# Mountain States Lamb Project

Kathryn Hearn
The Honors College
Oklahoma State University

December 2018

## INTRODUCTION

Protein companies across the United States aim to provide safe and desirable products to consumers. In order to maximize profits, these companies have to understand the buying patterns of consumers, and the science of keeping their products desirable. Meat purchasing decisions are influenced by color more than any other quality factor because consumers use discoloration as an indicator of freshness and wholesomeness. As a result, nearly 15% of retail beef is discounted in price due to surface discoloration, which corresponds to annual revenue losses of $1 billion (Smith et al., 2000). Many companies desire to understand how the meat discolors and how to prevent discoloration extending shelf life for their products.

While most studies on extended meat shelf life have been conducted on beef, it is important to understand the shelf life of other species as well, including lamb. According to USDA FSIS, raw lamb products can be packaged and kept 3-5 days before cooking. However, this can be extended by different packaging techniques. Currently, the storage lifetime for vacuum packed lamb held at − 1.5°C has been estimated to be between 60 and 70 days (Bell, 2001, James and James, 2002). Although the shelf life of lamb is greatly extended by vacuum-packaging, it will eventually spoil. Spoilage indicators include off-odors and discoloration (Bell, 2001).

Oxidation is one of the primary mechanisms of quality deterioration in foods and especially in meat products. The changes in quality are manifested by adverse changes in flavor, color, texture and nutritive value, and the possible production of toxic compounds. (Gray et al., 1996). Oxidation first begins when meat is exposed to oxygen. This occurs when oxymyoglobin, the meat pigment that gives lamb its reddish-pink color, is deteriorated to metmyoglobin, a brown pigment (Boles and Pegg, 2005).

Vacuum-packaging refers to meat that has been placed into a bag of low oxygen permeability and a vacuum applied prior to sealing (Kropf, 2004). As the vacuum is applied the packaging collapses ensuring close contact between the film and meat that can be further enhanced by shrink wrapping. When meat is sealed with little headspace in oxygen-impermeable materials, the residual oxygen at the meat surface/package interface will be rapidly converted to carbon dioxide by the respiratory activity of the meat (Bell, 2001). In oxygen-depleted atmospheres, growth of aerobic spoilage bacteria is prevented and the microflora changes to one that is dominated by slow growing, $CO_2$ tolerant bacteria (Borch et al., 1996).

One study suggests that metmyoglobin reducing activity is not the primary determinant of color or color stability of ovine longissimus muscle (Bekhit et al., 2003). Limited work on lamb primals has been published and in particular, information on the effect of different packaging atmospheres on the microbial flora and shelf life has not been previously reported (Sheridan et al., 1997). Therefore, the aim of this study is to further understand the effects of a treatment on vacuum packaged lamb primals and the resulting limitation of shelf life and microbial growth.

# MATERIALS AND METHODS

## Storage

All vacuum packaged products (leg, loin, rack, and ground lamb) were stored at 5°C for up to 60 days. At 5 day intervals, vacuum packages of each product (n = 24) were removed and examined. Fifteen replicates were set up for each atmosphere/temperature combination.

## Objective Color

The MiniScan EZ HUNTERLAB (aperture: 25 mm; Model 45/0, HunterLab Associates Laboratory Inc., Hong Kong, PRC) was set to Illuminant D65 and 10° standard observer. The HUNTERLAB was calibrated using a black and white tile (X = 80.4. Y = 85.3, Z = 91.5) and used at random throughout each display interval so as to account for device variation. Each sample surface was then measured with the HUNTERLAB, three replicate measures and the Instrument was repositioned after each measure with care to avoid connective tissue and fat deposits, and ensure complete aperture coverage (HunterLab, 2012). Data from both instrument was then reported as average colorimetric values (AMSA, 2012).

**Subjective Color**

Visual assessment of lean color (1 = bright reddish-pink to red; 8 = black discoloration), fat and bone discoloration (1 = no discoloration; 4 = extremely discolored), surface discoloration (1 = no discoloration (0%); 6 = extensive discoloration (81-100%) and acceptability (0 = no discount; 2 = discarded) were performed by a 6-member trained panel using American Meat Science Association (2012) Meat Color Measurement Guidelines. For the visual display color, panelists visually scored (with the below scales) each product while still in package. The scores were sorted by treatment type and averaged by day. For the visual display color after package sacrifice, the products were allowed one hour to bloom. Panelists visually scored (with the below scales) each product. The scores were sorted by treatment type and averaged by day.

