The Effect of Electrical Stimulation and Hot Boning on Veal Quality

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Introduction

During chilling and storage under refrigeration an important carcass weightloss is brought about by evaporation. By reducing the chilling period this disavantageous effect may be minimized. At present this is increasingly being achieved by conveying carcasses to blast chillers during the early post mortem period. Particularly in the case of lean lightweight calve carcasses this may occasionally result in conditions liable to provoke cold shortening. On the other hand the heat transfer from the carcass can only be partially influenced by the external chilling conditions (Bailey 1972) This may cause considerable variation in colour within joints (Taylor et al. 1980) and to some extent affect waterbinding (Jolley et al. 1980).

Removing the meat from the carcass as soon after slaughtering as possible increases the rate of heat transfer. This practice, commonly known as hot (de)boning may exclude bones and some offals from chilling and consequently refrigeration space may be used more efficiently (Cuthbertson 1980). However to avoid the excessive muscular contraction and the potential cold shortening after hot boning electrical stimulation within 1 hour post mortem appears to be a prerequisite (Carse 1973, Davey et al. 1976, Chrystall and Hagyard 1976).

In one of our earlier studies (Smulders et al. 1981) we examined some meat quality characteristics of beef cuts produced in a slaughtering/processing chain including electrical stimulation and hot boning. Purpose of the experiments reported here was to study the effects of electrical stimulation and hot boning on sensoric quality parameters of veal under fast chilling conditions. Some microbiological data are reported by Smulders et al.(1982).

Materials and Methods

Data were collected in two experiments involving 2 x 20 calves of the Friesian Holstein (FH-) breed of approximately 22 weeks old. 2 x 10 Calves were stimulated electrically (ES) immediately after bleeding (approximately 2 minutes post mortem). Stimulation was conducted using 300 V, 50 Hz, intermittent pulses of 2½ seconds with 1½ seconds interval. 2 x 10 Calves served as non-stimulated controls (C). All carcasses were subjected to a standard slaughtering procedure.

pH and temperature were determined at a depth of 2½ cm in the longissimus and semimembranosus muscle at 1, 2½ 4½, 6½, 8½, and 24 hours post mortem. Furthermore the central temperature was assessed at 15 cm depth with the probe inserted via the semimembranosus muscle.

Carcasses were weighed and scored for muscling, fat cover, and lean meat colour at 55 minutes post mortem. Following spraying with tap water carcasses entered 3 "shock"tunnels at approximately 1 hour post mortem where they were chilled during 30 minute periods at -14°C, -8°C, and -4°C respectively at an air velocity of 8 ms^{-1}. Subsequently carcasses were conveyed to a chillingroom at 2°C and an air velocity of 0.2 ms^{-1}. Upon arrival in this chillingroom (2½ hours post mortem) from 2 x 10 carcasses longissimus cuts of approximately 500 g with a mean temperature of 25°C were excised (hot boned=HB). 24 Hours post mortem 2 x 10 similar cuts were taken from the cold carcass (cold boned=CB). From five randomly distributed locations on the exposed cross section of the muscle samples were collected for replicate measurements of sarcomerelength using the laser diffraction technique described by Voyle (1971). Similar samples were taken for the determination of total hematin (Hornsey 1956).

All hot boned cuts were sprayed with a 1 % $^{v}/_{v}$ lactic acid solution, vacuum packed and immersed in ice water for approximately 5 hours. Both hot and cold boned cuts were stored at 2° C.

At 7 days post mortem vacuum packs were opened and drip loss and colour were assessed (driploss due to an experimental error only in experiment 2). The cuts were heated in a waterbath until a core temperature of 70°C was reached. Using a mechanically driven borer cores were excised from all cuts in a longitudinal direction. From each cut ten such 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 in $kg.cm^{-2}$. Similarly prepared cores were used in preference tests for tenderness by a trained 14 person taste panel.

After averaging over replicate measurements, data were subjected to a one-way analysis of variance or to an analysis according to a split plot 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 appropiate 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 a ES and C sample. Comparisons within these pairs were made by a trained 14 member taste panel, each member assigning a rank and score for tenderness to each sample. Differences between these ranks and scores were calculated within pairs and subjected to a two-way analysis of variance. The general mean and the difference between treatments were tested against an appropiate mean square or combination of mean squares.

Results and Discussion

Table 1 presents the means of carcass characteristics for the various experimental groups. In experiment 1 a significantly higher warm carcass weight was found in the ES group as compared with the controls. As the difference is relatively small it seems unlikely that this will influence the quality traits under investigation (van der Wal et al 1979). Carcass lean colour scores at 45 minutes post mortem showed no significant differences between ES and C treatments.

pH and temperature data are presented in table 2. In both experiments electrical stimulation resulted in a significantly more rapid pH-fall during the first 8 hours post mortem. At 1 hour post mortem the pH in the ES carcasses was approximately 6.0. The temperature decline in both muscles only occasionally showed differences when comparing ES and C carcasses. The combined pH/Temperature data show that 6-8 hours post mortem the pH has fallen below 6.0 in the control carcasses while temperature at this time is still above 11°C. According to the generally accep-

ted concept of cold shortening (pH > 6.2 at temperatures < 11°C) this phenomenon should not occur in these carcasses (Bendall 1972). In fact, temperature decline in the longissimus muscle approximates those conditions described by Bendall as ideal in terms of tenderness (ten and ten rule)

Table 1. Means for carcass traits; in each scale 1 is preferable to 2, 2 to 3 etc.

