TENSILE TESTS ON PERIMYSIAL CONNECTIVE TISSUE

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INTRODUCTION

Meat tenderness comes from the mechanical properties of cooked muscles fibres and connective tissue. After cooking the structures are closely linked due to thermal shrinkage of collagen. Therefore it is not possible to separate the contribution of each structure the resistance of cooked meat from results of mechanical tests performed on whole samples. Some empirical parameters can be deduced from the stress-strain curves, which give an indication of the resistance of myofibrillar or connective structure (Bouton *et al.*, 1975a) but the parameters are not only dependent on one structure and in some cases they cannot be determined (Bouton *et al.*,1975b).

The specific resistance of meat structures has been measured by tensile tests on these structures extracted from cooked meat. In particular Lewis and Purslow (1989) have shown that breaking strength increased from raw to cooked at 50°C, thereafter decreasing with cooking temperature up to 90°C. Lewis *et al* ., (1991) have demonstrate a reduction in strength of the perimysial connective tissue, due to conditioning, for both raw and meat cooked at 50°C. At higher temperatures (60-80°C) no effect of conditioning was seen.

The purpose of this study is to analyse the effect of both cooking temperature and sarcomere length on some mechanical properties of perimysial connective tissue extracted from raw or cooked meat.

MATERIAL AND METHODS

Sternomandibularis from 9 cull cow (7-8 years old) were excised within 1 h after slaughter. The muscle of one side was cut in two halves and sealed in plastic bags. One half was put at 0°C and the other at 15°C. The muscle of the other side was stretched, sealed and put at 15°C. The day after slaughter all the samples were stored at 4°C for 1 week.

Pieces of meat (5 x 3 x 3 cm) were either kept raw or cooked 1.5 h at 60 or 80°C.

Strips of perimysial network (length= 10 mm, width =3 mm, the longer dimension in the direction of muscle fibres) were removed with a scalpel and stored in 9 g NaCl /l water.

Tensile tests on perimysial strips were performed on an INSTRON 4302 with a speed of 6 mm/min until total breaking of the sample. Strips were tested in the direction of muscle fibres. The following parameters were calculated :

Maximun stress for which the cross section of the strips was calculated from weight, length, assuming a density of 1, breaking stress, Energy, Modulus and breaking strain.

Collagen content of the strips was calculated according to Kopp and Bonnet (1982). Sarcomere length was measued by diffraction laser described by Cross *et al.,* (1981).

RESULTS :

There is an effect of both temperature and sarcomere length on the mechanical parameters but there is a strong interaction. Therefore the two effects were analysed separately.

Whatever the sarcomere length, maximum stress, modulus and energy decreased from raw to cooked. (Fig 1). But the difference between 60 and 80°C was not significant. There was a great variation among animal. The breaking strain increases from raw to cooked (fig 2).

Whatever the temperature there was an increase of maximum stress, modulus and energy from contracted to stretched. The breaking strain decreased as sarcomere length increased (fig 2).

No significant changes were observed in sarcomere length between raw meat and meat cooked at 60°C. A decrease of 10% was noted at 80°C.

MODELISATION

1 -Breaking strain

For raw meat the theoretical values of the angle between collagen fibres and muscles fibres is given by

$\mathrm{Tan}(\alpha) = \mathrm{Tan}(\alpha_0)*\lambda^{-3/2}$ (Lepetit 1991)

with λ the length ratio of meat (λ=Sarcomere length/2µm) and α_0 the angle at rest length between collagenous fibres and muscle fibres

$\mathrm{Tan}(\alpha_0) = \sqrt{2}$

At rest length (Sarcomere length about 2 µm) the waviness of collagenous fibres is about 1.15. That means that the wavy length is 1.15 times the straight length of the collagenous fibre.

With these figures, the deformation necessary to unfold the collagenous fibres in the tensile test can be calculated. This curve is plotted fig 3. As collagen fibres are not elastic in the raw state, they are expected to break since they are straight, if there is no slippage. The discrepancy between this curve and the data of breaking strain shows that, in that experiment, the breaking strain is not linked to the theoretical value of deformation for the unfolding of the collagen fibres.

