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Packaging Effects on Shelf-Life and Sensory Traits of Enhanced Beef

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Summary

Beef strip loins and top sirloins were enhanced and steaks were stored in one of three packaging systems: high-oxygen barrier trays, low-oxygen peelable trays, or vacuum packages. After dark storage for 8 or 15 days, simulating distribution time, steaks were displayed up to 3 days in a retail case. Steak discoloration and sensory traits were rated. Extended dark storage and retail display were detrimental to flavor and color. In this study, the best packaging systems were those that minimized opportunities for oxidation — vacuum packaging and, as long as dark storage was limited to eight days, high oxygen packaging.

Introduction

Recent innovations with packaging films and equipment technology require careful consideration of packaging options for a given beef product. High-oxygen packaging allows for a bright red color of beef, but accelerates conversion of fresh beef from bright red to a more brownish color. Low-oxygen packaging systems do not impart a bright red color of beef, but maintain the color in retail display if the package remains intact. There is a strong interest in the marketplace for beef products enhanced with ingredients designed to improve texture, flavor, and consistency. The objectives of this study were to determine the effects of commercial case-ready packaging systems on sensory, shelf-life, color, and color stability characteristics of enhanced beef.

Procedure

USDA select grade beef strip loins and top sirloin butts were selected at a commercial meat processing facility. At the plant, each primal was weighed, pumped with a commercial enhancement solution (water, salt and phosphate), and sliced into 1-inch thick steaks using a commercial slicer. Steaks were randomly packaged using one of three packaging systems: 1) a Ross 3320 and a high-oxygen barrier tray with approximately 20% carbon dioxide and 78% oxygen, 2) a Ross Junior model S3180 and a peelable tray with approximately 22% carbon dioxide, 78% nitrogen and 223 ppm of oxygen, or 3) vacuum packaged into oxygen-impermeable bags. The sirloin steaks were lightly misted with a rosemary extract to minimize oxidation.

Packaged steaks were allocated to one of two periods of dark storage (8 or 15 days), to be followed by up to 3 days of retail display. During display a team of trained evaluators rated the steaks' surface discoloration using a scale where 1 = 0% discoloration, 2=1-10% discoloration, 3=11-20% discoloration and so on. After one or three days of retail display, steaks were frozen and held for evaluation by a trained, 10-member sensory panel.

A trained sensory panel evaluated juiciness, tenderness, flavor intensity, intensity of off-flavor, and flavor desirability. The panel was not trained on flavor desirability, so the extent to which preference result can be applied to the general population is limited. These data were obtained as an indicator of panelist reaction to the products. All sensory traits were evaluated on 8-point rating scales, where 1=extremely dry, extremely tough, extremely mild flavor, no detectable off-flavor, extremely undesirable flavor, and 8=extremely juicy, extremely tender, extremely intense flavor, extremely intense off-flavor, and extremely desirable flavor. Panelists also identified off-flavors. Steaks were cooked to 158°F on Farberware Open Hearth broilers.

Results

Steak Discoloration

There were no differences among packaging and storage treatments for strip steaks at the start of the retail display period (Figure 1). Beginning one day of retail display, greater discoloration was detected for the low oxygen, peelable packages, regardless of storage time, and for the high oxygen packages stored in the dark for 15 days. For the duration of retail display, these differences continued to diverge from the vacuum packaged steaks and the high oxygen steaks stored in the dark for just eight days. These data suggest the low oxygen, peelable packages retained sufficient residual oxygen to catalyze myoglobin oxidation to the metmyoglobin state, thereby increasing the brown appearance. Presumably, a low oxygen, peelable package without residual oxygen would have lower levels of discoloration. Under high oxygen, storage of strip steaks for

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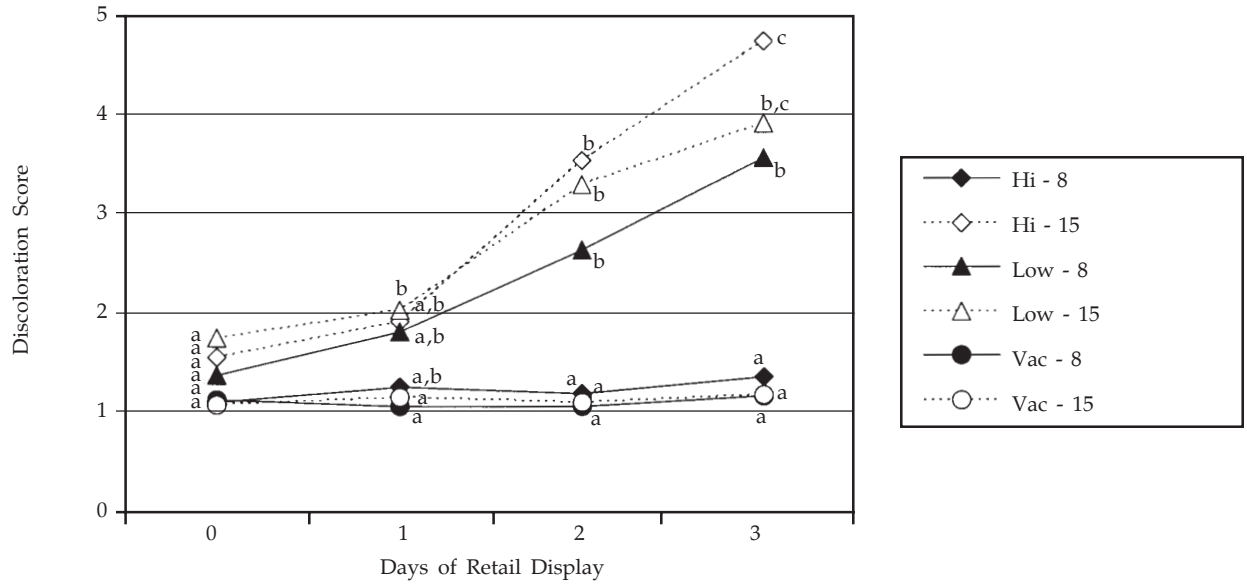

