EFFECT OF LOW VOLTAGE AND HIGH VOLTAGE ELECTRICAL STIMULATION ON PORK QUALITY

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MARY

ses from 36 Large White gilts, 70-80 kg live weight, were randomly allocated to three experimental groups. Pigs from the first group electrically stimulated (ES) with low voltage during bleeding (85v, 14Hz for 64 sec) before splitting. The left sides were rapidly chilled in -15°C for 75 min and then at 1°C for 23h; right sides were chilled conventionally in air at 1°C for 24h. Carcasses from the second group unstimulated (NES), and sides chilled either rapidly or conventionally. In the third group, two different ES treatments were used 20 min slaughter; left sides were stimulated with low voltage, and right sides with high (700v, 12.5 Hz for 90 sec). Both sides were rapidly

oss, colour and texture were measured in *M. longissimus thoracis et lumborum* at 3 and 10 days post-slaughter.

ays post-slaughter the high voltage ES (HVES) treatment gave meat which was most tender, which was not pale and lost no more drip ES controls. Low voltage ES (LVES) during bleeding gave meat which was 18% more tender than the (NES) controls, but the vement in tenderness was not as great as the 28% achieved with HVES. Unexpectedly, LVES, applied 20 min after slaughter, was almost ctive in improving tenderness (by 17%) as LVES applied during bleeding.

rness improved from 3 days to 10 days in all ES samples, but not in NES controls, suggesting a degree of cold-toughening in the latter, with conventional chilling.

RODUCTION

ugh the early reports of electrical stimulation of pigs were rather conflicting regarding effects on eating quality (Westervelt and Stouffer, Johnson *et al* , 1982; Gigiel and James, 1984), a considerable amount of research evidence since then indicates that ES can be used to ve tenderness of pork, although care must be exercised to avoid possible detrimental effects. These arise mainly from the rapid pH fall ed by ES, which with high muscle temperature, can lead to PSE-like conditions in the meat. These manifest themselves as undesirable ess and excessively high drip loss.

r & Tantikov (1989; 1992) and Dransfield *et al* (1991) found a considerable tenderising effect from high voltage ES, with up to 30% vement over non-stimulated controls. Although drip loss tended to be slightly higher with ES, this disadvantage was largely overcome rapid chilling, which could be carried out on stimulated carcasses without the danger of cold-shortening toughness. Taylor & Tantikov) found high voltage ES more effective than low voltage ES applied immediately after sticking. A further advantage of high voltage was could be applied successfully later in the dressing line, say at 20 min post-slaughter. The perceived need for low voltage ES to be applied ly as possible because it relies to a large extent on the central nervous system to transmit current to the musculature, could place irable constraints on factory stimulation procedures.

study was undertaken to evaluate the relative tenderisation produced with low and high voltage ES, with low voltage ES applied either g bleeding or at 20 min post-slaughter, the chosen time for high voltage stimulation of pigs.

PERIMENTAL

- Thirty-six Large White gilts were used for this study, liveweight 70-80 kg and with P2 backfat thickness ranging from 8 to 15mm.

tment design - Animals were divided into three equal groups, subjected to different treatments. The first group were stimulated as whole ses during bleeding with low voltage (85v, 14Hz for 64 sec). After splitting, one side was chilled in air at 1°C for 24 hr (LV ES-CC), e the other was chilled in air at -15°C for 75 min and then at 1°C for 23h (LVES-RC). The second group were not stimulated, with one side ntionally chilled (NES-CC) and the other rapidly (NES-RC). Carcasses in the third group were split and electrically stimulated at 20 min slaughter, one side with low voltage (LVES (20) RC) and the other with high voltage (HVES-RC); all sides were rapidly chilled.

porative weight loss during chilling - The difference between hot side weight at 45 min and cold side at 24h was expressed as ntage of hot weight.

