71st ICoMST
GIRONA - CATALONIA - SPAIN
3rd-8th August - 2025

DIFFERENTIAL IMPACT OF ELECTRICAL STIMULATION ON BEEF MUSCLES

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I. INTRODUCTION

The tenderness of beef from Nellore cattle (Bos indicus) is highly variable, often requiring extended aging periods to reach an acceptable level. In this context, electrical stimulation (ES) serves as a valuable tool to accelerate tenderization and enhance overall meat quality. Its mechanism of action involves increasing the glycolysis rate, hastening the onset of rigor mortis, and promoting postmortem proteolysis [1]. However, the effects of ES can vary depending on the muscle's fiber type profile and its anatomical location within the carcass. Therefore, investigating these variations is crucial for optimizing stimulation protocols and maximizing meat quality in tropically adapted cattle.

II. MATERIALS AND METHODS

Carcasses (n=21) from Nellore non-castrated males were randomly selected to be used in the present study. After carcasses were split, the halves were assigned to one of the following treatments: CON – non-stimulated carcass or electrical stimulation (ES) – using single frequency of 300V AC, 15 Hz (single square wave). For ES treatment a cycle of 4 seconds on and 2 seconds off, with 60 seconds total time application was used. The left carcasses were stimulated within 20 minutes after slaughter while the right carcasses were kept as control. Hot carcasses were weighed (HCW) and chilled for 24h (0 – 2 °C). The pH and temperature declines were recorded immediately after ES in both halves, and at 3, 6, 9 and 24h postmortem. After 24h chilling, samples from *Longissimus thoracis* (LT; between 11-13th ribs) and *Supraspinatus* (SS) muscles were taken and 4 steaks (2.5 cm tick) were fabricated from each carcass side, vacuum packaged and aged for 0, 7, 14 and 21d. The steaks were used for Warner-Bratzler shear force (WBSF) determinations. Additionally, samples were taken for sarcomere length measure [2] and myofibrillar fragmentation index (MFI) analyzes [3]. The data was analyzed as a completely randomized design in a 2 × 2 factorial arrangement (CON *vs* ES × LL *vs* SS) considering the fixed effects of treatments, muscles, and their interaction, with the random effect of slaughter. When applicable, time (ageing days) was considered as repeated measurement. Analyzes were carried out using the Mixed procedure of SAS.

III. RESULTS AND DISCUSSION

The hot carcass weight average was 316.5 ± 21.28 kg. A significant treatment × time interaction effect ($P < 0.001$) was observed for pH decline, with a faster rate associated with ES treatment. Differences emerged immediately after the treatment was applied to the half carcass and persisted throughout the first 24 hours postmortem. Temperature was affected only by time ($P < 0.001$), indicating that pH differences between treatments were not influenced by this trait. Sarcomere length did not differ (1.72 and 1.70 ± 0.030 μm for ES and CON, respectively).

Significant interactions were observed for treatment × muscle ($P < 0.001$), treatment × time ($P = 0.02$) as well as muscle × time ($P < 0.001$) for WBSF. Lower WBSF were observed for ES samples compared to CON in both muscles, with SS samples being more tender than LT ($P < 0.05$; Figure 1). The difference in WBSF between ES and CON was more pronounced in LT steaks compared to SS.

The differences between ES and CON were more pronounced at the beginning of the ageing period and decreased as ageing time increased (Figure 2). No differences were observed in the WBSF values for CON samples up to 7 days of ageing, but WBSF significantly decreased after 14 and 21 days. For ES samples, no differences in WBSF were observed up to 14 days, with lower values recorded after 21 days of ageing.

The SS muscle showed lower WBSF values at all time points (Figure 3). For the LT muscle, no differences in WBSF were observed up to 7 days of ageing, followed by a greater decrease after 14 and 21 days. However, the rate of WBSF decrease throughout the ageing period was lower, with differences observed only between 24h (fresh) and 21 days of ageing.

The MFI values tended to be higher for the ES treatment in non-aged samples (24h postmortem; P = 0.06), however they did not differ after 7 days of ageing (Figure 4). The greater increase in MFI was observed up to 7 days of ageing with a small change after this period. The MFI differences between ES and CON were subtle, suggesting that differences in WBSF values were more related to the physical disruption of muscle fibers than to proteolysis [4].