Trait	experiment 1		experiment 2	
	ES	C	ES	C
Warm carcass weight (kg)	135[a] v	120[b]	135	137
Carcass muscling score (scale 1-5)	1.4	1.7	2.3	2.3
Subcutaneous fat cover score (scale 1-3)	1.6	1.4	1.4	1.8
Lean meat colour score (scale 1-4)	2.0	2.0	1.5	2.0

v Within experiments figures with different superscripts differ significantly.

The chilling procedure is sufficient in decreasing the temperature to the compulsory level mentioned in the EEC-regulations on transport (EEC 1975).

Table 2. Mean pH and temperaturedata for (cold boned) longissimus and semimembranosus muscle.

Muscle	hrs. p.m.	experiment 1						experiment 2					
		pH		temperature$_{2\frac{1}{2}cm}$		temperature$_{15cm}$		pH		temperature$_{2\frac{1}{2}cm}$		temperature$_{15cm}$	
		ES	C	ES	C	ES	C	ES	C	ES	C	ES	C
M.longissimus dorsi	1	5.93[a] v	7.08[b]	37.0	37.3	-	-	5.92[a]	6.94[b]	39.1	38.4	-	-
	2½	5.49[a]	6.74[b]	24.3	25.2	-	-	5.54[a]	6.42[b]	28.4[b]	27.0[a]	-	-
	4½	5.42[a]	6.31[b]	20.1	20.3	-	-	5.56[a]	6.13[b]	18.3	17.6	-	-
	6½	5.41[a]	6.10[b]	15.9	15.3	-	-	5.56[a]	5.96[b]	14.2	13.8	-	-
	8½	5.43[a]	5.76[b]	12.3	11.9	-	-	5.53[a]	5.68[b]	11.6	11.5	-	-
	24	5.41	5.42	4.2	3.9	-	-	5.44	5.48	3.9	4.0	-	-
M. semimembranosus	1	6.12[a]	6.95[b]	33.7	35.1	39.9	39.2	5.88[a]	6.82[b]	39.4	38.5	41.3[b]	40.1[a]
	2½	5.51[a]	6.79[b]	21.7	21.6	39.9	38.5	5.58[a]	6.29[b]	27.1	27.1	39.7	39.4
	4½	5.42[a]	6.28[b]	19.2[b]	17.0[a]	35.5	35.4	5.51[a]	5.95[b]	19.4	19.8	31.5	31.0
	6½	5.40[a]	6.05[b]	15.9	14.3	30.3	29.7	5.51[a]	5.71[b]	16.0	16.7	26.0	25.4
	8½	5.40[a]	5.68[b]	12.8	12.8	24.4	24.4	5.49	5.57	14.2	14.6	21.3	21.5
	24	5.40	5.40	5.4	5.1	8.2	8.0	5.41	5.43	4.1	4.0	4.9	4.8

v Within experiments figures with different superscripts differ significantly; a is preferable to b

Table 3 presents the results on sarcomerelength, colour, drip and cooking loss, and Instron Warner Bratzler maximum shear force values of longissimus samples.
As expected sarcomerelength in both experiments was found to be lower on hot boned control samples. However under the allegedly "ideal" temperature conditions one would not expect to find this the case after cold boning. Discrepancies like this also occurred in earlier experiments with beef (Eikelenboom et al. 1981, Smulders et al. 1981a). Moreover, even electrical stimulation has not sufficed to absolutely prevent shortening of sarcomeres. Although the energy should be virtually depleted at the time of muscle excision, small reserves apparently may still cause contraction. In the first experiment this has led to significantly shorter sarcomeres in ES/HB as compared with ES/CB samples.