- pH was measured at 45 min, 3h and 24h using 1g samples of LTL homogenised with 10ml iodoacetate solution.

ling rate - Temperatures during chilling were recorded in the deep LTL.

p loss - Drip loss was measured by suspending 25mm slices of LTL in plastic bags and expressing the liquid that accumulated over 48h at as a percentage of the initial raw meat weight.

our - Lightness (L*) of the same LTL sample was measured using a Minolta Chroma Meter CR -200.

ole opacity - Opacity was measured on the LTL sample by a Fibre Optic Probe (FOP), values >50 indicating PSE and <18 DFD meat.

Texture - Two sections of LTL 10 cm long from each loin were vacuum packed and held at 1°C until 3 and 10 d from slaughter, before cooki in water at 80°C to an internal temperature of 78°C. Samples were then cooled in iced water overnight, and 10 blocks measuring 2 x 1 x 1 cm were cut from each sample with muscle fibres running longitudinally. The instrumental texture parameters, yield and compression force were determined using Volodkevitch jaws on a Stevens CR Analyser. Ten replicate blocks were measured to give mean values for each sample.

Data analysis - Analysis of variance examined the effects of treatment; mean values and standard deviations were calculated for each treatm plus all comparisons between treatments which were significant. Differences between treatments were tested for significance at 5% (*) and 1 (**) levels, using the Fischer test, based on standard error of difference between means derived by analysis of variance.

RESULTS

Pigs - There were no significant differences between treatment group pigs in terms of carcass weight and backfat thickness.

Cooling rate - Conventional chilling reduced deep LTL temperature to 10°C in 5h from slaughter, while rapid chilling achieved 10°C by 3.4

Evaporative weight loss - Conventionally chilled sides lost 2.2% weight during the 24h chilling; rapidly chilled sides lost 1.5%.

pH - Table 1 shows clearly how ES, low and high voltage, reduced pH at 45 min and 3h after slaughter. LVES, at the earliest time after slaughter, gave the lowest values. By 3h, pH in ES sides was between 0.4 and 0.5 units lower than NES controls, well below pH6. Differences between ES and NES sides were always significant (**) at 45 min and 3 h. There was no significant difference in pH at 24h.

Lightness (L*) - Low voltage ES at bleeding gave muscle which was significantly lighter than NES controls (Table 2), although the difference was unlikely to be visible to the eye. There was no significant difference with ES, low or high voltage, applied 20 min post-slaughter.

FOP - There was no significant treatment effect on muscle opacity measured by FOP although LVES samples had the highest values. All FO values were, however, within the range of 'normal' muscle, neither PSE or DFD,

Drip loss - The general level of drip was low. LVES at bleeding gave the highest drip loss, while there was no difference between NES sid and those stimulated with high or low voltage at 20 min post-slaughter and rapidly chilled.

Texture - The improvement in tenderness from ES, both high and low voltage, is clearly demonstrated in the yield and compression force da in Table 3 and in the comparison between treatments in Table 4. Samples from HVES at 20 min post-slaughter and LVES during bleeding we significantly more tender (**)than NES controls. At 3 d post-slaughter, measurement of yield force showed that tenderness was improved ov NES controls by 27% with HVES and by 15% with LVES, applied either during bleeding or at 20 min after slaughter. The contrast between and NES was greater when compression force was compared. Here, the improvement was 35% with HVES, 24% with LVES and 22% with LVES at 20 min.

By 10 days, the difference between ES and NES samples had increased, mainly because ES samples became more tender with ageing, and th NES controls did not. Table 4 shows that by 10d all comparisons between ES and NES had become significant (**). By yield measurement, the improvement with HVES over NES increased to 38% and with LVES to 24%. By compression measurement, the improvement with HV was 53%, 33% with LVES during bleeding and 29% with LVES at 20 min post slaughter.

DISCUSSION

The pigs used in this trial were similar in weight, breed and sex, and came from the same farm. Differences in quality factors could therefore clearly attributed to differences in ES/chilling treatments. The rapid chilling rate, by reducing deep LTL to 10°C by 3.4h, was fast enough to make cold - shortening likely, and even with conventional cooling which achieved the same temperature within 5 hr of slaughter, the possibili of some cold-shortening could not be ruled out. The value of reducing surface temperature quickly was shown by the reduced evaporative weight loss with rapid chilling. The saving of 0.7% compared with conventional chilling should be a strong economic argument in favour of rapid chilling.

