CO = 64% N_2, 35% CO_2, 0.4% CO; CO_2 = 99.6% CO_2, 0.4% CO; N_2 = 99.6% N_2, 0.4% CO; Ar = 99.6% Ar, 0.4% CO.

Color score scale: 2 = bright red or pinkish red; 5 = reddish tan or pinkish tan.

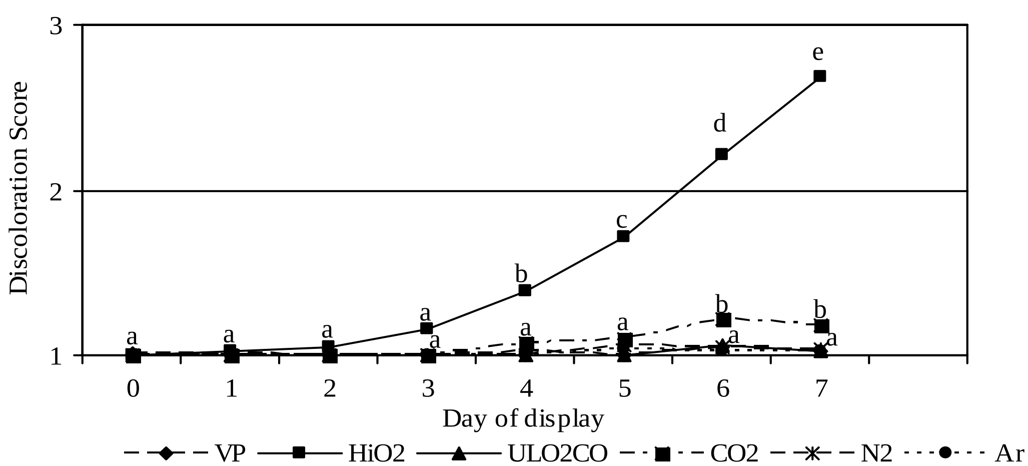

Figure 3. Display Discoloration Score Means for Strip Loin Steaks Packaged in Different Atmospheres.

[abc]Means without a common superscript letter differ ($P<0.05$).

VP = vacuum packaging; HiO_2 = 80%/O_2, 20%CO_2; ULO_2CO = 64% N_2, 35% CO_2, 0.4% CO; CO_2 = 99.6% CO_2, 0.4% CO; N_2 = 99.6% N_2, 0.4% CO; Ar = 99.6% Ar, 0.4% CO.

Discoloration score: 1= 0%, 2=1-19%, 3=20-39% metmyoglobin.

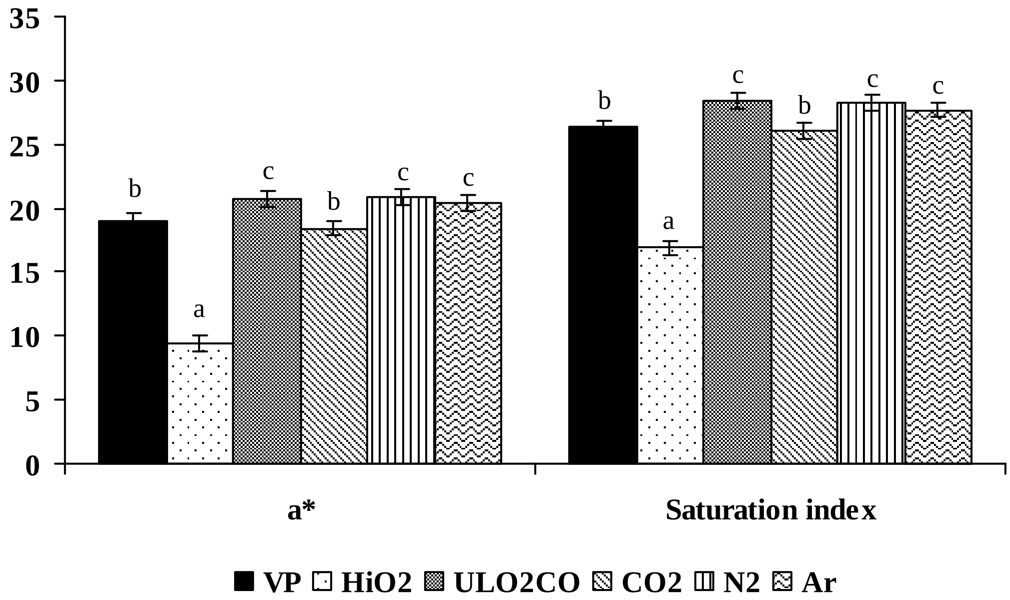

Figure 4. Instrumental Internal Cooked Color Means for Strip Loin Steaks Packaged in Different Atmospheres.

[abc]Means without a common superscript letter differ ($P<0.05$).

VP = vacuum packaging; HiO_2 = 80%/O_2, 20%CO_2; ULO_2CO = 64% N_2, 35% CO_2, 0.4% CO; CO_2 = 99.6% CO_2, 0.4% CO; N_2 = 99.6% N_2, 0.4% CO; Ar = 99.6% Ar, 0.4% CO.