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Extra Low Voltage Stimulation of Beef Carcasses

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SUMMARY

Two experiments, one with young steers, the other with old cows, were conducted to determine the effectiveness of stimulation with a rectal probe used in conjunction with a stimulation unit having a maximum output voltage of 45 V DC. In both experiments hindquarter muscles from stimulated carcasses were more tender than the corresponding muscles from comparable carcasses that had not been stimulated. This method of stimulation had no effect on the forequarter muscles. Because the stimulation unit uses Extra Low Voltage (ELV) guarding of the probe or carcasses is not normally required.

ELV stimulation with a rectal probe offers an easy, practical method of enhancing the tenderness of meat from animals of all ages.

A complete rectal probe/stimulation unit is available commercially. This unit is suitable for use in small abattoirs with a kill rate of up to 30 head/hour.

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INTRODUCTION

An earlier Meat Research Report (16/77) presented results from several experiments which clearly indicated that meat from stimulated carcasses was more tender, as measured by taste panels and by machine (Warner-Bratzler determinations), than meat from comparable unstimulated carcasses. There are many ways in which electrical stimulation can be applied to a carcass, some of these were detailed in a subsequent Meat Research Report (1/79). In general the greater the applied voltage the greater is the enhancement of tenderness and commercial stimulation units in use in other countries use voltages in the range 400V - 1100V (1,2). Studies at the CSIRO Meat Research Laboratory have shown that stimulation of beef sides or carcasses with voltages as low as 45V DC can lead to an increase in tenderness (3). The finding that extra low voltages can produce effective stimulation has recently been confirmed in Sweden where a system using 15V has been successfully tested (6).

In Australia, voltages below 110V D.C. and 32V A.C. are classified as Extra Low Voltage (ELV) and are generally accepted as being safe to use with minimum precautions. The State Electricity Commission of Queensland has stated that if ELV is used for stimulation there is no need to guard either the electrodes or the carcass, but at any voltage above ELV, the electrodes and the entire carcass must be guarded from human contact. Thus there are many practical advantages in using ELV, as compared to higher voltages, for carcass stimulation.

Two important factors in determining the effectiveness of stimulation with a particular voltage are (i) the time between the stunning of the animal and the application of the stimulation current and (ii) the effectiveness of the contact between the electrode system and the carcass. For maximum effect, stimulation should commence as soon as possible after the animal has been stunned i.e. before dressing has commenced. With low voltage systems it is essential that contact be made with the fat or muscle of the carcass and not just with the hide. This will normally mean that it is necessary for the electrodes to penetrate the hide with consequent risk of contamination of portion of the carcass by bacteria present on the hide. If stimulation is applied via a rectal probe the problem of carcass contamination does not occur and the animal can be stimulated

as soon as bleeding is completed (there is a risk of ecchymosis ("blood splash") if stimulation is applied before bleeding). Early studies at the Meat Research Laboratory used commercial bull electro-ejaculator probes but a robust simplified rectal probe has since been designed and tested.

This report presents the results of 2 experiments, one with young steers and one with old cows, designed to determine the effectiveness of extra low voltage stimulation with this rectal probe.

MATERIALS AND METHODS

Stimulation unit.

The unit has been described in some detail in a previous Meat Research Report (1/79). The output is pulsed direct current*, with a pulse width of 2 msec and a pulse frequency of 40 pps. The stimulation period of 90 seconds is divided into three stages;

(i)	0 - 30 sec	25V
(ii)	30 - 60 sec	35V
(iii)	60 - 90 sec	45V

* NOTE: The output of this stimulation unit is pulsed direct current. When interpreting the safety regulations the electrical authorities classify it as alternating current, not direct current, and therefore the maximum voltage allowed under the ELV classification is 32 volts (Root Mean Square) which has a peak voltage of 45. Thus this unit uses the highest peak voltage (45) acceptable as ELV by the authorities.

Experimental design.

Two experiments were conducted, in each experiment 4 animals were stimulated while 4 similar animals were not stimulated (controls). The sides from the control animals were always treated identically to those from the stimulated animals. In experiment 1 the animals were Hereford steers (2-3 years; carcass weight 160-190 kg) while in experiment 2 the animals were cracker cows of various breeds (8-15 years; carcass weight 100-160 kg).

