Effects of Feeding Wet Distillers Grains Plus Solubles and Vitamin E on Beef Tenderness and Color Under Different Packaging Systems

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Summary

The effects of feeding wet distillers grains plus solubles (WDGS), vitamin E supplementation (E), and modified atmosphere packaging (MAP) on Warner Bratzler shear force (WBSF) and sensorial tenderness were investigated in m. longissimus lumborum *aged 7 or 21 days. Steers (n = 90) were allocated to dietary treatments consisting of corn or 35% WDGS with 0, 100, 300, 500, and 1000 I.U. of E per head daily. After aging, muscles were displayed for 5 days under O_2 permeable film, high O_2 and low O_2 atmospheres. Feeding 1000E extended color stability of permeable film-packaged steaks during retail display. Feeding WDGS led to higher discoloration in steaks packaged under high O_2 when compared to other treatments. High O_2 packaging led to lower tenderness when compared to other packaging methods ($P < 0.05$), and vitamin E supplementation provided color stability to steaks from animals fed WDGS.*

Introduction

Previous research showed feeding wet distillers grains plus solubles (WDGS) led to higher lipid oxidation and decreased color stability in beef due to an increase in polyunsaturated fatty acids (PUFA) (*2009 Nebraska Beef Report*, pp. 107-109). These fatty acids are more easily oxidized compared to mono and saturated lipids. When vitamin E is supplemented in diets, it is deposited at the cellular membrane and offers protection to PUFA against pro-oxidant factors. Therefore, detrimental oxidation caused by feeding WDGS may be mitigated by adding 500 I.U/ of vitamin E daily during the same feeding period (*2009 Nebraska Beef Report*, pp. 113-115; *2009 Nebraska Beef Report*, pp. 115-117). However, we hypothesize that the same pro-oxidant factors might also affect proteins, which could lower tenderness due to oxidation of calpain and protein crosslinking.

Procedure

Yearling steers (n = 90) were randomized to six dietary treatments (Corn, WDGS, WDGS +100E, WDGS+300E, WDGS+500E, WDGS+1000E) where level of WDGS was 35% (DM basis) and vitamin E was 100, 300, 500, or 1000 I.U. per head daily beyond the basal diet. The basal diet for corn contained 189.8 I.U. of vitamin E per head daily, whereas the basal diet for WDGS contained 211.4 I.U. Dietary treatments lasted 128 days. M. *longissimus lumborum* (LD) were excised from both short loins of each carcass and aged for 7 or 21 days. After aging, four 1-inch thick steaks were cut from each strip loin. Steaks were vacuum packaged and frozen following 5 days of retail display in O_2-permeable film, low O_2 or High O_2 modified atmosphere packages (MAP). Four display cases were set at 32 - 36°F, and light intensity varied from 60 to 200 Lux. For WBSF and sensorial tenderness analysis, steaks were grilled to 95°F, then flipped and grilled until they reached 158°F at the geometric center. A nine-member panel was screened, selected, and trained to evaluate tenderness on an eight-point hedonic scale (from 1 = extremely tough to 8 = extremely tender). For WBSF, after cooking, steaks were cooled for 1 hour at 39°F and cores were removed with a drill press parallel to muscle fiber orientation. From each steak, 6 cores (0.5 inch in diameter) were sheared on an Instron Universal Testing Machine with a Warner-Bratzler blade. The crosshead speed was 250 mm/min with a 500 kg load cell. The tenderness differential (Δ) between 0 and 5 days of retail display was calculated by subtracting day 5 values (WBSF and sensorial tenderness) from day 0 values. Thus, a negative value indicates a loss of tenderness during retail display. Discoloration was assessed by a four-member panel that scored visual discoloration from 0% red (not discolored) to 100% brown (completely discolored) every day during four days of display. Data were analyzed as a split-split plot design where the whole plot was diet, the split plot was aging, and the split-split plot was MAP. Animal (both muscles) within diet was considered the whole plot error term, aging by diet the split plot error term, and MAP by aging by diet the split-

Table 1. Tenderness of steaks displayed under different packaging systems.

