EFFECT OF *RIGOR* TEMPERATURE AND SHORTENING ON MEAT TENDERNESS OF LAMB

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INTRODUCTION

Shortened meat is tough (Locker and Hagyard 1963, Hertzman et al. 1993), but the extent of shortening in practical situations is not monitored or even known. For example, it is not known by how much shortening post excision contributes to toughness in hot boned meat, whether such shortening is affecting tenderness or whether there is an ideal time to remove meat from a carcass without shortening induced toughness.

In beef, meat tenderness is affected by the amount of shortening (Tornberg 1996) as well as the temperature of *rigor mortis* (Devine et al. 1999) and it was shown that the calpains responsible for tenderisation were significantly reduced when the *rigor* temperature was greater than 15°C (Simmons, 1996). This situation has not been explored in lamb, where there is a process termed accelerated conditioning and ageing (AC & A) that involves electrical stimulation and holding above 6°C. *Rigor* occurs under such circumstances in under 3 hours when the meat is likely to be above 15°C unless the chilling is extremely rapid. The AC & A process does produce tender meat, but it is not known whether the tenderness could be better. We have explored the situation using two *rigor* temperatures (15°C and 35°C), and prevented shortening by tightly wrapping the meat in a polyethylene cling film in one instance to prevent shortening and leaving the meat unwrapped in the other instance where the meat is free to shorten.

The tension that produces shortening in unrestrained meat was monitored, using an isometric force transducer, at the two temperatures using the same muscle as for the tenderness experiment.

METHODOLOGY

A total of 12 sheep were killed, slaughtered at different times several days apart in an experimental processing facility, in an identical way. The sheep were captive bolt stunned and then electrically stimulated at 30 min post stun (1100 V peak, 14.28 alternating sine wave pulses per second for 90 seconds at 2.0 A peak per carcass).

The *m longissimus thoracicus et lumborum* (LT) from the right side was removed and tightly wrapped in a cling polyethylene film and the LT of the opposite side was left unwrapped. In one set of muscles, the wrapped and unwrapped muscle was held at 15°C and for the other set of muscles, the wrapped and unwrapped muscle was held at 35°C in a water bath. The sample at 35°C, immediately upon attaining *rigor*, was chilled to 15°C as rapidly as possible by immersion in water at 0°C. All meat samples were aged at 15°. Portions of the LT were removed and frozen at appropriate intervals (Fig. 2) with the first sample regarded as zero ageing.

Small pieces of LT (20mm long, 0.8g) obtained from muscles after stimulation, were glued to discs with superglue and these were attached to force transducers in a temperature controlled organ bath (Myobath-4, World Precision Instruments Inc, Sarasota, USA) to measure isometric tension. The meat pieces were submerged in paraffin to exclude oxygen and maintained at either 15°C or 35°C.

RESULTS AND DISCUSSION.

The tension recordings for the lamb LT as it entered *rigor* mortis for each of the two temperatures are shown in figure 1 and are similar to those for beef LD (Devine et al. 1999). The rise in tension is faster than for beef and this is consistent with the acceleration of glycolysis due to electrical stimulation. The tension recorded for 35°C is approximately four times that for 15°C. The tension is

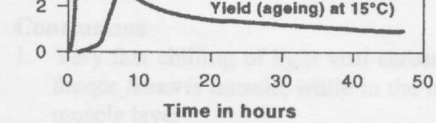

Figure 1. Isometric tension traces from muscles held at 35°C and 15°C obtained from stimulated lamb LT.