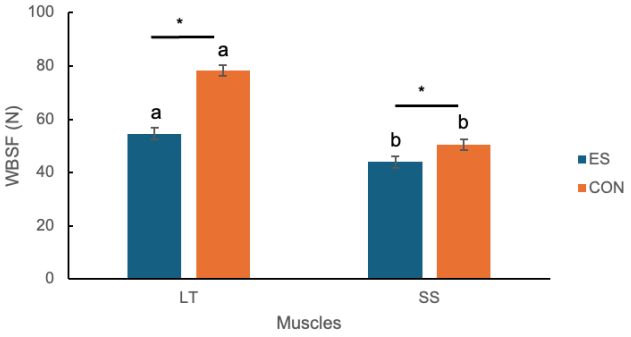


Figure 1. Warner-Bratzler shear force (WBSF) of *Longissimus thoracis* (LT) or *Supraspinatus* (SS) of electrically stimulated (ES) and non-stimulated (CON) *samples*. * Treatments differ ($P < 0.05$) within muscle; [a,b] Muscles differ ($P < 0.05$) within treatment.

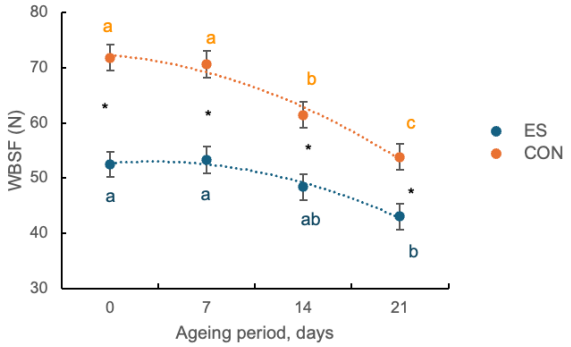


Figure 2. Warner-Bratzler shear force (WBSF) of electrically stimulated (ES) and non-stimulated (CON) *samples according to the ageing period*. *differences ($P < 0.05$) between treatments within time; [a-c] differences ($P < 0.05$) between time within treatment.

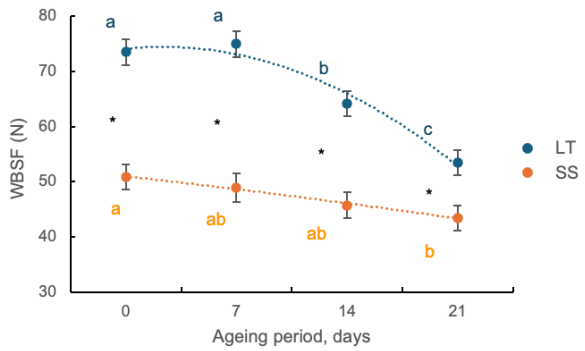


Figure 3. Warner-Bratzler shear force (WBSF) of *Longissimus thoracis* (LT) or *Supraspinatus* (SS) samples according to the ageing period. *differences ($P < 0.05$) between muscles within time; [a-c] differences ($P < 0.05$) between time within muscle.

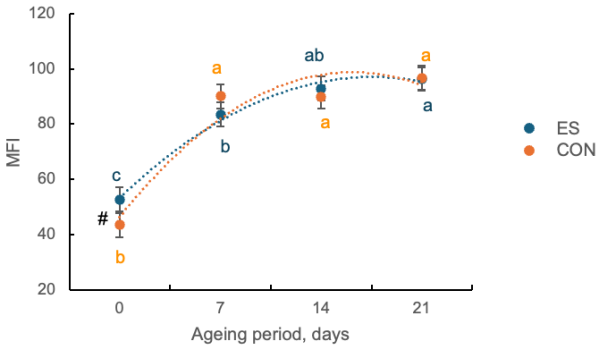


Figure 4. Myofibrillar fragmentation index (MFI) of electrically stimulated (ES) and non-stimulated (CON) *samples*.. [#]differences ($P = 0.06$) between treatments and within time; [a-c] differences ($P < 0.05$) between time within treatment.

IV. CONCLUSION

Electrical stimulation is a powerful tool to enhance tenderization in beef of Nellore cattle, reducing waste and resources in the production chain. Although the beneficial effects are somewhat different among muscles, both LT and SS were positively affected by the treatment. The SS was always more tender than LT, although ES affected more the LT than SS. Beef tenderness accelerated and extended when carcasses were electrically stimulated. Small progress in tenderization after long aging (21d) in SS muscle with greater intermediate (α-red) fibers must be further evaluated, as it could be avoided, which was not the case for glycolytic LT.

ACKNOWLEDGEMENTS

Acknowledgments to FAPESP (Grant number #2021/10205-5 and #2024/15648-0) and Fluxo for the loan of the equipment.

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