CARBON MONOXIDE HEADSPACE ACTIVITY OF MODIFIED ATMOSPHERE PACKAGED BEEF STEAKS

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Introduction

Carbon monoxide in modified atmosphere packaging (MAP) prolongs the color stability of meat by forming a reasonably stable form of myoglobin, carboxymyoglobin (Hunt et al., 2004). Currently, the approved level of use in the US is 0.4% CO in MAP (FDA, 2004). This is because foods exposed to low levels (0.4% to 1.0%) of CO are considered safe for human consumption (Sørheim et al., 2006). The use of CO at the 0.4% level in MAP improved meat color by stabilizing color without masking spoilage (Hunt et al., 2004). Carbon monoxide at 0.5% improved the color stability of fresh and enhanced pork chops (Krause et al., 2003). Luno et al. (2000) evaluated lower levels of CO in MAP and concluded that meat packaged under CO at 0.1% and 0.25% has similar color stability to meat packaged under high-oxygen; however, meat packaged under CO at 0.5% and higher has greater color stability properties than meat packaged in high-oxygen atmospheres. The use of a gas in meat packaging as a percentage of the atmosphere does not account for differences in headspace and the partial pressure of CO. Consequently, molecular availability of CO is not controlled. Our objective was to evaluate color development of MAP beef steaks packaged in the presence of prescribed CO molarities.

Materials and Methods

Steaks from paired USDA Select strip loins (n=6) were sectioned into 250 mL portions (2.5 cm x 8 cm x 12.5 cm) and assigned to one of six MAP packaging treatments (Table 1). The ideal gas law ($PV=nRT$) was used to determine CO molarity. Packaging atmospheres were comprised of 0.0, 0.2, 0.4, or 0.8% CO, 30% CO_2, and balanced with N_2. To control headspace, impermeable nylon bags were filled with a prescribed volume of H_20, sealed, and placed in the package. Two oxygen scavengers were activated and included in each package. Time between cutting and packaging was minimized to reduce oxygenation. Packages were stored in dark conditions at 4ºC for 4 d and 7 d. Atmospheric CO (ppm), instrumental (CIE L*a*b*) color, and carbon monoxide penetration depth (mm) were measured at d 4 and 7. Headspace CO was measured using a Bridge Tri-Gas Analyzer (CO measured to 1 ppm). The experiment (n=6 replications) was analyzed using the mixed procedure of SAS.

Table 1: Modified atmosphere package treatments

Treatment	Headspace (L)	Meat:Gas	mMol CO	% CO Gas (Certified)
A	0.40	0.50	0.07	0.4% CO
B	0.70	0.29	0.1	0.4% CO
C	1.10	0.18	0.2	0.4% CO
D	0.40	0.50	0.1	0.8% CO
E	1.10	0.18	0.1	0.2% CO
Control	0.70	0.29	0.0	0.0% CO

Results and Discussion

The mMol of CO in packages decreased ($P<0.001$) from d 0 through d 7. The decrease in atmospheric CO is listed in Table 2. Treatment C had the most ($P<0.001$) CO in its atmosphere at d 4 and at d 7. Moles of CO in each treatment decreased ($P<0.05$) by approximately half from d 4 to d 7. Accordingly, CO penetration depth increased ($P<0.05$) by 0.16-0.4 mm from d 4 to 7.

The a* value was used to indicate steak redness. Because the packaging systems were free of O_2, only COMb could develop. Thus, a* was an indicator of COMb development. The a* value increased ($P<0.05$) from d 4 to d 7. At d 4 of display among CO packaged steaks, D had the highest a* value, E had the lowest a* value, and A, B, and C were intermediate. At d 7 of display among CO packaged steaks, D had the highest a* value, E had the lowest a* value, and A, B, and C were intermediate. Also, Treatment E steaks had the least ($P<0.001$) atmospheric CO on d 7. Changes in CO penetration depth and a* value are listed in tables 3 and 4, respectively.

Table 2: mMol CO in Package

CO Treatment	Day 4	Day 7
A (0.4%; 0.07 mMol)	0.049[f]	0.020[h]
B (0.4%; 0.10 mMol)	0.091[b]	0.043[g]
C (0.4%; 0.20 mMol)	0.146[a]	0.075[d]
D (0.8%; 0.10 mMol)	0.093[b]	0.068[e]
E (0.2%; 0.1 mMol)	0.082[c]	0.005[i]
Control (0%; 0 mMol)	0.000[j]	0.000[j]

[a-j] Means lacking common superscript letters differ ($P<0.05$)

Table 3: Penetration Depth (mm)

CO Treatment	Day 4	Day 7
A (0.4%; 0.07 mMol)	3.98[c]	4.40[b]
B (0.4%; 0.10 mMol)	4.03[c]	4.19[bc]
C (0.4%; 0.20 mMol)	4.30[bc]	4.70[b]
D (0.8%; 0.10 mMol)	4.38[b]	5.36[a]
E (0.2%; 0.1 mMol)	3.77[c]	4.29[b]
Control (0%; 0 mMol)	0.00[d]	0.00[d]

[a-d] Means lacking common superscript letters differ ($P<0.05$)

Table 4: CIE a* Values

CO Treatment	Day 4	Day 7
A (0.4%; 0.07 mMol)	30.71[cd]	33.25[b]
B (0.4%; 0.10 mMol)	31.76[bc]	33.38[ab]
C (0.4%; 0.20 mMol)	29.82[d]	32.12[b]
D (0.8%; 0.10 mMol)	32.78[b]	34.77[a]
E (0.2%; 0.10 mMol)	28.3[e]	32.62[b]
Control (0%; 0 mMol)	22.61[f]	24.02[f]

[a-f] Means lacking common superscript letters differ ($P<0.05$)

Although C had the most moles of CO available, C did not have the highest d 7 a* value or deepest CO penetration depth. Treatment D had the highest percentage of CO (0.8%) and a small headspace (0.4 L), and D had the deepest ($P<0.001$) CO penetration depth and also had the highest a* value on d 4 and d 7. This suggests a synergy between percent-CO and volume of headspace that is beneficial for COMb development that may be more important than molecular availability of CO alone.

Increased concentration of CO in a small headspace can result in increased COMb development when compared to COMb development of beef steaks packaged in a larger headspace of CO at lower concentrations.

Conclusions

Although CO is believed to have a strong binding affinity to Mb, this research indicates that increased concentration and reduced headspace can may have a stronger influence on COMb development than just availability of CO. Reducing headspace reduces package size and subsequently can have many economic advantages. However, reducing headspace results in less available CO to bind to Mb. Smaller headspaces in combination with higher concentrations of CO (0.8%) may be the optimum way to decrease package size while maintaining or improving color stability of fresh meat.

References

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