EFFECTS OF ELECTRICAL STUNNING AND STIMULATION ON MEAT QUALITY UNDER COMMERCIAL CONDITIONS IN URUGUAYAN BEEF CATTLE

G. Brito*, C. Fiol, J.M. Soares de Lima and M. Del Campo

Programa Nacional de Carne y Lana, INIA Tacuarembó, 45000 Tacuarembó, Uruguay.
Email: gbrito@tb.inia.org.uy

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Introduction

There is a growing concern in the meat industry about the reliability of the stunning equipment and its advantages on meat quality. The non-penetrating and captive bolt guns might be encouraging the distribution of BSE prions from the brain to the edible products, making them an inappropriate alternative. The electrical stunning could solve this problem but one of its pitfalls is that it can cause blood splash. In commercial beef abattoirs pre-rigor rapid chilling of beef carcasses has been used to increase chiller capacity, minimize evaporative loss and improve microbiological conditions. The electrical current applied to the carcass affects *post-mortem* changes of muscle and meat quality: acceleration of *rigor mortis*, physical disruption of the myofibrillar matrix, acceleration of proteolysis (increasing intracellular calcium levels and activating calpain-calpastatin system) and meat appearance improvement (Morton *et al*., 1999). The objective of this study was to evaluate the effects of electrical current (stunning and stimulation) on carcass pH decline, beef appearance and tenderness of the steaks at two ageing times.

Materials and Methods

Four hundred and forty three Hereford steers were randomly assigned to one of these treatments: T1: Electrical stunning (ES) followed by electrical stimulation (EE) (n=112), T2: ES (n=111), T3: Mechanical stunning (MS) followed by EE (n=105) and T4: MS (n=115). Animals were slaughtered in a commercial abattoir. Steers from T1 and T2 were electrically stunned using a voltage of 850 V (60 Hz and 1.5 A). The MS was done using a pneumatic air injection stunner. Carcasses of T1 and T3 were electrically stimulated using high voltage (400 V, 60Hz), 1,5 minutes after bleeding for 20 seconds in 3 times. The National Classification System (INAC, 1997) was registered in hot carcasses and the USDA Quality Grade System (USDA, 1997) in cold ones. Carcass pH and temperature were monitored using a portable pH meter (ORION, model 210A) with gel electrode and a thermometer (Barnant 115) with a type E thermocouple. The pH meter was calibrated a room temperature (25^{o}C) before each measurement. Measurements were recorded at about 1, 3, 6, 12, 24 and 72 hours *post-mortem* in the M. *longissimus* of each left side at the location of 10th /11th rib interface. For each measurement the pH probe and the thermometer were inserted into carcass with a similar depth. A 7-cm thick steak was obtained from the M. *longissimus dorsi* at the mentioned location. All visible subcutaneous fat was removed and 3 steaks were prepared and vacuum packaged individually. Two of them (2.54-cm thickness) were aged for 7 and 14 days at 2-4 ^{o}C for tenderness determination. The bags were opened and the exudation on the surface of the steaks was removed with paper towel. The M. *longissimus* steaks were placed inside polyethylene bags and cooked in a water bath at 80 ^{o}C until an internal temperature of 70 ^{o}C was achieved. During cooking the internal temperature was tracked by the Barnant 115 thermometer with type E thermocouple. About six 1.27-cm diameter cores were removed from each steak parallel to the muscle fibre orientation. A single peak shear force measurement was obtained for each core using Warner Bratzler (model D2000) and an average value was calculated for each steak. Muscle colour was measured on the l*ongissimus dorsi* at 72 hours *post-mortem* at 10th/11th rib in the L*, a*, b* colour space using a colorimeter (Minolta Chroma meter C10) with an 8 mm diameter measurement area.

