E29

The industrial application of calcium chloride injection of beef M. Longissimus Dorsi and M. Semimembranosus

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BACKGROUND

In recent years there has been great interest in the use of calcium chloride injection as a means of more rapid tenderisation of beef. It has been found that pre-rigor infusion of bovine carcasses with calcium chloride (0.3 M, 10% w/v) results in almost complete tenderisation within 1 day *postmortem*, (Wheeler *et al.* 1991, and references therein). The effect of the post-rigor calcium chloride injection was found to be similar to the pre-rigor counterpart. Increased tenderisation resulted by 7 days *postmortem* compared with controls (Wheeler *et al.* 1992).

The mechanism responsible for the observed tenderisation is thought to be due to the activation of the calpains, however the mechanism is still not fully understood. The evidence for calpain activity lies in the fact that accelerated proteolysis of myofibrillar proteins which are degraded by calpains as well as rapid autolysis of calpain resulted on injection with calcium (Koohmaraie 1988). Because of the beneficial effects of calcium chloride on tenderness the feasibility of scaling up the process to industrial level was investigated. Previous workers have used a hand stitch pump with four needles (Wheeler *et al.* 1993) or a bone-in pickle injector (Geesink 1993). A Fomaco industrial poultry injector with forty needles (2mm diameter) for optimum delivery of calcium chloride was used in this work.

OBJECTIVE

To examine the effect of post-rigor calcium chloride injection on *postmortem* tenderisation of M. *Longissimus Dorsi* and M. *Semimembranosus* using an industrial poultry injector.

METHODS

At 24 hr *postmortem* M.*Longissimus Dorsi* (LD) and M. *Semimembranosus* (SM) were excised from the right side of 24 Hereford-X heifers. The LD muscle was removed between the 13th rib and 5th lumbar vertebrate. The muscles were randomly assigned to the three treatments (eight per treatment), i) control (not injected), ii) 0.2 M calcium chloride injection and iii) 0.1 M calcium chloride injection. Muscles were injected 27 hr *postmortem* using a Fomaco 40 needle automatic poultry injector. Muscles were injected once to a level of 11.5% (LD) and 9% (SM). Solutions were 13°C when injected and meat temperature was 8°C. After injection the muscles were allowed drip for 15 min then reweighed to determine final percentage injection. After weighing muscles were vacuum-packed and stored at 4°C until further sampling. At 2, 7, and 14 days *postmortem* (d2, d7 and d14 respectively) the muscles were sampled for pH, sarcomere length, electrophoresis of myofibrillar proteins, shear force determination and sensory analysis.

RESULTS AND DISCUSSION

The pH of the LD and SM muscles were unaffected by injection with calcium chloride ($CaCl_2$) at either level as compared with controls ($p > 0.05$). Sarcomere lengths did not show the extreme contraction found in the pre-rigor case (Geesink 1993) and values of treated samples were similar to controls. The appearance of a 30 kDa peptide fragment early *postmortem* has been associated with calpain induced fragmentation of myofibrillar proteins. The appearance of the 30 kDa band at d2 *postmortem* was variable in the $CaCl_2$ treated samples. By d7 however the $CaCl_2$ treated samples gave, in general, a more intense 30 kDa band than controls with a corresponding loss of desmin suggesting a higher degree of proteolysis.

The effect of the different treatments on tenderness was evidenced by improved taste panel scores and reduced Warner Bratzler shear force (WBS) values. The results are reported on Table 1. The tenderising effect was most pronounced on d7 postmortem with highly significant differences ($p < .001$) between treatments for both muscles, LD and SM. Overall texture and residual chewiness parameters for the sensory analysis profile are significantly better ($p < 0.01$) for LD, d7 *postmortem*. These data are consistent with results of Wheeler et al (1993). They found that sensory tenderness ratings were higher ($p < 0.05$) for LD injected with $CaCl_2$ 24 hr *postmortem*. In the case of mature loin steaks Diles et al (1994) found increased sensory scores for tenderness, juiciness and palatability on d7 and d14 for 0.15 M and 0.2 M $CaCl_2$ injection. Improved sensory scores for d14 LD and SM were recorded but the differences from controls are not significant. Overall flavour was not affected even at the higher concentration of added $CaCl_2$. However some panelists noted a bitter and metallic aftertaste for d2 LD and SM, injected with the higher concentration of salt, but not on later days of ageing.

WBS values are reduced in steaks cooked at 60°C and at 80°C in $CaCl_2$ injected LD as compared with controls on d2 and d7 *postmortem*. By d14 the differences were no longer apparent. WBS values are reduced in SM muscle on all days of ageing in $CaCl_2$ treated samples compared with controls. The differences observed are significant ($p < 0.01$) on d7 *postmortem*. Wheeler (1993) found a significant reduction in shear force ($p < 0.05$) for post-rigor $CaCl_2$ injection of LD and SM. The values for d7 LD (4.2 kg) and d7 SM (4.10 kg) for steaks cooked to 70 °C are intermediate between our results for steaks cooked to 60 and 80 °C.

CONCLUSIONS

The post-rigor injection of calcium chloride on an industrial scale did accelerate tenderisation of M. *Longissimus Dorsi* and M. *Semimembranosus* particularly early *postmortem*. WBS are significantly reduced ($p < 0.01$ in the case of d7 SM) as are sensory analysis tenderness scores ($p < .001$ for d7 LD and SM). The greatest improvement in $CaCl_2$ treated samples occurs between d2 and d7. On extended ageing to d14 the calcium chloride treated samples do not continue to improve to the same extent. WBS and sensory scores are no longer significantly different from controls. It would appear that there is an early beneficial effect of calcium chloride injection resulting in possibly a reduced ageing period. However after 14 days ageing no textural benefit has accrued from the calcium chloride injection and therefore is of no overall value at an industrial level.

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TABLE 1
Means of Warner-Bratzler shear force (kg) and sensory tenderness[d] for two muscles on Day 2, 7 and 14 *postmortem*.

	Longissimus Dorsi					M. Semimembranosus				
	C[a]	0.2[b]	0.1[c]	p	sed	C[a]	0.2[b]	0.1[c]	p	sed
Day 2										
Tenderness[d]	4.14	4.51	4.23	NS	.36	3.29	3.84	3.70	*	.26
WBS 60	3.8	3.29	3.59	NS	.41	4.55	4.19	3.60	NS	.43
WBS 80	8.00	6.48	6.13	NS	.89	9.49	8.24	8.38	NS	.68
Day 7										
Tenderness	5.10	6.20	5.74	***	.24	3.32	4.32	4.21	***	.25
WBS 60	3.03	2.76	2.52	NS	.37	4.00	3.57	3.40	**.	19
WBS 80	5.29	4.42	4.99	NS	.77	6.66	5.79	6.33	NS	.63
Day 14										
Tenderness	5.56	6.03	5.90	NS	.13	4.63	4.93	4.65	NS	.42
WBS 60	2.47	2.69	2.78	NS	.28	3.21	2.79	3.10	NS	.21
WBS 80	4.63	4.52	4.87	NS	.96	4.40	3.60	3.85	NS	.31

[a] C = Control, [b] 0.2 = 0.2 M Calcium chloride injection [c] 0.1 = 0.1 M Calcium chloride injection
[d] 1= extremely tough, 8= extremely tender