Progress in Agricultural Engineering Sciences 19 (2023) S1, 27–33
DOI: 10.1556/446.2023.00079

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Comparison of the effect of organic acid mixture on quality parameters of red deer meat and beef

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ORIGINAL RESEARCH PAPER

Received: September 9, 2023 • Accepted: November 12, 2023
Published online: November 27, 2023

ABSTRACT

This study investigates the effect of 2% lactic acid and 2% ascorbic acid mixture on the quality parameters of red deer meat and beef. After treatment samples were stored at 4 ± 1 °C. The following meat quality parameters were evaluated: pH, color, and microbiological count on days 1, 7, 14, and 21. The results showed that at the end of the experiment, the pH of the treated samples was slightly higher than the non-treated samples, indicating that the lactic acid and ascorbic acid mixture had a mild acidifying effect on the meat. The color of the treated and non-treated samples did not show any significant difference. However, the microbiological count in the treated samples was lower than the non-treated samples. These findings suggest that an acid mixture could be used as a natural preservative to enhance the microbial safety of red deer meat and beef.

KEYWORDS

red deer, beef, ascorbic acid, lactic acid, color

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1. INTRODUCTION

Red deer round and beef round are two types of meat that are highly valued for their flavor and nutritional value. However, bacterial contamination can lead to spoilage and reduced shelf life of these meats (Jay et al., 2005). The use of organic acids as a meat preservative is a promising solution to this problem. Extensive research has been conducted on organic acids for their ability to enhance the quality of meat products. This study has been shown to have antimicrobial properties and can improve meat quality parameters, such as tenderness, color, and shelf life (Naveena et al., 2006). Specifically, lactic acid and ascorbic acid have been found to be effective in reducing the growth of pathogenic bacteria and improving the overall quality of meat (Carpenter et al., 2011). Ascorbic acid, also known as vitamin C, has been used as an antioxidant to prevent the oxidation of fats and proteins in meat, which can lead to spoilage (Dave and Ghaly, 2011). Several previous studies have investigated the use of organic acids to preserve red deer meat and beef.

Despite these previous studies, there is still limited research on the use of a combination of lactic acid and ascorbic acid to preserve red deer meat and beef. This study aims to fill this gap by investigating and comparing the effect of a 2% lactic acid and 2% ascorbic acid mixture on the quality parameters of red deer meat and beef. By comparing the results of this study with previous research, a better understanding can be gained of the potential for using organic acid mixtures as a natural preservative to enhance the microbial safety of red deer meat and beef.

2. MATERIALS AND METHODS

2.1. Sample preparation

Fresh samples of beef and red deer rounds were procured from a local processing facility and transported to the laboratory packed in polyethylene bags under chilled condition at 4 ± 1 °C. The samples were then sliced into steaks (approximately 10 × 5 × 1.5 cm) of comparable size. Subsequently, the steaks were divided into two groups, namely the control group and the treatment group, using a random assignment. The control group steaks were vacuum-packed in polyethylene bags and stored in a refrigerated cabinet at 4 ± 1 °C, while the treatment group steaks were treated with mixture of 2% lactic acid and 2% ascorbic acid, sprayed on both the bottom and top surfaces of the steaks at room temperature. The concentration of the solutions applied was 1% in relation to the initial weight of the meat, with 2 g of solution used for 200 g of meat. After the treatment, all the samples were vacuum-packaged and placed in cold storage at a temperature of 4 ± 1 °C for a period of 21 days. The evaluation of quality parameters was conducted on days 1, 7, 14, and 21 of the storage periods.

2.2. pH measurement

The pH measurement of both the treated and non-treated beef and red deer meat samples was performed using a one-hand pH meter (Testo, Model 206-pH2, UK). The pH measurements were measured three times for each sample directly from the muscles. Prior to the measurements, the pH meter was calibrated using buffer solutions with pH values of 4.0 and 7.0.

2.3. Color measurement

The surface color of the beef and red deer meat were measured using a Chroma Meter CR-400 (Konica Minolta, Inc., Osaka, Japan). Prior to each measurement, the chroma meter was calibrated with a white tile according to the manufacturer's instructions. For each sample, 20 replicate measures were taken, covering the entire surface area of the meat samples in the vacuum package. The measurements included the values for L^* (lightness), a^* (redness), and b^* (yellowness).

2.4. Microbiological evaluation

10 g of meat samples were accurately weighed and mixed with 90 mL of buffered peptone water. The resulting homogenate was subjected to serial 10-fold dilution. From the appropriate dilution, 0.1 mL of the sample was transferred into duplicate plates for the Aerobic Plate Count (APC) using nutrient agar through the pour plate method. The plates were then incubated at 37 °C for 48 h (ICMSF, 1986). Following incubation, the colonies were counted, and the results were reported as colony-forming units per gram of meat (CFU g^{-1}).

