THE ROLE OF COLLAGEN IN MEAT TOUGHNESS ; AN ASSESSMENT OF THE INFLUENCE OF METABOLIC AGE.

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Background.

From the consumers viewpoint texture is the most important parameter for the eating quality of meat (Dransfield et al 1984). Although collagen is a minor component of muscle when compared to the myofibrillar proteins, intramuscular connective tissue (IMCT) is generally accepted as being the major source of consumer perceived toughness in meat, provided care has been taken to avoid the well documented pitfalls likely to cause myofibrillar compaction and consequent toughening due to cold shortening. (Locker 1960) However despite efforts by this laboratory and others only weakly positive correlations have been demonstrated between one or more of the biochemical characteristics of IMCT and either the perceived or measured toughness of meat. (Bailey 1988)
It has been understood for many years that different breeds within a meat animal species develop at different rates to achieve different mature animal sizes. Similarly it is generally accepted that the female gender of meat animal species do not achieve as great a mature size as the male although their initial growth is at least equal to that of the male. The IMCT from muscles of animals with disparate mature body sizes may differ appreciably, for example, IMCT from a rapidly maturing breed may demonstrate a greater degree of collagen maturation than that from a slower maturing breed at any single chronological time point during normal growth. This is especially important as "meat animal" size is achieved appreciably before mature animal size and the former may represent a different proportion of mature age in a rapidly maturing breed compared to a slower maturing breed.
Brody (1945) proposed using metabolic body size to convey proportionality to the study of beasts of different mature sizes and Taylor (1965) introduced the concept of metabolic age to relate maturing time (in days from conception) to mature animal size. Webster (1989) combined these two concepts to provide size-independent indices of growth between species and across genera i.e. metabolic age $\theta = t.M_a^{-0.25}$, where Ma is the mature animal weight and t is the chronological age from conception in days.

Objective.

It was our aim to investigate ; (a) the crosslinking characteristics of the IMCT of a single muscle derived from both genders of several bovine, meat animal breeds with different mature sizes using the above formula to standardise the data. (b) To relate the resulting data to sensory-panel perceived textural assessments of that same muscle.

Methods.

Animal selection. The maternal breed of all the animals in this survey was Friesian. Between 12 and 14 animals, unequally divided between genders, were obtained from 5 pedigree sire breeds, Piedmontese, Charolais, Hereford, Limousin and Belgium Blue. These animals were humanely slaughtered under carefully controlled and monitored conditions upon reaching normal "meat animal" size for the sires breed, in practice between 422 and 791 days of chronological age. After controlled carcass chilling and conditioning procedures the sirloin muscle (longissimus thoracis) was removed and blast-frozen to -20°C and then stored at that temperature until required for cooking, prior to sensory panel assessment, and biochemical analysis.

Organoleptic assessment. Meat and Livestock Commission (MLC) sensory panellists were asked to score samples of steak after cooking according to 4 criteria; initial and sustained juiciness, tenderness and residual connective tissue using a range from 1 - 8 where 8 was most succulent, most tender or had most residual connective tissue.

Biochemical analyses. Muscle samples were extracted, prior to collagen cross-link analyses, to remove the bulk of the myofibrillar proteins according to the method of Avery and Bailey (1995). The purified IMCT was reduced with sodium borohydride, acid hydrolysed and then pre-fractionated using CF-1 cellulose fibre prior to modified amino acid analysis of the mature and intermediate crosslinks according to the method of Sims and Bailey (1992).

Results.

Figure 1 demonstrates the excellent correlation between increased tenderness associated with decreased residual connective tissue (RCT), both assessed by the MLC sensory panel. Interestingly, it also shows that samples derived from heifers are consistently more tough than those from steers, even for an identical RCT value. This strongly suggests a difference in the quality of the IMCT from each source.
Figure 2 demonstrates precisely this difference in IMCT quality between genders suggested by figure 1. In the case of steers the increased RCT is associated with increased IMCT intermediate crosslinking (increasing ratio) whilst that of the heifers is associated with increased IMCT mature crosslinking (decreasing ratio).
Figure 3 is characteristic of the correlations obtained by this laboratory and others of the relationship between a single mature crosslink, pyridinoline in this case, and increasing chronological age whilst figure 4 demonstrates (a) the greater metabolic maturity of the heifer group, despite their obviously being age matched and (b) the trend in the heifer group alone towards increased crosslink maturation.