**Microbiology**

A 10 g sample was removed from the lean surface of the lamb primal (leg, loin, and rack) and ground lamb and homogenised in a Colworth Stomacher (Model BA6021, A.J. Seward & Company Ltd., London, UK) for 30 seconds with 90 ml of maximal recovery diluent [MRD; Becton Dickinson Microbiology Systems (BBL), Cockeysville, MD USA]. Bacterial numbers were estimated from plates surface inoculated with 1 ml of the meat solution. All plates were inoculated in duplicate and the inoculum spread on the surface of aerobic count Petrifilm (3M healthcare, 2510 Conway Ave, St. Paul MN 55144 USA).

**Statistical Analysis**

Least square means were generated using the MIXED procedure of SAS (SAS 9.4; SAS Inst., Cary, NC). For all analysis, when a significant F-test was identified $P < 0.05$, least square means were separated using a pairwise T-test (PDIFF option).

## RESULTS

There was no statistical difference between the control and treatment visual color scoring for any of the products: leg, loin, rack or ground (Figure 1, 2, 3, 4). There was no statistical difference ($P > 0.05$) between surface discoloration in any product after package sacrifice (removal from display) throughout the study. No significant difference ($P > 0.05$) was expressed in acceptability in any product after package sacrifice throughout the study. There was no statistical difference ($P > 0.05$) in the visual color with product still in package for any of the products: leg, loin, rack and ground lamb. This is illustrated in Figure 5, 6, 7, and 8. There was no significant ($P > 0.05$) difference in fat and bone discoloration, surface discoloration or acceptability in any of the products throughout the entire study.

There were no significant differences ($P > 0.05$) in objective readings across any product throughout the entire study. All products remained highly acceptable for the duration of the project based on objective color readings (L*, a* and b*). Data not presented graphically.

Odor was evaluated on every package on day of sacrifice. No off odors were detected in any leg, loin or ground products. However, all racks (control and treatment) had off odors. We are unaware of any differences in handling or packaging that may have caused the off odors and microbial counts remained acceptable.

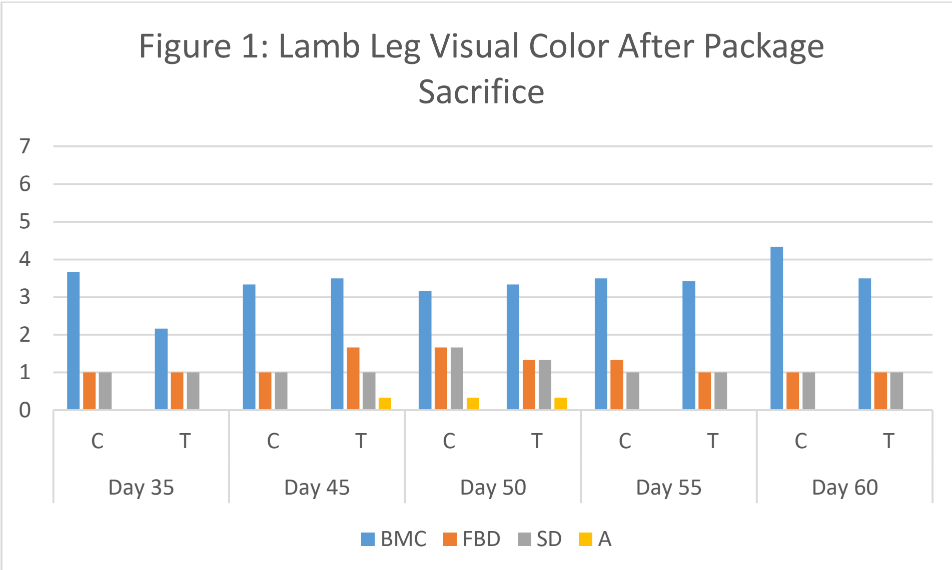


Figure 1: Lamb Leg Visual Color After Package Sacrifice
7
6
5
4
3
2
1
0
C
T
Day 35
Day 45
Day 50
Day 55
Day 60
BMC
FBD
SD
A