The most easily measured effect of ES on muscle is the rapid drop in pH, and this is sometimes taken to indicate the effectiveness of stimulati In these experiments, the greatest pH fall, measured at 45 min, resulted from LVES applied during bleeding. This is not surprising since the other ES treatments were not applied until 20 min after slaughter. There may, however, be an additional reason, that immediately after slaugh the muscle is more reactive to ES than it is later. It was interesting to note that LVES at 20 min post-slaughter dropped pH by more or less the same amount as HVES applied at the same time, to a level 0.3 units lower than the NES controls. This effect on pH by LV applied as late as 2 min after slaughter was unexpected in view of the conclusions of Bendall (1980) and Fabiansson *et al* (1979) that LVES is effective only if applied immediately after death. The mechanisms by which stimulating current is transmitted through the musculature of a carcass are not yet clear.

oss was affected by ES, with the highest losses from LVES applied during bleeding, reflecting the rapid pH fall with that treatment. lation later, high or low voltage, had little effect on drip although the advantage of rapid chilling in reducing drip loss was noticeable. rise, the early LVES gave the palest meat, although instrumental colour and FOP values showed no PSE symptoms.

ain reason for ES is to improve meat tenderness, possibly by avoiding cold-shortening toughness. It is interesting to note, therefore, that ES controls, rapidly and conventionally chilled, were both significantly tougher than ES samples, suggesting that both chilling treatments duced a certain amount of cold shortening toughness. This view is reinforced by the fact that the NES controls did not bcome more tender ageing from 3d to 10d, unlike the ES samples which become even more tender with ageing.

e ES treatments produced more tender pork than the NES controls. The differences were highly significant (<0.01) at 3d and even more so d. HVES applied at 20 min had the highest tenderising effect, with mean shear values 2kg lower than NES controls at 3d, and 3kg lower at These are relatively large differences in tenderness, and they were achieved without increasing drip loss or adversely affecting appearance. S applied during bleeding was not quite as effective in improving tenderness as HVES but it still produced pork which was significantly tender than NES controls, by 1kg at 3d and 2kg by 10d. Again these are worthwhile improvements in tenderness, but in this case drip was considerably increased, even with rapid chilling.

most interesting result was the effect of LVES applied 20 min after slaughter. Not only did it produce a pH fall similar to HVES applied at ame time, but it had as much tenderising effect as LVES applied during bleeding. Although the tenderising effect of LVES was not as great at of HVES, the fact that LVES was still effective 20 min after death again contradicts earlier views that it is effective only if carried out diately after slaughter. This is the first recorded study demonstrating this effect with LVES, which, if confirmed in future experiments, remove some of the inconvenient restraints of low voltage stimulation.

NCLUSIONS

igh and low voltage, significantly improved tenderness of pork. High voltage ES, 20 min after slaughter, gave the most tender meat, with trimental effect on drip loss or appearance. Low voltage also improved tenderness compared to NES controls, but not to the same extent as voltage. Low voltage applied immediately after slaughter increased drip loss, but if applied later at 20 min post-slaughter gave no increase p.

is study, LVES was effective in tenderising pork, even when applied 20 min post-slaughter.

ulated pork became more tender with ageing from 3d to 10d; NES controls were tougher at 3d and tenderness did not improve with ageing.

FERENCES

all, J.R. (1980) Developments in Meat Science I, ed. Lawrie, R.A. Elsevier Applied Science Publishers, 37.

nfield, E., Ledwith, M.J. & Taylor, A.A. (1991). Meat Science, 29, 129.

nsson, S., Jonsson, G. & Ruderus, H. (1979). Proc. 25th Europ. Meeting of Meat Res. Workers, Budapest. 2.3.

el, A.J. & James, S.J. (1984). Meat Science, 11, 1.

son, D.D., Savell, J.W., Weatherspoon, L. & Smith, G.C. (1982). Meat Science, 7, 43.

or, A.A. & Tantikov, M.Z. (1989). Proc. 35th Int. Cong. Meat Sci & Technol, Copenhagen, 1157.

or, A.A. & Tantikov, M.Z. (1992). Meat Science, 31, 381.

ervelt, R.G. & Stouffer, J.R. (1978). J. Anim. Sci., 46, 1206.

