THE EFFECT OF LOW VOLTAGE STIMULATION ON pH FALL AND MEAT TENDERNESS IN LAMBS

N. J. Simmons, K.V. Gilbert, J.M. Cairney

Meat Industry Research Institute of New Zealand, P.O Box 167, Hamilton, New Zealand

Keywords: Stimulation, pH fall, temperature, tenderness

Introduction

Low voltage stimulation (≤ 80 volts) has been shown to accelerate rigor onset in beef (Bouton *et al*, 1978) and lamb (Chrystall *et al*, 1984) when applied during bleeding. Moreover, it has been claimed that successful low voltage stimulation is dependent upon a functioning central nervous system (Morton & Newbold, 1982) and thus can only be applied soon after death. Recent work (Shaw *et al* 1996) demonstrated that low voltage stimulation can be applied after carcass dressing some 20 minutes post-mortem and still be effective. However, Fabiansson & Reutersward, (1985) found that the effectiveness of low voltage stimulation can be highly variable and anecdotal evidence claims that variability is dependent upon animal type and subsequent processing. It is unclear whether these effects are due to differences in the time and duration of the stimulation or the subsequent chilling rate. The aim of this work was twofold: to evaluate the effect of time post-mortem and duration of low voltage stimulation on pH fall and tenderness; and to examine the effect of low voltage stimulation on pH fall in muscles held at two constant pre-rigor temperatures.

Materials and Methods

Crossbred lambs from two age and weight groups were selected from a commercial processing line over a period of four weeks. The animals were electrically stunned using a head-to-back electrode configuration (Thornton-Ascot Ltd) for four seconds. The stimulation current was generated with a MIRINZ low voltage stimulator (14.3 pulses per second with current controlled between 180 and 200 mA) and applied via an electrode onto the gambrel and another inserted through the neck. Stimulation was applied at sticking (5 minutes post-mortem) for either 60 (E60) or 120 (E120) seconds or after dressing (20 minutes post-mortem), for 60 (L60) or 120 (L120) seconds. There were 10 lambs in each treatment group.

At 20 minutes after stimulation, the pH of each carcass was measured using an Ingold pH probe inserted directly into the longissimus dorsi (LD). Two readings were taken in the area of the last rib and the average was recorded. The animals were placed into a chiller (ambient temperature 4°C) and at 90 minutes and 4 hours further pH measurements were made.

The following day the LD was removed from each carcass and prepared for shear force testing with a MIRINZ tenderometer after cooking to an internal temperature of 75°C. Ten replicates per sample were cut into 1cm x 1cm strips parallel to the fibre axis, and sheared perpendicular to the fibre axis

The second experiment involved 16 lambs of similar ages and weights. Stimulation for 60 seconds was applied either at sticking (E60) or at 20 minutes after dressing (L60). The LD was removed from both sides of the carcass as soon as possible after stimulation and dressing and no longer than 40 minutes post-mortem. The loins were placed in waterproof weighted polythene bags; and one side from each carcass was put in a water bath maintained at 15°C while the other was held at 35°C. Thereafter, at regular intervals up to the point of rigor mortis, the pH was measured., and shear force measurements were made on each sample at rigor, as detailed above.

Results

Low voltage electrical stimulation significantly reduced the muscle pH when applied at sticking or 20 minutes post-mortem (immediately prior to pH measurement). There were no significant differences between the stimulated treatments at any measurement time-point. The rate of pH fall subsequent to the stimulation was the same for all treatment groups and did not differ significantly from the un-stimulated control group (data not shown). Low voltage stimulation resulted in significantly lower shear force values at 24 hours post-mortem compared to un-stimulated samples and this was irrespective of stimulation time or duration.

Table 1. Effect of time and duration of stimulation on post-mortem pH fall and shear force

Treatment	pH_{20}		pH_{90}		$pH_{4\ hours}$		Kgf (24 hours)	
E60	6.22	(0.09)	6.24	(0.06)	6.08	(0.11)	11.1	(2.8)
E120	6.20	(0.11)	6.11	(0.10)	6.01	(0.09)	10.9	(2.6)
L60	6.17	(0.08)	6.23	(0.09)	5.93	(0.08)	10.7	(2.4)
L120	6.28	(0.10)	6.21	(0.09)	6.01	(0.09)	11.6	(3.4)
Control	6.67	(0.09)	6.29	(0.08)	6.23	(0.07)	13.5	(2.1)
Significance	***		***		**		*	

Figures are means (s.d). * $P<0.05$, ** $P<0.01$, *** $P<0.001$

Pre-rigor holding temperature effected the rate of pH fall (Figures 1 to 6). At 35°C the rate of decline could be described by a linear regression in un-stimulated muscles while at 15°C the early post-mortem pH fall was slower, although it increased later. Stimulated samples

followed similar patterns but at both temperatures the variability between samples was larger than the un-stimulated group, irrespective of the application time. The shear force values for the un-stimulated group were higher for the 15°C compared to 35°C maintained (15.1 vs. 12.9) irrespective of treatment. Similarly, the stimulated treatments also had higher shear force values from the 15°C held samples (14.0 vs 11.2 - E60 and 13.7 vs 11.5 – L60) although the range of values were larger in the stimulated muscles maintained at 15°C.