The animals were stunned with a captive bolt pistol, pithed and shackled by one hind leg. The rectal probe was inserted prior to hoisting the animal. After hoisting, the animal was "stuck" and when bleeding had finished the stimulation unit was switched on. The time

from stunning to stimulation was between 2 and 7 minutes. When the current was switched on there was an immediate stiffening and upward extension of the free hind leg and, in some cases, of the two front legs. This stiffening lasted for approximately 30 seconds, the legs then commenced to relax. By the end of the stimulation period the legs had usually returned to their pre-stimulation position. After stimulation the rectal probe was removed and the carcasses dressed in the conventional manner. The dressed carcasses were split and the sides transferred to a holding room (air temperature 12°C). At 2 hours after stunning the sides were transferred to a small chiller (air temperature 1°C). The sides were at all times suspended by the Achilles tendon. At 24 hours post stunning the sides were removed from the chiller and boned out. The following muscles were removed from one side of each carcass for tenderness tests (the cuts from which the muscles are obtained are also listed);

Biceps fermoris	(BF)	Silverside
Vastus lateralis	(VL)	Knuckle
Longissimus dorsi	(LD)	Striploin
Gluteus medius	(GM)	Rump
Psoas major	(PM)	Fillet

In experiment 2 only, the following muscles were also removed;

Semimembranosus	(SM)	Topside
Semitendinosus	**(ST)**	**Silverside**
Deep pectoral	(DP)	Brisket
Triceps brachii	(TB)	Blade

Measurement of pH

The pH of 5 muscles (SM,BF,VL,LD and TB) was measured at 1 hour after stunning. A pH meter fitted with a probe type electrode was used, the electrode being inserted into a shallow cut made into the muscle. pH values for individual muscles were taken as the mean of three measurements.

Warner Bratzler measurements

The Warner Bratzler (WB) shear device was used for the assessment of tenderness. This device records the force in kg required to shear through a standard size sample of muscle across the fibre direction. Samples weighing about 200 gm are cut from the muscle to be tested and

cooked for 90 min in polyethylene bags totally immersed in water maintained at 80°C. After cooking the samples are cooled in cold running water for 30 min. Excess surface moisture is removed with an absorbent paper towel, the samples rewrapped in polyethylene and stored at 0-1°C overnight.

Standard size sub samples (cross section 1 cm^2) are prepared from the cooked sample for testing. Each Warner Bratzler shear value is the mean of 5 values for that particular muscle.

A particular shear force value does not necessarily indicate a particular tenderness score that would be allocated to that muscle by a taste panel. However as a general statement, the higher the shear value the tougher the meat. The following values can be used to assist in interpreting the shear values listed in the tables in this report.

0 - 5 kg	=	tender
5 - 10 kg	=	slightly tough
10 - 15 kg	=	tough
> 15 kg	=	very tough

RESULTS AND DISCUSSION

pH values.

The 1 hr pH values for the muscles from the stimulated carcasses were significantly less than those from the control carcasses (Table 1). The mean values for the stimulated carcasses (6.3 and 6.4) are similar to those recorded previously with low voltage or extra low voltage stimulation (3,4,7). With high voltage stimulation 1 hr pH values can be as low as 5.9 (3). For all muscles except the TB (blade) the differences between stimulated and control values were statistically significant ($P < 0.05$).

TABLE 1

Mean pH values at 1 hour after slaughter for muscles from stimulated and control (unstimulated) beef carcasses.

MUSCLE	EXPT. 1 (steers)		EXPT. 2 (Cracker Cows)	
	Control	Stimulated	Control	Stimulated
SM (Topside)	7.0	6.1	6.9	6.2
BF (Silverside)	6.9	6.3	7.0	6.4
VL (Knuckle)	7.1	6.1	7.0	6.2
LD (Striploin)	7.1	6.3	7.0	6.6
TB (Blade)	7.0	6.8	6.9	6.8
MEAN	7.0	6.3	7.0	6.4

For statistical significance ($P < 0.05$) values for individual muscles must differ by 0.3

Warner Bratzler measurements.

The WB shear values for muscles from the stimulated and control carcasses are listed in Tables 2 and 3. In experiment 1 (Table 2) there were marked differences in shear values between muscles from the stimulated and control carcesses. With the exception of the PM (fillet) these differences were statistically significant ($P < 0.05$). In experiment 2 (Table 3) the differences were less marked and for several muscles the differences were not statistically significant.

