ELECTRICAL STIMULATION

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The current CSIRO Meat Research guidelines for effective electrical stimulation of beef carcasses are as issued in January 1985. These guidelines only relate to beef. Electrical stimulation of sheep and pig carcasses is not currently practised in Australia, although stimulation of sheep is common in New Zealand, particularly where sheep are blast frozen directly from the slaughter floor. This paper, therefore, is mainly related to beef carcasses.

1. Why Introduce Electrical Stimulation?

Weight loss and microbiological growth on carcasses are minimised when the carcasses are chilled quickly. Unfortunately, if a carcass is chilled before it is in rigor, the muscles of commercial significance will toughen. This toughening results from an increased shortening of muscles due to exposure to cold and is called “cold shortening”. The lower the temperature at which rigor mortis is achieved, the more severe is the cold shortening. Muscles that are already in rigor will not cold shorten, regardless of the temperatures to which they are chilled.

The electrical stimulation (ES) of freshly slaughtered animals accelerates the natural processes leading to rigor mortis. It may be expected that the benefits to tenderness in muscles subjected to ES will be:

- in muscles free to shorten post-mortem, e.g.
  - *M. longissimus dorsi* (LD) (eye of loin);
  - *M. semimembranosus* (SM) (largest muscle in topside or inside);
  - *M. gluteus medius* (GM) (muscle of rump);
  - *M. vastus lateralis* (knuckle);
- greatest in superficial muscles, e.g. LD;
- small when chilling conditions employed (i.e. slow chilling) do not result in the deleterious post-mortem shortening in unstimulated muscles; and
• small or non-existent when muscle has high ultimate pH, i.e. pH >5.9.

One definition of an effective ES system for beef is one when carcasses are chilled rapidly (<10°C at centre of the loin muscle (M.longissimus dorsi (LD)) in 10 hours), at least 95% of the LD muscles with an ultimate pH <5.8 and cooked by a standard CSIRO procedure have shear force values of <8kg.

ES facilitates the introduction of hot boning, as table cuts may be removed from hot carcasses and rapidly chilled or frozen without the risk of extreme toughening.

2. Selection of ES System

Introduction

There are two systems:

HV (High Voltage);

ELV (Extra Low Voltage).

The choice between the two is generally decided on the following factors:

HV  -  high capital cost
     -  No labour cost
     -  Usually positioned at the end of the slaughter floor but can be installed in any suitable position after sticking;

ELV  -  Low capital cost
     -  Labour after stunning is required to insert and remove probes
     -  Incidence of broken backs may increase with downward pulling hide strippers.

Above 30 cattle per hour, it is suggested that management consider the HV system.
ELV Systems – 45V Maximum

ELV systems require minimum electrical protection for operators, provided peak and r.m.s. voltages are a maximum of 45 and 32V respectively.

Four systems have been trialled:

- Nostril - Rail via Shackle (N-S)
- Nostril - Leg
- Nostril - Rectum (N-R)
- Rectal.

These systems are illustrated in Figure 1.

\[ \text{Figure 1: Electrode configurations and systems used for Extra Low Voltage stimulation of beef carcasses} \]
Figure 2 illustrates the resistance and current relationship for each system.

![Graph showing current and resistance relationship for different earthing configurations](image)

**Figure 2:** Relative changes in current and resistance for Extra Low Voltage using different earthing configurations

The Rectal system is only effective in the hindquarter.

Nostril-Rectal and Nostril-Leg systems require:

- 200 ma per carcass;
- nostril electrodes must be inserted at least 12 cm.

Carcasses being stimulated must not be in contact with other carcasses.

Carcasses should be stimulated within four minutes of slaughter and immediately after bleeding, 0.5+ 1.0 kg of additional blood is commonly expressed during stimulation.

The results of a test comparing three ELV systems with non-stimulated carcasses is given in Figure 3.
Figure 3: Proportion of samples classified as tender for LD muscles (WB Shear Force ≤8 kg)

Maintenance and Testing of ELV Systems

Electrical connections must be maintained in good condition.

The ammeter supplied should be accurate and read at least 200 ma for modern "Hetech" systems. Hetech Technologies manufacture an ELV test instrument which identifies amps, voltage and waveform, and determines effective/ineffective stimulations. Problems such as low mains supply voltage, loss of contact with the rubbing bar electrodes and faults in the control system are revealed with this instrument.

HV Stimulation

High voltage stimulation may be applied up to 60 minutes after stunning but the sooner it is applied after sticking the better.
There are three positions to consider:

- After sticking (Note the possible increase in the incidence of broken backs if down-pulling hide-stripers are used. Hide damage from electrodes is also possible).
- After hide stripping and before evisceration.
- After inspection (this avoids requirement to sterilise electrodes between carcasses).

The voltage used is related to time from sticking. Refer to Figure 4.

![Minimum Applied Voltage (RMS, Half Sinusoid)](image)

**Figure 4:** High voltage electrical stimulation minimum applied voltage (RMS half sinusoid)

HV electrical stimulation installations must comply with stringent safety regulations. They must be inaccessible to personnel during operation. Typical installations are illustrated in Figure 5.
Figure 5: Typical ES cabinet arrangements
It should be noted that allowance must be made for lap times, morning tea breaks or any other operational practice which may extend the time from stunning to stimulation as the effectiveness of stimulation is reduced when the indicated times are exceeded.

