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Abstract

Case-ready meat provides many benefits, including quality and safety. Meat packaged in high-oxygen (HiO2) modified atmosphere packaging (MAP) has a desirable bright red display color but may have increased off-flavors and decreased tenderness. According to several international research reports, steaks aged and packaged in HiO2 MAP had more off-flavor, including warmed-over flavor, and were less tender and juicy than steaks aged in vacuum packaging (VP). Research at Kansas State University found that injection-enhanced beef quadriceps muscles packaged in HiO2 MAP were less tender and had more offflavors than those in ultra-low oxygen MAP. Detrimental effects of O2 on tenderness might be caused by protein oxidation. Oxidation of beef muscle proteins early postmortem inactivates the primary enzyme (Î¼-calpain) necessary to break down proteins postmortem, which results in decreased myofibrillar proteolysis and limited tenderization. Injection-enhancement improves tenderness and juiciness while decreasing variation and often is used in conjunction with MAP. Several studies have reported that enhanced steaks were more tender and juicy than non-enhanced steaks. Several researchers found an increase in beef flavor associated with enhanced steaks, but others have reported a decreased or no change in beef flavor. Offflavors associated with enhanced beef include salty and oxidative. Objectives of our study were to determine the effects of packaging atmosphere and injection-enhancement on beef strip loin, eye of round, and chuck clod tenderness, sensory traits, and desmin degradation.

Keywords

Cattlemen's Day, 2008; Kansas Agricultural Experiment Station contribution; no. 08-212-S; Report of progress (Kansas State University. Agricultural Experiment Station and Cooperative Extension Service); 995; Beef; Cattle; Modified atmosphere packaging (MAP); Injection-enhancement; Beef tenderness; Sensory traits

PACKAGING ATMOSPHERES AND INJECTION ENHANCEMENT AFFECT BEEF TENDERNESS AND SENSORY TRAITS[1]

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Introduction

Case-ready meat provides many benefits, including quality and safety. Meat packaged in high-oxygen (HiO_2) modified atmosphere packaging (MAP) has a desirable bright red display color but may have increased off-flavors and decreased tenderness. According to several international research reports, steaks aged and packaged in HiO_2 MAP had more off-flavor, including warmed-over flavor, and were less tender and juicy than steaks aged in vacuum packaging (VP). Research at Kansas State University found that injection-enhanced beef quadriceps muscles packaged in HiO_2 MAP were less tender and had more off-flavors than those in ultra-low oxygen MAP. Detrimental effects of O_2 on tenderness might be caused by protein oxidation. Oxidation of beef muscle proteins early postmortem inactivates the primary enzyme (μ-calpain) necessary to break down proteins postmortem, which results in decreased myofibrillar proteolysis and limited tenderization.

Injection-enhancement improves tenderness and juiciness while decreasing variation and often is used in conjunction with MAP. Several studies have reported that enhanced steaks were more tender and juicy than non-enhanced steaks. Several researchers found an increase in beef flavor associated with enhanced steaks, but others have reported a decreased or no change in beef flavor. Off-flavors associated with enhanced beef include salty and oxidative. Objectives of our study were to determine the effects of packaging atmosphere and injection-enhancement on beef strip loin, eye of round, and chuck clod tenderness, sensory traits, and desmin degradation.

Experimental Procedures

Strip loins (SL; n=12 pairs); eye of rounds (ER; n=12 pairs); and clods (CC; 12 pairs from the same carcasses as the SL and ER plus 12 additional pairs) were obtained from the same USDA Select A-maturity carcasses. On day 7 postmortem, each muscle from one side of the carcass was injection-enhanced with a commercial solution (beef broth, potassium lactate, sodium phosphate, salt, and rosemary), and each muscle from the other side was non-enhanced. One-inch-thick steaks were cut from the muscles and packaged in VP; ultra-low oxygen with CO (ULO_2CO) (0.4% CO/35% CO_2/69.6% N_2) MAP; or high-oxygen MAP (HiO_2) (80% O_2/20% CO_2) and assigned to 7 or 14 day tenderness measurement postmortem or display followed by 18 or 28 day tenderness measurement post-