2.5. Statistical analysis

To evaluate the influence of the treated and non-treated methods on the quality of beef ($n = 8$) and red deer meat ($n = 8$) samples, a statistical analysis was carried out using IBM SPSS27 (Armonk, NY 2020) as the statistical software. The data was subjected to analysis of variance (ANOVA). ANOVA was used for statistical analysis, focusing on the effects of the acidic treatment and storage period factors and post hoc analysis was performed using Tukey's HSD test. Before ANOVA, we checked for homogeneity (Levene's test) and normality (Kolmogorov-Smirnov and Shapiro-Wilk test). Some color attributes and aerobic plate count showed slight deviations, likely due to the non-normal distribution of microorganisms in foods and the influence of fat tissues on color. Despite these limitations, ANOVA was applied to assess results statistically. Statistical significance was determined at a significance level of $P < 0.05$.

3. RESULTS AND DISCUSSION

3.1. pH measurement

The results showed (Table 1) variations in pH values between the treated and non-treated samples, as well as differences between the two meat types. The pH results of the study indicate that there were no significant differences between the treated and non-treated samples in both beef and red deer meat. However, some minor variations were observed between the two groups at different time points.

On Day 1, the average pH values of the treated samples were slightly lower than those of the non-treated samples in both beef and red deer meat, though the difference was not significant with the given sample numbers. This slight difference could be attributed to the mild acidifying effect of the lactic acid and ascorbic acid mixture used in the treatment. The 2% lactic acid and 2% ascorbic acid mixture pH was 2.8. These results align with previous research by Carpenter et al. (2011), who reported similar trends in pH reduction in meat samples treated with lactic acid and ascorbic acid individually.

Table 1. Effect of lactic acid and ascorbic acid mixture and vacuum packaging on pH values of beef and red deer meat samples during retail display at 4 ± 1 °C

Day	Treatment	Beef	Deer
		pH	
1	Treated	5.48 ± 0.07[b]	5.60 ± 0.03[b]
	Non-treated	5.59 ± 0.10[b]	5.68 ± 0.03[b]
7	Treated	5.44 ± 0.15[b]	5.57 ± 0.02[b]
	Non-treated	5.54 ± 0.04[b]	5.56 ± 0.04[b]
14	Treated	5.25 ± 0.06[a]	5.33 ± 0.06[a]
	Non-treated	5.24 ± 0.10[a]	5.38 ± 0.05[a]
21	Treated	5.10 ± 0.07[a]	5.38 ± 0.04[a]
	Non-treated	5.06 ± 0.05[a]	5.31 ± 0.16[a]

[ab]Different letters are for significantly different groups of treatment (Tukey, $p < 0.05$).
Data are recorded as Mean ± Standard Error.
Treated (sprayed with 2% lactic acid and 2% ascorbic acid mixture).

The significant decrease in pH during the storage time of both types of meat can be attributed to several biochemical and microbial processes. Meat pH changes with the increasing bacterial population. As stated by Gill (1983), that the pH of beef with increasing bacterial growth was decreased.

3.2. Color measurement

The instrumental color analysis results (Table 2) demonstrate that there were no significant differences observed between the treated and non-treated samples of both beef and red deer meat in terms of color parameters except beef day one L^* and red deer meat day 14 L^* values. This indicates that the lactic acid and ascorbic acid mixture treatment did not have a noticeable effect on the color characteristics of the meat samples.

The lack of significant differences in color parameters such as lightness (L^*), redness (a^*), and yellowness (b^*) between the treated and non-treated samples suggests that the organic acid mixture did not induce any discernible changes in the overall color appearance of the meat. These findings are consistent with previous study that reported similar result when evaluating the effect of organic acid treatments on meat color (Carpenter et al., 2011).

3.3. Microbiological evaluation

The microbiological evaluation was conducted to compare the microbial load in both beef and red deer meat samples that were treated with lactic acid and ascorbic acid mixture and non-treated samples (Table 3).

