DIFFERENT PACKAGING ENVIRONMENTS ALTER TENDERNESS AND SENSORY TRAITS FROM NON-ENHANCED AND INJECTION-ENHANCED BEEF

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Introduction

Case-ready meat provides many benefits, including better microbial control and extended shelf life. Packaging meat in high-oxygen (HiO_2) modified atmosphere packaging (MAP) results in a desirable bright red display color (Seyfert et al., 2005) but may have increased off-flavors and decreased tenderness. 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) (Tørngren, 2003; Sørheim et al., 2004; Clausen, 2004; and Madsen and Clausen, 2006). Seyfert et al. (2005) found that beef quadriceps in HiO_2 MAP were tougher and had more off-flavors than those in ultra-low oxygen MAP. Clausen (2004) believes that the detrimental effects of O_2 on tenderness may be caused by protein oxidation. Rowe et al. (2004) found that oxidation of beef muscle proteins early postmortem inactivated μ-calpain and decreased myofibrillar proteolysis, thus limiting tenderization.

Injection enhancement improves tenderness and juiciness and is used in conjunction with MAP. Increasing injection percentage from 6 to 10% in beef round muscles decreased oxidation but increased non-typical beef flavors (Seyfert et al., 2005). Hoffman (2006) found that enhancement of cow longissimus (LD) and semitendinosus (ST) muscles resulted in more tender and juicier steaks that were saltier and had less overall beef flavor than steaks that were non-enhanced. Wicklund et al. (2005) found similar results in beef loin steaks. The objectives of our study were to determine the effects of packaging atmosphere and injection-enhancement on beef tenderness, sensory traits, and desmin degradation.

Materials and Methods

Paired LD (n=12); ST (n=12); and triceps brachii (TB; n=24) were obtained from the same USDA Select, A-maturity carcasses at 2 d postmortem. On d 7 postmortem, muscles from one side of the carcass were enhanced (beef broth, phosphate, natural flavoring solution); muscles from the opposite side were fabricated into non-enhanced 2.54 cm-thick steaks. Muscles were fabricated into treatments of VP; 80% O_2/20% CO_2 (HiO_2); or 0.4% CO/35% CO_2/64.6%N_2 (ULO_2CO) and assigned to either 14 d tenderness or display followed by 18 or 28 d WBSF, respectively. Steaks packaged in HiO_2 MAP were in dark storage (2°C) for 4 d and all other steaks for 14 d. Steaks for Warner-Bratzler shear force (WBSF) were cooked to 70°C in a forced-air convection oven. One steak from each muscle and each packaging atmosphere was removed from MAP on d 14, then vacuum packaged and stored (-20°C) for sensory analysis. Steaks for sensory analysis were thawed (2°C), cooked to 70°C, and sliced into samples. Trained panelists (n=8) evaluated warm samples in duplicate for sensory attributes with 8 = most- and 1 = least-juicy, intense, and none/abundant off-flavor. Desmin degradation was used to measure postmortem proteolysis. Extraction, electrophoresis, Western blotting, and quantification of desmin was measured on d 7 and 14 postmortem according to procedures outlined by Wheeler et al. (2002). Statistical analysis was done using the MIXED procedure of SAS.

Results and Discussion

Injection-enhancement pump levels of muscles after about 30 min of initial injection and prior to fabrication were 10.7% for the LD, 8.2% for the ST, and 13.0% for the TB.

Table 1. Warner-Bratzler shear force means and SE (0.08) for d × packaging treatment

Packaging	d postmortem		
Treatment[a]	7	14	18/28
HiO_2	4.79[b]	4.01[c, y]	3.79[d, y]
ULO_2CO	4.79[b]	3.98[c, y]	3.39[d, z]
VP	4.79[b]	3.93[c, y]	3.30[d, z]

[a]HiO_2 (80% O2, 20% CO_2); ULO_2CO (0.4% CO/35% CO_2/64.6%N_2); VP (vacuum packaging)
[bcd]Means with different superscripts across rows differ (P<0.05)
yz=means with different superscripts down columns differ (P<0.05)

Table 2. Warner-Bratzler shear force means and SE (0.18) for muscle × enhancement treatment × d

