The Effect of Electrical Stimulation and Hot Boning on Beef Quality

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Introduction

Electrical Stimulation (ES) of beef carcasses has been shown to increase the rate of glycolysis in musculature and to hasten the onset of rigor mortis thus enabling fast carcass chilling immediately following slaughtering without risking cold-shortening (Davey et al., 1976). In addition ES could prevent the toughening of pre-rigor excised meat and therefore facilitate hot processing, combining the advantageous effects of both these procedures (Gilbert & Davey, 1976; Gilbert et al., 1976; Seideman et al., 1979). In many instances however practical conditions do not involve fast chilling rates or hot boning procedures. It is, therefore, of interest whether ES is profitable in the absence of cold shortening conditions. It has been suggested that irrespective of the prevention of cold induced toughening ES can increase the tenderness of beef and the term "extra tenderizing effect" has been proposed (Vanderkerckhove and Demeyer, 1978).

The purpose of this study was to investigate whether ES has such an additional tenderising effect and to see whether ES in combination with hot-boning and fast chilling can yield a product of at least equal quality as compared to conventionally processed meat.

Material and Methods

Ten meat-bulls of the Meuse-Rhine-IJssel (MRIJ) breed of approximately 1½ years old were immediately electrically stimulated after bleeding and decapitation (5-10 min. post mortem). Stimulation took place with 300 Volt, 50 Hz, either continuously (n=5) or intermittently (n=5; impulses of 2½ seconds and 1½ seconds interval), via stainless steel electrodes mounted in the tail and neck region for a total of 1½ minute. Ten animals served as non-stimulated controls (NS).

pH and temperature of the M. adductor and M. longissimus dorsi were determined at 1, 2, 4, 6, 8 and 24 hrs. post mortem (p.m.) at a depth of approx. 2½ cm.

A sample of approximate 800 g was removed from the longissimus muscle at the 8-10th rib at the righthand carcass-sides at 3-4 hrs. post mortem ("hot boned" = HB). Immediately after excision these hot boned (HB) samples were weighed, vacuum-packed, chilled in icewater for approximately 5 hrs. and subsequently stored at 2°C. After storage of the carcasses at 2°C for 24 hrs. cold boned (CB) samples of the lefthand carcass-sides were taken ("cold-boned" = CB), weighed, vacuum packed, and kept at 2°C.

Seven days post mortem drip-loss and colour (Hunter L, a and b values) were determined and samples were heated in a water-bath until a central core-temperature of 70°C was reached. 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 on an Instron Universal testing machine. Cold boned stimulated vs control samples were paired for a preference-test by a trained 10 member taste panel. Each pair of cores was ranked and scored for tenderness.

After averaging over replicate measurements, data were subjected to a one-way analysis of variance or to an analysis according to a splitplot model based on well-known general methods (Snedecor and Cochran, 1967). Differences between treatments were tested by t-tests using the between or within carcass residual mean square or an appropriate combination of these. In the latter case the number of degrees of freedom can be approximated by taking the corresponding figure for the between carcasses mean square.

For the preference test, pairs were formed consisting of an NS and ES carcass. Comparisons within these pairs were made by a trained 10 member taste panel each member assigning a rank and a score for tenderness to each sample. Differences between these ranks and scores, calculated within pairs, were subjected to a mixed model analysis of variance. The general mean and the difference between treatments were tested against an appropriate mean square or combination of mean squares.

Results and Discussion

Carcass characteristics and measurements of the various groups of animals are presented in table 1.

Table 1. Means of carcass traits.

Trait	ES/continuously	ES/intermittent	NS
Warm carcass weight (kg)	319[a*]	342[a]	345[b]
Subcutaneous fat cover score (scale 1-5)	3.00	2.80	3.25
Carcass muscling score (scale 1-5)	3.53	3.47	3.80

* figures with different superscript differ significantly ($p < .05$)

Comparing stimulated and non-stimulated groups we found a significantly higher warm carcass weight in the latter. However this relatively small difference, not corresponding with a difference in age, is unlikely to be of any significance as regards the meat-quality parameters measured in this breed of cattle (Van der Wal et al., 1979).

The pH and temperature data are presented in table 2.

Table 2. Mean pH and temperature data for (cold-boned) longissimus and adductor muscle.

Muscle	hrs. p.m.	pH			Temperature		
		ES^c	ES^I	NS	ES^c	ES^I	NS
M. longissimus dorsi	1	6.70^{a*}	6.70^a	7.47^b	37.0^a	38.7^b	38.3^b
	2	5.70^a	6.00^a	7.17^b	32.6	33.5	34.6
	4	5.50^a	5.56^a	6.67^b	23.8	23.4	24.2
	6	5.42^a	5.54^a	6.34^b	18.5	18.7	18.5
	8	5.44^a	5.50^a	6.07^b	14.5	14.5	14.6
	24	5.48^a	5.56^{ab}	5.67^b	5.5^a	5.5^a	6.0^b
M. adductor	1	6.20^a	6.42^a	7.05^b	39.4	40.4	39.7
	2	5.82^a	6.24^b	6.73^c	39.1^a	38.1^a	37.4^b
	4	5.52^a	5.68^a	6.29^b	33.9^a	35.1^a	32.0^b
	6	5.44^a	5.56^a	5.89^b	29.7	29.2	30.0
	8	5.44^a	5.52^a	5.69^b	24.9	25.6	25.2
	24	5.40	5.42	5.45	11.0	11.5	12.0

* figures with different superscript differ significantly ($p < .05$)

With the exception of pH-values 2 hrs p.m., both stimulation methods resulted in a significantly more rapid pH-fall during the first 8 hrs. p.m.