In both beef and deer meat samples, there were no significant differences observed between the treated and non-treated samples until day 14. This suggests that the lactic acid and ascorbic acid mixture treatment had a mild inhibitory effect on the microbial growth in both types of meat during the initial storage period. However, on days 14–21, a significant difference was observed between the treated and non-treated samples. The treated samples exhibited a significantly lower microbial count compared to the non-treated samples. This indicates that the lactic

Table 2. Values of instrumental texture parameters of vacuum packed treated and non-treated beef and deer meat samples during 21 days of retail display at 4 ± 1 °C

Day	Treatment	Beef			Deer		
		L*	a*	b*	L*	a*	b*
1	Treated	35.12 ± 2.55^{c}	10.13 ± 0.85^{a}	2.60 ± 0.79^{ab}	30.23 ± 1.60^{c}	9.36 ± 0.61^{a}	2.01 ± 0.25^{ab}
	Non-treated	31.47 ± 1.40^{a}	11.39 ± 0.89^{a}	1.49 ± 0.27^{a}	30.25 ± 1.40^{c}	9.16 ± 0.61^{a}	2.15 ± 0.50^{abc}
7	Treated	32.15 ± 2.38^{ab}	11.59 ± 0.72^{ab}	1.85 ± 0.39^{a}	29.08 ± 1.62^{b}	9.58 ± 0.62^{a}	2.35 ± 0.42^{bc}
	Non-treated	30.22 ± 1.70^{a}	12.80 ± 1.16^{b}	1.52 ± 0.43^{a}	29.37 ± 1.82^{b}	10.03 ± 0.42^{ab}	2.16 ± 0.17^{abc}
14	Treated	33.07 ± 2.11^{b}	13.39 ± 0.50^{c}	2.57 ± 0.48^{ab}	27.51 ± 1.39^{a}	11.12 ± 0.57^{c}	2.05 ± 0.39^{abc}
	Non-treated	32.92 ± 1.37^{b}	14.06 ± 0.87^{c}	2.16 ± 0.65^{ab}	29.98 ± 1.97^{bc}	11.28 ± 0.78^{c}	1.77 ± 0.50^{a}
21	Treated	33.59 ± 1.97^{b}	11.58 ± 0.68^{ab}	3.32 ± 0.42^{b}	28.60 ± 1.92^{ab}	11.02 ± 0.85^{bc}	2.42 ± 0.39^{bc}
	Non-treated	34.72 ± 1.77^{c}	12.83 ± 0.74^{b}	3.01 ± 0.32^{b}	29.45 ± 1.37^{b}	11.79 ± 0.87^{c}	2.43 ± 0.21^{c}

[abc]Different letters are for significantly different groups of treatment (Tukey, $p < 0.05$).
Data are recorded as Mean ± Standard Error.
Treated (sprayed with 2% lactic acid and 2% ascorbic acid mixture).

Table 3. Effect of lactic acid and ascorbic acid mixture on aerobic plate count (log cfu g^{-1}) of vacuum-packed beef and red deer meat samples during 21 days of retail display at 4 ± 1 °C

Day	Treatment	Beef	Deer
1	Treated	3.34 ± 0.34^{a}	3.39 ± 0.21^{a}
	Non-treated	3.26 ± 0.23^{a}	3.25 ± 0.22^{a}
7	Treated	3.45 ± 0.45^{a}	3.57 ± 0.36^{ab}
	Non-treated	3.64 ± 0.37^{ab}	3.38 ± 0.31^{a}
14	Treated	4.14 ± 0.29^{b}	4.19 ± 0.52^{b}
	Non-treated	4.00 ± 0.45^{b}	4.01 ± 0.41^{b}
21	Treated	4.90 ± 0.55^{c}	5.30 ± 0.56^{c}
	Non-treated	4.27 ± 0.35^{b}	4.55 ± 0.41^{b}

[abc]Different letters are for significantly different groups of treatment (Tukey, $p < 0.05$).
Data are recorded as Mean ± Standard Error.
Treated (sprayed with 2% lactic acid and 2% ascorbic acid mixture).

acid and ascorbic acid mixture treatment had a pronounced effect in reducing the microbial load in both beef and red deer meat after an extended storage period.

Comparing the beef and red deer meat samples until day 21, there were no significant differences in terms of microbial load. This suggests that both types of meat responded similarly to the lactic acid and ascorbic acid mixture treatment in terms of microbial inhibition during the evaluated period.

These findings are consistent with previous researches that demonstrated the antimicrobial effects of lactic acid and ascorbic acid treatments on meat products (Enkhbold et al., 2023; Friedrich et al., 2008). These studies have reported reductions in microbial counts and improved microbial safety in meat samples treated with organic acids.

4. CONCLUSION

In conclusion, the study investigated the effect of a 2% lactic acid and 2% ascorbic acid mixture on the quality parameters of beef and red deer meat samples. The results showed no significant differences in color between treated and non-treated samples. However, the treated samples exhibited a significantly lower microbial count on day 21 compared to non-treated samples. Overall, the lactic acid and ascorbic acid mixture shows promise as a natural preservative, effectively reducing microbial load in both meat types without adverse effects on color. Further research can optimize the application of these organic acids in meat preservation.

ACKNOWLEDGEMENTS

The research was supported by the Doctoral School of Food Science of Hungarian University of Agriculture and Life Sciences.

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