	Packaging System			
Trait[1]	High O_2 MAP	Low O_2 MAP	O_2-Permeable	Standard Error
WBSF, kg	3.63[b]	3.39[a]	3.37[a]	0.03
Δ WBSF, kg	-0.19[b]	0.04[a]	0.05[a]	0.05
Tenderness rating	5.87[b]	6.16[a]	6.16[a]	0.04
Δ tenderness rating	-0.13[b]	0.17[a]	0.08[a]	0.04

[1]WBSF = Warner-Bratzler shear force; tenderness rated on an 8-point hedonic scale where 1 = extremely tough and 8 = extremely tender.
[a,b]Means in the same row with different superscripts are significantly different ($P < 0.05$).

Table 2. Dietary effects on tenderness characteristics of beef strip steaks.

	Treatment means							*P*-value for Contrasts				
		WDGS										
Trait[1]	Corn	0 E	100 E	300 E	500 E	1000 E	Standard Error	Linear	Quadratic	Corn vs WDGS (no E)	Corn vs WDGS (with E)	WDGS (no E) vs WDGS (with E)
WBSF, kg	3.59	3.51	3.28	3.60	3.46	3.33	0.08	0.24	0.04	0.54	0.02	0.19
Δ WBSF, kg 7 days aged	0.18	-0.13	0.37	0.07	-0.03	0.29	0.11	0.29	0.30	0.06	0.99	0.02
Δ WBSF, kg 21 days aged	-0.29	-0.15	-0.24	-0.11	-0.22	-0.18	0.11	0.29	0.93	0.33	0.30	0.80
Tenderness rating	5.93	5.95	6.17	6.23	5.98	6.00	0.04	0.03	0.02	0.83	0.01	0.04

[1]WBSF = Warner-Bratzler shear force; Delta = shear force differential during retail display (d 5-d 0); tenderness rated on 8-point hedonic scale where 1 = extremely tender and 8 = extremely tough.

split plot error term. Data were analyzed using the GLIMMIX procedure of SAS (Version 9.1, Cary, N.C., 2002). When significance ($P \leq 0.05$) was indicated by ANOVA, means separations were performed using the LSMEANS and DIFF functions of SAS.

Results

Results of WBSF and taste panel (TP) tenderness are shown in Tables 1 and 2. High O_2 MAP resulted in greater shear force values and lower TP tenderness ratings compared to the other two packaging systems, likely due to protein oxidation. In addition, display under high O_2 MAP conditions caused a significant decrease in tenderness, measured by shear force or taste panel tenderness ratings, during the display period. This implies that the decrease in tenderness occurred as a result of oxidation of myofibrillar or cytoskeletal proteins rather than through oxidation of the calpains, as the tenderness decrease was observed even after 21 days post mortem, when most of the proteolytic activity from calpains would have been complete.

Vitamin E provided a small, but significant protective effect against oxidation-induced toughening in beef from cattle fed WDGS and E, which had lower shear force values and higher sensorial tenderness ratings compared to corn-fed beef with no supplemental E.

The beneficial effects of E were evident when comparing beef from cattle fed WDGS without supplemental E to cattle fed WDGS with E – those without the supplemental E became tougher during retail display after 7 days of aging. After 21 days of aging, however, there were no differences among treatments, suggesting that aging reduced the capacity of the meat to resist oxidation, regardless of the amount of supplemental dietary E. The tenderness response to supplemental dietary vitamin E was quadratic in nature, with the lowest shear force values and among the highest sensorial tenderness ratings for cattle fed WDGS + 100 E. The curvilinear nature of these relationships is difficult to explain.

Regarding color, significant effects were observed when the strips were aged for 21 days (Figures 1 and 2). Long aging periods occur when beef is exported to other countries, and these

