Rectal Electrical Stimulation of bull carcasses.

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Introduction

Electrical Stimulation (ES) of whole beef carcasses or sides shortly after slaughtering has been studied extensively and is commercially introduced in many countries, although there are still unsolved problems. Most studies on Electrical Stimulation involved the use of high voltages, however some authors reported that low voltage stimulation could also be efficient (Bouton et al., 1978, 1980 a,b; Taylor and Marshall, 1980; Ruderus, 1980; Shaw and Walker, 1977).
For reasons of safety a low voltage system is more attractive than a high voltage system and especially for smaller slaughtering plants there are considerable practical avantages in using low, rather than high voltages.
With low voltage systems, stimulation should commence as soon as possible after killing i.e. before dressing is commenced. By using a rectal probe, the problem of early carcass contamination by the electrode(s) does not occur (Bouton et al, 1980 b) , but there are reasons to doubt the effectiveness of such a combination electrode for the whole carcass because according to Salé (1980) the position of the electrodes is the most important factor in the distribution of the electric field in the carcass.
In this paper, we report results of an experiment designed to investigate the effectiveness of a commercially available rectal stimulation unit on muscle pH, temperature, tenderness, sarcomere length, bag drip and cooking loss under cooling conditions, which were not supposed to result in cold-shortening. Indeed earlier work indicated a slight tenderizing effect of ES not related to the prevention of cold-shortening (Vandekerckhove and Demeyer, 1978; Demeyer and Vandendriessche, 1980).

Material and Methods.

Animals and treatment of carcasses:
Sixty three bulls of the blue-white Belgian breed of approximately 1 2/3 years of age (mean values $\pm$ SE for live weight : 631 $\pm$ 5 kg and dressing % : 64.5 $\pm$0.2 %) were slaughtered in the slaughterhause of our laboratory on 4 days after stunning using a captive bolt pistol and pithing. On each day, half of the animals (in total 32) were electrically stimulated immediatly after bleeding (3 to 6 minutes post mortem) with the rectal "Tender-Pulse" stimulation apparatus manufactured by B.M.& B.D. Vidler, Australia (pulsed direct current, pulse width 2 msec, 40 Hz pulse frequency). The stimulation period of 90 second of this apparatus is divided in three stages : (1) 0 - 30 sec : 25 V peak, (2) 30 - 60 sec : 35 V peak and (3) 60 - 90 sec : 45 V peak. The other 31 animals served as untreated controls. After dressing and splitting, the carcass sides were chilled in a 4°C cooler and between 21 and 24 hours post mortem (p.m.), the longissimus dorsi (8th thoracic rib) of the right sides was removed, vacuum packed and stored at 4°C until 8 days p.m. and then evaluated for drip, cooking loss, Warner-Bratzler peak shear force and laser sarcomere lenght.
Temperature and pH- determinations :
Temp. and pH of the M. Semitendinosus (ST), Long. dorsi (8th rib)(LD) and Triceps Brachii (TB) of the right sides were measured at regular intervals after slaughtering up to 8 hours p.m. as described earlier (Demeyer et al, 1980). For rate of cooking regression following $y = a\ e^{-bt}$ was calculated (y = temperature °C and t = hours p.m.). For rates of pH fall the regression following $y = y_\infty + (y_0 - y_\infty)\ e^{-bt}$ with y = pH measured, y_∞ = 5.40, being the average end - pH of all sampled muscles, y_0 = pH on time t = 0 was calculated. The latter equations where then used to estimate the temperature 45 minutes p.m., the time after stunning at which pH 6.00 is reached, temperature at pH 6.00 and pH values at 1 and 2 hours p.m.

Drip, cooking - loss, shear force and sarcomere lenght determinations :
Bag drip was measured as follows : the LD samples were weighed before vacuum packing and after wiping with a cloth when they are removed from the package on the 8th day p.m. The ratio of the weight-difference and the initial weight x 100 is called the drip percentage. Cooking loss was obtained in a similar way by weighing before and after the cooking needed for the Warner - Bratzler shear force determination.
Warner - Bratzler peak shear force and laser sarcomere length were determined as described earlier (Demeyer et al, 1980).

Results and discussion.