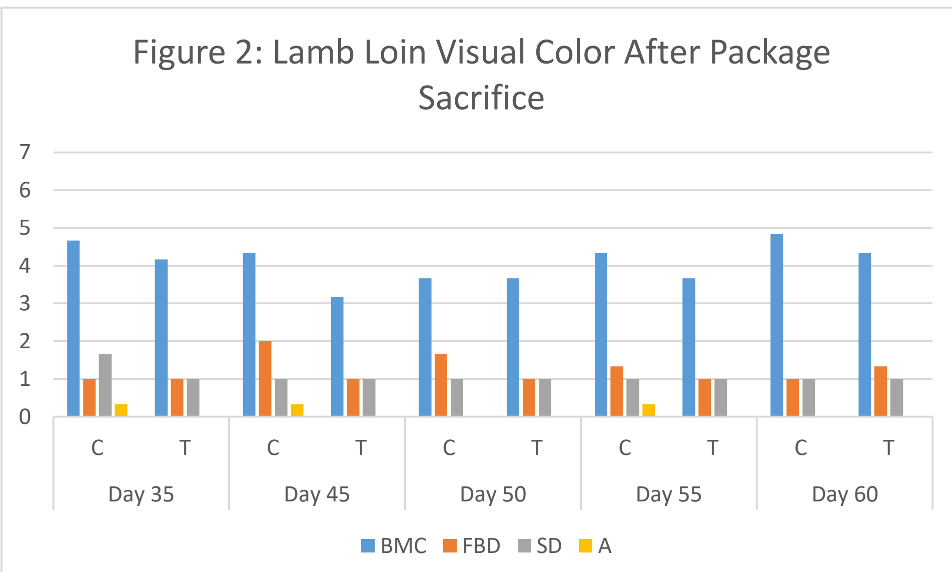


Figure 2: Lamb Loin Visual Color After Package Sacrifice
7
6
5
4
3
2
1
0
C
T
Day 35
Day 45
Day 50
Day 55
Day 60
BMC
FBD
SD
A

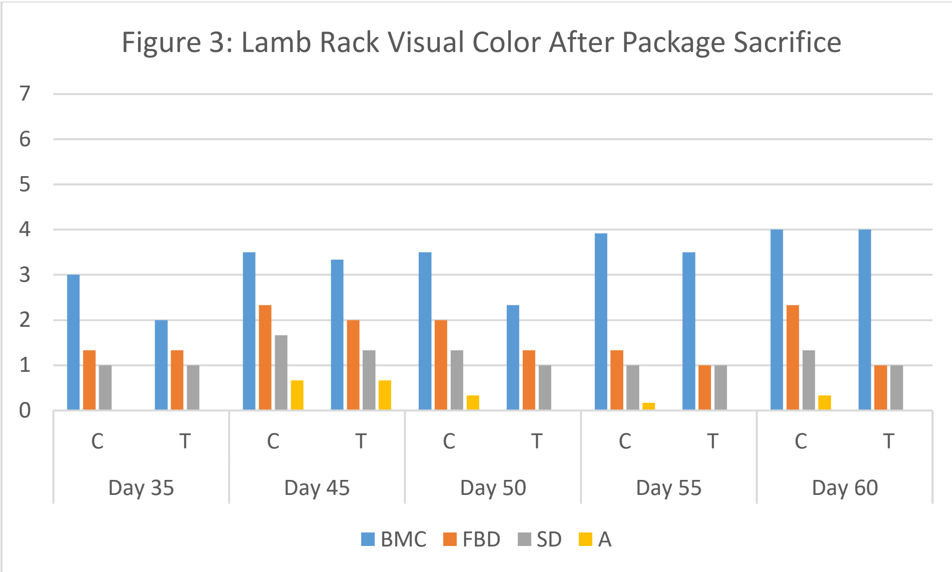


Figure 3: Lamb Rack Visual Color After Package Sacrifice
7
6
5
4
3
2
1
0
C
T
C
T
C
T
C
T
C
T
Day 35
Day 45
Day 50
Day 55
Day 60
BMC
FBD
SD
A