TABLE 2

Warner Bratzler shear values (kg) for muscles from stimulated and control (unstimulated) beef carcasses.

EXPT. 1 - HEREFORD STEERS

MUSCLE	Control	Stimulated
BF (Silverside)	11.5	4.7
VL (Knuckle)	11.7	6.0
LD (Striploin)	19.8	13.4
GM (Rump)	10.2	5.0
PM (Fillet)	3.5	3.2
MEAN	11.4	6.5

For statistical significance ($P < 0.05$) values for individual muscles must differ by 3.9.

For interpretation of shear values see page 5.

TABLE 3

Warner Bratzler shear values (kg) for muscles from stimulated and control (unstimulated) beef carcasses.

EXPT. 2 - CRACKER COWS

MUSCLE	Control	Stimulated
BF (Silverside)	14.2	9.6
VL (Knuckle)	16.5	9.9
LD (Striploin)	15.0	15.7
GM (Rump)	13.3	8.5
PM (Fillet)	5.4	5.8
SM (Topside)	16.1	10.6
ST (Silverside)	14.2	13.5
DP (Brisket)	12.9	13.1
TB (Blade)	10.4	10.0
MEAN	13.1	10.7

For statistical significance ($P < 0.05$) values for individual muscles must differ by 4.3

For statistical significance ($P < 0.05$) values for means must differ by 2.3

For interpretation of shear values see page 6.

The results of experiment 1 show clearly that meat from carcasses that have been stimulated with 45V via a rectal probe is more tender than meat from similar carcasses that have not been stimulated. While it could not be claimed that the muscles from the stimulated carcasses of the cracker cows were tender, even with these animals stimulation has caused a marked reduction in the toughness of some muscles.

In one case in experiment 1, the LD (striploin) had a WB shear value of 5.2, but most of the striploins from the stimulated carcasses had high shear values. In a series of experiments in which carcasses were stimulated with 1100 V, only 47% of the striploins were acceptably tender (8). It therefore appears that even with high voltage stimulation this muscle gives a very variable response. WB results and pH values indicate that ELV stimulation with a rectal probe has little or no effect on the muscles of the forequarter DP (brisket) and TB (blade).

In a previous experiment at the Meat Research Laboratory beef sides were stimulated with a maximum voltage of 45V. Taste panel assessments as well as WB shear values were used to determine changes in tenderness. Taste panel results indicated that meat from stimulated sides was more tender than meat from unstimulated sides (3). Thus the enhancement of tenderness associated with ELV stimulation can be detected by taste panels as well as by WB shear determinations.

Comparisons with Tenderstretch.

Previous experiments (4) have shown that meat from stimulated sides is similar in tenderness to that from sides which have been suspended from the pelvis (Tenderstretch) during chilling. The Tenderstretch method causes a marked improvement in the tenderness of the LD (striploin) and for this muscle the Tenderstretch process would be superior to stimulation. However when considered over several muscles there is little difference between stimulation and Tenderstretch as methods of improving meat tenderness.

Hot Boning

One of the recommended uses for electrical stimulation is in conjunction with hot boning. Because of the poor results with the forequarter and the moderately high 1 hr pH values, ELV stimulation with the rectal probe cannot, in general, be recommended for use with hot boning. If hot boning is to be undertaken it will be necessary, in most cases, to use high voltage stimulation.

Possible practical applications of ELV stimulation with a rectal probe.

This system has already been successfully used by butchers in country slaughterhouses with a kill of 1 - 6 head per day. In one instance the butcher has adopted the technique of removing the head before commencing stimulation and then working on the head during stimulation. Thus no time is lost because of the stimulation process.

The system can also be used in small abattoirs with a kill rate of up to 30 head/hour. The electrode would be inserted manually at the time of shackling and the stimulation current applied for 90 seconds after sticking. The electrode would then be removed and washed before insertion into the next carcass. Work should not be carried out on the carcass immediately before or during stimulation as

vigorous contractions of the legs of the carcass may occur at any stage during stimulation.

The system could also be used in abattoirs with higher throughputs, using one power supply with a distributor system supplying several rectal probes. The major cost with this method is the labour cost of manually inserting and retrieving the probes.

