PROBLEMS ASSOCIATED WITH LOW VOLTAGE STIMULATION OF BEEF IN AUSTRALIA by

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INTRODUCTION

Low voltage electrical stimulation (ES) systems, unless they meet the local extra low voltage (ELV) regulations, require the same stringent safety procedures and precautions which are mandatory for high voltage systems. Current Australian ELV regulations state that the RMS voltage should be a maximum of 32V with a peak of 45V. These regulations differ from those overseas, e.g. Ruderus (1980), where, apparently, peak voltages of over 80V are acceptable. This paper describes work carried out (a) to evaluate two commercial ELV stimulation systems in use in Australia which utilise a current pathway from the nose to earth via the shackle/rail, and (b) to investigate methods for improving the performance of these systems under commercial conditions.

MATERIALS AND METHODS

Experimental procedures

Two commercial ES units were used. System A employed 45V (peak) square wave pulses of alternating polarity. System B employed 45V (peak) square wave pulses of 40 ms pulse width, continuous pulsing, with alternating polarity, and used a series of impulses: on for 3s, off for 1s. In normal commercial use, both systems are used with a nose electrode and an earth path via the shackle/rail.

The animals used were 12-24 months old (checked by dentition at slaughter) with carcass weights from 140-220 kg and fat depths, over the loin at the last rib, from 1-25 mm. Approximately half the animals were from feedlots. All animals were part of the normal 'kill' at a local meatworks.

Muscle samples, described as 'pre rigor,' were all removed within 2 hr of slaughter from the *M. Longissimus dorsi* (LD) and those LD samples described as 'post-rigor' were removed after overnight chilling at 0-5°C, i.e. about 24 hr post slaughter. Carcasses were stimulated within 4 min of slaughter and usually immediately after bleeding. The pH of each muscle sample was measured at 1-2 hr and 24 hr post slaughter, using a probe type combined electrode (Philips C64/1) and a Watson Victor 5004 portable pH meter.

After removal from the carcass each muscle sample, trimmed of extraneous fat and connective tissue, had a final weight of 120-250g and was then placed in a polyethylene bag. The 'pre-rigor' samples were immersed in ice-slush for 24 hr to induce cold shortening. Both 'pre- and post-rigor' samples were cooked at about 26 hr post slaughter in polyethylene bags totally immersed in a water bath maintained at 80±0.5°C for 1 hr.

WB shear measurements were carried out using previously described techniques (Bouton & Harris, 1978).

Experiment 1

Ninety-three animals were used in the first experiment; 13 were controls (unstimulated) and 80 were stimulated for 40s using system B with a nose electrode and a shackle/rail earth. 'Pre-rigor' samples were taken from all 93 animals, but the 'post-rigor' samples were from 62 (51 stimulated, 11 control) animals.

Experiment 2

The second experiment involved measuring carcass resistance and/or current (with a cathode-ray oscilloscope) using different earthing points on 15 carcasses for both A and B systems.

Experiment 3

Seventy-two animals were used: nine groups of eight. Group 1 were controls, groups 2 & 3 were stimulated 40s with systems A & B used in the commercial mode, viz. with the nose electrode and a shackle/rail earth, and groups 4-9 were stimulated with system A, either with an anal earth or an earth which contacted the shackled leg for 40, 60 or 80s (six treatments).

Experiment 4

About 50 animals per treatment group were used. The groups were (a) controls (unstimulated) - (n = 48), (b) system B used for 40s in its normal nose-shackle/rail configuration - (n = 54), (c) system B used for 40s with an anal earth electrode - (n = 50) and (d) system B for 40s with an earth electrode which contacted the hide between the rump and stifle joint of the shackled leg (n = 72). Samples of LD muscle were removed 'pre- and post-rigor' as before.

Statistical methods

The Duncan Multiple range test (Duncan 1955) was used to test for significance between treatment group means.

RESULTS AND DISCUSSION

Experiment 1

The results from this experiment, in which system B was used in its normal commercial configuration, are shown in Figs 1 & 2. Only a third of the 'pre-rigor' samples and two thirds of the 'post-rigor' from stimulated carcasses were acceptably tender (WB shear force values less than 8 kg). There was a high proportion (c.20%) of carcasses with dark cutting meat (LD 24 hr pH values >5.9) but even if these were excluded there was still an unacceptably high proportion of samples removed 24 hr post slaughter from stimulated carcasses which were tough.

Experiment 2

The unsatisfactory results obtained in Experiment 1 (system B) and in other experiments (reported here in experiment 3) using system A in a nose-shackle/rail configuration may have resulted from high resistance in the leg of the animal.

The changes in resistance and current with the different placement of the earth electrode for both systems (A & B), are shown in Fig.3. The change in relative resistance as the earth electrode was placed at different points on the carcass was clear. Relative current decreased and resistance increased as the earth electrode was moved distally from the anus.

