5-P82

GEOMETRICAL MODIFICATIONS OF PERIMYSIAL CONNECTIVE TISSUE IN MEAT DURING COOKING

Grajales, Alicia, Lepetit, J. and **Favier, R.** Station de Recherches sur la Viande. INRA, THEIX -63122 CEYRAT, FRANCE

Keywords : Beef, connective tissue, perimysium, collagen, muscle fibres, sarcomere length, cooking loss, angle.

Background :

The role of intramuscular connective tissue on meat toughness has been the topic of many investigations. Light *et al* (1985) inferred that in muscles the amount of perimysial collagen is much more important than the amount of endomysial collagen. They also showed that in muscles the variation in the amount of intra-muscular connective tissue is mainly due to perimysium, the amount of endomysium remaining almost constant. It is now evident from studies undertaken by Purslow (1985), Totland *et al* (1988) and McCormick (1994), that perimysium is the connective network with the greatest contribution to variations in meat toughness. In perimysium, as in endomysium, there is a criss-cross network of collagen fibres. At rest length, that is, when sarcomere length is about 2 µm, the angle between collagen fibres and muscle fibres is close to 55° and the waviness of the collagen fibres is at its maximum. In raw meat, the changes in geometrical or mechanical characteristics of endomysium with sarcomere length have been modelled by Field and Faber (1970), Purslow and Trotter (1994). Similar changes for perimysium have been modelled by Purslow (1989) and Lepetit (1991). No corresponding work on cooked meat has been reported in the literature.

The mechanical properties of any network of fibres can be predicted from two variables: the angle between fibres and the direction of the strain applied to the network, and the elastic modulus of the fibres. Therefore, the mechanical properties of the perimysial network in cooked meat will be predictable if the variations of the angle and of the modulus of collagen fibres during cooking are known.

Objectives :

The purpose of this work is to give a method for calculating the angle between collagen fibres and muscle fibres in cooked meat.

Materials and methods :

Experiment 1 :

Normal and contracted *Semimembranosus* muscles of a cull cow (7 years) after 14 days of ageing at 4°C were used. Samples (4.5x2x1cm) with the longest dimension in the direction of muscles fibres were cut so that a perimysial sheet was visible on one face. The samples were heated directly in a water bath for 15 min at 40, 50, 55, 60, 65, 70 and 80°C. Cooking loss were measured and sarcomere length was determined using the method of Cross *et al* (1981). The samples were then put under a video camera and illuminated with an UV light (365 nm). The angle between collagen fibres and muscles fibres was determined using image analysis software (Visilog 5).

Experiment 2 :

Samples (10x6x4 cm) were cut from normal and contracted *Semimembranosus* and *Longissimus Dorsi* muscles from 4 cull cows after 14 days of ageing. They were heated in vacuum bags in a water bath for 90 min at 40, 50, 55, 60, 65, 70 and 80°C. Cooking loss and sarcomere length were measured.

Calculation :

Assuming that the variations of the angle between muscles fibres and collagen fibres are due to variations in the diameter and sarcomere length of muscles fibres, this angle can be calculated by the following equation :

$$\tan(\alpha_c) = \sqrt{2}\left(\frac{SL_c}{SL_0}\right)^{-\frac{3}{2}}\left(\frac{P_c}{P_0}\right)^{\frac{1}{2}}$$

where : α_c is the angle between muscles fibres and collagen fibres at the temperatures of cooking. SL_0 the value of sarcomere length at rest length (2µm) and SL_c the sarcomere length after cooking.

P_0 the initial weight of the sample and P_c the weight after cooking.

Results :

Experiment 1 : In the raw samples the angle decreased with increasing sarcomere length (figure 1). This is a well known relationship (Rowe, 1974). During cooking, a small decrease in the angle was observed at temperatures above 60°C regardless of the initial sarcomere length of the sample (figure 1). The experimental data are in good agreement with the theoretical values calculated from sarcomere length and cooking loss.

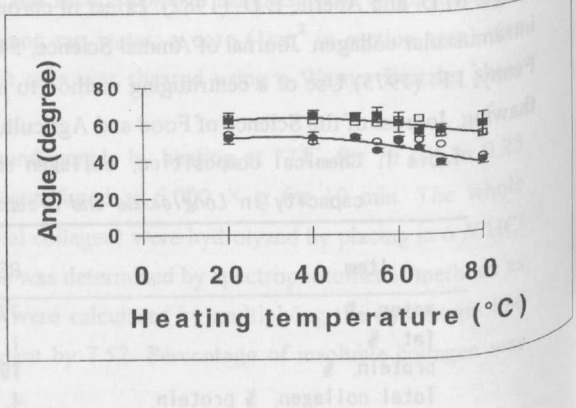

Figure 1 : Variation with temperature of the angle between muscle fibres and collagen fibres. Muscle *Semimembranosus*.
Contracted (raw sarcomere length 1.5 µm) : ■ Experimental □ Theoretical
Normal (raw sarcomere length 2.0 µm) : ● Experimental ○ Theoretical