Discussion

These results demonstrate that the phase of an animals development can profoundly influence both the proportion of residual connective tissue, and the cross-link profile of IMCT. Over the period of this experiment, 422 - 791 days, the trend of both genders was towards increased tenderness and reduced RCT. This may not be surprising as the animals were "finishing", in production terminology. Calculating metabolic age serves to accentuate the observed differences in IMCT between the genders but does not indicate a fundamental difference in collagen biochemistry between them, merely that within these breeds the females mature faster.

Unfortunately metabolic age did not provide the hoped for means of smoothing the data towards linearity. This also may not be surprising as the pre-requisites of crosslink maturation are not understood and may themselves not be of a linear order, unlike indices such as weight gain upon which data the formula was developed.
It is unfortunate that none of these breeds are especially rapid developers and that the numbers within each group remained too small for meaningful differentiation between genders within each breed. However using metabolic age in preference to chronological age has provided an insight into the differences that exist in IMCT biochemistry between genders across all breeds with the likelihood that it remains true within breeds. Future studies of changes to IMCT with time should beware of how mature animal size and the gender of the study animals will influence the experimental outcome.

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Fig. 1

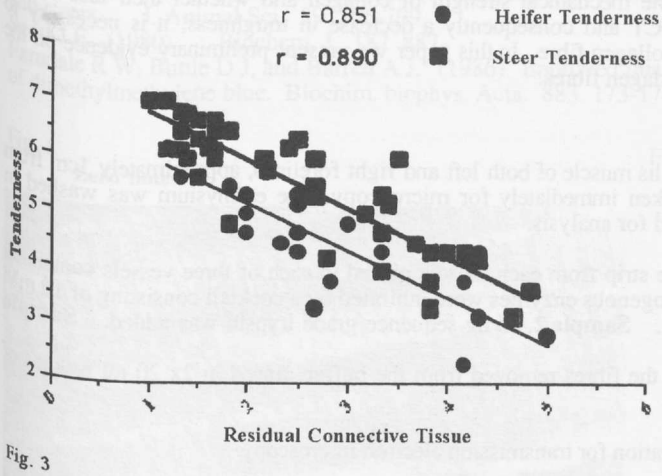

Fig. 2

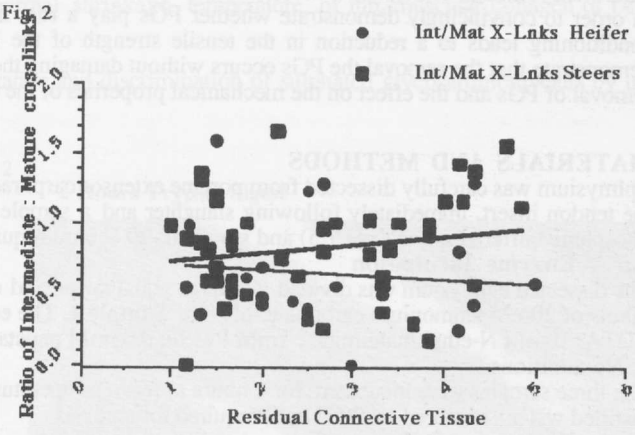

Fig. 3

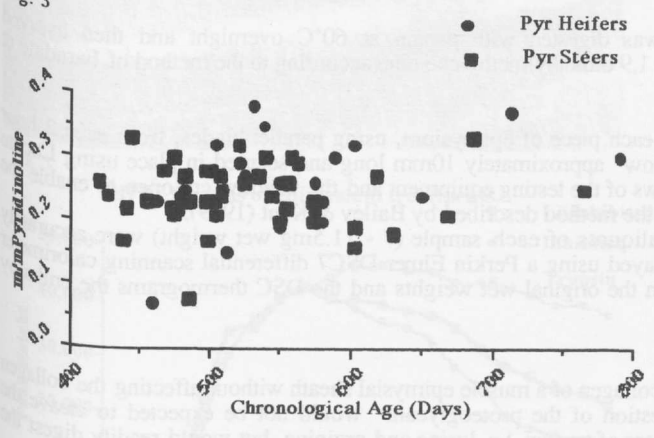

Fig. 4