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mortem. Steaks packaged in HiO_2 MAP were held in dark storage at 36°F for 4 days while all other steaks were stored for 14 days in the dark at 36°F before display under fluorescent lighting. Steaks for Warner-Bratzler shear force (WBSF), sensory panel evaluation (1 = extremely tough, dry or bland; 8 = extremely tender, juicy and intense; n=8 trained panelists) at 18 (HiO_2) or 28 days (ULO_2CO and VP) postmortem, and desmin degradation were cooked to 158°F before analysis.

Results and Discussion

Targeted injection-enhancement pump levels were 10%. After approximately 30 minutes of initial injection and just prior to fabrication, pump level was 10.7% for the SL, 8.2% for the ER, and 13.0% for the CC.

Tenderness, according to WBSF, resulted in a packaging treatment × day interaction ($P<0.01$, Figure 1). Steaks packaged in HiO_2 MAP were less tender at the end of display (day 18 postmortem) than steaks packaged in VP or ULO_2CO MAP (day 28 postmortem). Because there was no difference on day 14 postmortem, we attributed the difference in tenderness primarily to the fewer days postmortem associated with HiO_2 MAP at the end of display. The different storage times used for the two MAP treatments are similar to current industry procedures.

There was a muscle × enhancement treatment × day interaction ($P<0.05$) in which steaks from enhanced muscles were more tender ($P<0.05$) than non-enhanced steaks (Figure 2). Tenderness increased with time postmortem (day 14 to 18/28) in enhanced SL and CC steaks but not in ER steaks. Non-enhanced steaks were similar in tenderness on day 7 and 14 postmortem but were more tender on day 18/28 postmortem for all muscles. Enhanced SL steaks were more tender ($P<0.05$) than non-enhanced steaks on day 7 postmortem, which was day 0 of packaging. This indicates that injection-enhancement has an immediate effect on tenderness. Injection-enhancement might increase tenderness through water binding, a dilution effect, or through physically altering the muscle structure with the injection needling process; however, the exact method of action is currently unknown.

There was an enhancement treatment × packaging treatment interaction for myofibrillar tenderness ($P<0.05$), beef flavor and off-flavor ($P<0.01$), and overall tenderness ($P<0.05$) (Figures 3 and 4). According to sensory panelists, non-enhanced steaks packaged in HiO_2 MAP were less tender and had less beef flavor and more off-flavors ($P<0.05$) than those packaged in ULO_2CO MAP and VP. The SL (5.9 ± 0.1) and CC (6.0 ± 0.1) were more tender according to myofibrillar tenderness ($P<0.05$) than the ER (5.1 ± 0.1). Enhanced steaks packaged in VP had more ($P<0.05$) beef flavor than those packaged in HiO_2 MAP.

The main effect ($P<0.01$) for juiciness revealed that enhanced steaks (5.7 ± 0.1) were juicier ($P<0.05$) than non-enhanced steaks (5.1 ± 0.1). The muscle main effect ($P<0.01$) for juiciness resulted in steaks from SL (5.5 ± 0.2) and CC (5.9 ± 0.1) muscles being juicier ($P<0.05$) than steaks from ER (5.0 ± 0.2) muscles. There was a packaging treatment main effect ($P<0.01$) for juiciness. Steaks packaged in HiO_2 MAP (5.3 ± 0.1) were less juicy ($P<0.05$) than steaks packaged in ULO_2CO MAP (5.6 ± 0.1), whereas steaks packaged in VP (5.4 ± 0.1) were intermediate and not different in juiciness from steaks packaged in HiO_2 and ULO_2CO MAP.

