Automatic electrical stunning of veal calves in a V-type restrainer

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Introduction

In The Netherlands practically all pigs and a majority of all sheep are stunned electrically before slaughter. To stun adult cattle and calves, captive bolt is still the only method used. Many methods for electrical stunning of cattle in the abbatoir have been described in the literature (Tervoert, 1950; Lubadel, 1960; Lambooy 1981; Devine et al., 1985). However none of these methods is practiced generally.

An automatic electrical stunning method is generally used to stun pigs. The stunning equipment consists of two V-type restrainers which run at a different speed in order to separate the successive animals. At the end of the second restrainer each pig touches the electrodes and the current is activated (Müller, 1981). The stunning method is practical for high speed slaughter lines, relatively inexpensive and fully automatic.

After every stunning method, blood splashes in the carcasses were observed. Compared with the other stunning methods, electrical stunning caused the most blood splash (Leest et al., 1970; Kirton et al., 1981; Burson et al., 1983). In lambs it is observed that blood splash is caused by rupturing of blood vessels (Leet et al., 1977).

Research was conducted for veal calves in an adapted pig automatic electrical stunner to observe the effects on the animal's welfare as well as their meat quality.

Materials and methods

An automatic electrical stunner for pigs was adapted for veal calves by increasing the height of the restrainer. The electrodes were placed in a head-withers stunning position. The experimental animals were showered in the first restrainer to increase the electrical conductivity of the skin. The calves were separated to prevent the electrical current from affecting more than one animal at a time. In the first trial the successive calves were separated by running the two restrainers at a different speed. In the second trial the experimental calves walked through the first restrainer in single file over a wooden floor. The experimental calves were stunned automatically and electrically (600V, 2s) in the second restrainer, whereas the controls were stunned by captive bolt either in the restrainer for the first trial, or in a cage for the second trial.

The experimental and control veal calves (males, about 200 kg live weight, Dutch Friesians and Holstein Friesians) were selected at random from a group of animals. The experiments were performed in a veal calf slaughterhouse. At the end of the slaughter line (45 min. post mortem) the carcasses were weighed and visually scored by a classifier of the slaughterhouse for shape, colour and fatcovering (scores 1=more muscular, lighter, thinner to 10=more angular, darker, fatter). More over the acidity (pH_1) and temperature (T_1) of the longissimus muscle (LD) was measured. After 18 hrs. cooling the carcasses were weighed and the acidity (pH_2) and temperature (T_2) of the LD were measured again.

The left (50%) or the right (50%) sides of 12 carcasses per treatment of each trial (randomly selected) were cut and deboned. The dissection parts were examined for blood splash. Moreover, subjective blood splash scores were recorded according to anatomical location and the seriousness of the haemorrhage (0 = none; I = minor; 2 = serious). A 2 cm thick slice of the LD at the last rib was removed. The following day a transverse section was cut from the slice, the colour measured by Hunter CIELAB (L > white; a > red; b > yellow) and total heamatin was determined according to the method by Hornsey (1956).

The meat quality parameters acidity, temperature, visual scores, meat colour and haematin values were statistically tested by the t-test. The differences between the treatment and control groups in frequences of blood splash in the muscles and fasciae were tested by the x^2-test (Pearson's, $p \leq 0.05$).

Results

It was difficult for many of the calves to enter the restrainer. Several calves were retained in the restrainer in a position in which their forehand was lower than their hindquarters. This was a result of their anatomically smaller forehand. Generally many animals had a low headposture in the restrainer, while some calves turned their head away from the electrodes. In the case of a low forehand retaining and a very low headposture, the calf's head did not touch the head electrodes, resulting in the current passing between the neck and the loin of the animal rather than the head-withers position. This situation occurred in 3 out of 100 in the first trial and in 13 out of 100 calves in the second trial.

