INTERACTION BETWEEN PRE-SLAUGHTER HANDLING AND LOW VOLTAGE ELECTRICAL STIMULATION AND THE EFFECT ON BEEF QUALITY.

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Background

The rate of post-mortem glycolysis in muscle has been shown to be an important determinant of meat tenderness (Smulders *et al.*, 1990, Marsh, 1993, O'Halloran *et al.*, 1997). For instance, a slow rate coupled with a rapid temperature decline leads to cold shortening. Low voltage electrical stimulation (LV) applied within a few minutes of slaughter was designed to accelerate post-mortem glycolysis, thus avoiding cold shortening. In addition electrical stimulation is thought to facilitate further improvement in tenderness via enhanced proteolysis and structural weakening (Ho *et al.*,1996).

The efficacy of LV stimulation is dependent on several factors, most notably, the rate of cooling. However, there is recent evidence that suggests the response to stimulation may interact with the pre-slaughter management of the animal. In cattle, Wythes *et al.*,(1988) showed that stimulation of carcasses from animals which had been rested for a day before slaughter produced more tender meat than in those animals rested for only a few hours. Nortje *et* al, (1986) found exercise prior to slaughter resulted in a reduced tenderising effect due to stimulation. Rapid glycolysis associated with pre-slaughter handling and stimulation has also been found to interact and influence the process of tenderisation during ageing (Daly *et al.*, 1995).

Objective

The purpose of this experiment was to investigate the effect of the interaction between minimal pre-slaughter stress and low voltage electrical stimulation on meat quality.

Methods

Animals and Experimental Design: Sixty *Bos indicus* (0 - 75 %) crossbred steers were randomly selected from a pen of 100 steers in a commercial feedlot where they had been fed on a high quality grain ration for approximately 70 days. The steers, averaged 219 kg carcase weight, had fat depths at the P8 site ranging from 8 – 22 mm and were between 18 and 36 months of age (estimated by dentition at slaughter). The experimental design was a 2x3x2 factorial, comprising two pre-slaughter handling treatments (fasted, or not-fasted prior to slaughter), three low voltage stimulation treatments (no stimulation, 10 or 40 seconds duration) and two ageing periods (1 or 14 days).

Pre-slaughter Treatments: Five days prior to slaughter, 30 steers were randomly selected from the pen and transported 60 km to holding pens at the abattoir, where they were fed *ad libitum* the same ration as in the feedlot up until slaughter (non-fasted treatment). The remaining 70 steers in the pen were transported to the abattoir 24 hours prior to slaughter and held overnight off feed, with access to water, thus pre-slaughter handling included trucking and fasting (fasted treatment). Within each handling treatment, groups of 10 steers were allocated to three stimulation treatments, viz: no stimulation (NS), 10 (10 secs) or 40 seconds (40 secs) duration. Stimulation (45V, 36 pulses/s) was applied within two minutes of stunning using a nostril probe in conjunction with a hydraulically powered rubbing bar. Sides entered the chiller ca. 90 minutes after stunning. During the chill cycle the air speed was 1.065m/s with an air temperature of –2°C to 1.5°C.

Measurement: Three carcasses from each of the handling/stimulation treatments were selected to monitor changes in pH and temperature. (measurements were recorded at the 12/13th rib site at ca. hourly intervals post-slaughter, up until ultimate pH was estimated to have been achieved). The right striploin was used for sensory evaluation and the left striploin for objective tenderness measurements. On day 1, half of each striploin was vacuum packed and frozen at –20°C, whilst the other was vacuum packed and aged for 14 days at 1°C. Allocation of ageing period alternated between the cranial and caudal ends of the striploin. For sensory evaluation, five 25mm steaks were cut from the cranial end of the frozen striploins using a bandsaw, halved and allocated to an incomplete randomised block design. Half steaks were thawed at 4°C for 24 hours and the epimysial tissue removed prior to cooking. Samples were cooked on an electric clam bake griller for 4 minutes at 180°C to achieve an internal temperature of 70°C. Trained taste panel sessions were conducted using 15mm cubes which were served warm under green lights with each member tasting six samples per session, twice a day. Sensory scores were made on a continuous, unstructured 10 cm line anchored at each end by the terms, extremely tough, or dry (0) and extremely tender, or juicy (100). Drip loss was measured by hanging 85g of muscle in a plastic bag at 1°C for 48 hours (Taylor and Dant, 1971). The objective measurement samples were thawed in a chiller, at 4°C for 48 hours and prepared for cooking. The blocks weighing 250g were cooked at 70°C for 60 minutes in a water bath, prior to cooling in running water for 30 minutes and chilling overnight. Rectangular strips (150x66 mm) were cut parallel to the fibre orientation for Warner Bratzler peak force measurement and wedge samples (15 mm high) for compression determinations (Bouton *et al.*, 1971). Sarcomere length was measured using the Helium-Neon laser diffraction technique described by Bouton *et al.*, (1973).

