EFFECTS OF INJECTION OF CALCIUM AS A LACTATE SALT ON TENDERNESS AND FLAVOUR OF BEEF

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BACKGROUND :

Injection of bovine muscle with calcium chloride solutions have been shown to increase the ageing rate and to improve the final tenderness of meat (Morgan *et al.*, 1991). However, these effects are dependent on the *post-mortem* time of the injection and on the amount of calcium injected. In some conditions undesirable effects were obtained. Indeed, *pre-rigor* injection induces a large contraction of the muscles (Geesink *et al.*, 1994) and gives an off-flavour to the cooked meat (StAngelo *et al.*, 1991). In order to avoid such detrimental effects, Wheeler *et al.* (1993) and Lansdell *et al.* (1995) recommended performing the treatment *post-rigor* and injecting 5% (w/w) of a 0.2M $CaCl_2$ solution. Miller *et al.* (1995) reported that meat treated with these conditions was well accepted by the consumers. However, Morgan *et al.* (1991) found that *post-rigor* injection of calcium could also induce bitterness in cooked meat. Rousset-Akrim *et al.* (1996) observed that bitterness and abnormal flavour appeared after 3 days of ageing and increased during further storage using the same amount of calcium injected as that recommended by Lansdell *et al.* (1995). We postulated that these defects could be due to the association of the cation Ca^{++} and the anion Cl^-, phenomenon known for salty taste as the anion paradox (Ye *et al.*, 1991), and could be avoided by using other calcium salts.

OBJECTIVES :

In order to determine if off-flavour and bitterness induced by calcium injection of meat are related to the type of salt used, injections of calcium lactate have been performed. The effects of the treatment on the flavour as well as on the ageing rate and the final tenderness of meat have been studied.

METHODS :

Animals and muscles. *Longissimus thoracis* and *lumborum* M. from the two half-carcasses of five Friesian cull cows (6 to 8 years old, 290 to 345 kg carcass weights) were excised one hour after slaughter and cut in 2.5 cm-thick slices. *Pre-rigor* injections were immediately performed. All the slices were vacuum-packaged and stored in a 15°C-water bath until day 1. Then *post-rigor* treatments were performed and all the vacuum-packed samples were stored at 4°C until measurements were made.

Treatments. The meat slices were randomly assigned to injections with 10 % (w/w) of a 0.1 M or 0.3 M calcium lactate (CaL) solution (Codex® - Carlo Erba) in the *pre-rigor* (pH ≈ 6.9) or in the *post-rigor* stage (pH ≈ 5.4, at day 1). An eight-needle (0.6 x 25 mm) multi-pipette was used to inject the solution at various and regular locations. Untreated steaks were used as controls.

Determinations. The rate of pH fall was determined at d0. At d1, d2, d6 and d14, the mechanical resistance of raw myofibres (ageing index) was measured according to Lepetit *et al.*, 1986. The sarcomere lengths were measured at d6 using laser diffraction (Cross *et al.*, 1980). Mechanical strength of cooked meat (30 min immersion in a 60°C water bath, Culioli (1994)), drips, cook losses and dry matter contents were determined at d2, d6 and d14. Sensory analysis of meat grilled to a core temperature of 55°C was performed at these same *post-mortem* times.

Statistical analysis. Data were analysed by one way analysis of variance, using the GLM procedure of SAS (SAS 6.07). When significant differences were detected ($p<0.05$), means were compared using the least significant difference method.

RESULTS AND DISCUSSION :

Rate of pH fall. The controls entered *rigor* in approximately 9 hours and reached the ultimate pH in 15 hours. The injection of 0.1M or 0.3M CaL solutions greatly accelerated the rate of pH fall and *rigor* onset occurred in approximately 3 to 4 hours, while the ultimate pH was reached in 6 to 8 hours. No significant influence of the dose of calcium was observed and the ultimate pH was not different from that of the controls.

Table 1 : Sarcomere lengths and myofibrillar resistance.

Samples	Sarcomere lengths (µm)	Myofibrillar resistance* (N/cm^2) d 1	d 2	d 6	d 14
Control	1.96 ± 0.04 [a]	21.04 ± 10.62 [a]	15.42 ± 7.49 [a]	10.09 ± 4.36 [a]	5.61 ± 0.80
CaL 0.1M-*pre-rigor*	1.26 ± 0.11 [b]	6.75 ± 1.96 [b]	6.27 ± 2.08 [b]	4.90 ± 0.73 [b]	4.67 ± 0.87
CaL 0.3M-*pre-rigor*	1.23 ± 0.04 [b]	5.85 ± 2.06 [b]	5.21 ± 1.60 [b]	4.33 ± 0.59 [b]	4.46 ± 0.41
CaL 0.1M-*post-rigor*	1.95 ± 0.05 [a]	14.14 ± 5.93 [ab]	9.44 ± 4.45 [ab]	5.90 ± 2.04 [b]	5.63 ± 1.36
CaL 0.3M-*post-rigor*	1.93 ± 0.03 [a]	14.41 ± 6.23 [ab]	8.69 ± 5.70 [ab]	5.25 ± 1.07 [b]	4.64 ± 0.82

* Stress (N/cm^2) in compression at a 20% strain. Data in the same column with the same superscript do not significantly differ ($p<0.05$). The shaded region indicates samples statistically differing from control.

