Meat quality traits in lamb M. longissimus thoracis et lumborum: The effect of pre-slaughter stress and electrical stimulation.

R. D. Warner [12], J. J. Bond[2], M. G. Kerr[1]

[1]Victorian Institute of Animal Science, Agriculture Victoria, Private Bag 7, Werribee Victoria 3030 Australia.
[2]Department of Biological and Food Sciences, Hoppers Lane, Werribee, Victoria 3030 Australia.

BACKGROUND

Physical stress immediately pre-slaughter can increase the pH decline rate post-slaughter (Gregory, 1996). Electrical stimulation of beef and lamb carcasses post-slaughter is routinely used in commercial industry to prevent cold-induced toughening of muscles through cold-shortening (Chrystall and Devine, 1998) but under conditions of very rapid pH fall and slow chilling, there can be a risk the meat will become tough (Gregory, 1996). In pork, rapid pH fall post-slaughter combined with high muscle temperatures, are well-known to cause denaturation of musc proteins and subsequent reduced water-holding capacity and PSE pork (Warner *et al.*, 1997). As both pre-slaughter stress and post-slaughter electrical stimulation induce a rapid pH fall post-slaughter, it is postulated that electrical stimulation may be producing negative effects on lam tenderness and water-holding capacity in situations where antemortem stress is occurring. It is unclear how these parameters effect water-holding capacity, protein denaturation and proteolysis during the pre-rigor period and during ageing.
Objective: To investigate the effects of antemortem stress and electrical stimulation of the carcass on post-mortem biochemistry and subseque meat tenderness, muscle water-holding capacity and protein denaturation in the lamb M. *longissimus thoracis et lumborum* (LTL) muscle.

METHODS

The experiment was designed as a 2x2 using 32 lambs with the following treatments: (a) Exercise/antemortem stress; NO STRESS vs STR (comprising 10 minutes of constant activity with a stockperson , 1 minute run, 1 minute rest, at 15 min. pre-slaughter and 5 shocks, 15 seco apart, with an electric prodder in while lambs were restrained in a V - restrainer, (b) Low voltage electrical stimulation (ES; NO ES vs ES seconds, constant current of 147 mA and 28-36Volts, apllied at 5 min post-mortem.). Subsequent to stunning and slaughter, carcasses w chilled at 2°C chiller and the changes in temperature, pH and glycogen in the *longissimus thoracis et lumborum (LTL)* were measured (dire for pH/temperature or by sampling and subsequent laboratory assays for glycogen) at regular intervals until rigor mortis onset and again at 2 post-slaughter. At 24 hr, the LTL muscle was removed from each side and randomly allocated to 0 or 3 days of ageing at 2°C in a vacuum After ageing, samples were removed from the bag and the following measurements conducted on the fresh sample; Warner-Bratzler peak s force, cook loss, surface exudate (filter paper method, converted to drip loss %), surface colour (L*, a*, b*) after a 30 min. bloom usi Minolta chromameter 200b and ultimate pH. Samples were also taken and frozen for subsequent analysis of sarcomere length using diffraction, sarcoplasmic protein solubility and myofibrillar ATPase activity. All methods are described in Warner *et al.* (1997). Date analysed by ANOVA to examine the main effects of STRESS and ES and their interaction on the variables measured.