Electrical stimulation (HB+CB) resulted in a significantly higher driploss percentage in longissimus samples as compared with controls (HB+CB). A possible explanation for this may be the extremely fast pH-fall, which in combination with a relatively high muscle temperature, may have caused considerable denaturation of the sarcoplasmatic proteins. This would be accompanied by a decreased waterbinding capacity which in this experiment is also clearly reflected in increased cooking losses. Data supporting this assumption are reported by Eikelenboom and Smulders (1982). C/HB samples show a tendency to have a higher percentage driploss, a finding which is in agreement with our data obtained in similar experiments with beef (Smulders et al. 1981b). Our results strongly suggest that a

Table 3. The Effect of Electrical Stimulation (ES) and boning procedure (hot boning=HB; cold boning CB) on tenderness, waterbinding, and muscle colour characteristics of veal calves (n=10 in each subgroup)

Trait	experiment 1				experiment 2			
	ES		C		ES		C	
	HB	CB	HB	CB	HB	CB	HB	CB
Sarcomerelength(µm)	1.50^{b} ▽	1.67^{a}	1.38^{b}	1.46^{b}	1.59^{ab}	1.72^{a}	1.31^{c}	1.56^{b}
Drip loss(%)	-	-	-	-	3.18^{bc}	3.57^{c}	2.54^{ab}	2.03^{a}
Cooking loss(%)	15.35^{b}	15.97^{b}	12.32^{a}	14.52^{b}	23.13^{ab}	24.41^{b}	21.60^{a}	22.76^{ab}
Colour Hunter L-value	46.04^{b}	49.32^{a}	41.88^{c}	44.47^{b}	45.35^{ab}	45.88^{a}	40.36^{c}	41.91^{b}
a-value	12.50^{a}	12.86^{a}	12.12^{a}	12.53^{a}	12.36^{a}	12.59^{a}	11.91^{a}	12.18^{a}
b-value	10.07^{b}	11.00^{a}	8.76^{c}	9.65^{b}	9.77^{a}	9.94^{a}	8.31^{c}	8.79^{b}
Total hematin (mg/g)	60.26^{bc}	51.69^{a}	71.44^{c}	58.07^{ab}	54.27^{a}	51.60^{a}	60.03^{a}	62.02^{a}
Instr.W-Br. shear force (kg/cm^2)	2.30^{ab}	2.18^{a}	3.24^{c}	2.81^{b}	2.85^{a}	2.31^{a}	4.05^{b}	3.68^{b}

▽ Within experiments figures with superscripts not containing a common character differ significantly at least at $p<.05$ level; a is preferable to b,b to c etc.

causal relation exists between cold shortening and drip loss percentage after a certain period of storage, a view which is supported by by Honikel et al. (1980) and or own previous findings (Smulders et al 1981a). Such an effect appears to be more marked in relatively large cutting surfaces as is the case in this experiment.

Although within experiments some significant differences do exist between treatment groups the analysis of variance showed that overall effects of electrical stimulation (HB+CB) and hot boning (ES+C) were significantly different as compared with their control treatments. L values as well as saturation ($S=(a^2+b^2)^{\frac{1}{2}}$,denoting lack of greyness or purity) were significantly increased by electrical stimulation whereas hot boning exerted an opposite effect.These findings are in agreement with our data on beef (Smulders et al. 1981b).Therefore the enhancement of lean veal colour by electrical stimulation may be partially counteracted by hot boning. Our other experiments on electrical stimulation of veal carcasses (Eikelenboom and Smulders 1982) suggest that the nature of this colour enhancement may to some extent have been due to denaturation of sarcoplasmatic proteins.

Instron Warner Bratzler maximum shear forces clearly reflect the difference in degree of contraction. Electrical stimulation has for the major part prevented the toughening effects of hot boning followed by immersion in ice water resulting in non significant differences between ES/HB and ES/CB samples. C/HB samples suffered severely from the extreme chilling in ice water. As already indicated by sarcomere lenghts C/CB samples also underwent some shortening.

Table 4 presents the pooled results of tastepanel preference tests of both experiments.

Table 4. Results of sensory panel preference tests for tenderness of electrically stimulated (ES) vs. control (C) veal samples in a hot boning (HB) and cold boning (CB) procedure; pooled data of two experiments.

Comparison	Preference for first treatment	SE	level of significance	Mean tenderness scores (ES vs C)	SE of Δ score	level of significance
ES/HB vs C/HB	63 %	5 %	$p<.01$	7.3 vs 6.8▽	.1	$p<.05$
ES/CB vs C/CB	65 %	4 %	$p<.05$	7.7 vs 7.3	.1	$p<.05$
ES/HB vs C/CB	45 %	4 %	NS	7.3 vs 7.5	.1	NS

▽ 10= extremely tender, 8= tender, 6= slightly tender, 5= slightly tough etc.

Paneldata show that ES samples are considered significantly more tender both in hot boning and cold boning comparisons. Differences in rank are attended with significantly better scores. Comparison of ES/HB and C/CB showed non significant differences in ranks and scores. It should be kept in mind however that that in our model-study hot boned samples were chilled extremely fast. It may be expected that if hot boned samples had been subjected to some form of conditioning, the results as regards tenderness might have been superior to those in the present study.

The results presented in this paper indicate that Electrical Stimulation improves colour and tenderness of veal but may adversely affect waterbinding capacity. Hot boning appears to result in a slightly darker colour but may reduce drinlosses to some extent. However cold shortening, a phenomenon which may occur under cooling conditions so far considered safe in this respect, appears to adversely affect drip loss after 6 days of aging.

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