The Effect of Electrical Stimulation on Veal Quality

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Introduction

In most countries consumers prefer white veal. Consequently production methods have been designed in the past to meet this demand, although there is still a considerable variation in lean colour. However, animal wellfarists may object against methods which include the housing in individual pens with slatted floors and the exclusive feeding of milkreplacer with sub-optimal Fe-levels. Research conducted at "Schoonoord" suggests that abnormal behaviour patterns may occur under these conditions (Van Putten, 1982; in press).

In various European countries research has been conducted towards alternative production systems, which has been reviewed recently at the E.E.C. Seminar "The Welfare of Veal Calves" (1981). Some alternatives include group housing and access to barley straw. However, one of the drawbacks of such production methods, is the fear among producers that quality will decline by the use of straw.

Beneficial effects of electrical stimulation in veal calves have been reported for tenderness (Smith et al., 1979) and recently also for lean colour scores (McKeith et al., 1982). We have found similar effects of this treatment in our experiments on beef (Eikelenboom et al., 1981; Smulders et al., 1981).

The present study was designed to investigate the effect of electrical stimulation on the quality of veal, housed in groups and with access to straw.

Material and Methods

A total of three experiments were conducted with 32, 28 and 28 veal calves of the Meuse-Rhine-IJssel (MRIJ) breed, respectively.

In experiment I the veal calves were housed in groups of 15 per pen (24 m^2) and they received milkreplacer through machine-feeding. In the other two experiments, animals were bucket-fed and housed in groups of 5 per pen (7.5 m^2). In all three experiments straw was used as a bedding material, while the animals had also access to fresh barley straw as additional feeding material (app. 100 g/day).

Bloodsamples were taken from all animals at one week ante mortem and analysed for haemoglobin (Hb), expressed in g%. In each experiment animals were paired on the basis of their Hb-levels and within each pair randomly assigned to electrical stimulation and control (unstimulated) treatment.

In the three experiments average liveweight (± S.D.) at slaughter was 214 (± 21), 212 (± 11) and 202 (± 13) kg, respectively. Electrical stimulation was applied via the nostrils and shackle immediately after debleeding (5 - 10 min post mortem) with a relatively low voltage (85 V peak, 14 Hz) for one minute, using commercially available equipment (Mitab®, Simrisham, Sweden).

The pH and temperature were determined at a depth of 2½ cm in longissimus and semimembranosus muscle at 40 min and 2½, 4½, 6½, 8½ and 24 hrs post mortem. Furthermore central temperature decline was assessed with the probe inserted at 15 cm depth via the semimembranosus muscle.

At 40 min and 24 h post mortem carcasses were weighted and their lean colour assessed at the exterior surface of the carcass in a scoring system of 1 (light) - 4 (dark), which is part of the grading system for commercial carcass evaluation. At 50 min post mortem carcasses entered the 'shock'tunnels and conveyed through its three compartments of 30 min periods at an air temperature of -14, -8 and -4 °C, respectively (air velocity of 8 $msec^{-1}$). Subsequently carcasses were cooled at 2 °C and at an air velocity of 0.2 $msec^{-1}$.

At 24 hrs post mortem the longissimus muscle was sampled at the 5-8th rib and muscle colour was scored visually (scale 1-4) as well as determined with the Hunter photometer (L, a and b values). From 5 randomly distributed locations on the cross section of the muscle, samples were collected for measurement of sarcomere-length (Voyle, 1971). Similar samples were also taken for determination of total haematine (Hornsey, 1956) and transmission value (Hart, 1962). A 600-800 g sample was vacuum-packed and stored at 2 °C.

At day 7 post mortem drip-loss and colour (Hunter photometer: L, a and b values) were determined and samples were heated in a waterbath until a central 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 in kg/cm^2. Similariy prepared cores were used in preference tests for tenderness.

After averaging over replicate measurements per carcass, data were subjected to analysis of variance. The model includes effects for treatment, experiments, pairs of carcasses within experiments and interaction between treatment and experiments. Since the analysis showed that interaction between treatment and experiments was only significant for 3 out of the 12 measurements for pH, treatment differences have been averaged over experiments.

