The effect of electrical stimulation on the meat quality of dairy cows

F.J.M. SMULDERS[▽], G. EIKELENBOOM[△] and J.G. VAN LOGTESTIJN[▽]

▽ Department of the Science of Food of Animal Origin, Section Hygiene, Faculty of Veterinary Medicine, The University of Utrecht, The Netherlands
△ Research Institute for Animal Production "Schoonoord", Zeist, The Netherlands

Introduction

The prevention of cold shortening and thaw rigor by electrical stimulation has been shown to be an important factor in enhancing meat tenderness (Carse 1973, Chrystall and Hagyard 1976, Davey et al. 1976). Moreover some authors report an additional tenderizing by electrical stimulation (Grusby et al. 1976, Savell et al 1977, Vanderkerckhove and Demeyer 1978, Will et al.1979, George et al. 1980, Smulders et al. 1981a) the potential mechanism of which has been reviewed by Dutson et al. (1980).

Most of our earlier studies on electrical stimulation involved veal calves (Eikelenboom and Smulders 1982, Smulders et al 1982) or young meat bulls (Eikelenboom et al. 1981, Smulders et al. 1981a, 1981b). Little information is available on the effect of electrical stimulation on the meat quality of cows (Mc Keith et al. 1980, Sonaiya et al. 1982). However a major part of the beef consumed in the Netherlands originates from meat from dairy cows. In these animals the age related changes in collagen solubility and content of reducible cross-links are a major cause of variation in meat tenderness (Kauffman et al. 1964, Asghar and Yeates 1979, Sörensen 1981).

Purpose of our study was to investigate whether in the absence of cold shortening conditions electrical stimulation is an effective method for improving tenderness of beef originating from dairy cows.

Material and Methods

The righthand carcase sides of eleven 4 to 6 year old dairy cows of the Dutch Friesian (FH-) breed and selected from the normal commercial supply were stimulated electrically at 55 minutes post mortem using 300 V, 50 Hz pulses of 2½ seconds with 1½ seconds interval. Stimulation was carried out via stainless steel pin electrodes mounted in the tail and neck region. The lefthand sides of the carcases remained unstimulated and served as controls. Carcases were weighed.

The pH and temperature of the longissimus and adductor muscles were determined at 1,2,3,5,7,9 and 24 hours post mortem at about 2½ cm below the surface.

At 24 hours post mortem samples of approximately 800 grams were removed from the longissimus muscle at the 8-10 th rib section of both sides of the carcases. From five randomly distributed locations on the exposed cross-section of the longissimus samples were collected for replicate measurements of sarcomere length using the laser diffraction technique described by Voyle (1971). Muscle samples were weighed, vacuum packed and stored at 2°C. At day 7 post mortem drip loss and colour (using the Hunter photometer L a and b values) were determined and

samples were heated in a waterbath until a core temperature of 70°C was reached. The samples were cut in a longitudinal direction using a mechanically driven borer. From each sample ten cores were used for shear force measurements using a Warner Bratzler operating head mounted in an Instron Universal Testing Machine. Peak or maximum shear force was expressed as $kg.cm^{-2}$. Similarly prepared cores were used in preference tests for tenderness by a trained 20 member taste panel.

After averaging over replicate measurements per carcase data were subjected to analysis of variance based on well known general methods (Snedecor and Cochran 1976). The model includes effects for treatment and carcases. For evaluation of tenderness each member of a trained 20 member taste panel made comparisons between a stimulated and a control sample from the respective carcase side and assigned ranks and scores for tenderness (preference test).The analysis of taste panel results was based on differences within pairs of observations, subjected to a two-way analysis of variance with carcase sides and members of the panel as factors. The analysis showed that the contribution of the members of the panel to the variation was significant. Therefore the treatment effect, being the general mean of differences, may be tested against an appropriate linear combination of the mean squares of carcases and members and the residual mean square.

Results and Discussion

The average hot carcase weight was 291 kg.

Table 1 presents the resultsof pH and temperature measurements in longissimus and adductormuscle.