Construction and supply of ELV stimulation units.

Circuit diagrams for stimulation units and a diagram of the rectal probe are contained in Meat Research Report No. 1/79. Complete stimulation units and rectal probes are available commercially from A & B Electronics, 21 Murna Street, Jindalee, Queensland 4074 at an approximate cost of $575. This unit is illustrated on page 10.

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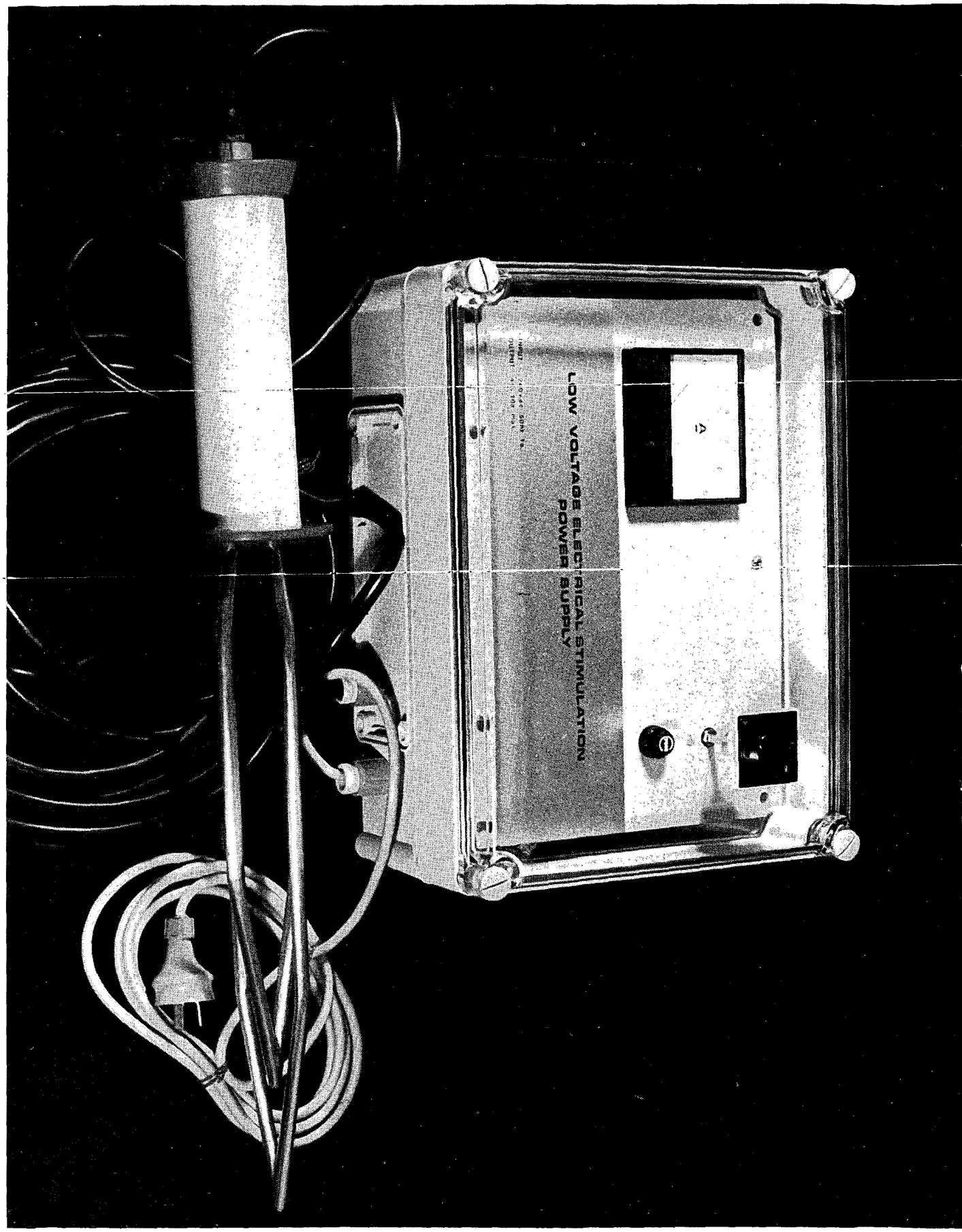
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