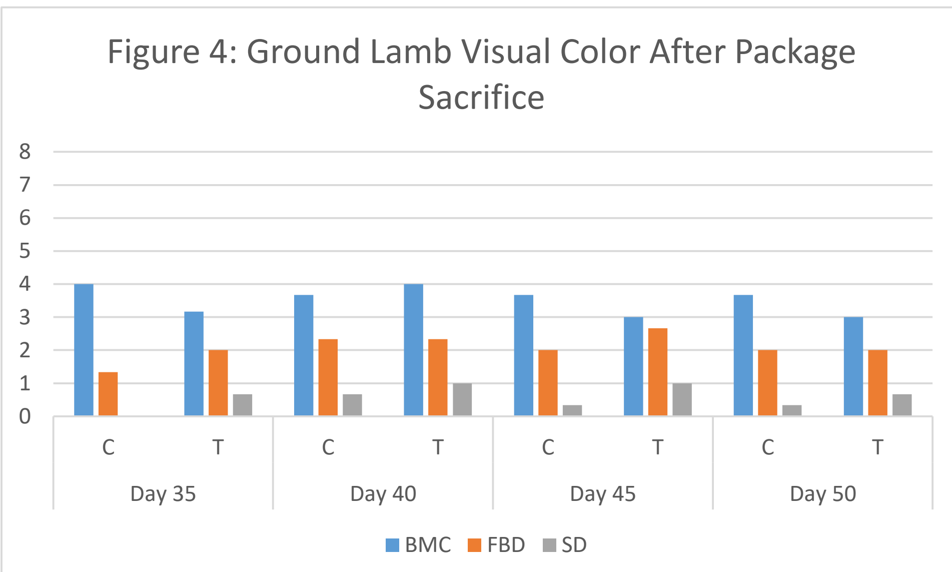


Figure 4: Ground Lamb Visual Color After Package Sacrifice
8
7
6
5
4
3
2
1
0
C
T
C
T
C
T
C
T
Day 35
Day 40
Day 45
Day 50
BMC
FBD
SD

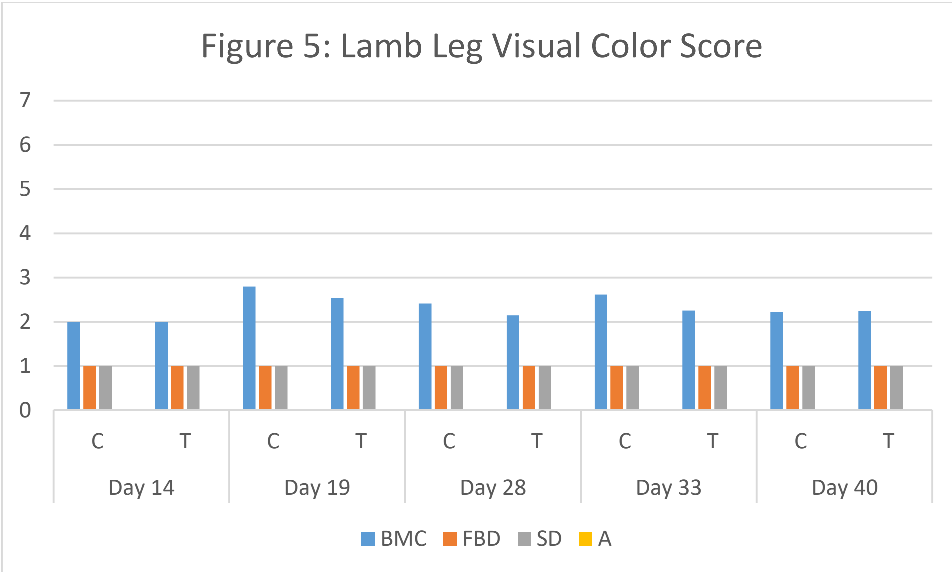


Figure 5: Lamb Leg Visual Color Score
7
6
5
4
3
2
1
0
C
T
C
T
C
T
C
T
C
T
Day 14
Day 19
Day 28
Day 33
Day 40
BMC
FBD
SD
A

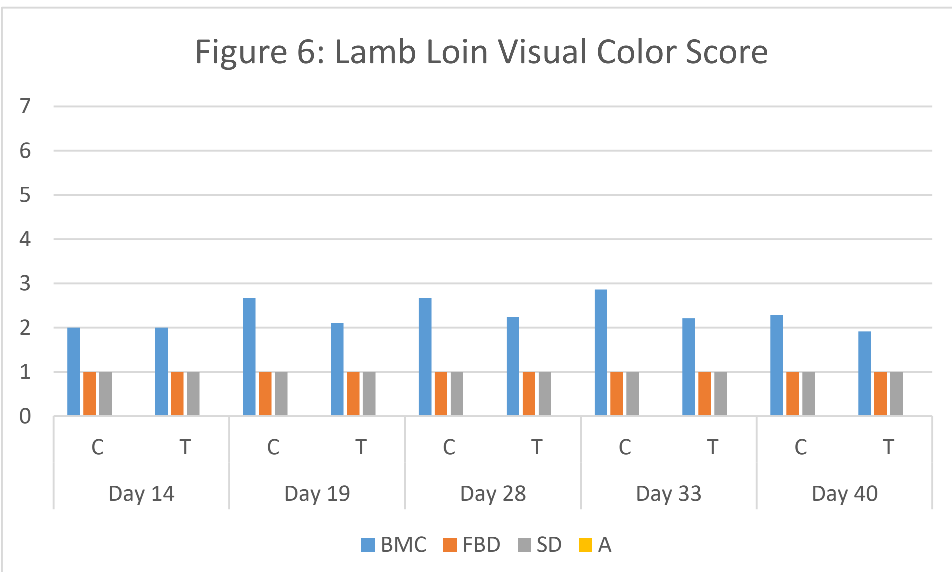


Figure 6: Lamb Loin Visual Color Score
7
6
5
4
3
2
1
0
C
T
C
T
C
T
C
T
C
T
Day 14
Day 19
Day 28
Day 33
Day 40
BMC
FBD
SD
A