There was a main effect ($P<0.01$) for perceptible connective tissue for the enhancement treatment and muscle. Enhanced (6.6 ± 0.1) steaks had less ($P<0.05$) perceptible connective tissue than non-enhanced (6.1 ± 0.1)

steaks (lower score = more connective tissue). The ER (5.9 ± 0.1) had more ($P<0.05$) perceptible connective tissue than the CC (6.4 ± 0.1), which had more ($P<0.05$) perceptible connective tissue than the SL (6.7 ± 0.1). There was also a main effect ($P<0.01$) for packaging treatment for connective tissue in which steaks packaged in HiO_2 MAP (6.2 ± 0.1) had more ($P<0.05$) perceptible connective tissue than steaks packaged in ULO_2CO MAP (6.4 ± 0.1) and VP (6.4 ± 0.1).

The most common off-flavors associated with steaks packaged in HiO_2 MAP were oxidative or rancid. Enhanced steaks had more ($P<0.05$) off-flavors than non-enhanced steaks, with typical descriptors of salty and metallic or chemical. Comments on many of the enhanced steaks indicated an undesirable mushy texture.

There was a muscle × enhancement treatment interaction for beef flavor ($P<0.05$) and off-flavor ($P<0.05$) (Figure 5). Enhanced CC steaks had more ($P<0.05$) beef flavor than enhanced ER steaks. Oxidative off-flavors associated with steaks packaged in HiO_2 MAP were expected because the O_2 present in the package atmosphere allows for more rapid and a greater extent of oxidation of proteins and lipids found in meat. Eliminating O_2 from the package environment, as done with VP or ULO_2CO MAP, drastically decreases the rate and extent of oxidation, resulting in fewer off-flavors and increased beef flavor.

There was a muscle × enhancement (day) interaction ($P<0.001$) for desmin degradation (data not shown). Desmin degradation in non-enhanced and enhanced steaks was similar ($P>0.05$). There was a day postmortem main effect ($P<0.001$) for desmin degradation, with day 14 postmortem (36.09% ± 2.9) having more ($P<0.05$) degradation than day 7 (23.67% ± 3.3). The SL desmin degradation increase ($P<0.05$) from day 7 to day 14 was independent of enhancement treatment. Strip loin steaks had more ($P<0.05$) degradation of desmin at day 14 than the ER or CC, regardless of enhancement treatment. Desmin degradation was not affected ($P>0.05$) by packaging type (data not presented) but was affected ($P<0.05$) by time postmortem.

In summary, more off-flavors were associated with enhanced steaks than non-enhanced steaks. Enhanced steaks were juicier and had less perceptible connective tissue than non-enhanced steaks. Steaks packaged in HiO_2 MAP were less tender according to sensory panelists and had more off-flavors than those packaged in either ULO_2CO MAP or VP. Sensory panelists found steaks packaged in HiO_2 MAP to be less tender than steaks packaged in VP or ULO_2CO MAP on day 18 postmortem, but WBSF results from steaks on day 14 postmortem were not different. Packaging treatment did not affect desmin degradation, which is a measure of tenderization during aging. Desmin degradation differed between SL and CC muscles, but these two muscles were similar in tenderness. Desmin degradation did not differ between control and enhanced muscles, yet enhanced steaks were much more tender than control steaks.

Implications

Differences in desmin degradation of different muscles might not be related to tenderness differences across muscles. Injection enhancement is expected to improve tenderness, but not because of increased desmin degradation. Packaging steaks in ULO_2CO MAP and VP would likely result in optimum tenderness and minimal off flavors compared with HiO_2MAP, but the purplish-red color of VP steaks generally is not acceptable to consumers.