Experiment 3

The WB shear force and pH results are listed in Table 1. The WB shear force and pH (2 hr) results obtained with system A indicated (a) that the effect of stimulation, together with the additional earth, significantly decreased the WB shear force and pH (2 hr) values relative to both the control and the normal (shackle/rail) stimulated samples, (b) that extending the duration of stimulation from 40-80s had no significant effect for 'post-rigor' samples with either extra earth configuration, and (c) for 'pre-rigor' samples the leg earth configuration needed longer than 40s, i.e. there was a reduction in WB shear force values with increase in stimulation time. From these results it was concluded that, provided samples were removed 'post-rigor,' and provided an additional anal or rump earth was used, a stimulation time of 40s was adequate. A point of interest was that although the stimulation systems in actual use at the meatworks (system A and system B with shackle earth) gave lower WB shear force and pH 2 hr values than the control samples, they both gave significantly higher values than those obtained using system A with either an anal or a leg earth, i.e. stimulation without the additional earth was not fully effective.

Experiment 4

This experiment was designed to investigate the effect of different earthing configurations on the shear force values obtained for a large number of samples of LD muscles removed 'pre-rigor' (Fig.4) and 'post-rigor' (Fig.5). All of the control (unstimulated) 'pre-rigor' and 85% of the control 'post-rigor' samples were unacceptably tough (shear force values >8 kg). This indicates that without electrical stimulation, most LD muscles from these young animals, which had been selected by commercial buyers for supermarkets, would have been unacceptably tough. Stimulation with system B with a shackle earth improved the situation since 85% of the 'pre-rigor' samples and 45% of the 'post-rigor' samples had shear force values >8 kg. However, the use of an earth electrode, whether via the anus of a rubbing electrode bar on the rump or the leg, further improved the tenderness so that only 12% of the 'post-rigor' samples had shear force values >8 kg. When those LD muscles having an ultimate pH greater than 5.9 were excluded, less than 5% of carcasses stimulated with an anal or leg earth had shear values >8 kg. For 'pre-rigor' samples 68% and 32% had values greater than 8 kg for the anal and leg earth systems respectively.

CONCLUSIONS

ELV stimulation with either system, in a nose-shackle/rail configuration, does not consistently result in tender LD muscles in the commercial operations studied, even though the animals are less than two years old, and stimulation is performed within four minutes of slaughter. When current flow is increased, by using an earth contacting the anus or leg region, the consistency of tenderness is increased so that when animals with an ultimate LD pH of 5.9, or greater, are excluded, 95% of LD muscles are acceptably tender. Obviously current flow could be increased by increasing stimulation voltages up to the 80-85V level which are used overseas. In Australia, where peak voltages are limited to 45V, the results indicate that the high resistance in the upper leg and shackle must be bypassed to give reliably effective stimulation.

REFERENCES

Bouton, P.E., & Harris, P.V. (1978), *J. Text. Studies, 9*, 395.

Ruderus, H. (1980), *Proceedings 26th Meeting European Meat Research Workers*, Colarado Springs.

TABLE 1: Warner-Bratzler initial yield force and pH values for LD samples removed 2 or 24 hr post-slaughter from unstimulated (control) carcasses or carcasses stimulated with systems A & B (40s shackle/rail earth) or with system A for 40, 60 or 80s using additional pathway to earth.

		TREATMENT								
Parameter	Time post-slaughter (hr)	Control	System A shackle/ earth	System B shackle/ earth	System A + anal earth			System A + rump earth		
Stim. time (s)	-	-	40	40	40	60	80	40	60	80
WB initial yield force (kg)	2	14.6^{a}	12.9^{ab}	11.6^{b}	8.6^{c}	8.5^{c}	7.8^{cd}	10.6^{b}	9.0^{bc}	7.0^{d}
	24	9.6^{a}	7.3^{b}	6.0^{b}	4.8^{c}	3.3^{d}	4.0^{cd}	4.0^{cd}	4.5^{c}	4.3^{c}
pH-2 hr	2	6.68^{a}	6.12^{b}	6.17^{b}	5.65^{c}	5.84^{cd}	5.82^{cd}	5.96^{d}	5.77^{c}	5.74^{c}
pH-24 hr	24	5.54^{a}	5.57^{a}	5.62^{a}	5.59^{a}	5.61^{a}	5.59^{a}	5.63^{a}	5.52^{a}	5.51^{a}

Means with same superscript in row not significantly different ($P<0.05$)

