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Prepared by: IJ Eustace, FD Shaw, RF Dickinson &
NG MC Phail

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Meat and Livestock Australia Limited
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Evaluation of an Electronic Monitor for use for ELV beef carcass stimultation units

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Summary

An electronic monitor which examines the output of beef carcass electrical stimulation units was evaluated. The monitor measures voltage, current, frequency and duration of each cycle and, at the completion of the current application, indicates whether the stimulation meets the CSIRO specifications. If it does, a counter advances by one to record it as effective and a green light illuminates. If it does not meet the specifications, it is recorded as ineffective, a red light illuminates and an audible alarm sounds. Additionally, red LED indicator lights identify the parameter(s) which did not meet specifications.

The monitor was trialled at an abattoir where it recorded over 98% of stimulations as effective.

Comparisons between groups of control (unstimulated) and stimulated carcasses at the abattoir indicated that stimulation caused a marked decrease in 1 hour post-slaughter pH values and an increase in 1 hour post-slaughter muscle temperatures. Additionally, muscles from the stimulated carcasses had longer sarcomeres and were more tender than the corresponding muscles from the control carcasses.

The stimulation monitor could play a role in quality assurance programs for the production of tender beef.

Introduction

It is widely acknowledged that electrical stimulation can play a valuable role in the production of tender meat. Numerous laboratory studies, using both objective (Warner-Bratzler, Instron) and subjective (taste-panel) measurements have demonstrated that, under most circumstances, meat from carcasses that have been electrically stimulated will be more tender than meat from similar carcasses that have not been stimulated (Bouton & Harris 1978, Ruderus 1980). A consumer study in Australia confirmed that electrical stimulation improves the tenderness of steaks (Kingston et al. 1987).

There are two types of stimulation system in use in Australian abattoirs, high voltage (HV) and extra low voltage (ELV). Specifications for these systems have been documented in industry guidelines (Anon 1985). For effective stimulation, current must be above a minimum value for an adequate time and specific waveforms and frequencies must be used. Thus stimulation equipment must meet certain specifications with respect to voltage, current, frequency and time. In addition there must be adequate contact between the carcass and the electrodes and the stimulation must be applied within a specified time after stunning of the animal.

The physical response of a carcass to the application of the electric current will indicate that the current is being applied but a particular physical response cannot be taken to indicate that the stimulation is adequate in terms of improving meat quality. Similarly, current flow indicated on an ammeter is not necessarily an adequate indicator of effective stimulation as a correct current reading may be obtained with an unsuitable waveform. Thus there is a requirement for an instrument which provides evidence of effective stimulation.

A stimulation monitor designed to evaluate the output of stimulation units was developed in New Zealand (Anon 1991). The monitor was trialled in Australia but it was felt it would be of limited use in this country because of differences between the stimulation units used in the two countries. An Australian company, HE TECHNOLOGIES* (HETECH), subsequently developed monitors for both the HV and ELV units used in this country.

The monitors measure voltage, current, frequency and time. They assess all four parameters and, at the completion of the current application, indicate whether the stimulation meets pre-programmed specifications. If it does meet the specifications, it is recorded as effective and a green light illuminates. If it does not meet the specifications, it is recorded as ineffective and a red light illuminates and an audible warning is sounded. Additionally, red LED indicator lights identify the parameter(s) which did not meet specifications.

* HE TECHNOLOGIES, PO Box 182 Springwood, Q. 4127

It is envisaged that the monitors would be located in the area where stimulation occurs and positioned so that the operator could observe the green/red lights. In the event of an ineffective stimulation, the carcass would either be re-stimulated or noted as not stimulated and would therefore not be eligible to receive certain brands relating to meat quality. To further assist in quality assurance, the monitor records the total number of effective and ineffective stimulations. This information can then be related, on a daily basis, to the number of carcasses processed.

One of the aims of this investigation was to confirm that the monitor indicated an effective stimulation when, and only when, the stimulator output complied with the relevant CSIRO specifications. Additionally, another aim was to demonstrate that when the stimulation was effective, there would be an advantageous effect on meat quality. Finally, it was intended to demonstrate that the monitor could be used as part of a quality assurance program for the production of tender meat.

Methods

A HETECH stimulation monitor was evaluated at a south-east Queensland abattoir. The abattoir routinely uses a HETECH stimulation unit, model LVS4. The current flows through the carcass from a nostril probe to a rubbing bar which makes contact with the carcass in the vicinity of the rump. A cathode ray oscilloscope was used to confirm that the output of the stimulator complied with CSIRO specifications (Anon 1985).

On four occasions, two groups containing equal numbers of carcasses were obtained from mobs of cattle derived from one property. One group was stimulated using the normal procedures in operation at the abattoir, the other group (control) was not stimulated. The number in each group on the different occasions was 19,15,10 and 10.

The stimulation monitor was observed while each of these experimental carcasses was being stimulated. Additionally, the monitor was left connected during normal abattoir operations to ascertain the incidence of effective stimulations. It was not continually observed during this aspect of the trials.

On all experimental carcasses, pH and temperature measurements were made at one hour after stimulation or, in the case of the control carcasses, one hour after stimulation would normally have been applied. pH was measured in the M.longissimus dorsi at the level of the 10th rib using a Watson-Victor pH meter with glass electrode. Temperature was recorded in a position adjacent to the pH measurement site and also in the deep butt. For this measurement, the probe was inserted through the obturator foramen to a depth of approximately 150 mm. A Fluke digital thermometer with probe was used for the temperature measurements.

