INTER-MUSCULAR RESPONSES TO EXTENDED LOW VOLTAGE ELECTRICAL STIMULATION OF LAMB

N.F.S. Gault*[1], A. Gordon[2] and E.L.C. Tolland[1]

[1] Agriculture, Food and Environmental Science Division[1], and Corporate Services Division[2], Agri-Food and Biosciences Institute, Belfast BT9 5PX, UK. Email: Norman.Gault@afbini.gov.uk

Keywords: electrical stimulation, lamb, eating quality

Introduction

Traditional electrical stimulation (ES) increases the rate of post mortem glycolysis in red meat carcasses, hence facilitating rapid chilling pre-rigor and avoiding cold shortening (Chrystall and Devine 2000). However, most conventional ES procedures aim to decrease the pH of the *longissimus dorsi* muscle to no less than pH 6.3 1h post mortem to avoid the risk of heat shortening. Conversely, Gault *et al.,* (2000) showed that 300 pulses of 100v low voltage electrical stimulation (LVES) applied to chicken carcasses after bleeding could quickly bring the breast muscle pH to pH 6.0, inducing very early rigor onset, yet having no adverse effect on meat quality.

Unlike chicken breast muscle which comprises mainly αW (fast-twitch high glycolytic) muscle fibres, the muscles of red meat animals consist of varying proportions of αW, αR (fast-twitch high oxidative) and βR (slow-twitch intermediate/high oxidative) muscle fibre types (Monin 1981). Gault *et al.,* (2005) subsequently demonstrated that the responsiveness of lamb carcasses to 300 pulses of LVES reflected the fibre type composition of the muscles analysed. The greatest glycolytic response was seen with predominantly αW fibre-type muscles, and the least with predominantly βR fibre-types. Even though some muscles reached pH 6.0 within 1h of slaughter, the LVES treatments used had no detrimental effect on meat quality *per se*, and limited to some extent the susceptibility of muscles to shortening-induced toughness when de-boned early.

This study assessed the glycolytic response of extended LVES procedures, at different duty cycles, in lamb carcasses, and how this might impact on early de-boning of lamb muscles of different fibre-type composition.

Materials and Methods

Forty-four (24 male; 20 female) Texel x Greyface crossbred lambs were used; mean live weight 41.02 kg (range 38-47kg). Groups of 4 lambs were randomly allocated to one of 10 LVES treatments. Each carcass received either 600 or 1200 pulses of 100v 10ms pulse width LVES at a frequency of 5, 10, 20, 50 or 100Hz. LVES was applied 90s after stunning and bleeding. A control group had no LVES treatment. All carcasses were dressed and split within 10 minutes of bleeding.

The muscles selected for assessment were the *m. semitendinosus* (ST; αW fibre-type); *m. longissimus dorsi* (LD; αR fibre-type) and *m. supraspinatus* (SS; βR fibre-type). These were removed from alternate carcass sides within each treatment for analysis immediately after splitting (early de-boned), while the matching sides were Achilles hung until 24h post-mortem (late de-boned). Chilling was carried out at 9°C for the first 24h post-slaughter. Muscles were then stored aerobically for one week at 2°C when the remaining analyses were completed.

Muscle pH (Bendall, 1975) was monitored at 1h, 2h and 24h post mortem in the early de-boned muscles, and at 24h in the late de-boned muscles. Sarcomere lengths (SL) (Koolmees *et al.,*1986) were measured in samples of early and late de-boned muscles at 48h post-mortem and cooking loss (CL) and shear force (SF) (Gault *et al.*, 2000) assessed at 48h and 7 days post mortem. Data were analyzed by ANOVA (Genstat, 2003).

Results and Discussion

As found previously (Gault *et al.*, 2005), muscle fibre-type had a significant ($P<0.001$) effect on muscle responsiveness to LVES. The predominantly αW fibre-type ST gave the greatest response, the αR fibre-type LD gave an intermediate response, and the βR fibre-type SS gave the least response compared to the controls (Table 1). The lowest frequencies also gave significantly greater ($P<0.001$) glycolytic responses compared to the 100Hz treatments, which were ineffective. Likewise, there was no significant improvement ($P>0.05$) in glycolytic response in any muscle when the total number of pulses was increased to 1200, irrespective of frequency (Table 1). Although significant ($P<0.001$) intermuscular differences were found for each quality attribute (Table 2), no significant ($P>0.05$) differences due to LVES treatment were found other than for pH_{1h} and pH_{2h} values. Early de-boning resulted in significantly shorter ($P<0.001$) sarcomeres and higher ($P<0.001$) 48h and 7d shear force values in the ST and SS (Table 3), little difference being seen with the LD. In general terms, this would suggest that the intermediate glycolysing LD was unaffected by early de-boning. In contrast, the fast glycolysing ST, which showed characteristics of early rigor onset, and the slow glycolysing SS, were both prone to a degree of shortening and toughening when be-boned early. A more detailed analysis of specific LVES treatments may help provide an explanation for this anomaly.