RESULTS

Temperature, pH and glycogen (Figures 1&2): The LTL pH was lower for the stress treatment at all time points post-slaughter but the depended on the ES treatment (ES.STRESS, P<0.05) The pH was much higher (P<0.05) for the no STRESS- no ES treatment then all treatments at all times measured until 6 hrs post-slaughter. The STRESS- NO ES treatment also generally had a higher pH (P<0.05) the STRESS-ES and NO STRESS-ES treatments. The STRESS animals had a lower pHu (P<0.05) and a higher temperature until 2 hrs slaughter (+1.5-3 °C for STRESS animals, results not presented). The muscle glycogen concentration in the LTL was lower for STRESS an at all time points post-slaughter (P<0.001for all), compared to NO STRESS animals. Muscle glycogen was also generally lower (P<0.0 carcasses undergoing ES compared to NO ES, except for the 30 min and 24 hr samples.
Meat quality and protein denaturation (Table 1):
Effect of stress: The STRESS treatment caused higher (P<0.01) drip loss and lower protein solubility compared to the NO STRESS treat All other effects of the stress treatment are discussed below under the interaction.
Effect of electrical stimulation and stress - For many of the variables, there was an interaction (P<0.05) between STRESS and ES such th effect of electrical stimulation depended on whether the animals had been stressed pre-slaughter. Thus animals undergoing NO STRESS an ES had higher Warner-Bratzler shear force (tougher meat) at 0 and 3 days of ageing, a surface colour which was darker (L*), less red (a* less yellow (b*) and lower cook loss at 0 and 3 days (P<0.05 for all).
There was no differences (P>0.05) between treatments in myofibrillar ATPase activity, sarcomere length or in protein solubility at 3 days.

In summary, lambs undergoing antemortem stress exhibited an increase in muscle drip loss and in cooking loss which was most likely a re the faster pH fall post-slaughter causing protein denaturation, as indicated by reduced protein solubility. Lambs which were not stress slaughter and were subjected to electrical stimulation post-slaughter exhibited an improvement in tenderness but water-holding capacit reduced. The meat quality of lambs which were stressed at slaughter was not detrimentally affected by the application of electrical stimulati

CONCLUSION: The application of electrical stimulation to lamb carcasses post-slaughter did not have any detrimental effects on tenderness but under conditions where the lambs were stressed at slaughter, muscle water loss was higher.

Table 1: The effect of stress (NO STRESS vs STRESS) and electrical stimulation (ES; NO ES VS ES) on meat quality and protein denaturation traits of lamb M. longissimus thoracis *et lumborum* for samples aged for 0 or 3 days.

	NO STRESS		STRESS		SED	F - Values		
	NO ES	ES	NO ES	ES	Stress x ES	Stress	ES	Stress x ES
Day 0								
Shear Force (kg)	8.16	6.27	6.85	7.80	0.895	ns	ns	0.036
Sarcomere Length (um)	1.83	1.92	1.84	1.89	0.049	ns	ns	ns
Colour L	30.99	33.03	33.58	32.97	0.633	0.01	ns	0.007
Colour a	17.9	19.1	19.5	18.8	0.392	0.019	ns	0.002
Colour b	7.0	7.6	8.2	7.7	0.286	0.006	ns	0.01
Cook loss %	33.08	35.7	38.76	39.13	0.711	<0.001	0.007	0.035
Drip loss %	1.65	1.48	2.98	2.39	0.493	0.004	ns	ns
Protein Solubility (mg/g)	64.44	65.12	60.88	62.18	1.259	0.001	ns	ns
ATPASE (umol/mg/min)	0.102	0.124	0.116	0.119	0.0110	ns	ns	ns
Day 3								
Shear Force (kg)	6.05	4.21	4.84	4.77	0.698	ns	0.066	0.085
Cook loss %	33.36	35.63	38.62	38.54	0.762	<0.001	0.055	0.041
Protein Solubility	64.29	62.48	61.88	62.09	1.656	ns	ns	ns

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Figure 1. Rate of pH fall in the LTL muscle in the first six hours post-mortem and ultimate pH at 24hr for the four pre-slaughter stress-electrical stimulation treatment combinations. Treatments are: NO STRESS-NO ES (●), NO STRESS-ES (○), SRESS-NO ES (▼), STRESS-ES (▽). Standard deviation of means in all treatments at a particular time point are indicated by error bars along the top of the graph.

Figure 2. Rate of glycogen fall in the LTL muscle in the first six hours post-mortem and at 24hrs for the four pre-slaughter stress-electrical stimulation treatment combinations. Treatments are: NO STRESS-NO ES (●), NO STRESS-ES (○), SRESS-NO ES (▼), STRESS-ES (▽). Standard deviation of means in all treatments at a particular time point are indicated by error bars along the top of the graph.