After electrical stunning, the calves exhibited a tonic cramp and displayed some convulsions. Afterwords they died and subsequently relaxed. The calves with the neck-loin stunning position died too. As soon as possible each calf was bled.

In the first trial all calves contained subcutaneous heamorrhages caudal to the shoulder. For this reason, the first restrainer was not used for the second trial.

For both trials, neither the warm or cold slaughter weights showed differences between the treatment and control groups (Table 1). In both trials the muscle pH values appeared to decrease significantly ($p \leq 0.05$) more rapidly (45 min. p.m.) and to a lower ultimate value (18 hrs. p.m.) in the treated calves (Table 1). In the first trial the visual colour scores of the carcasses of the electrically stunned calves were significantly ($p \leq 0.05$) higher which means a darker colour, whereas the Hunter values of the LD were significantly ($p \leq 0.05$) higher which means a lighter colour. Simultaneously, the haematin values were higher in the LD of the carcasses of the electrically stunned calves. In the second trial both colour parameters indicated a darker ($p \leq 0.05$) colour for carcasses and LD muscles respectively, while the heamatin values were higher ($p \leq 0.05$) (Table 1). At the same time the temperatures at 45 min. and 18 hrs. post mortem were significantly ($p \leq 0.05$) higher and lower, respectively.

Blood splash percentage was increased and was more serious in the carcasses of the electrically stunned calves when compared to the controls. Significant ($p \leq 0.05$) differences were observed in the longissimus, semimembranosus and rectus femoris muscles in the first trial, whereas in the second trial, the differences were significant ($p \leq 0.05$) in the longissimus and infraspinatus muscles as well as in the total carcass (Table 2).

Discussion

Limitations of electrical stunning of cattle included the rapid recovery and the convulsions, which endangered workers. Disorders of both the brain (generalised epileptiform insult) and the heart (failure) will overcome these problems, because the animal will die and only some slow convulsions may occur (Lambooy and Spanjaard, 1982). Electrocution is recommended by several investigators, because animals cannot recover and the meat quality is not negatively influenced (Blackmore et al., 1979; Lambooy, 1981; Gregory et al., 1984).

V-type restrainers are sometimes used for cattle (Grandin, 1980). During our experiments it was difficult for many veal calves to enter the restrainer. Moreover, the calves were retained with their forehand below their hindquarters and many calves had a low headposture resulting in some calves not being stunned. The last problem could be solved by lengthening the electrodes. Another problem was the separation of the calves by operating the successive restrainers at different speeds, because subcutaneous heamorrhages occurred caudal to the shoulder. The haemorrhages might be caused by stretching the animal at the interface of the two restrainers resulting in a negative influence on the animal's welfare and meat quality. The haemorrhages disappeared when the first restrainer was eliminated for the second experiment.

The pH in the muscles of the carcasses of the electrically stunned animals decreased more rapidly (45 min. p.m.) and to a lower ultimate value (18 hrs. p.m.) when compared to the controls (Table 1). The rapid pH decrease may be the result of phenomena similar to early post mortem electrostimulation (Eikelenboom et al., 1981; Smulders, 1984). A brighter colour observed after early post mortem electrostimulation (Smulders, 1984) was not observed in our experiments. The darker coloured muscles in the carcasses of the electrically stunned group may result from a higher total heamatin content (Table 1), which may suggest that bleeding is less complete (Warris, 1977) due to heart failure (Gregory et al., 1984).

Heamorrhages during stunning appear to be caused by ruptures of blood vessels which may result from supercontractions (Leet et al., 1977) or by movements between muscles during violent contractions while the animal is in an unnatural position in a V-type restrainer (Gilbert & Devine, 1982). In our trials, heamorrhages were observed at specific locations in the muscles and fasciae especially in the muscles around the caput humeri as well as in the muscles and fasciae of the infraspinatus, longissimus, semimembranosus and gastrocnemius (Table 2). Blood splashes were located at the same specific places both in carcasses of electrically and captive bolt stunned animals for both the restrainer and the cage. Van der Wal (1976) observed a high incidence of blood splash in muscles around the joint of the shoulder and the gracilis muscle in pigs. This phenomenon points to a predisposition of specific muscles for blood splash. However, in carcasses of electrically stunned calves the percentage and seriousness of blood splash were increased when compared to carcasses of calves stunned by captive bolt.