Table 1: Effect of LVES (pulses x frequency (Hz)) on intermuscular pH_{1h} values.

		600 pulses					1200 pulses				
Muscle	Control	5	10	20	50	100	5	10	20	50	100
ST	6.51	6.01	6.12	6.07	6.20	6.47	5.98	6.05	6.04	6.15	6.41
LD	6.51	6.21	6.24	6.23	6.29	6.66	6.15	6.15	6.25	6.36	6.50
SS	6.71	6.47	6.54	6.62	6.63	6.61	6.36	6.39	6.46	6.54	6.71
mean	6.58	6.23	6.30	6.30	6.37	6.58	6.16	6.20	6.30	6.35	6.54
P	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
n	4	4	4	4	4	4	4	4	4	4	4
lsd[a]	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
lsd[b]						0.16					

[a]least significant difference (P<0.05) within a column. [b]least significant difference (P<0.05) across columns.

Table 2: Intermuscular differences in the quality attributes of lamb for all treatments combined.

Muscle	pH_{1h}	pH_{2h}	pH_{24h}	SL_{48h} µm	CL_{48h} %	CL_{7d} %	SF_{48h} kg/cm^2	SF_{7d} kg/cm^2
ST	6.18	6.00	5.67	2.03	37.1	36.8	6.75	5.00
LD	6.32	6.15	5.56	1.88	31.7	31.6	4.94	3.95
SS	6.55	6.36	5.83	1.89	37.5	37.9	5.54	4.43
P	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
n	44	44	88	88	88	88	88	88
lsd P<0.05	0.03	0.04	0.02	0.03	0.49	0.48	0.25	0.19

Table 3: Effect of de-boning time on intermuscular quality attributes.

Muscle	pH_{24h} early	pH_{24h} late	SL_{48h} early	SL_{48h} late	CL_{48h} early	CL_{48h} late	CL_{7d} early	CL_{7d} late	SF_{48h} early	SF_{48h} late	SF_{7d} early	SF_{7d} late
ST	5.66	5.68	1.95	2.10	37.3	36.8	36.5	37.0	7.25	6.24	5.42	4.59
LD	5.56	5.55	1.88	1.89	31.3	32.2	31.3	32.0	4.88	5.00	3.93	3.98
SS	5.81	5.85	1.85	1.92	38.4	36.7	38.1	37.7	6.21	4.87	4.77	3.89
mean	5.68	5.70	1.89	1.97	35.7	35.2	35.3	35.6	6.11	5.37	4.70	4.15
P	<0.01		<0.001		<0.001		<0.05		<0.001		<0.001	
n	44	44	44	44	44	44	44	44	44	44	44	44
lsd[a]	0.02	0.02	0.04	0.04	0.70	0.70	0.68	0.68	0.35	0.35	0.27	0.27
lsd[b]	0.03		0.04		0.72		0.74		0.36		0.27	

[a]least significant difference (P<0.05) within a column. [b]least significant difference (P<0.05) across columns.

Conclusions

Enhanced LVES has limited potential in promoting rapid glycolysis and early rigor onset in all muscles of ruminant carcasses, due to the poor responsiveness of βR muscle fibres in multi-fibre-typed muscles. Likewise, more detailed investigations are needed to eliminate the potential for shortening defects when de-boning early.

References

Bendall J.R. (1975). Cold-contracture and ATP-turnover in the red and white musculature of the pig, post- mortem. Journal of the Science of Food and Agriculture, 26: 55-71.

Chrystall, B.B. and Devine, C.E. (2000). Meat and electrical stimulation. In: Encyclopedia of Food Science and Technology – 2nd edn. (F.J. Francis, ed). John Wiley & Sons, Inc., New York.

Gault, N.F.S., Burns, C., Tolland, E.L.C. and Kilpatrick, D.J. (2000). Effect of some electrical stimulation variables on wing flapping, post-mortem glycolysis and eating quality characteristics of broiler *pectoralis major* muscle. British Poultry Science, 41: 293-299.

Gault, N.F.S., Gordon, A. and Tolland, E.L.C. (2005). Inter-muscular differences in response to low voltage electrical stimulation of lamb. In: Proceedings of the 51st International Congress of Meat Science and Technology, 43.

Genstat 7 Committee. (2003). Genstat 7th edn., Lowes Agricultural Trust. VSL International Ltd.

Koolmees, P.A., Korteknie, F. and Smulders, F.J.M. (1986). Accuracy and utility of sarcomere length assessment by laser diffraction. Food Microstructure, 5: 71-76.

Li, Y., Siebenmorgen, T.J. and Griffis, C.L. (1993). Electrical stimulation in poultry: a review and evaluation. Poultry Science, 72: 7-22.

Monin,G. (1981). Muscle metabolic type and the DFD condition. In: The Problem of Dark-cutting in Beef. (D.E. Hood and P.V. Tarrant, eds.). pp 63-85. Martinus Nijhoff Publishers, The Hague.