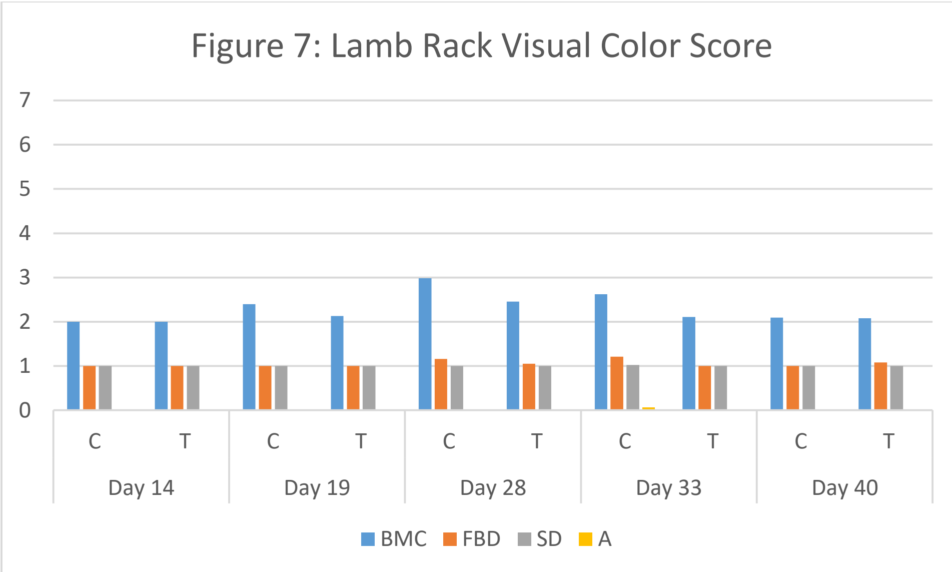


Figure 7: Lamb Rack Visual Color Score
7
6
5
4
3
2
1
0
C
T
Day 14
Day 19
Day 28
Day 33
Day 40
BMC
FBD
SD
A

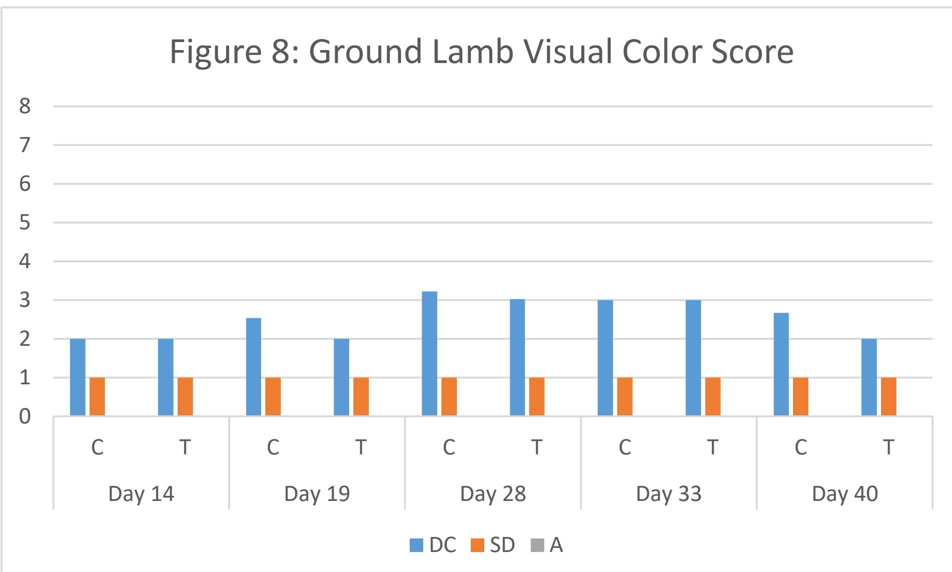


Figure 8: Ground Lamb Visual Color Score
8
7
6
5
4
3
2
1
0
C
T
Day 14
Day 19
Day 28
Day 33
Day 40
DC
SD
A

There was no statistical difference ($P > 0.05$) in microbial population for any product on initial testing of the product when placed in retail display. Figure 9 illustrates that there was only a statistical difference ($P < 0.05$) in microbial count on day 35 of the lamb leg, whereas the control had a lower population. However, microbial counts were then similar for the remainder of the study. Figure 10 indicates that the treatment had an overall statically lower microbial population than the control through the entire study on the lamb loin. Figure 11 illustrates that there was only a statistical difference ($P < 0.05$) in microbial count on day 55 of the lamb rack trial, whereas the treatment had a lower population. Figure 12 indicates that the treatment had an overall statically lower microbial population than the control through the entire study, with the exception of day 35, on ground lamb.