2 - Percentage of collagenous fibres involved in the test

Depending on the sarcomere length of meat, the angle between the collagenous fibres in the perimysial sheets are different. Not all collagenous fibres run throughout the sample. The percentage of collagenous fibres involved in the test decreases with sarcomere length. For sarcomere lengths lower than 1.3 µm theoretically no collagenous fibres run throughout the sample from one grip to the other. In this experiment the mean value of sarcomere lenght is 1.15 ± 0.1 µm Therefore the mechanical properties measured in contracted samples cannot theoretically be linked to those of collagen. For normal and stretched strips of perimysium the mechanical parameters can be corrected for the percentage of collagenous material which actually bear the force in the sample and which depends both on the percentage of collagenous fibres involved in the test and on the collagen content of the strip. The statistical analysis on these corrected parameters (Maximum stress and Energy) shows no effect of sarcomere length.

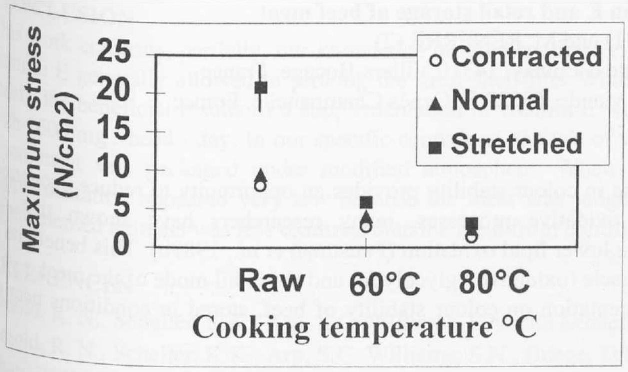

Figure 1 : Variation of maximum stress with temperature.

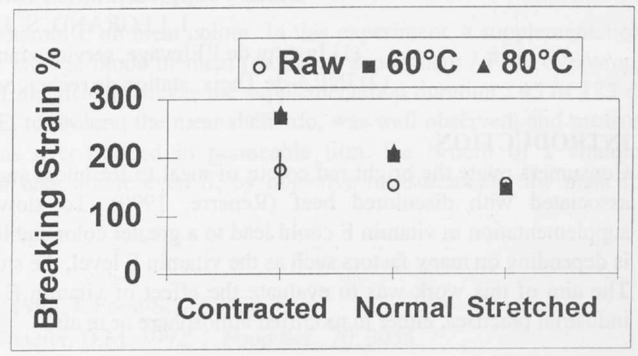

Figure 2 : Variation of breaking strain with contraction and stretching.

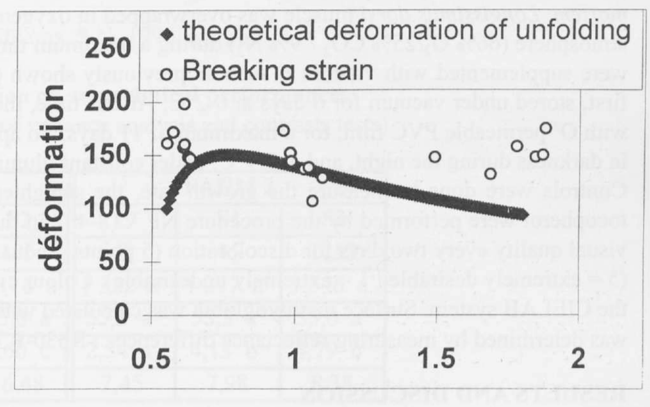

Figure 3: Changes in the deformation to unfold collagenous fibres in the tensile test and of breaking strain with meat length ratio.
Meat length ratio =Sarcomere length / 2.

CONCLUSION

The mechanical properties of perimysial connective tissue showed great changes during cooking in place in the sample. The decrease in resistance observed between raw meat and meat cooked at 60 and 80°C is in agreement with the results of Lewis *et al.*,(1991). Snowden *et al.*, (1977) have shown that the extensibility of collagen fibres increase the more they contract during cooking. An increase in breaking strain with increasing cooking temperature is observed for perimysium strips, and comes with cooking shortening. Therefore the phenomem observed by Snowden *et al.*, 1977 can partially explained the variations in breaking strain.

For contracted strips of perimysium, collagenous fibres are theoretically not involved in the test due to their angle. Moreover the unfolding of collagenous fibres has not the expected effect on breaking strain. Theses two observations can be explained if the angle between collagenous fibres are dispersed around the theoretical value or if other components of the perimysium affect the mechanical parameters. A direct observation of the collagenous fibres during the test is necessary to link the mechanical properties of perimysium strips to those of collagen fibres.

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