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# Effects of Antioxidants on Beef in Low and High Oxygen Packages

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**Summary**

*Color, lipid, and protein stability of beef strip loin steak treated with different antioxidants (tocopherol, tertiary butyl hydroquinone, rosemary, or combinations of two of the antioxidants) and packaged in low oxygen (2-5% $O_2$) or high oxygen (80% $O_2$) modified atmosphere packages were studied. The application of tertiary butyl hydroquinone on steaks prior packaging (either in low- or high-oxygen modified atmosphere packages) was significantly effective in minimizing color and lipid oxidation during retail display. Under modified atmosphere packaging (low- or high-oxygen modified atmosphere packaging), oxidation of myoglobin color pigments and lipids were unrelated to beef tenderness.*

**Introduction**

High oxygen modified atmosphere packages (80% oxygen and 20% carbon dioxide; HiOx– MAP) help sustain cherry red color of meat longer compared to steaks in oxygen permeable (PVC-OW) packages (*2011 Nebraska Beef Cattle Report,* pp. 100-102) or low oxygen modified atmosphere packages (LowOx-MAP; *2010 Nebraska Beef Cattle Report,* pp. 99-101). However, previous studies reported that HiOx-MAP significantly increases protein oxidation, thereby reducing steak tenderness (*2012 Nebraska Beef Cattle Report,* pp …). Dipping steaks in antioxidant solutions prior packaging may give a protective layer around steaks thereby minimizing color, lipid, and protein oxidation.

Therefore, two separate studies were performed to find out the effectiveness of application of different antioxidants, prior packaging, on color, lipid, and protein stability of strip loin steaks under HiOx- and LowOx-MAP systems.

**Procedure**

Five USDA Choice beef loin, strip loins (*longissimus lumborum*) for each study were aged at 36°F for 14 days from the boxed date. Each strip loin was cut into nine, inch-thick steaks (for color and instrumental tenderness tests), and half-inch thick steaks (half of the steak for either four or seven days retail display lipid oxidation test).

Steaks were held as untreated control (packaged in PVC-OW and LowOx-MAP or HiOx-MAP packages) or dipped in one of six antioxidant solutions containing alpha-tocopherol (Tocopherol; 300 ppm), tertiary butyl hydroquinone (TBHQ; 200 ppm), a commercial extract of Rosemary (Herbalox; 600 ppm; Kalsec Inc., Kalamazoo, Mich.), or combinations of two of the antioxidants (Tocopherol and TBHQ; TBHQ and Herbalox; Tocopherol and Herbalox). Preliminary tests were conducted to determine optimum concentrations and application methods. After antioxidant application, steaks were packaged in modified atmosphere packages containing low levels of oxygen (2-5% $O_2$, 10% $CO_2$ and 85% $N_2$; LowOx-MAP) or high levels of oxygen (80% $O_2$ & 20% $CO_2$; HiOx-MAP). All the packages were displayed for seven days in retail display cases at 32 ± 36°F under continuous 1,000-1,800 lux warm white fluorescence lighting. Color measurements (CIE a*redness values; by Minolta color meter) and discoloration (estimated as percent discoloration; by five trained panelists) scores were obtained daily during retail display period. The thiobarbituric acid reactive substances assay (TBARS) was performed to quantify lipid oxidation at 0, 4, and 7 days retail displayed steaks. Instrumental tenderness of steaks was measure by Warner-Bratzler shear force (WBSF) at the beginning and the end of retail display on steaks cooked to 160°F.

Data were analyzed by ANOVA in the GLIMMIX procedure of SAS (SAS Inst., Inc., Cary, N.C.). Separation of means was conducted using LSMEANS procedure with PDIFF and LINES options in SAS at $P < 0.05$.

**Results**

Steaks packaged in LowOx-MAP discolored at a more rapid rate than those in HiOx-MAP (Figure 1). Under LowOx-MAP, steaks treated with solutions containing TBHQ had significantly less (Figure 1; $P < 0.0001$) discoloration after three days of retail display than steaks treated with the other antioxidants. These differences were evident after six days for the HiOx-MAP study (Figure 1; $P < 0.0001$). Steak a* values decreased (less redness) during retail display (data not shown). This decline was more severe (data not shown; $P < 0.0001$) for steaks dipped in solutions that did not contain TBHQ and packaged in LowOx-MAP. However, there were no differences in a* values among treatments using HiOx-MAP (data not shown; $P = 0.14$).

Lipid oxidation of steaks also progressed during retail display (Figure 2; $P < 0.0001$). This increase in lipid oxidation was more severe (Figure 2; $P < 0.0001$) for steaks treated solutions not containing TBHQ. At the end of retail display, steaks in HiOx-MAP had significantly higher TBARS values than steaks in LowOx-MAP (Figure 2).

