IMPACT OF DIFFERENT ELECTRICAL STIMULATION SYSTEMS ON BEEF QUALITY AND PALATABILITY: CONSTANT CURRENT VERSUS CONSTANT VOLTAGE

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I. INTRODUCTION

Commercial carcass weights in North America have increased in the last decades and the efficacy of constant voltage electrical stimulation (CVES), also known as high voltage electrical stimulation, has been questioned. Using a constant current electrical stimulator (CCES), which applies a constant current but varies the voltage dependent on carcass impedance, Prieto et al. [1] observed a higher efficacy for improving beef quality than CVES used in previous studies [2]. Nevertheless, to date there are no studies comparing the effect of both electrical stimulation systems on carcass sides from the same animals. Hence, the objective of this study was to evaluate the effect of two electrical stimulation systems (CCES vs. CVES) applied to the same carcasses on meat quality and palatability of finished steers.

II. MATERIALS AND METHODS

In total, 38 crossbred steers within a wide range of hot carcass weight (348-476 kg) and fatness (7-26 mm) were used. At approximately 45 min post-mortem, one carcass side was CCES (2.04 A for 1 min with 2 s ON/2 s OFF pulses), using a stimulator designed and built by Agriculture and Agri-Food Canada's Lacombe Research and Development Centre, whereas the other side was CVES with a commercial stimulator (480 V; Koch–Britton, Kansas City, MO). After slaughter, pH (45 min, 3 h, 3 d, 6 d) and subjective (Japanese Meat Grading Association/JMGA–3 d) and objective colour (lightness/L^*, redness/a^*, yellowness/b^*, Chroma/C*, Hue angle/H^o–3 and 6 d, and after 4 d in retail display) were measured in *longissimus* muscle. Subsequently, purge loss (6 d), drip loss during retail display and cooking loss and shear force (3, 6, 12 d) were evaluated. Sensory analyses were performed by trained panelists on frozen-thawed 6 d aged steaks, as described in López-Campos et al. [3].

III. RESULTS AND DISCUSSION

There was an electrical stimulation × time interaction for pH, with CCES having lower pH at 3 h but higher pH at 3 d post-mortem than CVES carcasses, although these differences in pH disappeared by 6 d post-mortem ($P<0.01$, Fig. 1). The faster pH reduction in CCES carcasses at an early post-mortem stage could prevent cold shortening in these carcasses by ensuring earlier rigor onset and less rigor contraction. Although no differences in cooking losses were found ($P>0.1$), the CCES decreased meat purge ($P<0.05$) and drip losses ($P<0.01$) compared to CVES (Table 1). Regarding colour, CCES resulted in meat with better subjective JMGA scores ($P<0.05$) and a redder (higher a^* and H^o, $P<0.01$), yellower (higher b^*, $P<0.01$), and more intense colour (higher C^*, $P<0.05$) compared to meat from CVES carcasses (Table 1). The improvement in colour persisted at 6 d post-mortem and also after 4 d in retail display, as meat from CCES carcasses was lighter (higher L^*: 40.73 vs. 40.03, $P<0.05$), redder (higher H^o: 35.46 vs. 34.98, $P<0.05$) and yellower (higher b^*: 15.54 vs. 15.08, $P<0.05$) than meat from CVES. No significant differences were found on either meat shear force or tenderness evaluated by trained panelists ($P>0.10$, Table 1). Unexpectedly, meat from CVES carcasses had higher initial juiciness after 5-7 chews than meat from CCES ($P<0.05$), but this difference did not persist for sustained juiciness after 15-20 chews ($P<0.05$, Table 1). The CCES resulted in meat with higher corn aroma (0.177 vs. 0.042, $P<0.05$) and bloody/serumy flavour (0.765 vs. 0.487, $P<0.05$), both attributes being considered positive by consumers.

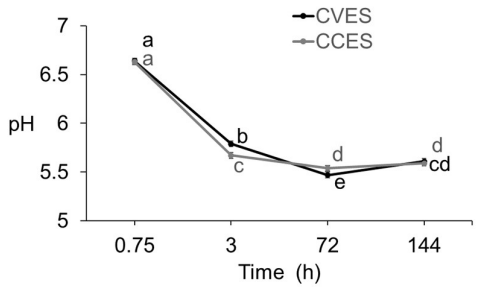

Figure 1. Interaction effect of constant current electrical stimulation (CCES) and constant voltage electrical stimulation (CVES) and time on pH values. Least squares means with standard errors are shown. Different lowercase letters represent P<0.05.

Table 1. Effects of constant current electrical stimulation (CCES) and constant voltage electrical stimulation (CVES) on meat quality and palatability.

	CVES	CCES	SEM	P-value
Meat quality				
JMGA colour score	4.37	4.05	0.13	0.018
Objective colour				
L^* (lightness)	38.3	37.9	0.56	0.423
a^* (redness)	22.2	22.7	0.41	0.041
b^* (yellowness)	15.3	15.8	0.24	0.001
C^* (Chroma,%)	26.9	27.6	0.46	0.011
H° (Hue angle)	34.5	34.8	0.30	0.009
Shear force (N)	57.3	57.0	2.35	0.841
Purge loss (mg/g)	13.7	12.3	0.06	0.029
Cooking loss (mg/g)	241	247	5.8	0.257
Drip loss (mg/g)	48.0	45.2	2.51	0.009
Meat palatability (Scores 1-9)[1]				
Initial tenderness	5.99	5.74	0.23	0.271
Initial juiciness	6.74	6.39	0.13	0.009
Beef flavour intensity	6.52	6.43	0.16	0.404
Off-flavour intensity	7.77	7.67	0.17	0.549
Amount of perceived connective tissue	7.13	7.00	0.17	0.328
Overall tenderness	6.40	6.21	0.18	0.277
Sustainable juiciness	6.48	6.35	0.09	0.138

SEM, standard error of least squares means; Significant values are formatted in bold (P<0.05). [1]Nine-point descriptive scales: 9 = extremely tender, extremely juicy, extremely intense beef flavour, extremely bland off-flavour, and no perceptible connective tissue; 1 = extremely tough, extremely dry, extremely bland beef flavour, extremely intense off-flavour extremely, and abundant perceptible connective tissue.

IV. CONCLUSION

These results show CCES as a more effective electrical stimulation method than CVES to enhance meat quality and flavour profile of finished steers, which could benefit the beef industry.

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REFERENCES

1. Prieto et al. (2022). Proceedings 68th International Congress of Meat Science and Technology (pp. 256), 22-25 August 2022, Kobe, Japan.
2. Juárez et al. (2016). Canadian Journal of Animal Science 96: 104-107.
3. López-Campos et al. (2018). Canadian Journal of Animal Science 98: 166-176.