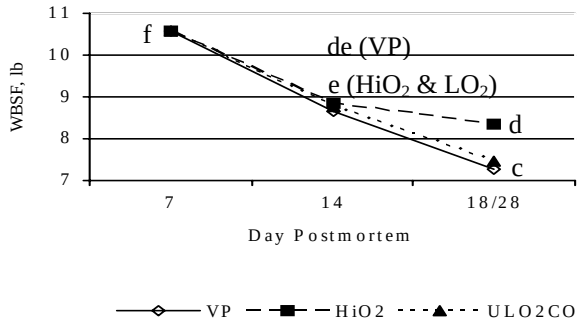

Figure 1. Packaging Treatment[a] x Day[b] Warner-Bratzler Shear Force Means for Strip Loin (SL), Eye of Round (ER), and Clod (CC) Steaks Packaged in Different Atmospheres

[a]HiO_2 = 80% O_2, 20% CO_2; ULO_2CO = 0.4% CO/35% CO_2/64.6%N_2; VP = vacuum packaging.
[b]Day 18 postmortem for the HiO_2 treatment and day 28 postmortem for the ULO_2CO and VP treatments
[cdef]Means without a common superscript letters differ (P<0.05).

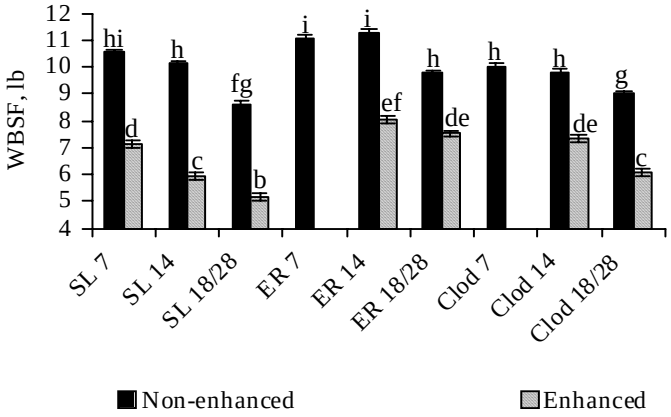

Figure 2. Muscle x Enhancement x Day[a] Warner-Bratzler Shear Force Means for Strip Loin (SL), Eye of Round (ER), and Clod (CC) Steaks.

[a]Days postmortem = 7, 14, or 18/28 (18 days postmortem for the HiO_2 treatment and 28 days postmortem for the ULO_2CO and VP treatments).
[bcdefghi]Means without a common superscript letter differ (P<0.05).

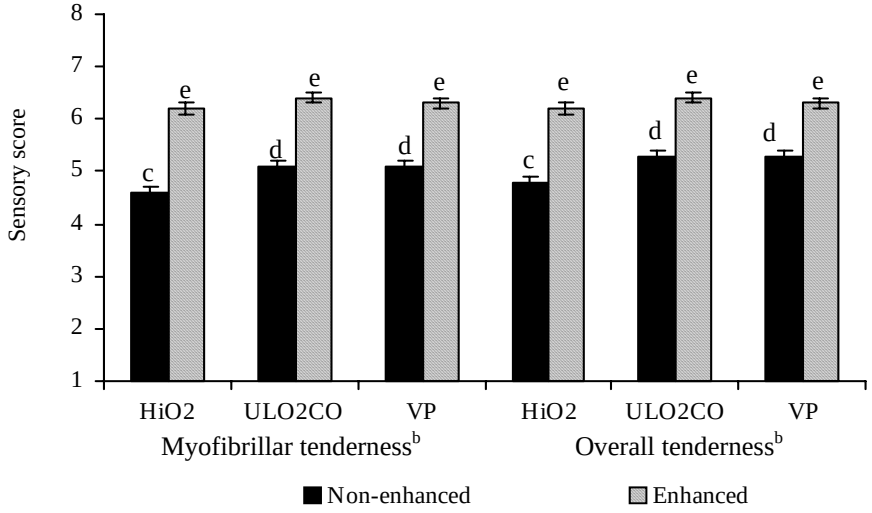

Figure 3. Enhancement x Packaging Treatment[a] Myofibrillar Tenderness and Overall Tenderness Means for Strip loin (SL), Eye of Round (ER), and Clod (CC) Steaks.

