Mechanism of Tenderness Improvement in Tenderstretched Beef Carcases

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Background

Suspension of beef carcases by the pelvic girdle (tenderstretching) is an alternative method of carcase hanging, which prevents the shortening of some commercially important muscles during rigor. A number of studies have demonstrated increased sarcomere length in raw muscle, and increased cooked meat tenderness, for many muscles from tenderstetched carcases. The mechanism of tenderness improvement observed is thought to result from effects on both the myofibrils and the connective tissue (Hostetler et al, 1970, 1973; Bouton et al, 1973 and Jeremiah et al, 1984). Sarcomere length is increased, reducing the overlap between actin and myosin, but the interpretation of the texture of cooked meat from observations made on the raw muscle structure is difficult (discussed by Zamora et al, 1998). Mechanisms other than structural changes maybe involved in improvement of tenderness. For example, stretching of living soleus rat muscle results in an elevation of $[Ca^{2+}]$ by influx from the extracellular space (Armstrong et al, 1993). As free$[Ca^{2+}]$ rises, hypercontraction and Z-line breakdown, by proteases that require millimolar concentrations of Ca^{2+}, can occur (Wrogemann et al, 1979).

Objective

The experiment described here was done as part of studies of to determine the mechanism of tenderisation resulting from tenderstretching beef carcases.

Methods

Cattle and carcases. Seventeen Angus steers were processed at 12-14 months of age. After about 45 minutes, the left-hand side was tenderstretched (suspended from the pelvis), and the right hand side was conventionally hung (Achilles tendon). The sides were chilled overnight at 0-2°C. The striploin (M.longissimus thoracis et lumborum) was removed from each side after chilling for 24 hours and six 20-mm thick steaks cut from each. The remainder of each striploin was divided into three and each third randomly assigned to one of the three ageing periods, 1, 7 or 14days. Samples were aged at 1°C and then stored at -20°C until required. *Objective Measurements.* Temperature and pH decline in the muscle were monitored for 12 h postmortem. Objective measurements of tenderness and cooking loss were made as described by Rymill et al. (1997). Calpain I and II and calpastatin activities were determined as described by McDonagh and Oddy (1997). Sarcomere length was measured on the samples aged for one day using the laser diffraction technique described by Bouton et al. (1973). *Sensory measurements.* Steaks were thawed for 24 hours at 3°C and cooked at 180°C for 3.5 minutes using an electric clam griller (to a medium-rare degree of doneness). Four 1.5cm ^{3} samples from each steak were evaluated by a trained taste panel. An incomplete block design was used, with 10-12 tasters over 12 sessions. Tenderness and juiciness were scored on a 0-100 scale, where 0 was extremely tough and dry and 100 was extremely tender and juicy. *Data analysis.* Temperature and pH decline were modelled to obtain a rate constant for each measure as a function of time. The effect of hanging treatment on these rates, on sarcomere length and protease activity was tested in a mixed model which included treatment as a fixed effect, and animal as a random effect. The effects of hanging treatment and ageing duration on objective measures of tenderness and cooking loss were tested in a mixed model with hanging treatment, ageing and hanging treatment x ageing included, and animal as a random effect. For subjective assessment of tenderness and juiciness by trained taste panel, the above model was used with order of tasting added as a fixed effect, and taster and steak (within animal) included as random effects.

Results and Discussion

Both objective and sensory evaluation showed that tenderness was improved ($P<0.05$) in tenderstretch carcases at all ageing times. Tenderness of tenderstretch product after one day ageing was equivalent to that of conventional product after 14 days ageing. There was a significant treatment by ageing interaction ($P<0.05$) for both objective and sensory tenderness measurements (Figures 1 & 2).

