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DETERMINING THE EFFECT OF ELECTROMAGNETIC-ASSISTED FREEZING ON PREVIOUSLY FROZEN BEEF QUALITY

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I. INTRODUCTION

To maintain an effective backstock of product in the meat industry, freezing has become a common practice for packers and further processors [1]. However, outgrowth of large and irregularly shaped ice crystals during the freezing process has shown to increase mechanical damage to the muscle fiber, resulting in increased negative quality attributes such as increased purge loss and decreased color stability [2]. Electromagnetic (EM) field application during the freezing process has been studied for its potential to alter ice crystal size and morphology, producing smaller and more evenly distributed crystals [3]. However, much of the current body of literature focuses on smaller portions of meat product. Thus, the objectives of this study were to determine the effect of EM assisted freezing on ice crystal size and its subsequent effects on quality and shelf stability of beef *Longissimus lumborum.*

II. MATERIALS AND METHODS

Longissimus lumborum (LL) were collected from both sides of 12 USDA Choice carcasses, halved into 4 equal parts and weighed. Halves were randomly assigned to 0, 2, 4, or 8 kV of EM and frozen under the designated treatments in a walk-in freezer (-20°C) for 24 hours. A temperature probe was inserted into the geometric center of half, and time to reach -18ºC was determined. Following treatment, frozen cores were taken for X-ray computed tomography (XRCT) for ice crystal size analysis. Weights were taken before and after coring to account for core weight. Frozen LLs were vacuum packaged and stored at -20ºC for 8 days before thawing at 2°C for 72 hours to reach at least 0ºC and weighed to measure total thaw yield. Halves were immediately fabricated into steaks and subjected to 10 days of simulated display. Histological analysis for muscle fiber spacing was measured on steaks with 0 day display. Protein degradation, free calcium concentration, and antioxidant capacity were conducted on steaks displayed for 0, 4, 7, and 10 days. Objective and subjective color measurements were conducted each day.

III. RESULTS AND DISCUSSION

It was found that the 4 kV treatments required the longest time to reach -18ºC from initial temperature, followed by 8 kV, with the 0 and 2 kV treatments resulting in the shortest time to freeze ($P<0.01$). A treatment effect was observed for purge loss in which the 8 kV treatment resulted in the lowest amount of purge loss compared to the control and other treated samples ($P<0.01$). This increased overall yield, however, cannot be explained by differences in ice crystal size as no differences in muscle fiber spacing or ice crystal diameter were observed ($P>0.05$). On the other hand, the 4 and 8 kV treatments resulted in the lowest amount of desmin degradation ($P<0.01$), and troponin-T degradation was lowest in the 8 kV treatment ($P<0.01$). An interaction between display day and treatment was observed for percent discoloration ($P<0.01$). On days 9 and 10, the 4 kV treatment had less discoloration than the 0, 2, and 8 kV

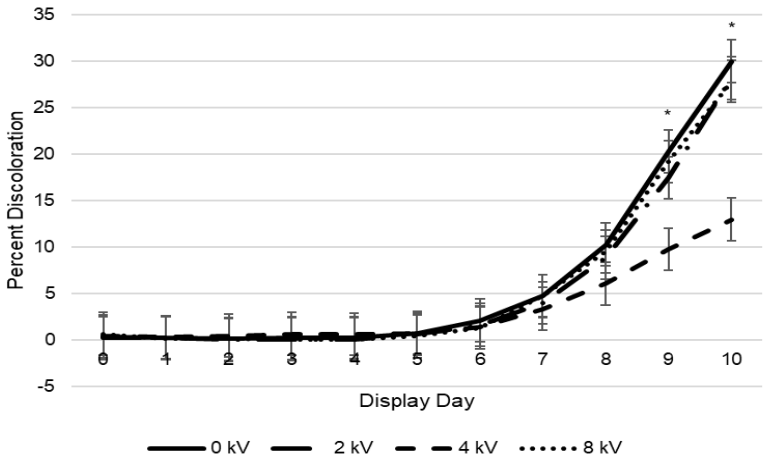


Figure 1: Interaction of display day and EM treatment on percent discoloration

treatments (P<0.01). Hydrophilic antioxidant capacity was found to be the highest in the 4 kV treatment (P<0.01), which could provide insights as to why discoloration was lower in the latter days of display.

Table 1: Main effects of freezing time, yield, muscle fiber spacing, ice crystal size, lipid oxidation, antioxidant capacity, protein degradation, and free calcium concentration on EM treatment

	0 kV	2 kV	4 kV	8 kV	SEM	*P* value
Time to -18ºC (min)	1430.33^{c}	1689.99^{b}	2435.43^{a}	2165.12^{b}	53.74	<0.01
Yield (%)	97.01^{b}	97.12^{b}	97.23^{b}	97.69^{a}	0.17	<0.01
Muscle Fiber Spacing (µm)	21.07	22.19	21.35	22.54	1.88	0.85
Ice Crystal Diameter (µm)	35.05	34.59	33.29	34.57	2.21	0.87
Lipid oxidation (mg MDA[3]/kg meat)	1.39	1.63	1.39	1.54	0.12	0.10
Lipophilic ORAC (TE[4]/g meat)	0.54^{a}	0.31^{b}	0.36^{b}	0.35^{b}	0.04	<0.01
Hydrophilic ORAC (TE/g meat)	10.28^{b}	10.10^{b}	11.87^{a}	9.19^{b}	0.67	<0.01
Total ORAC (TE/g meat)	10.82^{ab}	10.41^{b}	12.23^{a}	9.54^{b}	0.68	<0.01
Degraded Troponin-T (%)	56.51^{a}	54.29^{a}	54.41^{a}	45.39^{b}	2.49	<0.01
Degraded Desmin (%)	37.62^{a}	37.74^{a}	32.92^{b}	31.14^{b}	1.32	<0.01
Free Calcium (nmol/g protein)	2.26^{b}	2.76^{a}	2.65^{a}	2.80^{a}	0.11	<0.01

IV. CONCLUSION

While high voltage EM assisted freezing was not found to decrease ice crystal size, it has appeared to increase thawing yield in previously frozen beef LLs through an unknown mechanism, although the lower percentage myofibrillar degradation as expressed by troponin-T and desmin degradation appear to sufficiently maintain increase water holding capacity. Small amounts of heat were produced during the freezing process due to friction caused by the EM treatments, resulting in a longer time to freeze for treated samples compared to the control. This heat has been hypothesized to sufficiently denature proteins enough to expose animo acid residues in the protein structure that were capable of increasing antioxidant capacity, resulting in higher color stability [4]. The small increase in post-thaw yield and shelf-life of the product has the potential to provide a significant economic incentive for packers and further processors to utilize EM assisted freezing on a commercial scale. Further research on EM-assisted freezing is needed to explore its feasibility for large-scale integration into commercial freezer systems.

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