Ageing kinetics (Table 1). Calcium injections in the *pre-rigor* period markedly decreased the resistance of raw myofibres at d1. After d1, for both doses of calcium, myofibre resistance did not change significantly. *Post-rigor* injections also decreased the resistance of myofibres at d1, but to a lesser extent; however, ageing proceeded so that at d6 the resistance of raw myofibres was similar to *pre-rigor* injected samples. For aged meat (d14), no significant difference was noted between the controls and the treated samples.

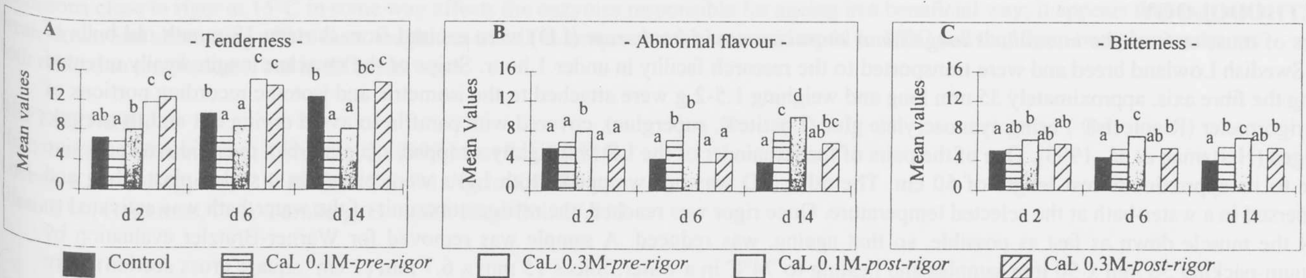
Table 2 : Mechanical strength of cooked meat.

Samples	Mechanical strength of cooked meat* (N/cm²)		
	d 2	d 6	d 14
Control	205.0 ± 75.9 a	178.1 ± 46.5 a	124.4 ± 35.1 b
CaL 0.1M-*pre-rigor*	155.2 ± 39.6 b	151.8 ± 36.4 b	143.6 ± 38.1 a
CaL 0.1M-*post-rigor*	152.5 ± 41.6 b	102.0 ± 11.4 c	91.1 ± 11.2 b

* Stress (N/cm^2) in compression at a 80% strain.
Data in the same column with the same superscript do not differ significantly ($p<0.05$). The shaded region indicates samples statistically differing from control.

Sarcomere lengths (Table 1). The controls and the *post-rigor* CaL-treated samples exhibited normal sarcomere lengths (1.93 to 1.96 μm). *Pre-rigor* treated samples exhibited significantly shorter sarcomeres (1.23 μm ± 0.04 μm and 1.26 μm ± 0.11 μm for 0.3M and 0.1M CaL injections, respectively). Moreover, two populations of sarcomeres were often observed in the *pre-rigor* treated samples, especially for the lower dose (0.1M) of calcium: 75% of the sarcomeres were contracted (≈ 1.2 μm), and 25% were only slightly shortened (≈ 1.73 μm).

Mechanical strength of cooked meat (Table 2). Mechanical strength was determined only for the 0.1M CaL injections. The strength of the control markedly decreased during ageing, from 205 to 124 N/cm^2. CaL injection induced a large decrease in the strength at d2 for both injection times. However, while no further change was observed for *pre-rigor* treated samples, *post-rigor* treated ones continued to age. At d14, *pre-rigor* injected meat was significantly tougher, whereas *post-rigor* injected meat tended to be more tender than the controls.



Means with the same letters are not significantly different ($p<0.05$).

Figure 1 : Sensory analysis.

Sensory analysis (Figure 1). *Pre-rigor* treatment did not modify the perception of tenderness at day 2, whereas it lead to tougher meat at day 6 and especially at day 14. Also, abnormal flavour and bitterness were detected from d2 and d6 for samples injected with 0.3M and 0.1M CaL, respectively; these defects increased during ageing and were dependent on the dose of calcium injected. *Post-rigor* treated meat was perceived more tender than the control from day 2 until day 14; however, the difference in tenderness at day 14 was significant only for the higher dose of calcium (0.3M). Defects in flavour were detected only for the higher dose of calcium and only after ageing.

Total (drip + cook) losses and losses in dry matter. *Pre-rigor* CaL-injected samples exhibited higher total losses and losses in dry matter than the controls (37% versus 26% and 3.6% versus 2.1% at day 14, respectively). *Post-rigor* treated samples also exhibited higher total losses than the controls (31% versus 26%, at day 14). They also showed a slight increase in losses in dry matter which were, however, quite similar to those of the controls (2.5% versus 2.1% at d14).

CONCLUSIONS :

***Pre-rigor* injections** of calcium lactate induced effects similar to those obtained with calcium chloride. Severe contraction, toughening after ageing, high losses, abnormal flavour and bitterness make this treatment inapplicable for meat consumption.

***Post-rigor* injections** of calcium lactate increased the rate of meat ageing. Final tenderness after 14 days could be still improved for the higher dose of CaL used (0.3M, 10% w/w). Although some abnormal flavour and bitterness could be detected after ageing, these effects were much less pronounced than those observed with the chloride salt of calcium (Rousset-Akrim *et al.*, 1996). Even non significant effects on flavour could be noted for the lower dose of CaL used (0.1M ; 10% w/w). Thus, calcium lactate appeared to be more appropriate than calcium chloride as it did increase meat ageing rate without inducing any major flavour problems.

LITERATURE :

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