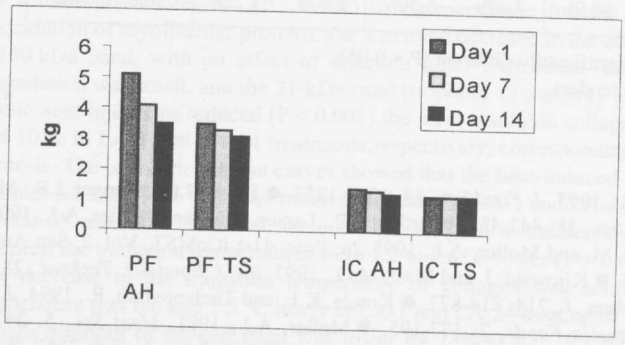

Figure 1. Mean Warner Bratzler peak force (PF) and compression (IC) values for Achilles hung (AH) and tenderstretch (TS) samples after 1, 7 and 14 days ageing

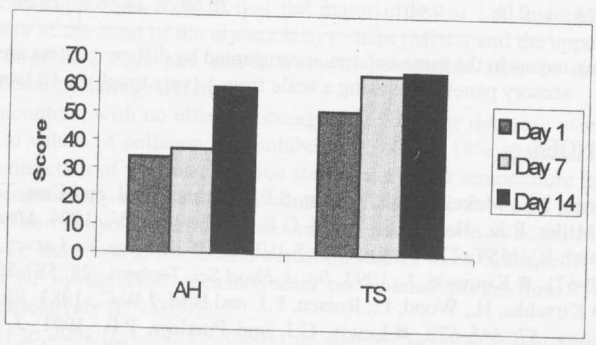

Figure 2. Mean tenderness scores for Achilles hung (AH) and tenderstretch (TS) samples after 1,7 and 14 days ageing

As determined by the objective measurements, very little ageing response was found for tenderstretch carcases, whereas for Achilles hung carcases, both peak force and compression values improved as the duration of ageing increased. The sensory panel results also showed a greater ageing response in conventionally hung carcases and, after 14 days ageing, this resulted in a similar level of tenderness as that of tenderstretched product. This data suggests that some ageing is beneficial for tenderstretch product.
Tenderstretch resulted in significantly greater sarcomere length (2.95 v. 1.93 ± 0.03 um, P<0.001)). Tenderstretched product also had 1% less cooking loss than did conventional product (20.61 v 19.57% ± 0.26, P<0.01). Calpain I and calpain II activities, measured one day post mortem, were not significantly different for the two treatments, but calpastatin activity was significantly higher in tenderstretch product (Table 1).

Table 1. Least square means (± se) for calpain/calpastatin activities one day post mortem.

Treatment	Calpain I (units/g muscle)	Calpain II (units/g muscle)	Calpastatin (units/g muscle)
Achilles hung	0.402 ± 0.078	2.233 ± 0.099	2.070 ± 0.184
Tenderstretch	0.554 ± 0.078	2.282 ± 0.099	2.439 ± 0.184
Treatment effect	NS	NS	P<0.05

These results suggest that there should be more protease-based ageing in conventional product and this was the case. If tenderstretching resulted in increased release of free Ca^{2+} from the sarcoplasmic reticulum, then this was not reflected in greater ageing during the period from 1-14 days. The lack of response to ageing in stretched muscle could also be due to the possibility that the effect of protease activity is simply less apparent in stretched muscle. In other words, the reduction in shear force resulting from the degradation of cytoskeletal proteins is minimal compared to that resulting from the reduction in the interaction between actin and myosin.
Both temperature and pH fell significantly (P<0.05) faster in tenderstretch carcases (data not shown). The temperature effect may have resulted from the stretching and hence thinning of the fat layer over the muscle. Interestingly, a faster rate of temperature fall would be expected to result in a slower rate of pH fall whereas the opposite actually occurred.
These results suggest that the physical treatment, tenderstretching, has altered the environment in the myofibre affecting the rates of certain biochemical activities. Additional studies of biochemical events in tenderstretched product are needed.

Conclusion
The impact of proteolysis in stretched muscle is substantially lower than that observed in muscle from conventionally hung carcases. The increased tenderness of beef from tenderstretched carcase does not result from proteolysis caused by the calpain enzyme system during an ageing period from 1-14 days post mortem.

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