In conclusion, automatic electrical stunning may be technically possible, if the successive calves can be separated in an efficient and acceptable way. Because of the anatomy of the calf a V-type restrainer appeared to be less suitable for fixation of veal calves. Electrical stunning caused a slight electrostimulation effect, as demonstrated by the more rapid pH fall and lower ultimate pH. A higher percentage of heamorrhaging was observed in the muscles and fasciae in electrically stunned calves processed through a V-type restrainer as compared to stunning by captive bolt in either a V-type restrainer or a cage. Further research is needed to minimize or eliminate the problems associated with automatic electrical stunning.

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Table 1. The average and standard deviation of carcass weights and meat quality parameters. The veal calves were stunned either electrically (automatic) or by captive bolt in a V-type restrainer or a cage (*; significant difference $p \leq 0.05$ according the t-test).

	Experiment 1		Experiment 2	
	Automatic electrical (double restrainer) (n = 100)	Captive bolt (double restrainer) (n = 100)	Automatic electrical (single restrainer) (n = 98)	Captive bolt (cage) (n = 100)
Warm carcass weight (kg)	149.1 ±15.7	148.1 ±13.6	143.4 ± 9.9	143.0 ± 9.7
Cold " "	146.0 ±17.1	146.2 ±14.5	142.0 ± 9.8	141.3 ± 9.6
pH (45 min.p.m.)	6.53± 0.22*	6.77± 0.20*	6.63± 0.32*	6.96± 0.28*
pH (18 hrs.p.m.)	5.57± 0.88*	5.65± 1.64*	5.52± 0.16*	5.87± 0.23*
Temperature (°C) (45 min.p.m.)	40.4 ± 0.4	40.2 ± 1.2	41.0 ± 0.5*	40.8 ± 0.5*
" (°C) (18 hrs.p.m.)	14.2 ± 1.2	13.9 ± 1.2	10.9 ± 1.5*	11.3 ± 1.3*
Shape score 1)	6.2 ± 1.2	6.4 ± 1.2	6.2 ± 1.0*	6.6 ± 1.0*
Meat colour score 1)	4.7 ± 1.4*	4.1 ± 1.4*	6.0 ± 1.6*	5.1 ± 1.4*
Fat covering score 1)	2.1 ± 0.8*	2.4 ± 0.9*	1.7 ± 0.8*	2.1 ± 1.0*
Hunter L 2)	50.9 ± 4.3* (n=12)	47.5 ± 2.1* (n=12)	50.7 ± 5.9* (n=12)	55.5 ± 4.1* (n=12)
" a 2)	7.1 ± 1.6 (")	6.9 ± 1.2 (")	10.1 ± 2.5 (")	8.2 ± 2.9 (")
" b 2)	14.0 ± 1.1 (")	13.4 ± 0.6 (")	14.3 ± 2.1 (")	15.1 ± 1.9 (")
Heamatin (mg/kg)	43.6 ±15.7 (")	35.9 ± 6.5 (")	52.3 ±17.3* (")	39.3 ±13.6* (")

1) 1 = more muscular, lighter, thinner
   10 = more angular, darker, fatter

2) L > more white; a > more red; b > more yellow

Table 2. The percentages and seriousness (0 = none; 1 = minor; 2 = serious) of blood splashes in the muscles (m) and fasciae (f) observed in half carcasses (50 % left and 50 % right) of 12 out of 100 veal calves. At the same time the total percentage of half carcasses with no, minor or serious blood splash are presented (*: significant difference $p \leq 0.05$ according the x^2-test).