In general, the control and treatment packages resulted in very similar shelf-life characteristics. The treatment showed an overall 1 log reduction in ground lamb total plate counts throughout the study.

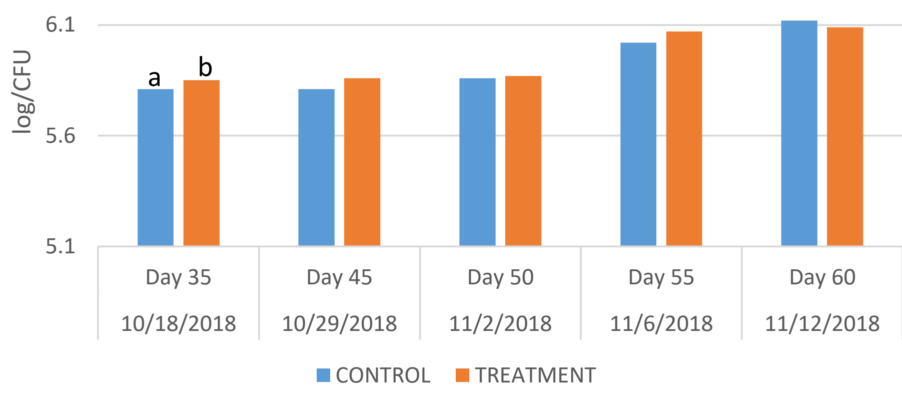



Figure 9: Lamb Leg Microbial Count

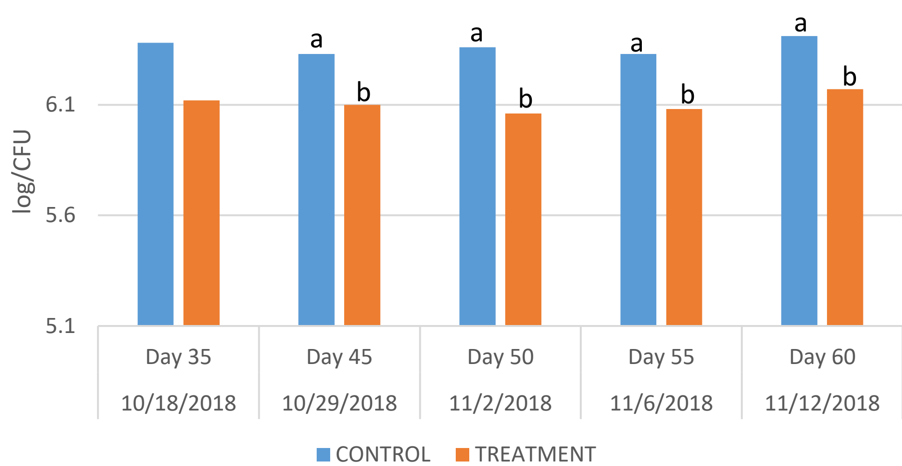



Figure 10: Lamb Loin Microbial Count

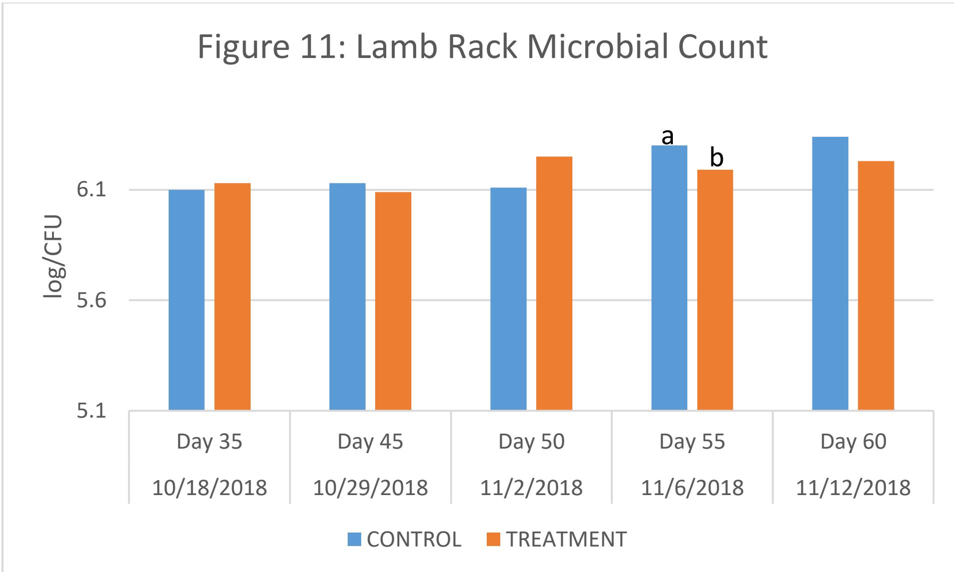


Figure 11: Lamb Rack Microbial Count
log/CFU
6.1
5.6
5.1
a
b
Day 35
10/18/2018
Day 45
10/29/2018
Day 50
11/2/2018
Day 55
11/6/2018
Day 60
11/12/2018
CONTROL
TREATMENT

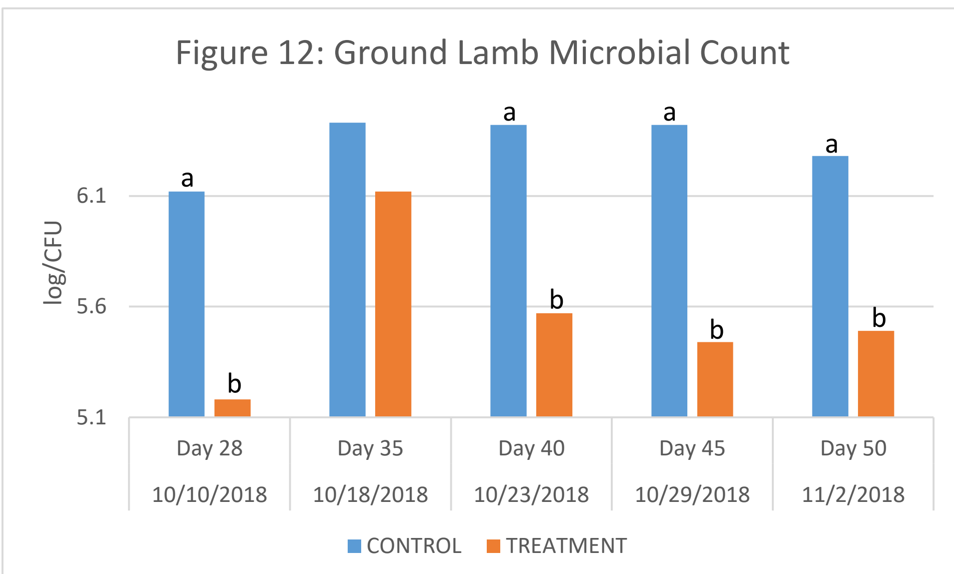



Figure 12: Ground Lamb Microbial Count
log/CFU
6.1
5.6
5.1
a
b
a
b
a
b
a
b
Day 28
10/10/2018
Day 35
10/18/2018
Day 40
10/23/2018
Day 45
10/29/2018
Day 50
11/2/2018
CONTROL
TREATMENT

# CONCLUSION

During the study there was no significance found in the visual color before and after package sacrifice for any of the products. In ground lamb products, shelf-life was improved because of lower microbial counts. Further research suggested would include a taste panel to determine if there is any off flavor associated with the treatment, or between the treatment and control on pull-date. Furthermore, increasing the handling stress and foot traffic in the retail case would simulate what the product would go through in the retail chain.

# REFERENCES


AMSA. 2012. Meat color measurement guidelines. American Meat Science Association, Champaign, IL.

Bekhit, A.E.D., G.H. Geesink, J.D. Morton, and R. Bickerstaffe. 2003. Metmyoglobin reducing activity and color stability of ovine longissimus muscle. J. Agric. Food Chem. (Vol 51. Supp. 20): 6026-6035.

Bell, R. G. 2001. Meat Packaging: Protection, preservation and presentation. Meat Science and applications. p. 463-490.

Boles, J. A. and Pegg, R. 2005. Meat color. University of Saskatchewan, Dept. Appl. Microbiol. Food Sci. Tech. Bull., Saskatoon, SK.

Borch, E., M. L. Kant-Muermans, and Y. Blixt. 1996. Bacterial spoilage of meat and cured meat products. International Journal of Food Microbiology. (Vol. 33): 103:120.

