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THE EFFECT OF DIFFERENT ELECTRICAL STIMULATION SYSTEMS AND BLAST CHILLING ON FUNCTIONAL PARAMETERS OF BEEF AND QUALITY OF FRANKFURTERS

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INTRODUCTION

Compared to the vast amount of information on the effect of electrical stimulation (ES) on fresh meat quality, very little is known about the effect of ES on the processing attributes of meat. According to Whiting *et al.* (1981) and Terrell *et al.* (1981), frankfurters made from high voltage ES meat were not significantly different than those made from non ES meat. However, a lower emulsifying capacity and stability and a lower gel strength from a mixture of isolated myofibrils were measured in low voltage ES meat in model systems by Choi *et al.* (1984) and Samejima *et al.* (1986) respectively. Samejima *et al.* (1986) reported that this effect was eliminated by the addition of pyrophosphate in the gel forming mixture. Although these observations were drawn from different experimental systems, they suggest a voltage dependent differential effect of ES on some functional characteristics of meat. Therefore, we have compared the effect of high and low voltage ES and mode of chilling on the functional parameters of beef and on the yield and quality characteristics of frankfurters.

MATERIALS AND METHODS

Twenty-four steers of common background were raised at the Agriculture Canada Research Station (Lacombe, Alberta) and were slaughtered when they reached Canada A1 grade. Carcasses were randomly allocated to one of four electrical stimulation treatments (control, low voltage, high voltage, combined low and high voltage). Low voltage ES (110V, 60Hz, 0.25A) was applied immediately after exsanguination and high voltage ES (500V, 60Hz, 1.5A) was applied to both sides of the carcass (alternating between right and left sides stimulated first within a treatment) after splitting (approximately 40 minutes post-mortem). Alternating between right and left sides within an ES treatment, one side of each carcass was chilled in the normal commercial manner (about 2°C for 24 hours) and the other side was immediately blast chilled (-20°C, 5m/s wind speed) for two hours before being conventionally chilled for the remainder of the 24 hours period. Chucks were removed from the chilled sides at 48 hours post-mortem. After deboning and trimming, they were frozen under vacuum and were shipped to the Food Research and Development Centre (St. Hyacinthe, Qc) for further analysis and frankfurter fabrication.

After thawing, pH readings were taken in the major muscles of the chuck (*spinatus* muscles, *triceps brachii*, *serratus ventralis*) and values were averaged. Water and fat contents were determined by proximate analysis and protein content was estimated by difference. For salt-soluble protein (SSP) measurements, duplicate 8g samples were homogenized (8000rpm, 30s) with 200ml of a cold 3% NaCl (w/w) solution and stored overnight at 4°C. After centrifugation (4°C, 10400G, 15min), the supernatants were filtered and salt-soluble protein concentrations (mg/ml) in the filtrate were determined by the Biuret method.

For emulsion capacity determinations (EC), 100mg of protein extract was placed in a 500ml cooled blender jar and the volume was made up to 60ml with cold 3% NaCl solution. Twenty-five ml of Canola oil were added and the mixture was homogenized at 11000rpm for 30s on a commercial Waring Blender. More oil (room temperature) was then

continuously added at a rate of 0.5 mls^{-1}. Emulsion formation and collapse were determined from resistance measurements and results were expressed as ml of oil/mg SSP. Final emulsion temperatures did not exceed 17°C.

Frankfurters were formulated to contain 64.8% water, 20% fat, 11.9% protein and 2% NaCl (before cooking). Phosphates were not used in the formulation. Meat, NaCl (1.7%), $NaNO_2$ (0.295%) and 75% of an ice water mixture (50:50) were chopped for one minute at high speed in a six blade cutter (Kilia, 40l model, Kiel, Gmbh). Ground pork backfat (-2°C), spices (0.8%) and the remaining ice water were then added to the bowl and emulsified for 170s. The final temperature of the mixtures varied between 12 and 15°C. The emulsions were extruded under vacuum and the links were cooked to a final internal temperature of 71°C. They were then showered and transferred to a cooler at 2°C for two hours prior to calculation of the cooking yields. L*, a* and b* values were measured on the internal surface of seven different links and texture profile analysis (Bourne, 1978) was carried out with an Instron texturometer using a double compression to 50% of the height of 30 cores (12.7mm height x 18.5mm skinless diameter). Hardness, cohesiveness, springiness and chewiness were determined for each sample.

The experiment was repeated six times and the data was analyzed according to a split-plot design with the effect of electrical stimulation in the main plot and the effect of chilling regimes in the sub-plot. Further comparisons between ES treatments were carried out using orthogonal contrasts.

