THE EFFECT OF PELVIC SUSPENSION ON SHEAR FORCE VALUES IN VARIOUS BEEF MUSCLES

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SUMMARY

Left and right carcass sides from 6 steers were either suspended from the pelvis or the Achilles tendon and slowly chilled from ca. 45 min until 2 d p.m. Between 12 and 16 d p.m. one muscle per day (from 6 animals) was sampled for determination of shear force, cooking loss and sarcomere length.
Pelvic suspension significantly increased sarcomere length of the 5 muscles studied, to a certain extent in function of their anatomical position. Changes in sarcomere length were not necessarily related to changes in shear force. A positive effect was observed in LO whereas SM, GM and ST muscles exhibited negligible changes. A significant adverse effect was noticed in the GB muscle. Cooking loss was significantly decreased by pelvic suspension for LO muscle, for other muscles no significant effect (GB, ST) or a slight negative effect (SM, GM) was observed.
The absence of tenderisation (particulary unexpected in the hindquarter muscles) suggests that the degree of tenderstretch through pelvic suspension may have an optimum and stresses that tenderness is not necessarily positively correlated with sarcomere length.

Introduction

Before and during the onset of rigor mortis muscle contraction or shortening occurs, resulting in tougher meat (Locker, 1960). Conventional suspension of carcasses from the Achilles tendon results in shortening of many muscles of the back and the hind limb. Prevention of shortening of muscles fibers during the onset of rigor allows improvement of meat tenderness (Locker, 1960; Herring et al., 1965).
After suspending beef carcasses by various methods, Hostetler et al., (1972) found that suspension of the carcasses from the obturator foramen (pelvic suspension) is a practical method to reduce muscle shortening during the onset of rigor mortis, thus significantly increasing post rigor sarcomere lengths and decreasing shear force values of certain muscles. The relationship between tenderness and sarcomere length of shortened or stretched beef muscles has been shown to be curvilinear (Herring et al., 1967). At sarcomere lengths up to 2.0 μm the relationship between shear force and sarcomere length is linear, whilst at lengths between 2.0 μm and 3.2 μm little change in shear force is observed when sarcomere length increases. Observations of Bouton et al., (1973) on sheep muscles confirmed that myofibrillar toughness is virtually independent of degree of muscle contraction for muscles with sarcomere lengths greater than 1.8 μm. Two peaks of toughness were found by Marsh and Carse (1974), a major one in beef sternomandibularis muscle strips, (cold) shortened about 35% and a minor one at about 25-30% muscle extension.
Apparently, the relationship between shear force and sarcomere length is complex. This means that caution is necessary when, for industrial purposes, pelvic suspension of beef carcasses is applied in an attempt to improve tenderness of commercially important muscles.
The work reported here was done to determine to what extent pelvic suspension of beef carcasses in industrial practice would affect meat tenderness of various muscles and if the results were affected by extended storage.

Material and methods

Six 18 month old steers of several breeds (Simmental, Charolais, Limousin) with a carcass weight ranging between 350-400 kg were slaughtered at a commercial slaughter plant. Electrical stimulation (90V peak D.C.) was applied twice, viz. on the whole carcass immediately after sticking (20 sec) and after splitting of the carcass (14 sec). Left and right carcass sides were suspended either from the pelvis (hook inserted through the

obturator foramen with the limbs hanging free) or the Achilles tendon ca. 45 min post mortem and were slowly chilled (4.5°C, air velocity 0.3 ms^{-1}) until 2 d p.m.

pH was measured in the *M. longissimus*. Carcasses were selected on the basis of the average pH ranging between 6.4- 6.5 at 45 min p.m.; between 5.9- 6.1 at 3 h p.m. and between 5.4- 5.8 at 24 h p.m.

At 2 days p.m. *Mm. semimembranosus* (SM), *gluteus medius* (GM), *longissimus* (LO), *gluteobiceps* (GB) and *semitendinosus* (ST) were excised, vacuum packaged and stored in a cold room at 2°C until 12 d p.m. Between 12 and 16 d p.m. one muscle per day from each carcass side (day 12 SM, day 13 GM etc.) was sampled for determination of shear force, cooking loss and sarcomere length.

Shear force: Warner Bratzler shear force was assessed on samples heated in polyethylene bags in a waterbath for about 50 min at 75°C (to a core temperature of 70°C) whereafter these were chilled in running tap water for 40 min (Boccard et al., 1981). Cooking loss was determined by weighing samples before and after heating. Rectangular samples of 1 cm^2 cross section were cut from the cooked samples, parallel to the muscle fibre direction. Shear force was measured using a draw bench (Adamel Lhomargy, Division d'Instruments S.A. Paris, France) equipped with a Warner Bratzler shearing device.

Sarcomere length (S.L.): Sarcomere length was determined by laser diffraction according to Koolmees et al. (1986).

Statistical analysis: Significance of difference was tested using Student t-test (paired comparison was appropriate).

Results and Discussion

In Table 1 the effect of pelvic or Achilles tendon suspension on sarcomere length is presented. Pelvic suspension resulted in a significant increase in sarcomere length of all five muscles. As expected, the efficacy of pelvic suspension in stretching the muscles depended on their anatomical position. When suspended from the Achilles tendon the SM, GM, LO and GM shortened (S.L. 1.66, 1.75, 1.69 and 1.75 µm, respectively), whereas shortening in the ST was prevented (S.L. 2.06 µm). These results are in agreement with previous reports of Bouton et al., (1973, 1974), Hostetler et al., (1970, 1975) and Shorthose and Harris (1990).

Changes in sarcomere length did not produce proportional changes in tenderness. Whilst in LO and ST muscles pelvic suspension produced similar increases in sarcomere length (LO: 0.6 µm and ST 0.7 µm), only tenderness of LO improved significantly (Table 2). The largest increase (1.3 µm) obtained in GB muscles was not accompanied by the greatest increase in tenderness. On the contrary, pelvic suspension had a significant negative effect on tenderness. In SM and GM muscles we did not observe a tenderizing effect of pelvic suspension, in contrast with findings of Joseph and Connolly (1977) who reported significant tenderness improvement, persisting up to fourteen days of ageing.

It is known that muscle shortening below rest length results in toughening while stretching of the sarcomere beyond rest length may result in little or no change in tenderness (Hostetler et al., 1970; Marsh and Carse, 1974).

The increase in sarcomere length observed in the present experiment is larger than reported by others, especially for SM and GM muscles (Joseph and Connolly, 1977; Bouton et al., 1973; Hostetler et al., 1975). Possibly in this experiment, pelvic suspension stretched muscles around 25-30% where significant tenderising is not observed (Marsh and Carse, 1974 Their Figure 1); this seems to be the case especially in muscles with a high connective tissue strength (Figure 1).

It has been reported that stretched muscles have an improved moisture retention which results in significantly lower cooking losses than in contracted muscles of the same fiber length (Bouton et al., 1976). In our experiment, pelvic suspension reduced cooking losses only in LO muscles (Table 3). In stretched muscles, exhibiting increased shear force values (GB, SM and GM) cooking losses were higher than Achilles tendon suspension, possibly because these muscles were subjected to higher connective tissue shrinkage during cooking.

Conclusions

Pelvic suspension effectively stretched all muscles examined. The fact that the relationship between increased sarcomere length and changes in tenderness was not linear suggests that tenderness is not necessarily positively correlated with sarcomere length and that pelvic suspension might have an optimum. It is possible that tender-stretching to rest length (2.1- 2.3 µ) should be pursued. This observation deserves further investigation.

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