EFFECTS OF COLLAGEN CHARACTERISTICS ON SENSORY ASSESSMENT AND SHEAR VALUES OF COOKED SHEEP *SEMIMEMBRANOSUS* MUSCLES

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SUMMARY

ncentration and heat-dependent solubility of collagen were measured in *semimembranosus* muscles of 36 sheep aged up to 5 years. gen concentration was unaffected by age, but solubility decreased with age from about 16 to 5%. Collagen from a subsample was ed for pyridinoline concentration, which ranged from about 0.30 to 0.55 mole per mole of collagen and was inversely related to gen solubility. These pyridinoline concentrations are higher than reported for other species or muscles, and might be responsible for gh thermal transition temperatures of collagen previously noted in this ovine muscle.

o assess the relative importance of collagen concentration and solubility on tenderness and texture, *semimembranosus* muscles were ed in boiling water to an endpoint of 75°C before sensory panel assessment and Warner-Bratzler shear tests. The panel data showed gen concentration was the more important determinant of eating quality, while the shear data were better correlated with solubility. In of the relative insolubility of collagen in this muscle, we propose that solubility hardly matters in textural perception when this muscle en quickly cooked. Collagen concentration is more important.

INTRODUCTION

llagen component of connective tissue is responsible for the so-called background toughness in meat that is not affected by pre- and iate post-slaughter handling techniques (BAILEY, 1972; LIGHT, 1986). Muscles with a high concentration of collagen tend to be er (DRANSFIELD, 1977; LIGHT et al., 1985). However, other properties of collagen are thought to be at least as important in the ess and texture component of eating quality (LIGHT et al., 1985). Most attention has been directed at the effect of collagen nking that occurs as animals become older. As crosslinking increases, the heat-dependent solubility of the collagen decreases and f the perimysial collagen remains as a resistant framework in cooked meat (BAILEY & LIGHT, 1989).

simple solubility test (HILL, 1966) is a useful indicator of heat-stable crosslinks. The present work uses this test for sheep *mbranosus* muscle. At the same time, the concentration of the crosslinking amino acid, pyridinoline (FUJIMOTO, 1977), is also ed as an indicator of collagen solubility. Finally, collagen solubility and concentration are related to sensory and shear tests.

MATERIALS AND METHODS

e of **semimembranosus** *muscles*

ix sheep were chosen, of any sex condition and a wide range of ages, as judged by dentition. After conventional slaughter, the d carcasses were hung anally so the posterior muscles of the hind leg could not passively shorten. After 24 hours at 15°C, the left and *emimembranosus* muscles were removed, frozen and stored at -35°C. Right side muscles were used for sensory evaluation and shear nd the left for chemical analyses.

ry evaluation and shear tests

uscles were compared four at a time, nine times in all. Thawed muscles were placed unrestrained in thick plastic bags, which were ed and immersed in a 100°C waterbath until the muscle internal temperature reached 75°C. This took about 21 min. The cooked es were cooled by plunging the bags into ice.

or shear tests, the central cross-sectional third was cut from the torpedo-shaped muscles. This piece was cut so that 1 cm x 1 cm test ould be sheared either parallel or perpendicular to the grain. The Warner-Bratzler peak shear force (kg) was recorded on an Instron

or sensory evaluation, the remaining 2/3 of the muscles was used. The meat was cut at right angles to the grain into slices 4 mm The slices were heated by microwaves before presentation to a skilled 12-member sensory panel. Assessments for tenderness and

texture were on scales of 1 to 9 where 9 meant extremely tender or highly acceptable texture and 1 meant extremely tough or texture wa
disliked intensely.

Analyses for collagen, protein and pH

The left side *semimembranosus* muscles were tempered and diced, and a representative fraction was homogenized. Samples (3 g) we analysed for collagen solubility and concentration (HILL, 1966; BERGMAN & LOXLEY, 1963). Acid hydrolysis (6M HCl) was for 16 of reflux at 120°C. Protein was determined from Kjeldahl nitrogen (AOAC, 1990). pH was measured after dispersing 1 g sampl homogenates in 10 ml of 5 mM Na iodoacetate, pH 7.0.

Pyridinoline analysis

Attempts to measure pyridinoline directly in hydrolysed whole meat homogenates failed because of high background fluorescence Therefore, connective tissue was isolated from diced meat (of 16 muscles) by a wet extraction method (HORGAN et al., 1991). Th technique resulted in a 50-fold enrichment over the collagen concentration of the whole muscle. Pyridinoline was determine fluorometrically by the chromatographic method of SMITH & JUDGE (1991).