Gray, J. I., E. A. Gomaa, and D. J. Buckley. 1996. Oxidative quality and shelf life of meats. Meat Sci. (Vol. 43 Supp. 1): 111-123.

HunterLab. 2012. Measurement method 5076.00. HunterLab Associates Laboratory Inc. p. 1-4.

James, S. J., and C. James. 2002. Meat refrigeration. Woodhead Publishing, Cambridge, U.K.

Kropf, D. H. 2004. Packaging: Vacuum. Encyclopedia of Meat Sci. p. 955-962.

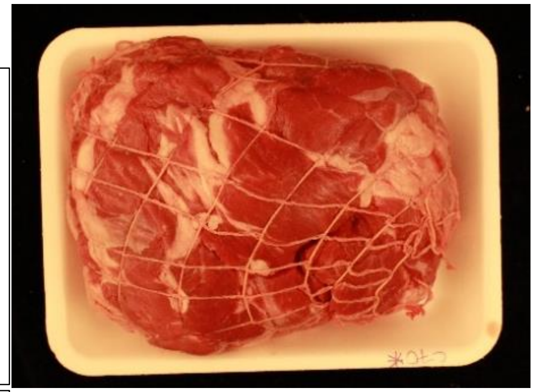
Sheridan, J. J., A. M. Doherty, P. Allen, D. A. McDowell, I. S. Blair, and D. Harrington. 1997. The effect of vacuum and modified atmosphere packaging on the shelf-life of lamb primals, stored at different temperatures. Meat Sci. (Vol. 45 Supp. 1): 107:117.

Smith, G. C., K. E. Belk, J. N. Sofos, J. D. Tatum, and S. N. Williams. 2000. Economic implications of improved color stability in beef. In: Antioxidants in muscle foods: nutritional strategies to improve quality. John Wiley & Sons, Inc., Hoboken, NJ p. 397-426.

# APPENDIX


Left: Lamb leg in package

Right: Lamb leg removed from package-Control




Left: Lamb loin in package

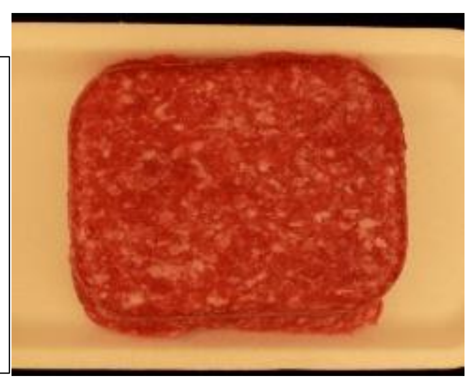
Right: Lamb loin removed from package-Control


Left: Lamb rack in package

Right: Lamb rack removed from package-Control


Left: Ground lamb in package

Right: Ground lamb removed from package-Control



| Display Color (DC) | Surface Discoloration (SD) | Acceptability |
|---|---|---|
| **1** Very Bright Red or reddish pink | **1** No Discoloration **(0%)** | **0** No Discount |
| **2** Bright Red or reddish-pink | **2** Slight Discoloration **(1-20%)** | **1** Reduced |
| **3** Dull Red or reddish-pink | **3** Small Discoloration **(21-40%)** | **2** Discarded |
| **4** Slightly Dark Red or reddish-pink | **4** Modest Discoloration **(41-60%)** | |
| **5** Moderately Dark Red or reddish-pink | **5** Moderate Discoloration **(61-80%)** | |
| **6** Dark Red or Tannish-Red or tannish-gray | **6** Extensive Discoloration **(81-100%)** | |
| **7** Dark Reddish-Tan or tannish-gray | | |
| **8** Tan or Brown | | |

| Bone Marrow Color (BMC) | Fat and Bone Discoloration (FBD) | Surface Discoloration (SD) | Acceptability (A) |
|---|---|---|---|
| **1** Bright reddish-pink to red | **1** No discoloration | **1** No Discoloration **(0%)** | **0** No Discount |
| **2** Dull pinkish-red | **2** Slight discolored | **2** Slight Discoloration **(1-20%)** | **1** Reduced |
| **3** Slightly grayish-pink/grayish-red | **3** Moderately discolored | **3** Small Discoloration **(21-40%)** | **2** Discarded |
| **4** Grayish-pink or grayish-red | **4** Extremely discolored | **4** Modest Discoloration **(41-60%)** | |
| **5** Moderately gray | | **5** Moderate Discoloration **(61-80%)** | |
| **6** All gray or grayish-black | | **6** Extensive Discoloration **(81-100%)** | |
| **7** Black discoloration | | | |