CARBON MONOXIDE PACKAGING SHOWS THE SAME COLOR IMPROVEMENT FOR DARK-CUTTING BEEF AS HIGH OXYGEN PACKAGING

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Abstract – The color of dark-cutting beef is not preferred by many consumers. Storage under a high oxygen (HiOx) atmosphere has been shown to improve dark colored beef, while there is scant information on color effects derived from other packaging atmospheres. In this study, carbon monoxide (CO) modified atmosphere packaging (MAP) was used to improve the color of dark-cutting beef (ultimate pH (pHu) ≥ 6.10), along with normal pHu beef and intermediate pHu beef (pH: 5.40-5.79; pH: 5.80-6.09, respectively) when held chilled for 20d. Compared with HiOx-MAP, CO-MAP exhibited a similar color improvement of *L, *a** values for dark-cutting beef. The *a** value was improved above the consumers` acceptance threshold after the dark-cutting beef was exposed either into HiOx or CO-MAP. But the highest score of the *a** value of dark-cutting beef reached at the beginning and ending storage under HiOx-MAPs and CO-MAPs, respectively. It seems like the color improvement mechanisms might be different between those two MAPs.**

Key Words – beef meat, CO-MAP, redness

I. INTRODUCTION

The abnormal color of dark-cutting beef is a concern for the beef industry, as it represents an economic loss in many countries. One approach to improve the quality of dark-cutting beef, is to use enhancement via lactic acid injection or to improve color using high oxygen (HiOx, 80% O_2, 20% CO_2) modified atmosphere (MAP). However, except for HiOx, there is scant information about whether other packaging forms can be used to improve the color of dark-cutting beef. As Carbon monoxide (CO) MAP has been successfully used to improve color and color stability of normal beef steaks, heavily marbled beef steaks and beef patties[1,2], this investigation was undertaken to determine the effect of CO-MAP on the color and color stability of dark-cutting beef.

II. MATERIALS AND METHODS

Chinese crossbred yellow cattle (Luxi × Simmental, 18-24 months of age) carcasses with normal ultimate pH (pHu, 5.40-5.79, n=4), along with four carcasses with intermediate pHu (5.80-6.09) and four with high pHu (≥ 6.10) were randomly selected on the slaughter line after grading (24h postmortem) at a beef abattoir. The *M. longissimus lumborum* were removed from both sides, vacuum packaged and transferred to the lab within 2h. Each muscle was then portioned into 2cm beef steaks, and randomly assigned to one of the following treatments: Vacuum packaging, HiOx-MAP (80% O_2, 20% CO_2) or CO-MAP (0.4% CO, 30% CO_2, 69.6% N_2). The packaging material was the same as that applied in a previous study [2], and all the steaks for each pHu group were stored at 2°C for 20d. Three steaks per carcass of each pHu group remained unpackaged and were prepared for day 0 samples (initial color, blooming for 30 min). Eight steaks from each packaging and each pHu group were randomly selected and were measured for various parameters at 4d, 8d, 14d and 20d of storage. The measurement of pH and color values were conducted as previously described [2]. The MIXED procedure (SAS,Version 9.0) was used with pHu group, storage time, packaging, and their interactions fitted as fixed effects, and animal with three pHu as a random effect. Tests of differences between predicted means were applied using the PDIFF statement and differences were considered significantly different at $P < 0.05$.

III. RESULTS AND DISCUSSION

There was an interaction ($P < 0.05$) of pHu×packaging type×storage time for L^* and a^* values. The pH values were significantly different between pHu groups either at the beginning of storage or over the entire storage time (data not shown). As expected, the initial L^* and $a^*$of DFD beef was significantly lower than normal and intermediate pHu beef groups (Table 1). As storage time extended to 20 d, the L^* value of vacuum packaged normal pHu beef was maintained, but the a^*value decreased from 22.0 to 15.7 due to the oxygen limitation. Meanwhile, the intermediate and high pHu beef was much more stable, with both L^* and a^* not changing ($P > 0.05$) during storage; reflecting the very low initial values.

