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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. Yearling 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 O2 permeable film, high O2, and low O2 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 O2 when compared to other treatments. High O2 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 189.8 I.U. of vitamin E per head daily, and the basal diet for WDGS with 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.

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

<table>
<thead>
<tr>
<th></th>
<th>High O2 MAP</th>
<th>Low O2 MAP</th>
<th>O2-Permeable</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>WBSF, kg</td>
<td>3.63a</td>
<td>3.39a</td>
<td>3.37a</td>
<td>0.03</td>
</tr>
<tr>
<td>Δ WBSF, kg</td>
<td>-0.19a</td>
<td>0.044</td>
<td>0.059</td>
<td>0.05</td>
</tr>
<tr>
<td>Tenderness rating</td>
<td>5.87a</td>
<td>6.16a</td>
<td>6.16a</td>
<td>0.04</td>
</tr>
<tr>
<td>Δ tenderness rating</td>
<td>-0.13b</td>
<td>0.17a</td>
<td>0.08a</td>
<td>0.04</td>
</tr>
</tbody>
</table>

1WBSF = Warner-Bratzler shear force; tenderness rated on an 8-point hedonic scale where 1 = extremely tough and 8 = extremely tender.

a,bMeans in the same row with different superscripts are significantly different (P < 0.05).
Table 2. Dietary effects on tenderness characteristics of beef strip steaks.

<table>
<thead>
<tr>
<th>Trait1</th>
<th>Corn</th>
<th>0 E</th>
<th>100 E</th>
<th>300 E</th>
<th>500 E</th>
<th>1000 E</th>
<th>WDGS</th>
<th>Standard Error</th>
<th>Corn vs WDGS (no E)</th>
<th>Corn vs WDGS (with E)</th>
<th>WDGS (no E) vs WDGS (with E)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WBSF, kg</td>
<td>3.59</td>
<td>3.51</td>
<td>3.28</td>
<td>3.60</td>
<td>3.46</td>
<td>3.33</td>
<td>0.08</td>
<td>Linear 0.24</td>
<td>0.29</td>
<td>0.29</td>
<td>0.02</td>
</tr>
<tr>
<td>Δ WBSF, kg</td>
<td>0.18</td>
<td>-0.13</td>
<td>0.37</td>
<td>0.07</td>
<td>0.03</td>
<td>0.29</td>
<td>0.11</td>
<td>Quadratic 0.29</td>
<td>0.93</td>
<td>0.33</td>
<td>0.30</td>
</tr>
<tr>
<td>Δ WBSF, kg</td>
<td>-0.29</td>
<td>-0.15</td>
<td>-0.24</td>
<td>-0.11</td>
<td>-0.22</td>
<td>-0.18</td>
<td>0.11</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tenderness rating</td>
<td>5.93</td>
<td>5.95</td>
<td>6.17</td>
<td>6.23</td>
<td>5.98</td>
<td>6.00</td>
<td>0.04</td>
<td></td>
<td>0.03 0.02</td>
<td>0.83 0.01</td>
<td>0.04</td>
</tr>
</tbody>
</table>

1WBSF = Warner-Bratzler shear force; Δ = 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.

Results

Results of WBSF and taste panel (TP) tenderness are shown in Tables 1 and 2. High O₂ 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 O₂ 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 conditions affect the discoloration of the meat.
periods usually take more than 21 days, when reduction in color stability may cause lower shelf-life. Low O₂ atmosphere led to 100% discoloration in the first day of display. In O₂-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 O₂ 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 O₂.

Red color of beef is due to the presence of oxymyoglobin; this pigment is formed by O₂ and myoglobin. In MAP with high levels of O₂, 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 O₂ where oxymyoglobin cannot be reduced to metmyoglobin. Metmyoglobin is responsible for brown color and discoloration. In this experiment, we observed that high O₂ packaged steaks had overall less discoloration and less tenderness compared to steaks packaged with low O₂ and O₂-permeable film. However, despite improved color stability due to oxymyoglobin stability, high O₂ 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 O₂ 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 O₂ 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 O₂ MAP and vitamin E supplementation improves the case life of beef from animals fed WDGS but decreases tenderness.

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