The individual pH and temperature measurements (not shown) indicate that according to the conditions described by Bendall (1972), cold-shortening has not occurred in any of the animals.
The effect of rectal ES on temperature and pH decreases as the distance of the muscle from the rectum increases (table 1). The lack of significant differences in the TB is in accordance with the observations of Bouton et al (1980 b) and is not surprising as the electric field must be very small at that distance from the combined electrodes. This suggests that the position of the electrodes determines which muscles are effectively stimulated (Salé, 1980). Also the fact that the peak current varied between 2 and 10 Amp. while the maximum peak voltage is only 45 V indicates that,even if we take into account the low impedance of the wet intestinal tract that makes the contact with the rectal probe, only part of the carcass carries the current the impedance of the whole carcass being ca. 130 Ohms according to Bendall (1980).
The pH results for the LD do not agree with the results of Bouton et al (1980 b) who found a significant Δ pH in the LD after rectal ES. This discrepancy may be related to the use of steers with carcass weights of 160-190 kg by Bouton et al (1980 b) wereas we used bulls of mean carcass weigth of 407 kg.

Table 1 : Effect of ES on pH and temperature (mean values ± SE).

Muscle	Temperature (°C)				Δ pH[1]		time (h)	
	45 min p.m.		at pH 6.00		1h p.m.	2h p.m.	at pH 6.00	
	Stimul.	Control	Stimul.	Control			Stimul.	Control
ST	39.9	38.9	38.4	30.9	0.67	0.56	1.2	3.6
	±0.2	±0.2	±0.4	±0.7	±0.02	±0.02	±0.1	±0.2
	xxx[2]		xxx		xxx	xxx	xxx	
LD	40.2	39.7	32.0	29.3	0.11	0.15	3.2	4.0
	±0.3	±0.3	±0.8	±0.9	±0.03	±0.03	±0.2	±0.3
	NS		x		NS	xx	x	
TB	38.8	38.5	28.2	28.7	0.03	0.00	5.4	5.1
	±0.2	±0.1	±0.7	±0.6	±0.01	±0.02	±0.3	±0.2
	NS		NS		NS	NS	NS	

[1] Δ = Control - stimulated

[2] x = $p < 0.05$; xx = $p < 0.01$; xxx = $p < 0.001$; NS = not significant ($p > 0.05$)

The difference in temperature at pH 6.00 especially in the ST muscle, may be important for tenderness improvement considering that the temperature coefficient of ageing is 2.4 between 0 and 40 °C (Davey and Gilbert, 1976).

Tabel 2 : Effect of ES on meat quality characteristics of LD (mean values ± SE)

	Drip (%)	Cooking loss (%)	Shear Force (kg)	Sarcomere lenght (μm)
Stimulated	2.03 ± 0.13	29.3 ± 0.3	4.8 ± 0.1 (n = 31)[1]	1.91 ± 0.04 (n = 31)
Control	2.08 ± 0.15	28.6 ± 0.4 (n = 29)	5.0 ± 0.2	1.87 ± 0.05
t	0.259 NS	1.321 NS	0.856 NS	0.685 NS

[1] Where not noted : n = 32 for stimulated and n = 31 for control animals

Rectal ES has no significant effect on shear force and sarcomere lenght of the M. Long. dorsi (tabel 2). These results are in accordance with the minimal effects of rectal ES on pH and temperature of the same muscle (table 1). Bouton et al (1980 b) found a significant effect on tenderness of LD samples of steers but also no significant effect on tenderness of LD samples of cows removed 24 h after slaughtering. In this study LD samples were evaluated 8 days p.m. and it is possible that an initial difference in tenderness has already disappeared at that time (Bendall, 1980).
The laser sarcomere length data also suggest that no cold-shortening has occured. Simple regression analysis of the peak shear force measurements of the LD (y) versus the laser sarcomere length values (x) results in the following equations : for the stimulated animals:

$y = 5.905\ (\pm 1.033) - 0.625\ (\pm 0.527)$ (mean coefficients ± SE) with $100\ r^2 = 4.8$
and for the control animals :
$y = 5.925\ (\pm 1.552) - 0.555\ (\pm 0.820)$ with $100\ r^2 = 1.6$
These equations indicate that there is no relation between shear force and sarcomere length in both cases.
Drip and cooking loss of the LD samples were not affected by rectal ES, which is not surprising as only slight differences in Δ pH were observed in that muscle.

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