The results of the temperature measurements show a slightly higher temperature at 2 and 4 hrs. p.m. in the adductor muscle of the control group.

Combination of pH and temperature measurements show that in the relatively slowly cooled lefthand carcass-sides the average pH has already fallen below 6.1 after 8 hrs. while the temperature is still above 10-12^{0}C. According to the general view (Bendall, 1972) cold-shortening in this control group is unlikely to have occurred.

Table 3 summarizes the results of driploss, colour, cooking loss and Instron-Warner-Bratzler shear force value. Both in HB and CB samples continuous stimulation resulted in higher cooking losses as compared with non-stimulated samples: 20.9 vs. 18.8 % and 22.7 vs. 20.9 % respectively. As otherwise no significant differences were observed between continuous and intermittent stimulation, data were pooled.

Table 3. Means for longissimus dorsi traits.

Trait	Stimulated		Non-Stimulated	
	HB	CB	HB	CB
Driploss (%)	2.88^{bc}	1.34^b	2.76^c	0.54^{a*}
Colour L-value	$31.7^{\ a}$	$33.1^{\ a}$	$29.4^{\ b}$	$31.3^{\ a}$
a-value	$16.0^{\ b}$	$18.4^{\ a}$	$14.2^{\ c}$	$16.7^{\ b}$
b-value	$7.9^{\ b}$	$9.3^{\ a}$	$6.7^{\ c}$	$8.3^{\ b}$
Cooking loss (%)	$19.8^{\ b}$	$22.2^{\ c}$	$18.8^{\ ab}$	$17.8^{\ a}$
W.Br.Shearforce (kg/cm^2)	2.87^a	2.80^a	5.91^c	3.81^b

* figures with different superscript differ significantly ($p < .05$)

a is preferable to b, b is preferable to c.

In this experiment both ES and HB procedures resulted in higher drip-losses. Within the HB-group ES showed no additional adverse effect.

As regards cooking-losses, a significant increase was observed after stimulation, intermittent stimulation being less drastic in this respect. These findings suggest that ES adversely affects water-holding capacity. The difference between hot and cold-boned control samples may possibly be explained by the fact that in cold-boned samples loss of moisture during the first day was not taken into account.

Colour assessment with the Hunter equipment showed for ES/HB-samples significantly higher L, a and b values, indicating a brighter red colour. A similar tendency for electrical stimulation was observed in ES/CB-samples, although the differences in L-values were not significant. Overall data on stimulated and non-stimulated groups showed significantly higher L, a and b values in both CB and in HB samples. Comparing the alternative (ES/HB) and conventional (NS/CB) ways of processing meat however, both procedures result in equivalent colour-values.

Warner-Bratzler maximum shear-force values indicate that cold-shortening may have occurred in the NS/HB-group only. Apparently electrical stimulation has overridden the toughening effect of hot-boning and fast chilling. In the CB-group however ES-carcasses showed an additional tenderization. When comparing ES/HB and NS/CB group a significant difference can be observed in favour of electrically stimulated varcasses.

Results of the taste panel preference test are shown in table 4.

Table 4. Taste panel preference; ranking and scoring for tenderness of cold boned samples.

Comparison	Preference for first treatment	SE	p	Difference in tenderness score	SE	p
ES_c - NS	88 %	8.2 %	.00	1.14	.27	.00
ES_I - NS	74 %	8.2 %	.02	.90	.27	.01

ES/CB and NS/CB samples were ranked and scored for tenderness by a trained panel. ES_{C}(continuously) and ES_I(intermittent) samples were preferred above NS-samples in 88 % and 74 % of all comparisons, relating to tenderness scores for ES_C, ES_I and NS samples of 7.28, 7.04 and 6.14, respectively.

Estimated differences between the two stimulation methods in taste panel ranking and scoring were non-significant.

The results presented in this paper suggest an equal improvement of colour and tenderness of beef by continuous and intermittent ES.

The increase in tenderness by ES seems to consist of both cold-shortening prevention and an "extra tenderising effect". More recent unpublished data support this view.

As far as tenderness is concerned the ES/HB procedure may produce meat of a similar quality as compared to the traditional NS/CB procedure. Drip and cooking losses are adversely affected by ES. In general, our results do not support the view (Cuthbertson, 1980) that hot boning reduces drip and cooking losses thus partially compensating for the negative effect of ES in this respect.

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