SURFACE PIGMENT SHIFTS DURING LIGHT DISPLAY FOR GROUND BEEF IN HIGH OXYGEN MODIFIED ATMOSPHERE PACKAGING

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Introduction

Modified atmosphere packaging (MAP) with headspace gas concentrations of 70-80% O_2 and 20% CO_2 is known to extend the colour life of fresh red meats. Jakobsen and Bertelsen (2000) found that mixtures with 55% to 80% O_2 in MAP maintained fresh beef colour better than lower concentrations. The high O_2 concentration oxygenates myoglobin (Mb) well below the meat surface and thereby aids in maintaining the bright red colour as oxymyoglobin (OMb) for a longer period of time than is possible with simple aerobic film over-wraps. MAP systems for fresh red meats are termed "case ready" and use is growing rapidly. By 2010, case-ready packaging for meats is expected to account for over 70% of retail meat packages in the U.S. (Makely, 2003).

Light catalyzes OMb oxidation in meats to the brown pigment metmyoglobin (MMb) (Bertelsen and Skibsted, 1987) and even small amounts of brown surface discoloration likely means product will be rejected by consumers although it may still be microbiologically safe. Daly and Acton (2004) reported that for packages of high O_2 MAP ground beef stored in the dark for up to 6 days at 0°C, Hunter +a values did not decline on the first day of display. Product stored in the dark for 2, 4, or 6 days prior to display had a colour life of approximately 2 days. This research was conducted to examine the shift in surface spectra, OMb and MMb, and redness via CIE +a* and visual panel ratings for ground beef packaged in high O_2 MA and displayed in lighting for 3 days.

Materials and Methods

Fresh ground beef (93-96% lean) in high-oxygen (80% O_2 target) MAP was obtained on the same day of grinding and packaging from a local USDA-inspected plant. Packaging was conducted with a Ross Reiser Model 3320 Packaging Machine (Reiser & Co., Inc., Canton, Massachusetts). Each package contained approximately 0.454 kg of ground beef placed on a pink barrier foam tray sealed with lid-stock film (Lid 550™) (Cryovac Division, Sealed Air Corporation, Duncan, South Carolina). The barrier foam trays had an oxygen transmission rate (OTR) of ≤0.1 cc/tray/24hr (@ 22°C, 0%RH, 1atm) and the top transparent, flexible multi-layer film had an OTR of ≤6cc/m^2/24hr (@22°C, 0%RH, 1atm). Product was held at approximately 3-4°C in the dark for 3 days to simulate shipping prior to light display.

Day 0 was defined in this study as the day packages were removed from dark storage and placed in lighted display. A surface light intensity of 120 foot-candles (ft-c) was used as measured by Extech Light Meters (Extech Instruments, Tampa, Florida). In the display, the light source was GE F20T12-CW fluorescent tubes. A temperature of 3.7°C was used and packages were continuously displayed for 3 days.

To measure surface colour of the MAP ground beef, a package was removed from display, inverted, and placed on a rigid surface. The bottom portion of the tray was cut with a scalpel and removed. A rigid rectangular plastic plate was placed against the bottom of the ground beef and used to press the original surface against the lid film. Sufficient pressure to ensure full contact between meat surface and lid film was applied and care was taken to avoid expressing pigment from the meat. The package was then held under slight pressure and placed at the 2.54 cm diameter aperture on a HunterLab UltraScan XE spectrophotometer (Hunter Associates Laboratory Inc., Reston, Virginia). Initially (day 0) and on each full day (day 1-3) of display, surface colour characteristics were measured at 8 different loci of each package. Two packages were measured for each of 3 study replications.

For measures in the CIE L*a*b* colour space, the UltraScan XE was operated with Illuminant C, 10° observer and specular reflectance excluded. Reference myoglobin pigment forms were determined by the method of AMSA (1991). Percent reflectance between 360-750 nm was recorded simultaneously with each colour measurement and reflectance values were converted to K/S. Percent OMb and MMb were calculated using the methods of Mancini *et al.*, 2003). On day 0 at the time of placing packages in the lighted display, 2 packages were also placed on a white background under 52 ft-c of fluorescent lighting for panel evaluation of surface color. At day 3, 2 additional packages were removed from display and evaluated under the same viewing conditions. A panel of 6 evaluators consisting of faculty members and graduate students with experience in meat science was used for subjective evaluation of ground beef lean colour. The evaluation scale used was as follows: 8 = very bright cherry red, 7 = bright cherry red, 6 = cherry red, 5 = slightly cherry red, 4 = slightly dark red, 3 = dark red, 2 = very dark red, 1 = grey.