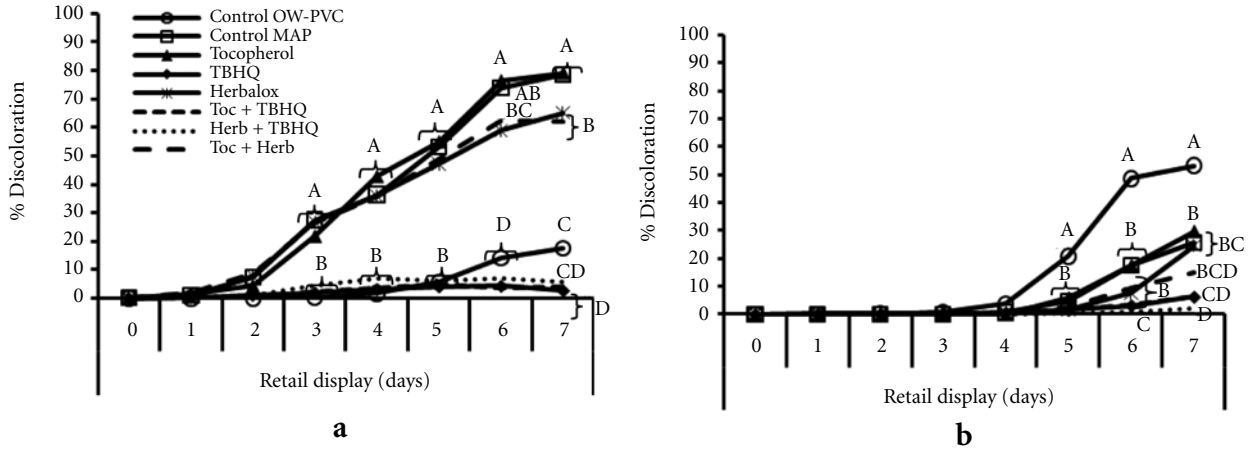


**Figure 1. Means of percentage discoloration of antioxidant-treated-strip loin steaks packaged in a) low oxygen (LowOx-MAP) and b) high oxygen (HiOx-MAP) modified atmosphere systems during seven days of simulated retail display conditions (Treatment × day, $P < 0.0001$). $^{A-D}$comparison among treatments within the same retail display day, means lacking a common superscript were significantly different at $P < 0.05$.**

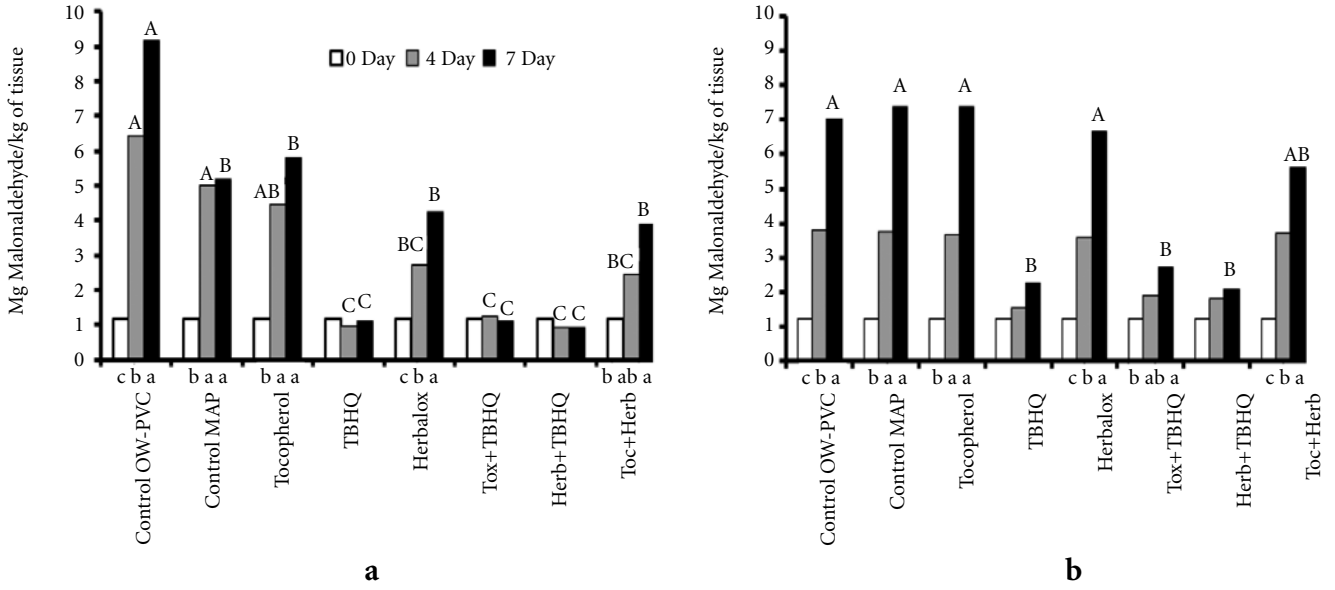


**Figure 2. Means of thiobarbituric acid reactive substances values of antioxidant-treated-strip loin steaks packaged in a) low oxygen (LowOx-MAP) and b) high oxygen (HiOx-MAP) modified atmosphere systems during seven days of simulated retail display conditions (Treatment × day, $P < 0.0001$). $^{A-C}$comparison among treatments within same retail display day, means lacking a common superscript were significantly different at $P < 0.05$. $^{a-c}$comparison among retail display days within same treatment, means lacking a common superscript were significantly different at $P < 0.05$.**

Under LowOx-MAP, steaks at the end of retail display had lower (data not shown; $P = 0.006$) WBSF values (more tender) than 0 day retail displayed steaks. This indicates that further postmortem tenderization is occurring during retail display period. However, a similar trend was not seen in steaks packaged in HiOx-MAP (data not shown; $P = 0.87$). A possible reason would be high oxygen condition in packages significantly interferes with further tenderization of meat by protein aggregation and inactivation of proteolytic enzymes. In addition, there were no significant differences in Δ WBSF (7 day – 0 day) values across all treatments for either study (data not shown; $P > 0.05$).

Under modified atmosphere packaging (LowOx- or HiOx-MAP), oxidation of myoglobin pigments, and lipids were unrelated to beef tenderness. The application of antioxidant TBHQ on steaks prior packaging in MAP (either Low or HiOx-MAP) was significantly more effective in minimizing myoglobin and lipid oxidation during retail display.

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