[a]HiO_2=80% O_2, 20% CO_2; ULO_2CO=0.4% CO/35% CO_2/64.6%N_2; VP=vacuum packaging.
[b]Tenderness: 1=extremely tough, 4=slightly tough, 6=moderately tender, 8=extremely tender.
[cde]Means within sensory traits without a common superscript letter differ (P<0.05).

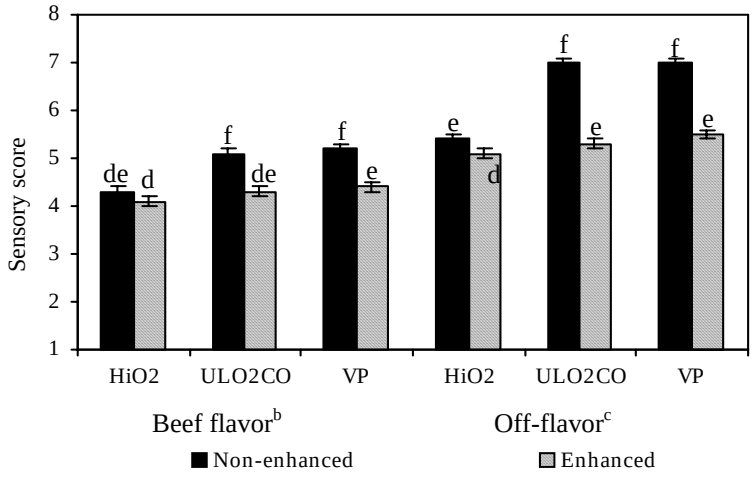

Figure 4. Enhancement x Packaging Treatment[a] Beef Flavor and Off-flavor Means for Strip Loin (SL), Eye of Round (ER), and Clod (CC) Steaks.

[a]HiO_2=80% O_2, 20% CO_2; ULO_2CO=0.4% CO/35% CO_2/64.6%N_2; VP=vacuum packaging.
[b]Beef Flavor: 1=extremely bland, 4=slightly bland, 6=moderately intense, 8=abundant
[c]Off-flavor:1=abundant, 5=slight, 6=traces, 7=practically none, 8=none.
[def]Means within sensory traits without a common superscript letter differ (P<0.05).

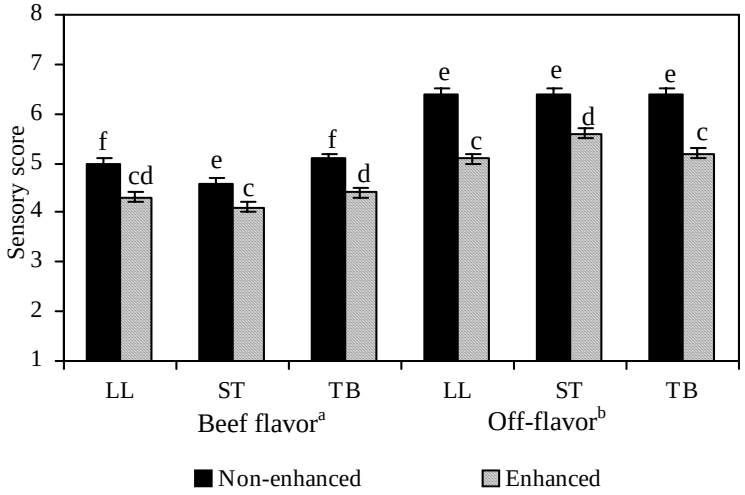

Figure 5. Muscle x Enhancement Beef Flavor and Off-Flavor Means for Strip Loin (SL), Eye of Round (ER), and Clod (CC) Steaks.

[a]Beef Flavor: 1=extremely bland, 4=slightly bland, 6=moderately intense, 8=abundant.
[b]Off-flavor: 1=abundant, 5=slight, 6=traces, 7=practically none, 8=none.
[cdef]Means within sensory traits without a common superscript letter differ (P<0.05).