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EFFECT OF STUNNING METHOD, ELECTRICAL STIMULATION AND PELVIC SUSPENSION ON THE RATE OF AGEING IN PORK.

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INTRODUCTION

Variations in the rate of ageing of pork have been reported (Rees *et al.*, 1997; Dransfield *et al.*, 1980-81; Buchter and Zeuthen, 1971and Harrison *et al.*, 1970) and may be due to differences in the rate of pH decline. Alterations in the rate of rigor development influence the activation of the tenderising enzymes, the muscle structure due to shortening and protein denaturation. Thus an experiment was designed to determine if the rate of rigor development can alter the rate of ageing due to the impact on protein denaturation and cold toughening.

METHODOLOGY

Twenty-four male finisher pigs were slaughtered and randomly allocated to a 2 x 2 factorial treatment design. The treatments were:

- Stunned in 90% CO_2 in air with an exposure time of 1.8 minutes and no electrical stimulation (CN)
- Stunned in 90% CO_2 in air, low voltage electrically stimulated (200 mA peak to peak with a frequency of 14Hz) at 4 minutes post slaughter for 15 seconds (CS)
- Electrically stunned - head to heart (1.3 amps, 4 sec) and no electrical stimulation (EN)
- Electrically stunned - head to heart (1.3 amps, 4 sec) and electrically stimulated at 4 minutes post slaughter for 15 seconds (ES).

The carcasses were split and the sides subjected to either pelvic suspension (P) or Achilles suspension (A) at 20 minutes post slaughter and chilled at 0-2°C. The pH and temperature of the longissimus muscle (LTL) was monitored at 40 minutes, 1 hour then every hour until a pH of less than 5.8 was obtained, referred to as rigor. The LTL was removed at rigor, and split into eight 150 g samples. Samples were randomly allocated to an ageing period of 0, 1, 2, 4, 6, 8 or 10 days, vacuum packaged and stored at 2°C. Warner-Bratzler shear force (WBSF), pH, and colour (CIE - L*) and drip loss were measured at rigor and WBSF was determined for all ageing times. At rigor and at 4 days post slaughter, 50 g muscle samples were frozen in liquid nitrogen for subsequent measurement of sarcomere length, and myofibrillar fragmentation index (MFI). To determine the rate of pH decline, temperature decline and rate of ageing, the average data was fitted to an exponential decay equation using Genstat 5. Meat quality characteristics were analysed using the ANOVA function of Genstat 5.

RESULTS

The rate of pH decline was faster for electrical stimulation than no electrical stimulation ($P < 0.05$) but there was no effect of stunning method or the method of suspension ($P > 0.05$ for both) (Figure 1). The time taken for rigor to be reached was reduced by both the method of stunning ($P < 0.05$) and the use of electrical stimulation ($P < 0.001$) (Table 1). The rate of temperature decline was not influenced by electrical stimulation, the method of stunning or the method of suspension ($P > 0.05$).

Sarcomere length measured at both rigor and 4 days post slaughter was longer ($P < 0.05$) in the electrically stimulated muscles relative to the non-stimulated muscles (Table 1). A trend towards shorter sarcomere length was observed in the pelvic suspended sides relative to the Achilles tendon suspension at rigor ($P = 0.06$). By 4 days post slaughter, the pelvic suspended muscles had a longer sarcomere length than the Achilles tendon suspended muscles ($P < 0.05$).

Electrical stimulation, the method of stunning and the method of suspension did not influence ($P > 0.05$) the myofibrillar fragmentation index at either rigor or at 4 days post slaughter (Table 1). WBSF was reduced ($P < 0.01$) by pelvic suspension at rigor, 1, 2 and 6 days post slaughter relative to carcasses suspended by the Achilles tendon. The WBSF was also reduced by electrical stimulation relative to non-stimulated carcasses at 1, 2 and 10 days post slaughter ($P < 0.05$) while electrical stunning reduced WBSF at 1 and 2 days post slaughter relative to those stunned with carbon dioxide ($P < 0.05$). The rate of ageing as defined by the rate constant for exponential decay equations was increased by low voltage electrical stimulation compared to non-stimulated carcasses ($P < 0.05$) but was not influenced by the method of stunning or the method of suspension.

At rigor, electrical stunning ($P = 0.07$) and electrical stimulation ($P < 0.05$) increased the L* value. L* value were not influenced ($P > 0.05$) by the method of suspension. Drip loss was increased by electrical stunning relative to carbon dioxide stunning ($P < 0.05$) but was not influenced by electrical stimulation or the method of suspension.

DISCUSSION

The rate of pH and temperature decline can influence tenderness due to two main factors – cold toughening and protein denaturation. Two methods were used to alter the rate of pH decline post slaughter in this experiment, the first being the method of stunning and the second being electrical stimulation. However, the method of stunning did not influence the rate constant for pH decline in this study. Although no differences in the rate constants were observed for pH decline, the electrically stunned pigs did reach a pH < 5.8 in the LTL faster than those stunned in carbon dioxide. The second method employed to alter the rate of pH decline was the use of low voltage electrical stimulation. Low voltage electrical stimulation resulted in a faster rate of pH decline. This faster rate of pH decline for the electrical stimulated sides resulted in a reduction in time of 4 hours to reach rigor relative to the non-stimulated carcasses. The impact of the rate of pH decline on

proteolytic activity is not what would be expected with no differences in MFI occurring between the treatments. Due to the faster rate of pH decline induced by the application of electrical stimulation, it would be expected that MFI would have increased in these muscles.