RESULTS AND DISCUSSION

Effect of age on semimembranosus *collagen*

Collagen concentration ranged from 0.36 to 0.78% of wet weight, with a mean of 0.58, which is comparable to published values for th muscle (CROSS et al., 1972; AALHUS et al., 1991). Collagen concentration was unrelated to age (r = 0.18, insignificant). The solubilit ranged between 16.9 to 4.05% and declined steadily with age (Fig. 1).

This age effect on solubility was expected and confirms the work of others. However, the collagen solubilities for two other shee muscles, *gluteus medius* and *biceps femoris*, also under study in this laboratory, were markedly higher than those of *semimembranosus* ov a similar age range (data not shown).

KING (1987) showed that the thermal transition temperature (an index of insolubility) of *semimembranosus* collagen was the highe of five major sheep muscles. Further, its transition temperature varied little with age, contrasting with a greater variation in the four othe muscles, *semitendinosus, biceps femoris, longissimus dorsi* and *psoas major*. Therefore, of the five muscles, *semimembranosus* had th least soluble (most mature) collagen in young animals, and its collagen solubility changed the least with age. The present solubility da support KING's findings.

Fig. 1. Solubility of collagen from *semimembranosus* muscle of sheep of different ages.

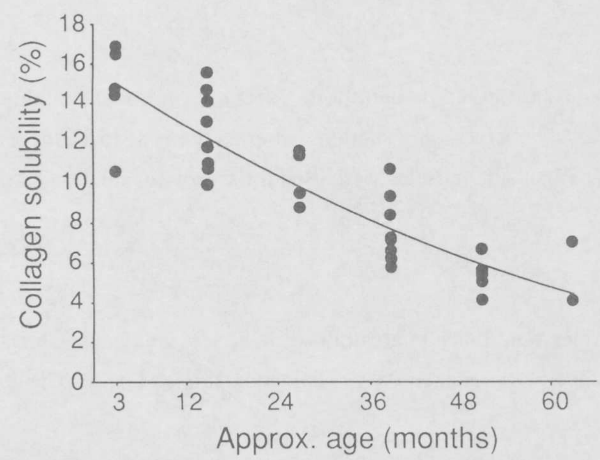
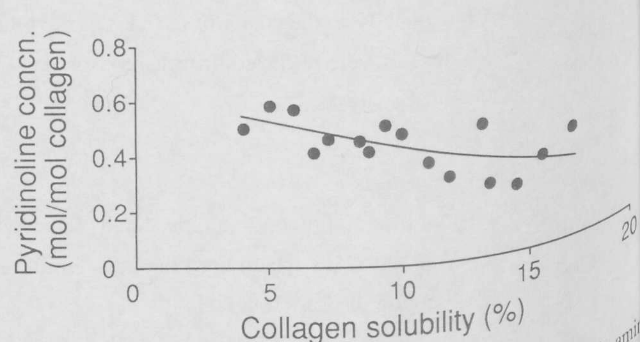


Fig. 2. Pyridinoline concentration as a function of *semimembranosus* collagen solubility



Because *semimembranosus* collagen is probably more insoluble than collagen from other major sheep muscles, the heat-stable amin acid pyridinoline might occur in higher concentrations in this muscle than in, say, *longissimus dorsi*. Pyridinoline concentration range from about 0.30 to 0.55 mole per mole of collagen, clearly increasing as the collagen solubility decreased (Fig. 2). These concentration gher than those obtained for *longissimus dorsi* collagen of goat (HORGAN et al., 1991) and cattle (SMITH & JUDGE, 1991). For ple, goat collagen, prepared by the same wet method as used here, contained about 0.2 mole of pyridinoline per mole of collagen. Therefore, as gauged by heat dependent solubility and the concentration of a mature crosslink, ovine *semimembranosus* is markedly uble.

ry and shear tests

ork was designed to ensure that connective tissue concentration and solubility were the major variables affecting mechanical rties. Thus, tests were done on rigor muscles but before the subtle effects of collagen ageing had begun (KING, 1987; STANTON & T, 1988; LEWIS et al., 1991); the muscles entered rigor at an optimum temperature for myofibrillar tenderness (LOCKER & YARD, 1963) and were held in a posture designed to prevent shortening (DAVEY & GILBERT, 1974); and the pH values of the rigor es were low and constant (data not shown).

The more soluble the collagen, the more tender the meat (Table 1; Fig. 3a). This was expected from the results of LIGHT et al.), who showed that the lower the concentration of heat-stable crosslinks in collagen (i.e. the more soluble it is), the more tender the . Other workers (e.g. CROSS et al., 1972, 1973, CROUSE et al., 1985) support this notion.