Table 1 The effect of electrical stimulation on pH and temperature of longissimus and adductor muscle

Muscle	hours post mortem	pH		temperature	
		ES	NS	ES	NS
longissimus	1	$6.34^{a\nabla}$	6.84^{b}	36.2	36.5
	2	6.13^{a}	6.55^{b}	32.5	32.1
	3	5.75^{a}	6.28^{b}	27.6^{b}	26.8^{a}
	5	5.62^{a}	5.95^{b}	20.4	20.6
	7	5.46^{a}	5.70^{b}	16.8	16.4
	9	5.45^{a}	5.68^{b}	13.5	13.4
	24	5.44^{a}	5.49^{b}	4.9	4.7

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adductor	*1*	*6.44[a]*	*7.00[b]*	*37.5*	*36.9*
	2	*6.18[a]*	*6.52[b]*	*33.6*	*33.4*
	3	*5.95[a]*	*6.26[b]*	*29.5*	*30.2*
	5	5.64[a]	5.89[b]	24.6	25.0
	7	5.41[a]	5.62[b]	20.7	21.5
	9	5.41[a]	5.51[b]	18.6	18.6
	24	5.42	5.43	8.8	8.7

∇ Figures with different superscripts differ significantly ($p<.05$); a is preferable to b

Electrical stimulation resulted in a significantly more rapid pH fall during the first 9 hours post mortem both in longissimus and adductot muscle. The significant difference in pH at 24 hours post mortem in the longissimus muscle suggests that the ultimate pH has not yet been reached in the control muscle at that moment. This assumption is the more likely as electrical stimulation is reported not to have a significant effect on the final contents of most metabolites as measured 42 hours post mortem (Laser Reuterswärd et al. 1981). Combination of the results of ph and temperature measurements show that in the control group conditions generally assumed to be indicative for cold shortening (pH 6.2, temperature 11°C)(Bendall 1972) were not present in either of the two muscles.

Table 2 presents the results of the measurements of sarcomerelength, colour, drip- and cooking loss and maximum shear force values of the longissimus samples

Table 2 The effect of electrical stimulation on longissimus muscle traits

Trait	ES	NS
sarcomere length (in μm)	1.45	1.50
colour, Hunter L - value	30.44[a∇]	29.40[b]
a - value	15.25	14.99
b - value	7.37	7.18
drip loss (%)	3.44[b]	2.97[a]

cooking loss (%)	25.63^{b}	22.00^{a}
Warner Bratzler maximum shear force ($kg.cm^{-2}$)	3.04^{a}	3.81^{b}

▽ Figures with different superscripts differ significantly ($p < .05$); a is preferable to b

In contrast with our experiments on electrical stimulation in veal and meat bulls (Eikelenboom et al 1981, Smulders et al. 1981a, Eikelenboom and Smulders 1982, Smulders et al. 1982) electrical stimulation did not result in significant differences in sarcomere length. However the effect of the treatment on colour and water binding characteristics found in the previous experiments was confirmed in the present experiment.Electrical stimulation increased drip- and cooking loss significantly by approximately 0.5 and 3.6 % respectively. The colour measurements showed significantly higher L-values in stimulated samples as compared with controls, thus indicating a brighter meat colour as a result of the treatment. Warner Bratzler shear force values were significantly lower after stimulation.

Table 3 summarizes the results of the taste panel preference tests

Table 3 The effect of electrical stimulation on ranks and scores of longissimus muscle samples in taste panel preference tests

	ES	NS	SED	P
mean ranking score[a]	1.30	1.70	.104	.00
mean tenderness rating[b]	6.90	6.55	.108	.00

a scored pairwise, 1 is preferred over 2
b 10= extremely tender, 8= tender, 6= slightly tender, 5= slightly tough etc

When ranked and scored for tenderness stimulated samples were found to be significantly more tender. Data in Table 3 correspond with a preference for stimulated samples of 70 % of all comparisons.

pH, temperature and sarcomere length measurements indicate that in this experiment cold shortening has been succesfully avoided. Nevertheless significant differences in tenderness between stimulated and control samples were found both instrumentally and sensorically.

The effect of electrical stimulation of carcases on meat tenderness is believed to be mainly confined to muscle components other than connective tissue. The effect is suggested to be related to an increased rate of

post mortem glycolysis which prevents cold shortening, to an increased release of lysosomal enzymes and to structural alterations of the myofibers. However Judge et al. (1980) reported diminution of collagen cross-links by electrical stimulation. The results of our experiment suggest that electrical stimulation of cow carcases does improve meat tenderness in the absence of cold shortening , although the mechanism of action of this additional tenderizing effect is not elucidated.

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