Figure 1. Discoloration scores for strip steaks during retail display in different packaging systems following 8 or 15 days of dark storage.

[a,b,c]Means within a day with no common letters differ ($P < 0.05$).
Rated on a scale where 1 = 0% discoloration, 2 = 1 - 10%, 3 = 11 - 20% and so on.

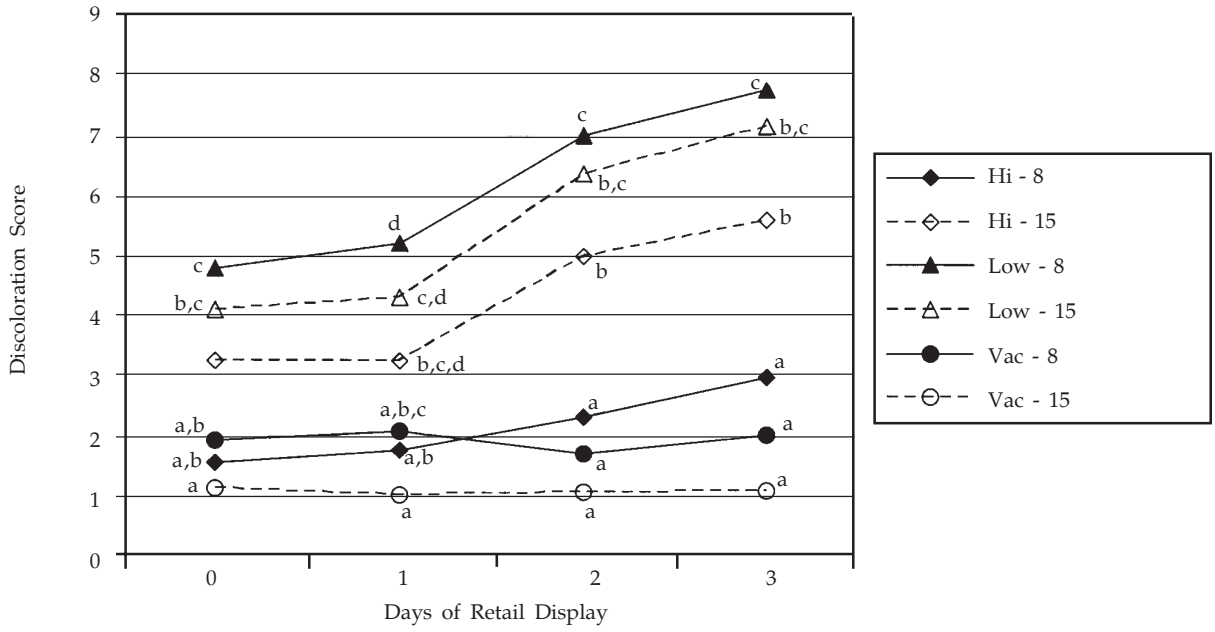

Figure 2. Discoloration scores for top sirloin steaks during retail display in different packaging systems following 8 or 15 days of dark storage.

[a,b,c]Means within a day with no common letters differ ($P < 0.05$).
Rated on a scale where 1 = 0% discoloration, 2 = 1 - 10%, 3 = 11 - 20%, and so on.

15 days is sufficient to promote discoloration. Minimizing the length of dark storage prior to retail display appears to avoid brown color development.

A nearly identical pattern of discoloration was observed with the sirloin steaks (Figure 2) in that low oxygen peelable packages, regardless of storage time, and high oxygen packages stored in the dark for 15 days had greater discoloration than the other treatments beginning at one day of retail display. The most notable difference among steak types was the greater extent of discoloration in the sirloin steaks. Differences in muscles

suggested this might occur and the sirloin steaks were misted with an antioxidant (rosemary extract) to minimize the effect. In this study, the antioxidant treatment was not successful in preventing the discoloration during retail display.