Statistical Analyses: The decline in pH over time was modelled using the exponential function $pH(t) = pH_u + (pH_0 - pH_u)e^{-kt}$, where pH(t) was pH at time t, pH_0 is the pH at time 0, pH_u is ultimate pH at time u and k the exponential rate constant, which was fitted using a non-linear package. Mixed model procedures were used, to analyse the effects of the treatments on the objective and sensory measurements. For objective measurements the model contained fixed effects for stimulation, handling, ageing, loin position and all first order interactions with the random effect being animal (handling*stimulation). For sensory analysis, the fixed effects were handling, stimulation, ageing, loin position, tasting order and all first order interactions with random effects for session, taster(session), animal(handling*stimulation). Non-significant interactions ($P>0.05$) were sequentially removed. Sarcomere length, cooking loss and drip loss were analysed using a generalised linear model that contained stimulation, handling, loin position and significant ($P<0.05$) first order interactions.

Results and discussion

There were no treatment effects on ultimate pH, although on the sub sample of carcasses in which pH and temperature changes were monitored there was a significant handling*stimulation interaction for the predicted pH at 3 hours post-mortem (P<0.05, Table 1). The interaction showed an accelerated rate of glycolysis in the non-fasted/non-stimulated animals, compared with the other treatments. The handling*stimulation interaction was also significant for both sensory and objective measurements of tenderness, whereby samples from the fasted/non-stimulated treatment were tougher than samples from the other treatments (P<0.05, Table1). The increase in toughness for this treatment suggests that some cold shortening occurred and whilst there was a trend for reduced sarcomere length in the fasted/non-stimulated treatment the effect was not significant (P>0.05, Table1). Ageing effects on tenderness (both objective and sensory) were highly significant (P<0.001). In this paper the discussion of ageing effect will be restricted to those interactions with either handling or stimulation treatments.

It is proposed that the accelerated pH decline in the non-fasted/non-stimulated animals would have led to the avoidance of any shortening and possibly led to enhanced proteolytic activity (Daly *et al.*, 1995, O'Halloran *et al.*, 1997), thus providing some explanation to the almost two-fold increase in shear force between the two non-stimulated treatments. These results also support the work of Smulders *et al.*, (1990) who suggested that fast glycolysing muscles were more tender than slow glycolysing muscles. Handling, stimulation, ageing and loin position significantly influenced shear force (P<0.05). Furthermore, there were significant (P<0.05) interactions of ageing*loin position and ageing*stimulation. In the latter interaction, product stimulated for 40 seconds aged significantly less (P<0.05) as determined by the change in shear force, than the 10 second stimulated carcases. Analysis of loin position showed a 0.5kg increase in peak force in steaks from the cranial to the caudal end. A trend (P=0.13) was detected for ageing*handling, whereby meat from the non-fasted animals aged more rapidly than product from the fasted animals, though to a lesser extent. This agrees with O'Halloran *et al.*, (1997), who showed reduced benefits of ageing in product from carcases with a rapid rate of glycolysis. It is difficult to explain why the product in the fasted/10 second stimulation treatment had increased shear force values and lower tenderness scores, given that the pH decline was almost identical to that of the non-fasted/non-stimulated and non-fasted/10 second stimulation treatment. In the fasted animals, where stimulation was effective in improving tenderness, 40 second stimulated carcases produced the meat achieving the highest sensory score. Significant though, was the fact that no combination of handling and stimulation treatment produced product that consumers would consider to be above average.

Meat from the non-fasted animals was juicier, had less drip loss and less cooking loss (see Table 1).

Conclusions

There was an interaction between the efficacy of LV stimulation and the pre-slaughter handling treatment of cattle and its affect on meat quality. The stress from trucking a relatively short distance and a 24 hour fast prior to slaughter was sufficient to slow down the rate of post-mortem glycolysis so that electrical stimulation of the carcass was required to increase the rate of the post-mortem pH decline and avoid toughening. Animals kept on feed until slaughter had a sufficiently rapid rate of glycolysis so that electrical stimulation of the carcass was not necessary.

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TABLE 1 Predicted means for the interaction between handling and low voltage stimulation on meat quality traits.

	Non-fasted			Fasted			Av.	Significance		
	0 sec	10 sec	40 sec	0 sec	10 sec	40 sec	s.e.	Hand	Stim.	Hand.*Stim
Objective										
Peak Force (kg)§	4.83	4.59	4.79	8.85	7.07	4.67	0.59	***	**	**
Compression (kg)§	1.52	1.65	1.55	1.83	1.61	1.67	0.06	*	n.s.	*
Drip loss (%)	0.72	0.65	1.26	0.93	1.30	1.25	0.10	P=0.05	P=0.05	n.s.
Cook loss (%)	22.76	23.94	23.18	24.75	23.67	23.92	0.27	*	n.s.	n.s.
Sarcomere length (μm)	1.94	1.91	1.89	1.81	1.97	1.87	0.41	n.s.	n.s.	n.s.
pH at 3 hours	6.01	5.97	5.53	6.33	5.87	5.48	0.08	n.s.	*	*
pH Ultimate	5.44	5.39	5.5	5.41	5.46	5.49	0.09	n.s.	n.s.	n.s.
Sensory										
Tenderness §	49.44	48.99	42.67	28.02	40.13	44.71	3.87	**	n.s.	*
Juiciness §	53.76	52.6	51.59	47.78	48.95	51.05	1.83	**	n.s.	n.s.

n.s. not significant, * P<0.05, ** P<0.01, *** P<0.001 § Values adjusted for ageing time.

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