Both MAPs improved *L** and *a** values generally for all pHu groups. The color of vacuum packaged dark-cutting beef was below or around the consumers` acceptance threshold (*a**=14.5) [3] after 8 days of storage. While, both MAPs increased *L** and *a** values of 20d stored intermediate pHu meat and dark-cutting beef to the same level as the initial color of normal pHu beef, which was consistent with a previous HiOx-MAP color improvement study for dark-cutting beef [4]. The *a** and *L** value of dark-cutting beef was increased by up to 10.7 and 9.7 units at 8d and 20d of storage, respectively, comparied with vaccum packaged high pHu samples. However, the *a** value of dark-cutting beef reached the highest level under HiOx atmosphere after being stored for 8 days, while the top score of the redness exhibited at 20d of the storage when the beef exposed with CO. It also showed the redness of HiOx-dark−cutting beef was decreasing slightly as storage time extended from 8d to 20d, while that of CO-MAP-beef was opposite. Those differences might be caused by the different gas permeatation rates into meat, that oxygen diffused to the meat much more easier than CO due to its higher percentage of O_2 within HiOx-MAP, and then the metmyoglobin accumulation resulted in a decreasing redness. As for CO atmosphere, the cherry red layer might be getting thicker as the CO permeated deeper as time extended, and the surface was getting redder.

Table 1 Effect of packaging and storage time on the color values of beef steaks with normal, intermediate or high pHu (5.40-5.79; 5.80-6.09; ≥ 6.10) stored at 2°C

*L**		Storage time (day)					
		0	4	8	14	20	SE
LpHu	Vacuum	40.3aix	40.3aix	41.0aiy	40.9aiy	41.1aiy	
	HiOx	40.3bix	44.6aix	46.0aixy	46.3aix	45.8aixy	
	CO-MAP	40.3bix	45.5aix	47.4aix	46.3aix	48.5aix	
IpHu	Vacuum	35.3ajx	35.3ajy	36.5ajy	37.33ajy	37.91ajx	
	HiOx	35.3bjx	42.4aix	42.5aix	42.71ajx	41.91ajx	0.59
	CO-MAP	35.3bjx	38.3abjy	40.4ajx	39.54ajxy	40.29ajx	
HpHu	Vacuum	29.3akx	30.1aky	29.3aky	30.3aky	30.0aky	
	HiOx	29.3bkx	38.6abjx	38.7abjx	38.7abkx	39.7ajx	
	CO-MAP	29.3bkx	37.0abkx	36.4abkx	37.1abkx	38.1ajx	
*a**		Storage time(day)					
		0	4	8	14	20	SE
LpHu	Vacuum	22.0aix	17.5biy	14.5biy	15.8biz	15.7biz	
	HiOx	22.0aix	25.0aix	23.2aix	22.6aiy	23.6aiy	
	CO-MAP	22.0bix	26.6aix	26.5aix	27.9aix	29.5aix	
IpHu	Vacuum	15.5ajx	15.6aiy	16.3aiy	16.6aiy	15.8aiy	
	HiOx	15.5bjx	23.9aix	23.5aix	24.5aix	22.1aix	0.72
	CO-MAP	15.5bjx	22.2ajx	25.7aijx	22.9ajx	23.7ajx	
HpHu	Vacuum	14.5ajx	13.9aiy	13.6aiy	14.7aiy	14.4aiy	
	HiOx	14.5bjx	23.2aix	24.3aix	23.0aix	22.5aix	
	CO-MAP	14.5cjx	19.4bjx	22.0abjx	22.6abjx	23.8ajx	

Notes: Means with different superscript letters (a-b) within the same row differ at $P < 0.05$; (i-k) within the same packaging group differ at $P < 0.05$; (x-z) within the same pHu group differ at $P < 0.05$.

IV. CONCLUSION

This is the first study to report the effect of CO-MAP on the color of dark-cutting beef. We found CO-MAP exerted similar effects to HiOx-MAP in high pHu beef making the meat appear lighter and redder. Further study, is warranted to investigate the underlying mechanism(s) of color development of dark-cutting beef under CO atmosphere and whether this is a better option than HiOx-MAP in terms of tenderisation.

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