Conclusions

Low voltage stimulation is effective when applied up to 20 minutes post-mortem, producing a significant reduction in pH although the subsequent pH decline did not differ from un-stimulated samples. Shear force values were also significantly reduced. However, the variation in pH fall between animals was large and the range of values was equivalent to, and in some instances higher than in the un-stimulated animals, suggesting variation in the response to stimulation between carcasses. When the samples were maintained at constant pre-rigor temperatures this variation continued and was more evident in the 15°C samples. Furthermore, at this temperature, the pH of some samples increased during the early post-mortem period, suggesting ATP re-synthesis accentuated by a direct temperature induced rise in muscle pH. The resulting slower rigor onset was reflected in the wider range of shear force values. Since the variability was present when samples were maintained at constant pre-rigor temperatures, it would appear that the response to low voltage stimulation is determined largely by the animal history rather than by processing conditions. Variability in the response to low voltage stimulation will contribute to variable time to rigor onset and tenderness development, and is likely to restrict its commercial application in plants where early attainment of a tenderness specification is required.

References

Bouton, P.E., Ford, A.L., Harris, P.V., Shaw, F.D. (1978). J. Food. Sci. 43, 5, 1392.

Chrystall, B,B., Devine, C.E., Ellery, S., Wade, L. (1984). New Zealand Jnl. Agric. Res. 27, 513.

Morton, H.C., Newbold, R.P. (1982). Meat Sci. 7, 285.

Shaw, F.D., Eustace, I.J., Warner, R.D. (1996). Int. Congress of Meat Sci and Tech. Lillehammer, Norway, 410

Figure 1. Effect of 35°C pre-rigor holding on pH decline in unstimulated muscles

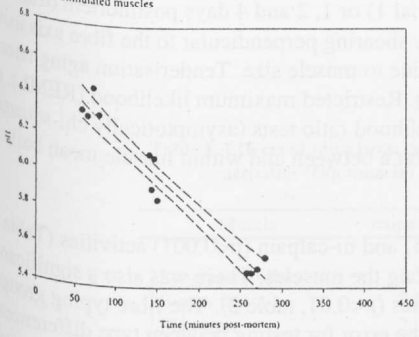

Figure 4. Effect of 15°C pre-rigor holding on pH decline in unstimulated muscles

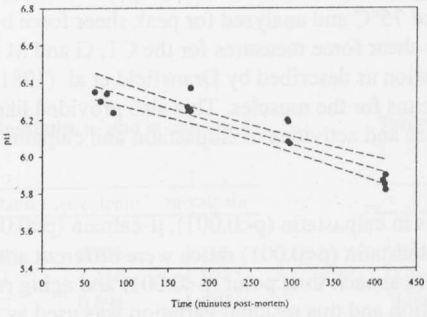

Figure 5. Effect of 15°C pre-rigor holding on pH decline in muscles stimulated at sticking

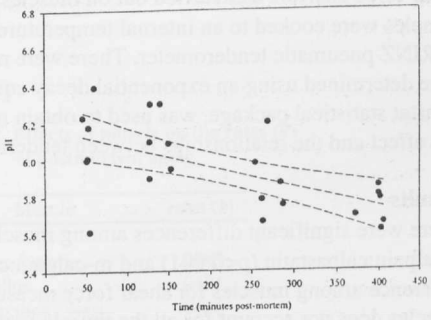

Figure 2. Effect of pre-rigor holding at 35°C on pH decline in muscles stimulated at sticking

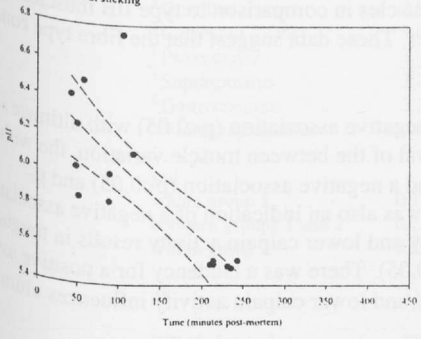

Figure 3. Effect of 35°C pre-rigor holding on pH decline in muscles stimulated at 20 minutes post-mortem

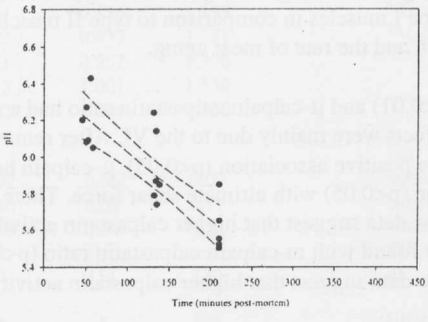

Figure 6. Effect of 15°C pre-rigor holding on pH decline in muscles stimulated at 20 minutes post-mortem