For evaluation of tenderness, each member of a trained 17-members taste panel made comparisons between a stimulated and control sample from each pair of carcasses 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 pairs of carcasses and members of the panel as factors. Since the composition of the panel was not fully consistent in all three experiments a separate analysis was conducted for each experiment. The analysis showed that the contribution of the members of the panel to the variation was non-significant. Therefore, the treatment effect, being the general mean of differences, may be tested against the mean square for pairs of carcasses. The results of the three experiments, which were similar, have been combined by averaging the means and by performing t-tests, using the pooled mean square for pairs of carcasses as an estimate of the variance.

Results and Discussion

The results of pH- and temperature measurements during the first 24 h post mortem are presented in Table 1. A significantly (P<.01) more rapid pH-fall was observed in the stimulated veal carcasses. At 45 min post mortem

the pH in these carcasses was already below 6.0, while in control carcasses these values were reached after app. 6 h. Deep muscle temperature in the M. semimembranosus was significantly higher in stimulated carcasses at 45 min post mortem. Similar tendencies were found at other sites and measuring moments.

Judged from the reported ambient or muscle temperatures the chilling rate in our study was higher as compared with the studies of Smith et al. (1979) and Mc Keith et al. (1982) on electrical stimulation in veal. Yet, combination of the results of pH and temperature measurements suggest that, according to Bendall's (1972) concept of the critical conditions (temperature < 11 °C and pH > 6.2), cold shortening should not occur in the underlying study.

Table 1. Mean values for pH and temperature of M. longissimus (rib) and M. semimembranosus (round) during the first 24 h post mortem from electrically stimulated (ES) and control (C) veal carcasses.

Muscle	Time post mortem	pH at 2½ cm		Temperature (°C) at 2½ cm		at 15 cm	
		ES	C	ES	C	ES	C
M. longissimus	40 min	5.86	6.83**	38.3	38.0	-	-
	2½ h	5.48	6.50**	24.0	23.8	-	-
	4½ h	5.45	6.26**	17.6	17.2	-	-
	6½ h	5.41	5.93**	14.2	13.7	-	-
	8½ h	5.39	5.70**	12.8	12.5	-	-
	24 h	5.38	5.50**	4.5	4.3	-	-
M. semimembranosus	40 min	5.89	6.85**	36.3	35.6	41.4	40.0**
	2½ h	5.46	6.44**	19.4	18.5	35.9	35.3
	4½ h	5.44	6.21**	14.8	14.5	30.1	29.7
	6½ h	5.39	5.84**	13.1	12.7	25.0	24.9
	8½ h	5.37	5.66**	11.8	11.6	21.0	20.9
	24 h	5.36	5.40**	4.7	4.7	7.1	6.9

** P<.01

In Table 2 the results of electrical stimulation on carcass lean colour and muscle colour characteristics are presented. No significant differences were found in plasma Hb-levels and muscle haem-pigment (myoglobine and haemoglobine), parameters which have been shown in various studies (Charpentier, 1966; Eeckhout et al., 1969) to be related to muscle colour. Therefore, the ante mortem classification of veal calves for treatments, on the basis of their plasma-Hb values, proved to have been succesfull.

At 45 min post mortem the lean colour score on the intact carcass, as is done in commercial practice, showed no significant difference between the treatments. However, at 24 h post mortem there was a significant improvement of carcass lean colour and of the colour of the longissimus muscle cross-sectioned at that moment. These observations are further supported by the results of objective measurements with the Hunter photometer at 1 and 7 days post mortem, which show significant differences between treatments in L (lightness) a and b values. Saturation ($S=(a^2+b^2)^{\frac{1}{2}}$), denoting lack of greyness or purity, was significantly (P<.01) increased in stimulated samples.

Table 2. The effect of electrical stimulation (ES) on carcass lean and longissimus muscle colour characteristics from veal calves preselected on their plasma Hb-values.