RESULTS AND DISCUSSION

The ultimate pH values and the amount of salt-soluble proteins extracted were higher in controls than in treatments ($P \leq 0.05$), as shown in Table 1. Voltage had no effect on these parameters ($P > 0.05$). There was also no effect of treatments on the emulsifying capacity of the extracted proteins ($P > 0.05$). On the basis of results reported by Whiting *et al.* (1981) and Rashid *et al.* (1983), who have shown that the solubility of both sarcoplasmic and myofibrillar proteins is unaffected by high voltage ES, the higher amount of SSP from unstimulated meat (control) reported herein was likely a consequence of higher ultimate pH. However, the effect of enhanced Z line integrity resulting from decreased neutral protease activity caused by ES cannot be discounted. The integrity of the Z disc can restrain transverse myofibrillar swelling (Offer and Trinick, 1983) and prevent myosin extraction in the absence of ATP or pyrophosphate (Goll *et al.*, 1970). The absence of voltage effects in this study suggests that ultrastructural damage reported with high voltage ES in the LD muscle (Savell *et al.*, 1978; Sorinmade *et al.*, 1982) did not promote protein extraction above that achieved with the procedure, or that the effects were absent from this part of the carcass.

The differences observed in pH and SSP between ES meats and controls had no further influence on the yield and quality characteristics of frankfurters ($P > 0.05$) (results not shown). According to Samejima *et al.* (1986), both aging and low voltage ES caused the appearance of a protein band at about 30000 daltons which could be associated with the degradation of myosin and which could decrease gel elasticity in mixtures of isolated myofibrils. However, our results showed that differences in the functional parameters due to ES had no influence on the comminuted product. In addition, high or low voltage ES or a combination of both caused no differences in the functional parameters of model systems or on the yield and quality of frankfurters ($P > 0.05$, results not shown).

However, despite the lack of effects on the functional parameters shown in Table 1 ($P > 0.05$, results not shown) blast chilling, which had no effect on the functional parameters of the meat ($P > 0.05$, results not shown), slightly decreased the cooking yield of the frankfurters ($P \leq 0.05$, Table 2). Jolley *et al.* (1983) reported that rapid chilling decreased the water holding capacity of finely comminuted rabbit meat more than slow chilling or rapid freezing, and attributed this effect to a possible higher integrity of the Z line. There was no significant effect of cooling regimes on the colour indices of frankfurters ($P > 0.05$), but conventional cooling decreased cohesiveness and chewiness parameters. Although statistically significant, differences observed were of very small magnitude and unlikely to be perceived by the consumers. There were no significant interactions between chilling and ES treatments on any of the parameters measured in this study.

CONCLUSION

Therefore, commercial application of any type of ES in combination with either conventional or rapid chilling, is unlikely to exert a significant effect on frankfurter yield and quality.

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Table 1. The effects of different electrical stimulation systems on functional parameters of beef.[1]

	Control	High voltage	Low & high voltage	Low voltage	SEM
pH	5.97[a]	5.81[b]	5.75[b]	5.80[b]	0.06
Salt-soluble proteins, mg/ml	3.18[a]	2.77[b]	2.81[b]	2.89[b]	0.12
Emulsion capacity, ml oil/mgSSP	1.32[a]	1.29[a]	1.28[a]	1.31[a]	0.02

[1] The effects of cooling treatments were not significant on these functional parameters. Means sharing a common superscript are not statistically different (P>0.05).

Table 2. The effect of conventional cooling and blast chilling on quality evaluation of frankfurters.[1]

	Conventional cooling	Blast chilling	SEM
Cooking yield, %	92.82[a]	92.37[b]	0.15
L*	61.32[b]	61.47[b]	0.17
a*	12.46[b]	12.47[b]	0.10
b*	19.35[b]	19.37[b]	0.09
Hardness, n^2	18.66[b]	19.01[b]	0.20
Springiness, cm^3	3.35[b]	3.38[b]	0.01
Cohesive-ness[4,6]	0.66[b]	0.67[b]	0.003
Chewiness[5]	41.37[a]	43.08[b]	0.58

[1] The effects of electrical stimulation treatments were not statistically significant (P>0.05) on any of the quality parameters of the frankfurters.
[2] Peak height in first compression as a force.
[3] Distance until peak reached in second compression.
[4] Ration of the second peak area to the first peak area.
[5] Chewiness = hardness x springiness x cohesiveness.
[6] Was significantly different at p=0.06.