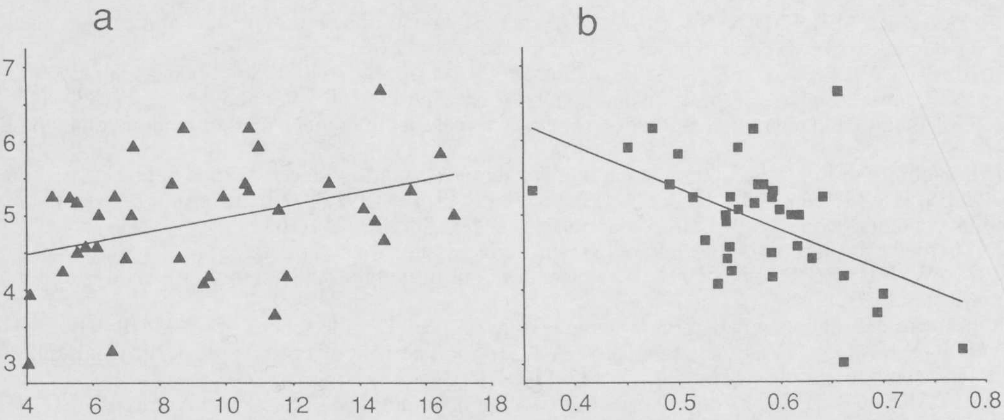
The correlation between tenderness and solubility was weak (r = 0.38, p<0.05) however, compared with that between tenderness and ntration (r = -0.53, p<0.001). This relationship with concentration held whether concentration was expressed as a percentage of wet ht (Table 1) or protein (data not shown). Texture was also better correlated with collagen concentration than solubility (Table 1). al studies involving comparisons between muscles (DRANSFIELD, 1977), within one muscle (REAGAN et al., 1976), and within (SMITH & CARPENTER, 1970), have shown significant correlations between tenderness and collagen concentration. In other s, by contrast, a significant relationship has not been found (e.g. CROSS et al., 1972, 1973).

In reconciling the present results with the theory that tenderness is related to collagen solubility, a simple explanation might be that *embranosus* collagen is so insoluble throughout a sheep's life that solubility hardly matters; instead, for that muscle it is the ntration of collagen that is more relevant. In other muscles with a cover a wider range of collagen solubility during the animal's life, ility might be more important.

Compared to sensory data, the shear data were better correlated with collagen solubility than with concentration (Table 1).

The cooking regime might have influenced our results. Solubility was measured in meat homogenates after heating at 77°C for 65 whereas the meat for sensory evaluation was heated for 20 min from cold to a similar endpoint. The collagen would have little unity to dissolve in the latter case. However, it remains unclear as to why the short, relatively cool heating regime employed was o elicit different responses from panelist and machine (Table 1).

Fig. 3. Panel mean tenderness scores for *semimembranosus* as a function of collagen solubility (a) and collagen concentration (b). The linear regression coefficient for solubility was 0.38, significant at p<0.05, whereas that for concentration was -0.53, significant at p<0.001.



y workers have successfully related physical testing results to sensory panel evaluation. Such was not the case here, with the best of correlations between shear and tenderness being only just significant (-0.34, p<0.05). The reason for this is clear from Table 1. The sensory panel evaluation and the shear tests emphasized different properties: collagen concentration and solubility respectively. In a st involving similar tests pooled across five bovine muscles, SEIDEMAN (1986) arrived at the same conclusion.

Concluding remarks

The key finding of this work is that in ovine *semimembranosus*, cooked to a temperature endpoint typical of lightly cooked meat, coll concentration was a better indicator of sensory panel judgement than was collagen solubility.

Inspection of Fig. 3b reveals a considerable variation in collagen concentration about the mean. If collagen concentration w strongly heritable, there is scope to select genes for the low collagen trait. In this laboratory some work is currently directed at colla properties in different breeds.

Table 1. Selected linear correlation coefficients (n=36) between collagen concentration or solubility and sensory and shear data.

Trait	Collagen concentration (% of wet wt.)		Collagen solubility	
	Correlation coefficient	Significance[Ψ]	Correlation coefficient	Significance
Tenderness	-0.53	***	0.38	*
Texture	-0.44	**	0.06	NS
Warner-Bratzler shear				
Parallel to grain	0.15	NS	-0.38	*
Across the grain	0.20	NS	-0.40	*
Work to shear				
Parallel to grain	0.11	NS	-0.34	*
Across the grain	0.16	NS	-0.41	*

Ψ Levels of significance: NS, not signif.; *, p<0.05; **, p<0.01; ***, p<0.001

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