Trait	Time (ante/post mortem)	ES	C	S.E.	Sign. of diff.
N		44	44		
Plasma-Haemoglobine	7 days a.m.	8.91	8.89	.04	NS
Carcass lean colour score	40 min p.m.	2.27	2.34	.15	NS
	24 h p.m.	2.00	2.34	.15	P < .05
Muscle colour score	24 h p.m.	1.61	2.82	.18	P < .01
Hunter L-value	24 h p.m.	49.9	46.8	.58	P < .01
a-value	24 h p.m.	11.4	10.6	.20	P < .01
b-value	24 h p.m.	10.2	9.5	.15	P < .01
Hunter L-value	7 days p.m.	49.8	47.9	.67	P < .05
a-value	7 days p.m.	11.3	10.3	.17	P < .01
b-value	7 days p.m.	10.0	9.3	.13	P < .01
Total pigment (haematin)	24 h p.m.	44.9	40.1	2.69	NS
Transmission value	24 h p.m.	38	27	1.97	P < .05

The effect of the treatment on colour may possibly be explained by some denaturation of sarcoplasmic proteins, resulting from the induced rapid post mortem pH-fall in stimulated carcasses. Indeed, we found significantly higher transmission values in stimulated carcasses, suggesting some decrease in water solubility of these proteins. Yet, transmission values indicative for PSE- meat (>70) in swine (Hart, 1962) were by far not reached in the stimulated veal.

Mean values for waterbinding and tenderness characteristics from electrically stimulated and control carcasses are presented in Table 3. No significant difference was observed in carcass weight loss through drip and evaporation during the first 24 h. However, a significant (P<0.05) increase in weight loss during vacuum storage and cooking of the longissimus samples was found. Similar observations were made in our studies on electrical stimulation in beef (Eikelenboom et al., 1981; Smulders et al., 1981). The effect of electrical stimulation on waterbinding may be explained from the observed effect of the treatment on sarcoplasmic proteins, discussed before. The study of Smulders et al. (1982) on the effects of electrical stimulation and hotboning in veal, conducted at the same plant, suggests that both electrical stimulation and cold shortening exert a negative effect on muscle waterbinding capacity.

In the present study a considerable cold shortening must have occurred in control carcasses, as indicated by the shorter sarcomere length and relatively large increase in maximum shear force. This condition was, as expected, clearly prevented in electrically stimulated carcasses.

The results of sensoric panel preference tests (ES vs C) are presented in Table 4. They show superior ranking and scoring of ES veal over control veal. The estimated preference for stimulated samples was 79.5 % (S.D.: 2.5%). As compared with the studyof Smith et al. (1979) the effect of electrical stimulation on tenderness is more pronounced, which is undoubtedly due to differences in the applied chilling rates.

Table 3. The effect of electrical stimulation (ES) on waterbinding and tenderness characteristics of longissimus muscle from veal carcasses.

Trait	Period/Time post mortem	ES	C	S.E.	Sign. of diff.
Carcass weight loss (%)	40 min-24 h	1.36	1.50	.07	NS
Drip loss (%)	24 h-7 days	2.74	2.23	.17	P < .05
Cooking loss (%)	7 days	22.76	21.41	.47	P < .05
Sarcomere length (µm)	24 h	1.66	1.23	.03	P < .01
W.-Br. max. shear force (kg/cm^2)	7 days	2.78	4.90	.18	P < .01

Table 4. Results of sensory panel preference tests for tenderness of electrically stimulated (ES) vs. control veal (C).

Trait	ES	C	S.E.	Sign. of diff.
Mean ranking score [a]	1.21	1.80	.05	P < .01
Mean tenderness rating [b]	7.21	6.09	.10	P < .01

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

The results of our study suggest that improvements in meat colour can be achieved through electrical stimulation in veal calves housed in groups and with access to straw. Since a possible negative effect on meat colour of such an alternative production method is counteracted, the treatment may possibly contribute to the introduction in practice of such improved production systems from the animal welfare point of view. Similar effects of electrical stimulation were found in veal calves derived from traditional production systems (Smulders et al., 1982 and data to be published).

The results of our investigations on electrical stimulation have led to the development of a new, safe and fully automatic system for early post mortem electrical stimulation, which is now in commercial operation in a veal plant.

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