		Experiment 1						Experiment 2					
		Automatic electrical (double restrainer) (n = 12)			Captive bolt (double restrainer) (n = 12)			Automatic electrical (single restrainer) (n = 12)			Captive bolt (cage) (n = 12)		
Degree of blood splash		0	1	2	0	1	2	0	1	2	0	1	2
m. pectoralis profundus	m	100.0			100.0			100.0			100.0		
	f	50.0	41.7	8.3	91.7	8.3		91.7	8.3		100.0		
mm. around caput humeri	m		91.7	8.3	33.3	66.7		25.0	75.0		25.0	75.0	
	f	100.0			100.0			100.0			100.0		
m. triceps brachii	m	75.0	25.0		91.7		8.3	91.7	8.3		100.0		
	f	75.0	16.7	8.3	100.0			91.7	8.3		91.7	8.3	
m. supraspinatus	m	58.3	41.7		91.7	8.3		100.0			100.0		
	f	100.0			100.0			100.0			100.0		
m. infraspinatus	m	50.0	33.3	16.7	66.7	33.3		83.3	16.7		100.0		
	f	33.3	50.0	16.7	50.0	41.7	8.3	50.0	50.0	*	91.7	8.3	*
m. latissimus dorsi	m	66.7	25.0	8.3	91.7	8.3		83.3	8.3	8.3	91.7	8.3	
	f	88.3	16.7		83.3	16.7		100.0			100.0		
m. sternocephalicus	m	100.0			100.0			100.0			100.0		
	f	100.0			100.0			100.0			100.0		
m. serratus ventralis	m	75.0	25.0		91.7	8.3		91.7	8.3		91.7	8.3	
	f	91.7	8.3		100.0			75.0	25.0		100.0		
forehand shank mm.	m	91.7	8.3		83.3	16.7		100.0			100.0		
	f	91.7	8.3		83.3	16.7		100.0			100.0		
m. longissimus	m	25.0	75.0	*	66.7	33.3	*	16.7	66.7	16.7*	75.0	25.0	*
	f	8.3	58.3	33.3	41.7	33.3	25.0		83.3	16.7*	41.7	58.3	*
m. iliopsoas	m	16.7	75.0	8.3	33.3	66.7		50.0	50.0		58.3	41.7	
	f	58.3	41.7		83.3	16.7		100.0			100.0		

Table 2: (continued)

		Experiment 1						Experiment 2					
		Automatic electrical			Captive bolt			Automatic electrical			Captive bolt		
		0	1	2	0	1	2	0	1	2	0	1	2
m. gracilis	m	75.0	25.0		83.3	16.7		91.7	8.3		75.0	16.7	8.3
	f	83.3	16.7		91.7	8.3		91.7	8.3		91.7	8.3	
m. semimembranosus	m	66.7	33.3		91.7	8.3		75.0	16.7	8.3	100.0		
	f	66.7	33.3	*		100.0	*	41.7	58.3		25.0	66.7	8.3
m. adductor	m	91.7	8.3		100.0			100.0			100.0		
	f	100.0			100.0			100.0			100.0		
hindquarter shank mm.	m	66.7	33.3		100.0			91.7	8.3		100.0		
	f	83.3	16.7		100.0			100.0			100.0		
m. rectus femoris	m	58.3	16.7	25.0	91.7	8.3		83.3	16.7		83.3	16.7	
	f	58.3	25.0	16.7*	100.0		*	58.3	41.7		91.7	8.3	
m. gastrocnemius	m	91.7	8.3		100.0			100.0			100.0		
	f	41.7	41.7		8.3	83.3	8.3	25.0	75.0		41.7	58.3	
remaining	m	75.0	25.0		83.3	16.7		83.3	16.7		100.0		
	f	75.0	16.7	8.3	100.0			91.7	8.3		100.0		
Total			25.0	75.0*		75.0	25.0*		50.0	50.0*		91.7	8.3*