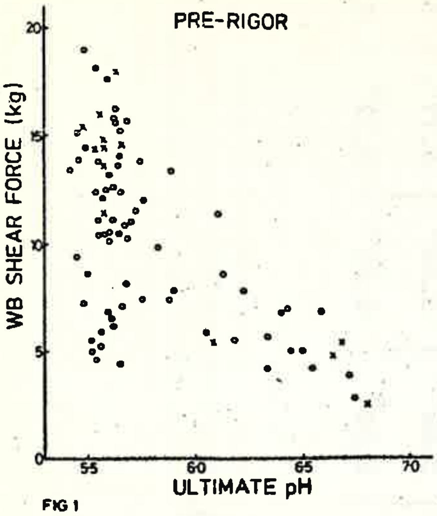

FIG 1

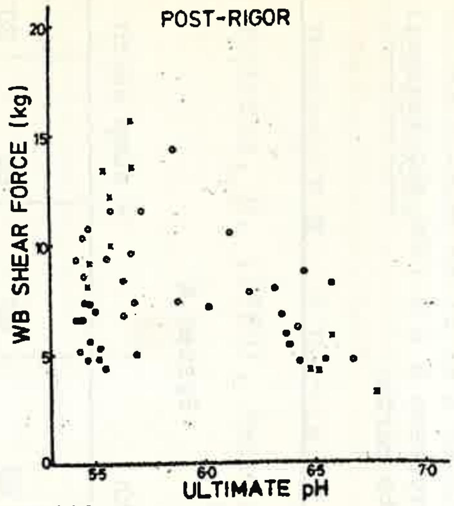

FIG 2

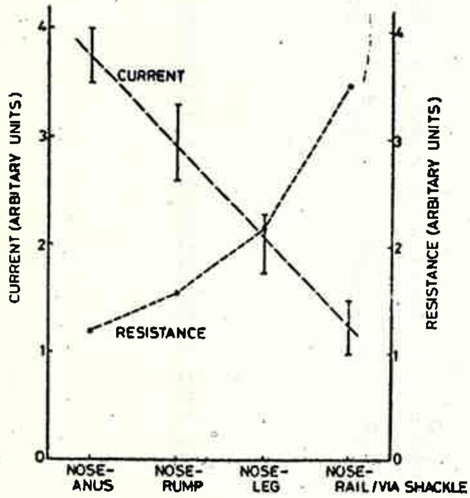

FIG 3

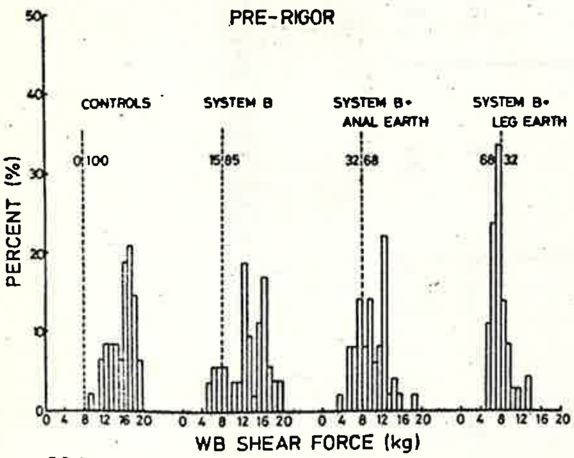

FIG 4

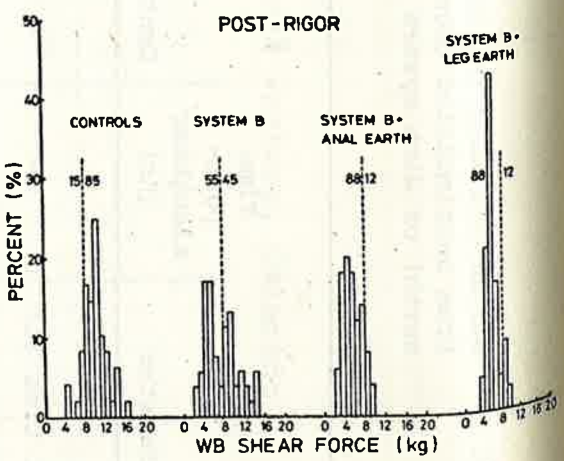

FIG 5

LEGEND TO FIGURES

FIG. 1 WB SHEAR FORCE RESULTS OBTAINED FOR COOKED STIMULATED (SYSTEM B) SAMPLES (O) AND CONTROL (X) LD 'PRE-RIGOR' MUSCLE SAMPLES OF DIFFERENT ULTIMATE pH VALUES.

FIG. 2 AS FOR FIG.1 BUT WITH 'POST-RIGOR' SAMPLES.

FIG. 3 RELATIVE CHANGES IN CURRENT AND RESISTANCE FOR BEEF CARCASSES STIMULATED WITH SYSTEMS A OR B USING DIFFERENT EARTHING CONFIGURATIONS. THE 'RUMP' EARTHING POSITION WAS HORIZONTAL TO THE ANUS WHILE THE 'LEG' EARTHING POSITION WAS APPROXIMATELY MIDWAY BETWEEN THE 'RUMP' POSITION AND THE KNEE JOINT.

FIG. 4 NUMBER OF SAMPLES HAVING SHEAR VALUES IN DIFFERENT RANGES FOR LD MUSCLES REMOVED 'PRE-RIGOR' FROM CARCASSES WHICH HAVE BEEN (A) UNSTIMULATED-CONTROLS, (B) STIMULATED USING SYSTEM B WITH NORMAL SHACKLE/RAIL EARTH, (C) STIMULATED USING SYSTEM B WITH ANAL EARTH OR (D) STIMULATED USING SYSTEM B WITH A LEG EARTH.

FIG. 5 AS F… FIG. 4 BUT WITH 'POST-RIGOR' SAMPLES.