3. Advantages and Disadvantages of ELV and HV ES

There are advantages and disadvantages with both systems. The following will attempt to identify these and recommend where the two systems are best suited.

**ELV**

**Advantages**

- Low initial cost
- Available commercially as a packaged unit
- Extra blood is obtained.

**Disadvantages**

- Must be applied after sticking within four minutes from stunning.
- If downward hide-pullers are used, the incidence of broken backs will probably increase.
- Its application requires an ongoing labour component. Additional labour may be required, dependent upon throughput.
- If done correctly, alteration of dressing procedures due to stiff legs will almost certainly be required.

**HV**

**Advantages**

- If applied in the bleeding area, extra blood is obtained.
- Is normally automatically applied and does not incur ongoing labour cost.
• Is effective up to a maximum of 60 minutes from stunning, allowing installation at many locations on the dressing chain. Allowance must be made for dressing chain stoppages for meal breaks and rest periods.

Disadvantages

• High initial cost
• Unsafe if improperly designed, installed or maintained
• An increase in the incidence of broken backs if applied prior to a downward hide-puller.

It is obvious from the advantages and disadvantages listed above that ELV stimulation is ideal for small abattoirs and slaughter houses. For larger abattoirs, the extra capital associated with automatic HV stimulation is normally justified by the labour savings.

4. Electrical Stimulation of Sheep and Lamb

HV electrical stimulation of sheep and lambs is not used in Australia. However, in New Zealand where rapid freezing immediately following slaughter is widely practiced, electrical stimulation is carried out.

In the case of sheep and lamb carcasses, freezing can be sufficiently rapid to prevent muscle from shortening. If these carcasses are then thawed rapidly, muscle shortening and toughening can be considerable and accompanied by significant drip loss. This “thaw shortening” can be prevented by keeping the meat at temperatures just below freezing for several days before allowing it to thaw. Although the chemical change which causes shortening can still proceed slowly at these temperatures, the muscle is restrained from shortening because it is still partially frozen.

Lamb and mutton frozen soon after slaughter and later cooked from the frozen state can be very tough due to both cold and thaw shortening.

In the case of lamb, ELV systems have proved ineffective.

In regard to lamb produced for the domestic market, results from two investigations are briefly presented, with conclusions.
1. **CSIRO Meat Research Laboratory**

   Maximum effect is achieved if HV ES is applied within 30 minutes of slaughter.

   Effective HV ES (stimulation 800V RMS, 1140V peak at 14.3Hz, within 30 minutes of slaughter for a period of 90 seconds) when carcasses were chilled within 50-60 minutes post-mortem significantly improved tenderness.

   Unless very rapid chilling is used, the tenderness of non-stimulated carcasses and stimulated carcasses are comparable within two to three days.

2. **National Food Centre, Ireland**

   In these trials, low-voltage stimulation of 90V DC for 2 minutes was used at the conclusion of bleeding (90V does not qualify as ELV in Australia).

   Two sets of chilling conditions were used:

   (i) -20°C with air speed 1.5 m/sec for 3 to 3.5 hours and then raised to -5°C and transferred to a holding chiller at either 0°C to 4°C;

   (ii) Control conditions for the trial were chilling at 4°C.

   Electrical stimulation was found to have no significant effect on meat tenderness. The rapid chilling process reduced weight loss after 24 hours from 1.6 to 0.82% for washed carcasses and 1.83 to 0.96% for unwashed carcasses.

   The chilling conditions which gave the most tender meat were -20°C for 3.5 hours at an air speed of 1.5 m/sec. Other researchers have had similar results. Surface hardening which may inhibit cold shortening through skeletal restraint is believed to be one mechanism which facilitates tenderness.
5. Electrical Stimulation of Pigs

Electrical stimulation of 62-85 kg pigs has been investigated in the United Kingdom. The trial and results were:

Stimulated - 700V, 12.5 Hz for 90 sec, 20 minutes from stunning. Groups of carcasses stimulated and unstimulated were subjected to various holding and chilling treatments.

40 minutes after stunning, carcasses were subjected to pelvic suspension for 6 hours and then re-suspended from the Achilles tendon.

40 minutes after stunning, sides were cooled in air at 1°C and 0.5 m/sec on in air at -15°C and 1.2 m/sec until deep loin reached 10°C (3 hours) and placed in a chiller at 1°C.

Electrical stimulation was shown to increase drip by about 0.3% when used in the absence of cold-shortening conditions (i.e. slow chilling). With chilling sufficiently fast to induce cold shortening, ES reduced drip by about 0.3%. Pelvic suspension also reduced drip. ES gave an increase in tenderness of pork aged seven days.

Other research on ES in pigs has shown that if ES is applied earlier, say within five minutes of stunning, paleness increases, particularly in stress-susceptible pigs.

6. Further Reading

The CSIRO paper Effective Electrical Stimulation of Beef Carcasses and Sides – Industry Guidelines Update, January 1985 should be reviewed prior to the installation of any electrical stimulation system.

7. References

CSIRO Meat Research Newsletter 81/l. Electrical Stimulation of Sheep and Lamb Carcasses.


CSIRO Meat Research Report 1/86. The Effects of Chilling, Ageing and Electrical Stimulation on the Tenderness of Lamb.


