EFFECTS OF HELIUM GAS UTILIZATION IN MODIFIED ATMOSPHERE PACKAGING (MAP) ON BEEF QUALITY

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I. INTRODUCTION

Microbial spoilage is one of the most common causes of decreases in meat quality and can lead to growth of visible colonies, textural changes, additional off-flavors, and odors that can lower consumer appeal [1]. Spoilage of fresh meat products poses a significant economic burden to the protein industry, as annual losses due to microbial spoilage are estimated to account for approximately 20% of meat production [2]. Helium gas has proven to create bactericidal effects against various microorganisms, including logarithmic reductions in *E. coli* cells [1]. This project was designed to determine if including helium gas in MAP impacted meat color and presence of E. coli Biotype I microorganisms on beef surfaces over a five-day shelf-life period.

II. MATERIALS AND METHODS

USDA Choice, boneless strip loins (n = 24) were fabricated into a total of 216 steaks. Steaks (n = 108) were assigned to microbial analysis and allocated to one of three MAP packaging treatments: (1) control (n = 36) MAP with a gas composition typical of commercial practices (60-80% O_2 and 20–30% CO_2), (2) MAP with high helium inclusion (n = 36), (60% O_2, 10% CO_2, 30% He), and (3) MAP with low helium inclusion (n = 36), (80% O_2, 10% CO_2, 10% He). The remaining steaks (n = 108) were assigned to color assessment and packaged using the same three MAP treatments outlined above. Five non-pathogenic *E. coli* Biotype I surrogate strains were used to prepare a surrogate cocktail for the inoculation of steak surfaces. Two 5 x 5 cm^2 areas on both the top and bottom lean surfaces of each steak (n = 108) were inoculated with 0.1 ml of the surrogate cocktail and randomly assigned to day 0, 3, or 5. Following a 10-min attachment period, pre-treatment samples (n = 108 top and 108 bottom, n = 216 total samples) were excised. Each sample was prepared and plated using the appropriate serial dilutions. Packaged steaks were held at refrigeration temperatures (4 °C) for the assigned storage time (day 0, 3, or 5). On days 0, 3, and 5 steaks (n = 12 steaks per MAP treatment/storage day 0, 3, and 5; n = 108 total steaks) were sampled and analyzed (n = 108 post-treatment top and 108 post-treatment bottom samples, n = 216 total post-treatment samples) following the same methods used before packaging. MAP steaks (n = 108) assigned to color assessment were stored (4 °C) with 1600 lx fluorescent lighting to simulate a retail display case. Steaks (n = 12 steaks per MAP treatment/storage day 0, 3, and 5; n = 108 total steaks) were held under these conditions for 0, 3, or 5 days. Visual assessments, fat color, and discoloration/uniformity of steak color were conducted by a 6-member trained panel [3]. Additionally, instrumental lean color was assessed on the unpackaged steaks (n = 108), and hue angle and chroma were calculated. Data were analyzed using the analysis of variance (ANOVA) function in JMP® Pro Version 15.2.1 (SAS Institute Inc., Cary, NC). When the model concluded significance, ($P < 0.05$), least squares means were separated using the Student t-test with the alpha level set at 0.05.

III. RESULTS AND DISCUSSION

In general, there were few differences among the treatments, and there was no identifiable trend in reductions of Biotype I *E. coli* microorganisms on lean surfaces. While it has been documented that helium gas is an effective method in reducing the quantity of pathogens on steak surfaces [4], overall our data do not support reductions when helium is included in MAP. Lean color for packaged and unpackaged steaks was not different (P > 0.05) across treatment type on storage day. Fat color for packaged and unpackaged steaks was not different (P > 0.05) on day 0 or 5, however, fat color for steaks treated with high helium were different (P < 0.05) on day 3 when compared to low helium treatment. Lean discoloration was not different across treatment for packaged and unpackaged steaks (P > 0.05) on any storage day. There were differences (P < 0.05) for *L** and *b** values among treatments averaged across days 0, 3, and 5, but there were no differences (P > 0.05) for *a** values. Hue angle values were not different across treatment groups (P > 0.05) for any storage day, however, there were differences (P < 0.05) in chroma values for day 3 and 5. There were no differences (P > 0.05) for *L** among storage days within any treatment. Instrumental *a** values displayed no differences until storage day 5, (P < 0.05) between the control and the low helium, with the low helium having a lower *a** value, indicating a decrease in redness. Additionally, at day 5, both high and low helium treatments had lower *b** values than the control.

Table 1. Least squares means of CIE color space values (*L*, a*, b**) across treatments averaged for days 0, 3, and 5

		CIE		
Treatment	*n*	L*	a*	b*
T1	12	48.52[b]	21.34[a]	15.84[a]
T2	12	48.85[b]	20.93[ab]	15.18[ab]
T3	12	50.67[a]	20.34[b]	14.85[b]
SEM		0.47	0.35	0.27
P-value		0.003	0.131	0.031

[1]Means within a column, by CIE value with different letters (a-b) are different (P < 0.05).
[2]Treatments: T1 = control (60-80% O_2 and 20–30% CO_2); T2 = high helium (60% O_2 , 10% CO_2, 30% He), T3 = low helium (80% O_2 , 10% CO_2, 10% He)

IV. CONCLUSION

Meat spoilage causes off-flavors, odors, and changes in product appearance, resulting in lower consumer acceptance of meat products at the retail level. Results from this study indicate that although helium gas utilization in modified atmosphere packaging did not have a significantly negative impact on meat color, it did not reduce *E. coli* Biotype I microorganisms on steak surfaces over a five-day period when compared to the average MAP gas mixture commonly utilized in industry. In this study, adding helium gas to MAP packages did not extend product shelf life when compared to commonly used gas mixtures, such as 60-80% O_2 and 20–30% CO_2.

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