Results and Discussion

Neither hot carcass weight (HCW), fat thickness (Fat) or marbling (Marb) were affected by different treatments (P>0.05). The mean HCW values for each treatment were, T1: 260.4 kg; T2: 259.6kg; T3: 259.6kg and T4: 262.3 kg. For Fat were: T1 5.65mm, T2: 5.67mm, T3: 5.64mm and T4: 5.54 mm. Marb score average for all the groups was Slight (Sl^{50}). The age of the steers was estimated by dentition and there was no difference (P>0.05) among treatments ($\bar{x}$: 4 teeth). The shear force (SF) values were under the threshold to separate tender from tough steaks (4.5 kgF). The effect of the electrical current (T1 and T2) treatments was observed in the SF values at 7 (SF7) and 14 (SF14) days of aging (P<0.01; Table 1). The steers stunned electrically were more tender than the animals stunned mechanically and it seems that EE did not modify the levels of tenderness within each stunning method. Eilers *et al*. (1996) found that *longissimus* steaks from EE carcasses had lower SF values (P<0.05) and received slightly higher panel tenderness score (P<0.01) than did *longissimus* steaks from Control carcasses. Using objective colour measurements, the carcasses on T1 presented the highest values for L*, a* and b* colour parameters (P<0.01) compared with the other treatments (Table 1), showing the effect of the electrical current (ES+EE) on the meat appraisal (brightness and color). Roeber *et al*. (2000) found that *longissimus* muscles of EE treated sides were brighter, redder and less blue than the *longissimus* muscle of control side (P<0.05). There was a treatment effect on the rate of pH fall (Figure 1). The treatments with ES had a faster pH decline than those with MS. This difference was significant (P<0.01) at 1, 3, 6 and 12 h post-mortem

comparing T1 and T2 vs. T3 and T4. Therefore, MS treatments showed differences between them. Carcasses in T3 had lower pH values at 1 (P<0.05), 3 and 6 h (P<0.01) *post-mortem* than those in T4. This suggests an EE effect on carcass pH decline, in agreement with previous studies (Hwang *et al*., 2001; Hwang *et al*., 2003; Strydom *et al*., 2005). These authors reported differences on pH values were observed between carcasses that received EE and control ones for at least the first 4 to 6 h post-mortem.

Table 1: Mean values for L*, a*, b* parameters and shear force (kgF) at 7 and 14 days of aging for each treatment.

Treat	L*	a*	b*	SF7	SF14
1	37.2 a	21.7 a	13.8 a	3.60 b	3.34 b
2	36.7 b	21.0 b	13.4 b	3.64 b	3.35 b
3	36.5 b	20.8 b	13.2 b	3.96 a	3.67 a
4	36.5 b	20.2 b	13.1 b	4.02 a	3.59 ab

[ab,] Columns with different letter are statistically different P<0.01.

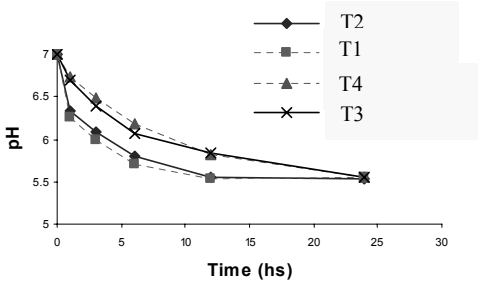

Figure 1: Rate of pH decline for each treatment (24 hs *postmortem* period).

Conclusions

There seems to be an effect by the ES on meat quality traits of Uruguayan Hereford steers in commercial conditions. In this population, the carcasses in which ES+EE was applied showed the highest muscle colour parameters, lowest pH values at 1, 3, 6 and 12 hs *postmortem* and most tender steaks. The use of ES also could have other advantages such as in food safety (i.e.: BSE). It was not clear if the EE had an effect on the measured meat quality variables, although in animals stunned mechanically, EE accelerated the pH fall in early *postmortem*. Further investigations should be conducted in Uruguayan beef cattle to study the effects of electrical stunning and stimulation on meat quality and food safety.

References

Morton, J.D., Bickerstaffe, R., Kent, M.P., Dransfield, E. and Keeley, G.M. (1999). Calpain-calpastatin and toughness in M. *longissimus* from electrically stimulated lamb and beef carcasses. *Meat Science*, 52, 71-79.

Eilers, J.D., Tatum, J.D., Morgan, J.B. and Smith, G.C. (1996). Modification of early postmortem muscle pH and use of *postmortem* aging to improve beef tenderness. *Journal of Animal Science*, 74, 790-798.

Strydom, P.E, Frylinck, L. and Smith, M.S. (2005). Should electrical stimulation be applied when cold shortening is not a risk? *Meat Science*, 70, 733-742.

Hwang, I.H. and Thompson, J.M. (2001). The effect of time and type of electrical stimulation on the calpain system and meat tenderness in beef *Longissimus Dorsi* muscle. *Meat Science*, 58, 135-144.

Roeber, D.L., Cannell, R.C., Belk, K.E., Tatum, J.D. and Smith, G.C. (2000). Effects of a unique application of electrical stimulation on tenderness, color, and quality attributes of the beef *longissimus* muscle. *Journal of Animal Science*, 78, 1504-1509.

Hwang, I.H. and Thompson, J.M. (2003) Effects of early postmortem pH on the quality of beef *longissimus*. *Asian-Australasian Journal of Animal Sciences,* 16(8), 1218-1223.