Muscle	d postmortem	Non-enhanced	Enhanced
Longissimus	7	4.78[a,yz]	3.24[b,z]
Longissimus	14	4.59[a, y]	2.70[b, y]
Longissimus	18/28	3.92[a, x]	2.35[b, x]
Semitendinosus	7	5.03[z]	-
Semitendinosus	14	5.11[a, z]	3.66[b, z]
Semitendinosus	18/28	4.43[a, y]	3.41[b, z]
Triceps brachii	7	4.55[y]	-
Triceps brachii	14	4.45[a, y]	3.33[b, z]
Triceps brachii	18/28	4.08[a, x]	2.75[b, y]

[ab]Means with different superscripts across rows differ (P<0.05)
[xyz]Means with different superscripts down columns differ (P<0.05)

There was a packaging treatment × d interaction for WBSF (Table 1). There was a muscle × enhancement treatment × d interaction for WBSF and steaks from enhanced muscles were more tender ($P<0.05$) at each time of measurement postmortem than non-enhanced steaks (Table 2).

Sensory panelists found non-enhanced steaks packaged in HiO_2 MAP were less tender, had less beef flavor, and more off-flavors ($P<0.05$) than ULO_2CO MAP and VP steaks (Table 3). The LD (5.9) and TB (6.0) were more tender ($P<0.05$) according to myofibrillar tenderness than the ST (5.1). Non-enhanced steaks (5.1) were less ($P<0.05$) juicy than enhanced steaks (5.7). 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, metallic or chemical, in addition to an undesirable mushy texture. Non-enhanced steaks packaged in ULO_2CO MAP or VP were more tender ($P<0.05$), had more ($P<0.05$) beef flavor, and had less ($P<0.05$) off-flavors than steaks packaged in HiO_2 MAP. Desmin degradation was not affected ($P>0.05$) by type of packaging type but was affected ($P<0.05$) by time postmortem (Table 4).

Table 3. Sensory means and SE (0.1) for enhancement × packaging treatment

	Myofibrillar tenderness		Beef flavor		Overall tenderness		Off-flavor	
Packaging treatment[a]	Non-enhanced	Enhanced	Non-enhanced	Enhanced	Non-enhanced	Enhanced	Non-enhanced	Enhanced
HiO_2	$4.6^{b, y}$	$6.2^{c, z}$	$4.3^{b, y}$	$4.1^{b, z}$	$4.8^{b, y}$	$6.2^{c, z}$	$5.4^{b, y}$	$5.1^{c, y}$
ULO_2CO	$5.1^{b, z}$	$6.4^{c, z}$	$5.1^{b, z}$	$4.3^{c, z}$	$5.3^{b, z}$	$6.4^{c, z}$	$7.0^{b, z}$	$5.3^{c, z}$
VP	$5.1^{b, z}$	$6.3^{c, z}$	$5.2^{b, z}$	$4.3^{c, z}$	$5.3^{b, z}$	$6.3^{c, z}$	$7.0^{b, z}$	$5.5^{c, z}$

[a]HiO_2 (80% O2, 20% CO_2); ULO_2CO (0.4% CO/35% CO_2/64.6%N_2); VP (vacuum packaging)
[bc]Means with different superscripts across rows and within sensory traits differ ($P<0.05$)
[yz]Means with different superscripts down columns differ ($P<0.05$)

Table 4. Desmin degradation (%) means and SE for muscle × enhancement(d) interaction of steaks packaged in different atmospheres

Muscle	Day	Non-enhanced	Enhanced	SE
LD	7	28.18^{xy}	34.20^{y}	4.86
LD	14	47.21^{z}	54.22^{z}	4.30
ST	7	19.25^{wxy}	-	4.85
ST	14	31.43^{y}	33.91^{y}	4.29
TB	7	13.03^{w}	-	3.92
TB	14	21.74^{wx}	28.06y	3.67

[wxyz]Means with different superscripts within columns differ ($P<0.05$)

Conclusions

In general, more off-flavors were associated with enhanced steaks than non-enhanced steaks. Steaks packaged in HiO_2 MAP were less tender and had more off-flavors. Packaging treatment did not affect desmin degradation.

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