Table 1. pH at 45 min, 3h and 24h post-slaughter in LTL of 72 pig sides within 6 treatments. Mean values of 12 pig sides for treatment with standard deviations.

Treatment	pH 45 min	pH 3 h	pH 24 h
NES-RC	6.59 (± 0.20)	6.25 (± 0.25)	5.57 (± 0.09)
NES-CC	6.55 (± 0.24)	6.10 (± 0.35)	5.58 (± 0.13)
LVES-RC	6.12 (± 0.20)	5.72 (± 0.19)	5.55 (± 0.08)
LVES-CC	6.12 (± 0.22)	5.72 (± 0.21)	5.52 (± 0.10)
LVES(20)-RC	6.27 (± 0.18)	5.92 (± 0.25)	5.55 (± 0.13)
HVES-RC	6.21 (± 0.14)	5.86 (± 0.27)	5.52 (± 0.10)

Table 2. Lightness (L*) and FOP values in LTL at 24h post-slaughter, and drip loss (% weight) over 48h at 1°C from LTL, of 72 pig sides within 6 treatments. Mean values of 12 pig sides per treatment with standard deviations.

Treatment	Lightness (L*)	FOP	Drip loss
NES-RC	47.13 (± 2.36)	23.67 (± 4.36)	2.99 (± 1.01)
NES-CC	48.47 (± 2.38)	23.67 (± 5.80)	2.54 (± 1.15)
LVES-RC	49.30 (± 2.92)	33.00 (± 11.95)	4.18 (± 1.69)
LVES-CC	49.85 (± 2.52)	32.75 (± 9.41)	4.38 (± 1.93)
LVES (20)-RC	46.99 (± 1.24)	28.75 (± 10.51)	2.82 (± 1.52)
HVES-RC	47.88 (± 1.97)	30.08 (± 12.26)	2.97 (± 1.66)

Table 3. Instrumental texture values for yield (kg) and compression (kg) in LTL at 3 and 10d post-slaughter of 72 pig sides within 6 treatments. Mean values of 12 pig sides per treatment with standard deviations.

	Texture			
	Yield		Compression	
Treatment	3d	10d	3d	10d
NES-RC	7.43 (± 1.43)	7.70 (± 2.00)	7.30 (± 1.48)	7.28 (± 2.32)
NES-CC	7.10 (± 1.82)	7.14 (± 1.29)	6.67 (± 1.98)	6.48 (± 1.69)
LVES-RC	6.11 (± 0.59)	5.76 (± 0.65)	5.16 (± 0.70)	4.77 (± 0.82)
LVES-CC	6.40 (± 0.63)	5.53 (± 0.98)	5.45 (± 0.88)	4.38 (± 0.77)
LVES (20)-RC	6.18 (± 1.13)	5.68 (± 1.11)	5.45 (± 1.08)	4.88 (± 0.95)
HVES-RC	5.31 (± 1.18)	4.58 (± 0.88)	4.55 (± 1.23)	3.73 (± 0.80)

Table 4 Mean differences in texture (yield and compression) between treatments at 3 and 10d, and levels of significance

	Yield, kg				Compression, kg			
Treatment comparison	3d		10d		3d		10d	
	diff	sig	diff	sig	diff	sig	diff	sig
HVES-RC v NES-RC	2.12	**	3.12	**	2.75	**	3.55	**
HVES-RC v NES-CC	1.79	**	2.55	**	2.11	**	2.75	**
LVES-RC v NES-RC	1.33	**	1.95	**	2.14	**	2.51	**
LVES(20)-RC v NES-RC	1.25	*	2.03	**	1.85	**	2.40	**
LVES-CC v NES-RC	1.03	*	2.18	**	1.85	**	2.90	**
LVES-RC v NES-CC	-	-	1.61	**	1.21	**	2.09	**
LVES-CC v NES-CC	-	-	1.46	**	1.21	*	1.60	
LVES(20)RC v NES-CC	1.00	*	1.38	**	1.50	**	1.71	