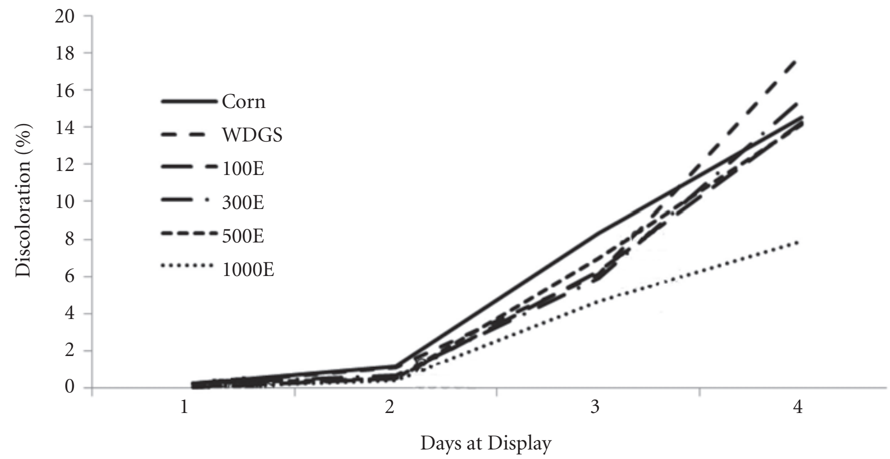

Figure 1. Discoloration of steaks aged 21 days and packaged with O_2-permeable film.

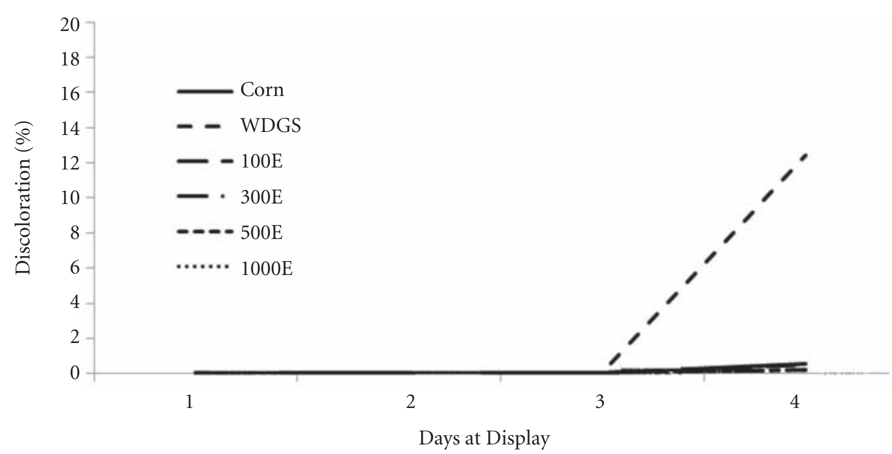

Figure 2. Discoloration of steaks aged 21 days and packaged under high O_2 atmosphere.

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periods usually take more than 21 days, when reduction in color stability may cause lower shelf-life. Low O_2 atmosphere led to 100% discoloration in the first day of display. In O_2-permeable film at the end of the display period, 1000 I.U. of vitamin E resulted in improved color stability when compared to other treatments. When High O_2 was used for packaging, steaks from animals fed WDGS had higher discoloration compared to those fed only corn at the conclusion of retail display period. However, any level of vitamin E supplementation mitigated detrimental effects on color when steaks were packaged with high O_2.

Red color of beef is due to the presence of oxymyoglobin; this pigment is formed by O_2 and myoglobin. In MAP with high levels of O_2, oxymyoglobin is more stable due to the high partial pressure of this gas inside the pack. This can explain less discoloration in steaks packaged under high O_2, where oxymyoglobin cannot be reduced to metmyoglobin. Metmyoglobin is responsible for brown color and discoloration. In this experiment, we observed that high O_2 packaged steaks had overall less discoloration and less tenderness compared to steaks packaged with low O_2 and O_2-permeable film. However, despite improved color stability due to oxymyoglobin stability, high O_2 atmosphere led to lower tenderness. This statement agrees with the findings of Lund et al. (*2007 Meat Science* 77:295-303) who showed that high O_2 atmosphere tended to increase toughness in meat due to protein oxidation. When vitamin E is supplemented, it is deposited in the cell membrane, protecting lipids from oxidation. In this experiment, up to 1000 I.U. of E per head daily was needed to provide better color stability to steaks packaged with permeable film.

Conclusion

We conclude that storing beef in high O_2 MAP caused a reduction in tenderness. Feeding supplemental dietary vitamin E provided a small, but significant protective effect against this oxidation-induced toughening, even in meat from animals fed WDGS. However, extended aging minimized the beneficial effects of E. The reduction in tenderness caused by protein oxidation appeared to be independent of calpain oxidation. This work demonstrated that the combination of high O_2 MAP and vitamin E supplementation improves the case life of beef from animals fed WDGS but decreases tenderness.

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