Approximately 20 hours after slaughter, a sample of M. longissimus dorsi was removed at the level of the 10th rib and transported to the laboratory. At approximately 24 hours after slaughter a pH measurement was made on this sample and subsequently sarcomere measurements (Bouton et al. 1973) were made. With two groups of 20 samples (10 stimulated, 10 control), Warner-Bratzler (W-B) shear determinations (Bouton & Harris 1972) were carried out on portions of the cooked (80°C for 1 h) muscles. Initial yield (IY) and peak force (PF) shear values were determined from the shear force-deformation curves. Cooking losses were calculated using pre- and post-cooking weights of the samples. An analysis of variance was used to determine the statistical significance of the results.

Results

A. Stimulation Unit

An examination of the waveform on the cathode ray oscilloscope revealed the following features:

(i) At the commencement of stimulation there was a "ramp" effect with the output increasing to a peak of 45 V over three seconds.

(ii) The pulse was an alternating square wave which was on for 100 ms and off for 12 ms. The pulse width was 25 ms.

The duration of current flow was timed to be in excess of 40 seconds.

B. Stimulation Monitor

The monitor recorded an effective stimulation for all 54 stimulated experimental carcasses.

The monitor recorded a total of 422 stimulations; 416 effective and 6 ineffective. One of the ineffective stimulations was observed to be due to inadequate current as a result of poor contact with the rubbing bar. Observers were not present when the remaining ineffective stimulations were recorded and thus the cause of the problem was not identified. Overall, 98.6% of carcasses were effectively stimulated.

C. Carcass And Meat Quality Measurements

A summary of the mean values for the carcass and meat-quality measurements is given in Tables I and II of this section, while more detailed results are presented in Tables III and IV (see appendix).

Table I. One Hour pH And Temperature Measurements - Summary

	Control	Stimulated
L dorsi pH	6.93	5.87
D butt t °C	40.19	41.52
L dorsi t °C	35.95	37.20

Differences between control and stimulated groups are statistically significant ($P < 0.05$).

Table II. Meat Quality Results - Summary

	Control	Stimulated
Sarcomere (μ)	1.76	1.86
W-B IY (kg)	7.88	4.75
W-B PF (kg)	8.41	5.14
Cook loss (%)	31.96	32.68
pH 24 hour	5.57	5.58

Differences, except for cooking loss and pH 24 hour, are statistically significant ($P < 0.05$).

Discussion

The results in Table I clearly demonstrate the effectiveness of the electrical stimulation. There has been a rapid fall in pH and an increase in temperatures as a result of the stimulation. The temperature differential is still detectable in the L. dorsi even though this muscle, particularly in the leaner carcasses, is almost directly exposed to the chiller air.

The sarcomere measurements indicate that there has been less cold shortening of the muscles of the stimulated carcasses. Electrical stimulation affects tenderness primarily by minimising the toughness associated with cold shortening.

The Warner-Bratzler measurements (Table II) provide evidence that the stimulation treatment led to an improvement in tenderness of these muscles.

Conclusions

The stimulation monitor confirmed that the stimulation unit at this abattoir was producing an output in accordance with the CSIRO specifications and that the stimulation system and procedures resulted in an effective stimulation in greater than 98% of cases.

Carcass and muscle measurements indicated that the electrical stimulation was effective in producing a rapid fall in pH and in improving meat quality.

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Appendix

Table III. Carcass Data

	Mob 1	Mob II	Mob III	Mob IV
Side wt Cont	222.7	184.3	211.1	171.8
Side wt Stim	227.4	182.8	211.9	169.1
Fat thick Cont	32.3	19.0	21.5	17.2
Fat thick Stim	32.7	18.5	25.9	18.7
Dentition Cont	4.8	8.0	6.4	7.0
Dentition Stim	4.1	8.0	5.8	7.2

Notes:

1. Values are means.
2. Units. Side weights are in kg, fat thickness in mm. Dentition is the number of permanent incisor teeth.
3. For Mob I, control and stimulation groups, n = 19.
   For Mob II, control and stimulation groups, n = 15.
   For Mobs III and IV, control and stimulation groups, n = 10.
   Within a mob, there are no statistically significant differences, between control and stimulated groups.

Table IV. Carcass And Meat Quality Results

	Mob I	Mob II	Mob III	Mob IV
pH 1 h Cont	6.90	6.97	6.98	6.89
pH 1 h Stim	5.69	5.97	5.95	5.95
D butt 1 h Cont	40.6	40.2	39.89	39.71
D butt 1 h Stim	41.7	41.7	40.92	41.35
L Dorsi 1 h Cont	34.6	35.6	37.37	37.45
L dorsi 1 h Stim	36.1	37.0	38.19	38.60
Sarcomere Cont	1.82	1.74	1.77	1.67
Sarcomere Stim	1.98	1.72	1.83	1.85
W-B IY Cont	nd	nd	7.97	7.79
W-B IY Stim	nd	nd	4.51	5.00
W-B PF Cont	nd	nd	8.38	8.43
W-B PF Stim	nd	nd	4.78	5.49
Cook loss Cont	nd	nd	31.80	32.12
Cook loss Stim	nd	nd	32.22	33.15
pH 24 h Cont	5.54	5.59	5.56	5.59
pH 24 h Stim	5.61	5.59	5.56	5.55

Notes.

1. Values are means.
2. Units. Temperatures are in °C, sarcomeres are in μ while Warner-Bratzler values are in kg.
3. All differences (Control vs stimulation), except for sarcomere values (mob II) and cooking loss (mobs III and IV) and 24 hour pH (mobs II, III and IV), are statistically significant ($P < 0.05$).