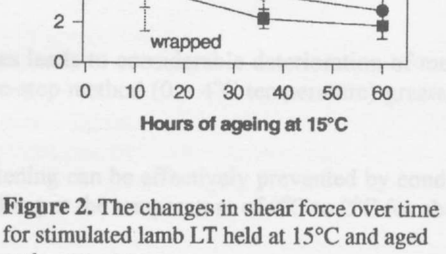

Figure 2. The changes in shear force over time for stimulated lamb LT held at 15°C and aged at the same temperature

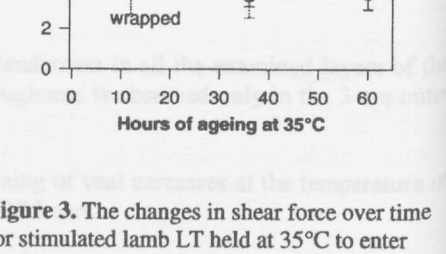

Figure 3. The changes in shear force over time for stimulated lamb LT held at 35°C to enter *rigor* mortis and aged at 15°C

generated from the moment the muscle strips are placed in the bath indicating the ability to shorten exists right up until the meat enters *rigor* mortis. For logistical reasons, the meat that went into *rigor* at 35°C was aged at that temperature in the Myobath-4 and the tension decline corresponds to the meat ageing. The yield corresponding to ageing rate at 35°C was much faster than that at 15°C – partly this was due to the higher peak tension as well as the increased ageing rate at 35°C.

For the intact LT used to determine changes in shear force, the mean initial values just after *rigor* entry for both wrapped an unwrapped lamb LT held at 15°C was 8.38±2.43 kgF for wrapped and 8.65±2.35 kgF for unwrapped muscle. The mean initial shear force just after *rigor* entry for both wrapped an unwrapped lamb LT held at 35°C was 9.8±1.6 kgF for wrapped and 11.8±3.02 kgF for unwrapped muscle. These shear force values are lower than 15 kgF when ageing was inhibited (Devine and Graafhuis, 1994). In the present experiments, the lower shear force values probably occurred as it was difficult to precisely define the moment of *rigor* entry and some muscle fibres will be tenderising while others have not yet reached *rigor*.

At 15°C, there is no significant difference between unwrapped and wrapped meat and the close agreement is maintained as the meat becomes more tender as it ages over the 60 hours to a final shear force value of 2 kgF. However, the difference between unwrapped and wrapped meat at 35°C is maintained for 48 hours when the shear force for the wrapped meat reaches its final tenderness values. At 60 hours the unwrapped meat catches up and the shear force values are similar at 3.7 kgF.

The Myobath-4 experiments show that muscle tension is generated right up until *rigor mortis*. Using the same experimental situation in preliminary studies, we found that the peak *rigor* tension generated is similar whether the meat is electrically stimulated or not (if one takes onto account the delays before the sample recording starts). This means that while we take care to avoid cold shortening, *rigor* shortening still is significant. Electrical stimulation merely avoids cold shortening through hastening *rigor* mortis and it accelerates processing (thus delivering meat to the customer earlier), allows faster ageing (as *rigor* occurs at a higher temperature).

Conclusion

- The experiments show that the force generated during *rigor* mortis for lamb LT is much greater at 35°C than 15°C.
- When *rigor* took place at 15°C, there is little difference in the final tenderness and of the time course of tenderisation for wrapped and unwrapped meat.
- When *rigor* took place at 35°C, not only does the wrapped meat have a slightly increased initial shear force value than 15°C, but the meat that is unwrapped and allowed to shorten has an even higher shear force value.
- The meat that entered *rigor* at 15 and 35°C and held at 15°C eventually aged to the same degree of tenderness. This is a significantly different situation to that in beef where meat entering *rigor* mortis at temperatures above 15°C has a significantly decreased potential to age and be tender. This can be interpreted as being due to the fact that enzyme degradation that occurs in beef after *rigor* at elevated temperatures is greater than that in lamb.
- As the meat in this study, was electrically stimulated, it is clear that electrical stimulation does not prevent *rigor* shortening at any temperature, but its advantage still remains in that cold shortening is avoided, especially in *prerigor* hot boning situations. If *rigor* temperatures are 15°C, the tenderness approaches that for cold boning situations.

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