Experiment 2 :

Slightly higher cooking losses were observed in contracted samples compared with normal samples, especially at the higher temperatures (figures 2). These results are in agreement with those of Bouton *et al* (1974). A slight increase in sarcomere length was observed at approximately 60°C in both normal and contracted samples. Then a small decrease was apparent at higher temperatures. Cold shortened samples contracted less with temperature which in agreement with the results of Bouton *et al* (1974). The angles calculated from the above equation show a slight decrease above 60°C in *Longissimus Dorsi* (figure 3). In *Semimembranosus* an increase was observed near 55°C followed by a significant decrease.

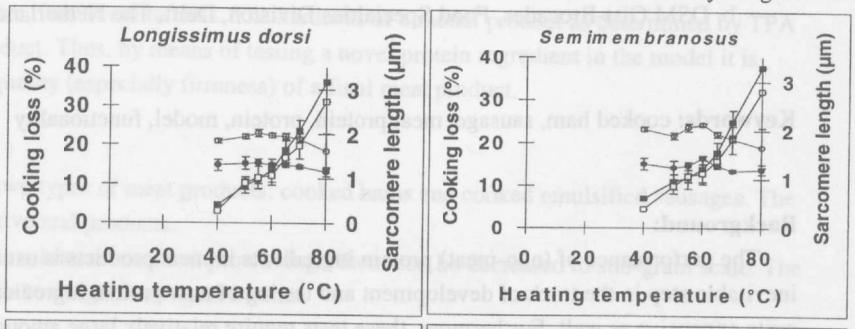

Figure 2 : Variation with temperature of sarcomere length and cooking loss.
Cooking loss : □ Normal ■ Contracted
Sarcomere length : ○ Normal ● Contracted

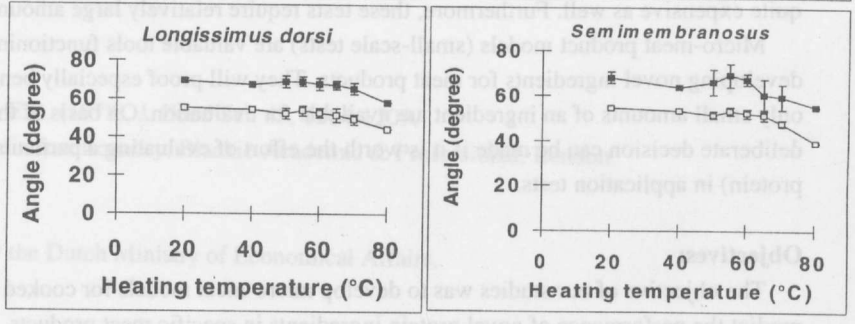

Figure 3 : Variation with temperature of the theoretical angle between muscle fibres and collagen fibres.
□ Normal ■ Contracted

Discussion :

During cooking, there were noticeable variations in the angle between perimysial collagen fibres and muscle fibres, both in normal and contracted samples. Depending on the geometry of the samples and the cooking conditions, the evolution of the angle with temperature can be slightly different. In small samples, water exudes rapidly from the sample during cooking, producing a continuous decrease in the angle which is not counterbalanced by the shortening of muscle fibres. In larger samples, fluid exudes at a slower rate and therefore the first change of the angle is a slight increase due to shortening. In both cases the large cooking losses observed above 60°C produced a decrease in the angle.

The decrease in the angle between raw samples and those at 80°C is about 25% in normal samples and about 10% in contracted samples. These variations can produce high changes in the elastic modulus of the perimysium as the angle of fibres is a very influential factor on the modulus of a network (Purslow, 1989).

Conclusions :

This work shows that a rapid and confident determination of the angle between perimysial collagen fibres and muscle fibres can be achieved from measurements of sarcomere length and cooking loss.

REFERENCES

Bouton, P.E., Harris, P.V., Shorthose, W.R. and Ratcliff, D. (1974) J. Food Sci., **39**, 869-875.
Cross, H.R., West, R.L. and Duston, T.R. (1981). Meat Sci., **5**, 261-266.
Field R.W. and Faber, J.J. (1970). Can. J. Physiol. Pharmacol., **48**, 394-404.
Light, N., Champion, A.E., Voyle, C. and Bailey, A.J. (1985). