PE4.38 Effects of packaging and lactate on ground beef cooked color 137.00

Surendranath Suman (1) spsuma2@email.uky.edu, R Mancini(2), M Konda 2, R Ramanathan 2 P Joseph 1
(1)Department of Animal and Food Sciences, University of Kentucky, Lexington, KY 40546, United States of America
(2)Department of Animal Science, University of Connecticut, Storrs, CT 06269, United States of America

Abstract - **Our objective was to determine the effects of packaging and lactate on premature browning in ground beef. Each of eight coarse ground beef (85% lean) chubs was divided into two batches of 2.25 kg. Potassium lactate was added to one 2.25-kg batch per chub in order to obtain a final concentration of 2.5% w/w. The other 2.25 kg batch per chub received only distilled water. Each batch was mixed and then finely ground through a 4.8-mm plate. From each batch, patties (100 g, 10 cm diameter) were assigned to either vacuum, high-oxygen, or aerobic packaging, and stored in the dark at 2°C for 2 or 4 days prior to cooking (endpoint temperature of 66°C or 71°C). Cooked patties were sliced parallel to the grilled surface, and CIE a* values were evaluated on the freshly exposed interiors. Lactate increased ($P < 0.05$) redness of raw ground beef compared with controls. However, lactate had no effect ($P > 0.05$) on a* values of cooked ground beef. Increasing endpoint temperature from 66° to 71°C decreased ($P < 0.05$) a* values in cooked ground beef in aerobic and vacuum packaging, but had no effect ($P > 0.05$) on ground beef packaged in high-oxygen. High-oxygen packaging increases the likelihood of premature browning in ground beef compared with vacuum and aerobic packaging.**

S. P. Suman (corresponding author) is with the Department of Animal and Food Sciences, University of Kentucky, Lexington, KY 40546, USA (Phone: +1-859-257-3248; Fax: +1-859-257-7537; E-mail: spsuma2@email.uky.edu)
R. A. Mancini is with the Department of Animal Science, University of Connecticut, Storrs, CT 06269, USA (E-mail: Richard.Mancini@uconn.edu).
M. R. Konda is with the Department of Animal Science, University of Connecticut, Storrs, CT 06269, USA (E-mail: Muralikrishna.Konda@uconn.edu).
R. Ramanathan is with the Department of Animal Science, University of Connecticut, Storrs, CT 06269, USA (E-mail: Ranjith.Ramanathan@uconn.edu)
P. Joseph is with the Department of Animal and Food Sciences, University of Kentucky, Lexington, KY 40546, USA (E-mail: pjose3@.uky.edu)

Index Terms **— Cooked color, Ground beef, High-oxygen packaging, Lactate, Premature browning.**

I. INTRODUCTION

Heat-induced denaturation of myoglobin is responsible for the characteristic dull-brown color of cooked meat products. Unfortunately, the denaturation temperature for myoglobin depends on several factors, and therefore, the relative appearance of cooked product is not necessarily a reliable indicator that ground beef has been pasteurized [1].

Although ground beef should be cooked to an internal temperature of 71°C [2], consumers generally do not use meat thermometers and assume that a brown color in the interior of beef indicates that the product has reached a temperature sufficient to inactivate foodborne pathogens. However, premature browning (PMB) is a condition in cooked beef in which myoglobin denaturation occurs at a temperature lower than necessary for pasteurization. This falsely conveys that thermal pasteurization has been achieved.

The redox state of myoglobin determines its resistance against heat-induced denaturation, with deoxymyoglobin being most resistant and metmyoglobin least resistant [3]. Thus, packaging plays a role in cooked color. For example, the tendency of beef to brown prematurely is greater in high-oxygen packaging (80% oxygen) than in traditional over-wrap packaging [4-6].

Lactate is an ingredient often used in case-ready beef processing. Although a significant amount of research has focused on lactate's role in raw color, no research has assessed the ingredient's effect on cooked ground beef color, especially when combined with high-oxygen packaging. Thus, our objective was to determine the combined effects of packaging and lactate on premature browning in ground beef.

II. MATERIALS AND METHODS

Each of eight coarse ground beef (85% lean) chubs was divided in half, resulting in two batches of 2.25 kg per chub. Potassium lactate was added to one 2.25-kg batch per chub in order to obtain a final concentration of 2.5% w/w. The other 2.25 kg batch per chub was used as a control and received only distilled water. Each batch was mixed and then finely ground through a 4.8-mm plate. From each 2.25-kg batch, 14 patties (100 g, 10 cm diameter) were assigned to 1 of 7 packaging x storage time combinations: (1) day 0, prior to storage and packaging; (2) 2 days of storage in vacuum; (3) 2 days of storage in high-oxygen; (4) 2 days of storage in aerobic packaging; (5) 4 days of storage in vacuum; (6) 4 days of storage in high-oxygen; (7) 4 days of storage in aerobic packaging. Therefore, 2 patties per batch were assigned to each packaging x storage combination. Of the two patties, one was later assigned to an internal endpoint temperature of 66°C and the other was assigned to 71°C. High-oxygen packaging (Hi-Ox) consisted of 80% O_2 + 20% CO_2 and aerobic packaging (PVC) consisted of oxygen-permeable polyvinyl chloride film. Packages were stored in the dark at 2°C for either 2 or 4 days prior to instrumental raw color analyses and cooking.

The raw surface color of each patty was determined on days 0, 2, and 4, immediately after packages were opened. CIE *a** values were measured using a HunterLab MiniScan XE Plus spectrophotometer with a 2.54-cm diameter aperture and illuminant A [7].

Patties were cooked to internal temperatures of 66°C or 71°C using a George Foreman clam-shell grill. Internal temperature was monitored using a handheld probe thermometer inserted into the geometric center of each patty. Cooked samples were removed from the grill and submerged in ice to minimize post-cooking temperature rise. Cooked patties were sliced parallel to the grilled surface, and CIE a* values were evaluated on the freshly exposed interiors.

The experimental design for cooked color was a split-split-plot with a randomized complete block in the whole-plot (n = 8). Each chub served as a block and each chub half received one of two lactate treatments (0 or 2.5%). Within the sub-plot, patties were assigned to 1 of 14 packaging x storage time x endpoint temperature combinations. Data were analyzed using the Mixed Procedure of SAS [8]. Fixed effects included lactate, packaging, storage time, endpoint temperature, and their interactions.

III. RESULTS AND DISCUSSION

There were no significant 4- or 3-way interactions for a* values of raw and cooked ground beef. There was a significant packaging x lactate and packaging x storage time interaction for raw color. In addition, there was a significant packaging x lactate and packaging x endpoint temperature interaction for cooked color.

Lactate increased ($P < 0.05$) redness of raw ground beef compared with controls (Table 1). In addition, raw ground beef packaged in either PVC or high-oxygen had more discoloration during storage than ground beef packaged in vacuum (Table 1).

Increasing endpoint temperature from 66° to 71°C decreased ($P < 0.05$) a* values in cooked ground beef packaged in PVC and vacuum, but had no effect ($P > 0.05$) on ground beef packaged in high-oxygen (Table 2). Lactate had no effect ($P > 0.05$) on a* values of cooked ground beef.

Our results are in agreement with previous research suggesting a beneficial effect of lactate on raw beef color [9]. However, the effects of lactate on raw color were not reflected in our cooked color data.

High oxygen packaging creates a thick layer of oxymyoglobin. However, the temperature at which oxymyoglobin denatures is less than the temperature at which deoxymyoglobin denatures. This was reflected in our cooked a* values, where increasing endpoint temperature had no effect on redness of ground beef in high-oxygen.

IV. CONCLUSION

Lactate can be used to improve raw ground beef redness without influencing cooked color. In addition, high-oxygen packaging increases the likelihood of ground beef premature browning compared with vacuum and oxygen-permeable PVC.

ACKNOWLEDGEMENT

This work was supported by funds from Kentucky Agricultural Experiment Station, University of Kentucky.

REFERENCES

[1] Bigner-George, M. E. & Berry, B. W. (2000). Thawing prior to cooking affects sensory, shear force, and cooking properties of beef patties. Journal of Food Science, 65, 2–8.

[2] USDA (1997). USDA advises consumers to use a meat thermometer when cooking hamburger. FSIS News and Information Bulletin. FSIS, USDA, Washington, DC, USA.

[3] Machlik, S. M. (1965). The effect of heat on bovine myoglobin derivatives in model systems and in beef semitendinosus muscle. Ph.D. Dissertation, Purdue University.

[4] Seyfert, M., Hunt, M. C., Mancini, R. A., Kropf, D. H., & Stroda, S. L. (2004a). Internal premature browning in cooked steaks from enhanced beef round muscles packaged in high-oxygen and ultra-low oxygen modified atmospheres. Journal of Food Science, 69, 142–146.

[5] Seyfert, M., Hunt, M. C., Mancini, R. A., Kropf, D. H., & Stroda, S. L. (2004b). Internal premature browning in cooked ground beef patties from high-oxygen modified-

atmosphere packaging. Journal of Food Science, 69, 721–725. -20.

[6] Suman, S. P., Faustman, C., Lee, S., Tang, J., Sepe, H. A., Vasudevan, P., Annamalai, T., Manojkumar, M., Marek, P., & Venkitanarayanan, K. S. (2005). Effect of erythorbate, storage and high-oxygen packaging on premature browning in ground beef. Meat Science, 69, 363–369.

[7] AMSA (1991). Guidelines for meat color evaluation. American Meat Science Association. Chicago, IL, USA.

[8] SAS (2007). SAS User's Guide version 9.1. SAS Institute Inc., Cary, NC, USA.

[9] Kim, Y.H., Hunt, M.C., Mancini, R.A., Seyfert, M., Loughin, T.M., Kropf, D.H., & Smith, J.S. (2006). Mechanism for lactate-color stabilization in injection-enhanced beef. Journal of Agricultural and Food Chemistry, 54, 7856-7862.

Table 1: Characterization of raw ground beef surface redness (a* value): Effects of lactate[1], packaging[2], and storage time at 2°C.

	Packaging[1]		
Enhancement	Aerobic PVC	Hi-Ox	Vacuum
Control	13.0a	20.4b	16.7c
Lactate	19.0a	23.0b	20.3a
P-value[3]	<0.05	<0.05	<0.05
SE	0.58	0.58	0.60
Storage time (d)			
0	19.5	19.5	19.5
2	18.3a	21.2b	24.2c
4	11.1a	10.8a	19.2b
SE	0.58	0.58	0.60

[1] Treatments include control ground beef without added lactate and ground beef with a final concentration of 2.5% lactate.
[2] Modified atmosphere packaging: Hi-Ox = 80% O_2 + 20% CO_2.
[3] P-value for control versus lactate comparisons within a packaging type.
SE = Standard error of the mean.
a-c Least square means within a row with a different letter are significantly different ($P < 0.05$).

Table 2: Characterization of cooked ground beef internal redness (a* value): Effects of lactate[1], packaging[2], and endpoint temperature.

	Packaging[2]		
Endpoint temperature (°C)	Aerobic PVC	Hi-Ox	Vacuum
66	13.3a	10.8b	16.9c
71	11.9a	10.5b	14.5c
P-value[3]	<0.05	0.51	<0.05
SE	0.23	0.24	0.26
Enhancement			
Control	12.8a	10.7b	15.4c
Lactate	12.4a	10.5b	15.9c
P-value[4]	0.30	0.65	0.33
SE	0.2	0.2	0.3

[1] Treatments include control ground beef without added lactate and ground beef with a final concentration of 2.5% lactate.
[2] Modified atmosphere packaging: Hi-Ox = 80% O_2 + 20% CO_2.
[3] P-value for endpoint temperature comparisons within a packaging type.
[4] P-value for control versus lactate comparisons within a packaging type.
SE = Standard error of the mean.
a-c Least square means within a row with a different letter are significantly different ($P < 0.05$).