Sensory Properties

Tenderness was not affected by storage or retail display periods (Table 1). A difference in tenderness was perceived by the panelists for the different packaging systems. The steaks from the high-oxygen packages were perceived to be less tender than the steaks from the vacuum packages in the top sirloin steaks and less tender than the strip steaks packaged in vacuum packages and low-oxygen packages. The mean scores for all treatments were still considered to be at least "slightly tender". Recent data in the literature suggests the enzymes responsible for tenderization are diminished in activity under oxidizing conditions. Perhaps the greater oxidation created by high oxygen levels contributed to reduced enzyme activity.

Extended dark storage was detrimental to off-flavor intensity and flavor preference for both steak types (Table 1). The same was true for extended retail display. This pattern was consistent across all packaging systems for strip steaks. In top sirloin steaks, the high oxygen packages were judged least desirable in off-flavor intensity and flavor preference. A trained panel was used to evaluate the samples, which might explain the uncommonly low flavor preference scores. It is clear, however, that modified atmosphere packaging of enhanced beef steaks creates the potential for undesirable flavors to develop.

Similarly, a greater number of panelists detected oxidized flavors in both steak types following extended dark storage (Tables 2 and 3). The same was true for the longer retail display period in the strip steaks.

Table 1. The influence of main treatment effects on sensory traits of enhanced beef steaks.

Steak Type	Trait[a]	Dark Storage 8 Day	Dark Storage 15 Day	Packing Type High Oxygen	Packing Type Low Oxygen	Packing Type Vacuum Packaged	Display Time 1 Day	Display Time 3 Day
Strip	Juiciness	4.82[b]	4.47[c]	4.88	4.48	4.57	4.66	4.63
	Tenderness	5.69	5.63	5.23[c]	5.87[b]	5.80[b]	5.73	5.59
	Flavor intensity	4.99[b]	5.47[c]	5.10	5.36	5.23	5.09	5.37
	Off-flavor intensity	4.04[b]	4.98[c]	4.39	4.90	4.25	4.21[b]	4.81[c]
	Flavor preference	3.35[b]	2.67[c]	3.10	2.69	3.23	3.20[b]	2.82[c]
Top Sirloin	Juiciness	4.65	4.79	4.84	4.46	4.86	4.71	4.72
	Tenderness	4.37	4.77	4.17[c]	4.55[b,c]	4.99[b]	4.44	4.69
	Flavor intensity	4.98[b]	5.43[c]	5.55[c]	4.94[b]	5.12[b]	4.97[b]	5.43[c]
	Off-flavor intensity	4.01[b]	4.80[c]	5.29[c]	3.91[b]	4.00[b]	4.12[b]	4.70[c]
	Flavor preference	3.03[b]	2.62[c]	2.26[c]	3.07[b]	3.16[b]	3.01[b]	2.65[c]

[a]Evaluated on 8-point rating scales where 1 = extremely dry, extremely tough, extremely weak flavor, extremely weak off-flavor, and extremely undesirable and 8 = extremely juicy, extremely tender, extremely strong flavor, extremely strong off-flavor, and extremely desirable, respectively.
[b,c]Means in the same row within a main effect bearing different superscripts differ ($P < 0.05$).

Table 2. Top sirloin butt: percentage of panelists detecting off-flavors.

Off-flavor	Storage Days 8	Storage Days 15	Packaging Hi-ox	Packaging Low-ox	Packaging Vacuum	Retail Days 1	Retail Days 3
Oxidized	50.7[a]	60.2[b]	69.2	52.7	44.4	55.5	55.3
Sour/Acidic	27.6[a]	39.7[b]	27.1	37.0	36.8	31.4	35.9
Metallic	15.2[a]	20.8[b]	16.1	18.7	19.0	17.0	18.9
Salty	5.6	7.3	10.5	2.1	6.8	5.3	7.6

[a,b]$P < 0.05$.

Table 3. Strip loin: percentage of panelists detecting off-flavors.

Off-flavor	Storage Days 8	Storage Days 15	Packaging Hi-ox	Packaging Low-ox	Packaging Vacuum	Retail Days 1	Retail Days 3
Oxidized	50.2[a]	63.7[b]	59.5	61.1	50.3	51.3[a]	62.6[b]
Sour/Acidic	37.3	43.6	32.6	44.9	43.8	35.1[a]	45.8[b]
Metallic	11.8	9.4	9.0	9.3	13.7	9.8	11.5
Salty	6.0	6.0	3.4	4.7	10.0	7.5	4.6

[a,b]$P < 0.01$.

Implications

Conditions that promote oxidation, like extended dark storage or retail display, result in the development of off-flavors in enhanced beef. Accordingly, retailers who seek to merchandise enhanced beef would be advised to minimize time in the marketing chain for the product.

[1]Chris R. Calkins, professor, Animal Science, Lincoln; Mike L. Buford, former graduate student.

[2]This project was funded in part by beef and veal producers and importers through their $1-per-head checkoff and was produced for the Cattlemen's Beef Board and state beef councils by National Cattlemen's Beef Association.