Data were analyzed using PROC GLM in SAS® (SAS Institute, Cary, NC). Mean comparisons were made using least significant difference (LSD) with $\alpha = 0.05$.

Results and Discussion

To confirm the high O_2 MA conditions, packages were analysed for headspace gases using a GOW-MAC Series 580 gas chromatograph (GOW-MAC Instrument Company, Bethlehem, Pennsylvania) equipped with a Hewlett Packard 3395 integrator (Hewlett Packard, China). From initial display (0 day) through day 3, the MA consisted of the following: 79.6-78.5% O_2, 14.7-14.3% CO_2, and 6.3% N_2 thus confirming the high O_2 MAP system.

K/S spectra from intial product at day 0 through day 3 are shown in Figure 1 for wavelengths appropriate for OMb and MMb. A characteristic double peak for OMb occurred at 540-542 and 578-580 nm and a single peak for MMb occurred at 630-634 nm. The percent surface OMb decreased ($P<0.001$) each day of display and was 83% on day 3 whereas the percent MMb increased ($P<0.001$) each day to 15% by day 3.

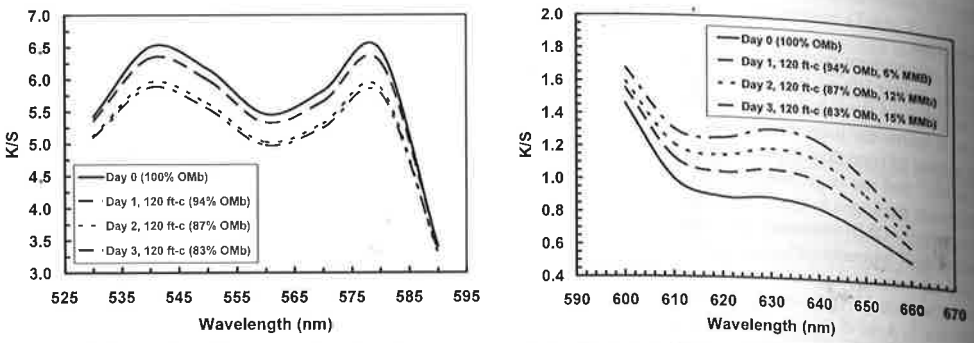

Figure 1: K/S spectra of the ground beef surface as packaged in a high O_2 MA. The spectra for surface oxymyoglobin (OMb, left) and metmyoglobin (MMb, right) from initial display (0 day) through day 3 in 120 ft-c of fluorescent lighting at 3.7°C confirms decreasing OMb with increasing MMb concentrations.

CIE +a* (redness) and panel scores (Table 1) for visual colour confirmed the decrease in redness due to the decline in OMb. There was a daily decrease ($P<0.05$) of +a* with no significant change in surface lightness (CIE L*). There was a decrease ($P<0.05$) for yellowness (CIE +b*) from day 0 (+4.0) to day 3 (+3.6). The visual colour change ($P<0.05$) determined by the panelists was a shift from near "bright cherry red" to "slightly cherry red".

Table 1: Colour parameters CIE +a* indicating a "redness" attribute and visual colour scores by panelists during the period of display for ground beef packaged in high O_2 MA at 3.7°C in 120 ft-c of fluorescent lighting.

Colour Parameter	Days of Light Display			
	0	1	2	3
CIE +a*	21.4 [a]	19.3 [b]	17.6 [c]	16.5 [d]
Colour Score	6.75 [a]	--	--	5.25 [b]

Means in each row having a different superscript letter are different at $P<0.05$.

Conclusions

Increase of product display time in lighting resulted in K/S surface spectra shifts denoting increased loss of redness for high O_2 MAP ground beef. Panelists scored visual colour as changing from bright cherry red at 0 day to slightly cherry red at the end of day 3 in display.

The findings suggest that even with the shifts that were measured, 2 days and possibly 3 days of shelf life were attained after product was placed in lighted display.

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