The rate of temperature decline was constant across all treatments. The 0-2°C chilling conditions used was sufficient to induce cold shortening in the non stimulated sides as indicated by the reduction in sarcomere length in the non stimulated muscles. Furthermore the chilling conditions were not slow enough to induce protein denaturation in the stimulated muscles as indicated by no differences in drip loss although a higher L* value was observed.

The effect of increased pH decline rate as a result of electrical stimulation, thereby preventing cold shortening is revealed in the rate of ageing and the WBSF values themselves. The rate of ageing was increased by low voltage electrical stimulation with tenderness values at 2 days post slaughter in the electrically stimulated carcasses only occurring to equivalent values in the non-stimulated carcasses by 10 days post slaughter. Furthermore, WBSF was reduced by low voltage electrical stimulation at 1, 2, and 10 days post slaughter. The ability for pelvic suspension to prevent cold shortening is seen in the reduction in WBSF at various times post slaughter. This suggests that pelvic suspension prevented cold shortening of the muscles relative to the Achilles tendon suspension and is confirmed by the sarcomere length measurements.

CONCLUSIONS

A faster rate of pH decline induced by electrical stimulation resulted in the prevention of cold shortening and improved tenderness. However, the faster rate of pH decline did not appear to induce an increased proteolytic activity nor did it induce protein denaturation.

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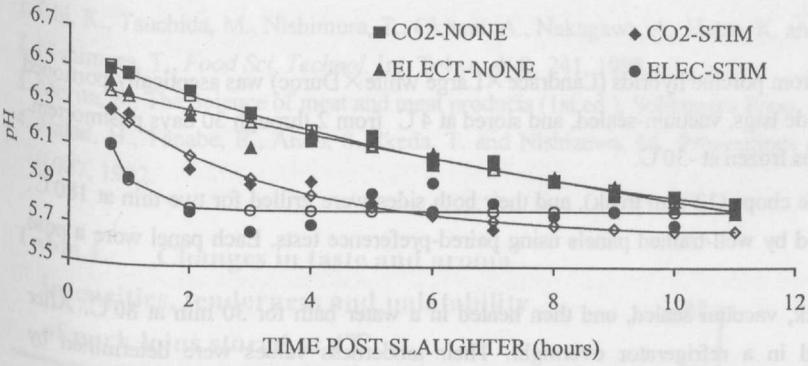

Figure 5.1 Mean rate of pH decline for pork *M. longissimus thoracis et lumborum* after carbon dioxide (CO2) or electrical head to heart stunning (ELECT), low voltage electrical stimulation (none (NONE) or for 15 seconds at 5 minutes post slaughter (STIM)). Each point represents the actual pH at each time measured and the line represents the fitted curve.

Table 1 The effect of stunning (CO2 verses electrical (elect)), stimulation (none verses 15 seconds) and suspension (Achilles verses pelvic) on time taken to reach rigor (time), Myofibrillar fragmentation index (MFI), sarcomere length (SL, μm), Warner Bratzler shear force (WBSF, kg) and meat quality measurements for pork loins at various times post slaughter.

	Stunning		Stimulation		Suspension		Significance[1]			
Time	CO_2	Elect	None	15 sec	Achilles	Pelvic	Stun	Stim	Susp	SED
S.L. rigor	8.25	6.58	9.42	5.42	7.50	7.33	P < 0.05	P < 0.001	NS	0.777
S.L. 4 days	1.73	1.84	1.68	1.89	1.73	1.83	NS	P < 0.05	P = 0.06	0.075
MFI rigor	1.78	1.91	1.74	1.95	1.78	1.91	P = 0.09	P < 0.01	P < 0.05	0.067
MFI 4 days	41.7	51.1	41.9	50.9	47.7	45.1	NS	NS	NS	6.63
WBSF Rigor	78.4	91.2	89.4	80.2	92.2	77.4	NS	NS	NS	8.39
WBSF 1 day	6.67	5.97	6.29	6.35	6.81	5.83	NS	NS	P<0.001	0.457
WBSF 2 days	7.69	5.87	7.68	5.87	7.38	6.17	P < 0.05	P < 0.05	P < 0.01	0.689
WBSF 4 days	6.77	4.85	6.60	5.02	6.50	5.12	P < 0.05	P < 0.05	P < 0.001	0.755
WBSF 6 days	6.19	5.02	6.31	4.90	5.71	5.50	NS	NS	NS	0.730
WBSF 8 days	5.78	4.52	5.23	5.07	5.64	4.65	NS	NS	P < 0.01	0.707
WBSF 10 days	5.56	5.15	5.86	4.84	5.60	5.11	NS	NS	NS	0.691
drip loss (%)	5.08	5.03	5.61	4.50	5.50	4.61	NS	P < 0.05	NS	0.454
Surface lightness (L*)	2.38	4.61	3.04	3.95	3.50	3.49	P < 0.05	NS	NS	0.832
	43.8	46.4	43.5	46.7	45.1	45.0	P = 0.07	P < 0.05	NS	1.33

[1]Susp = suspension, Stim = stimulation, Stun = stunning method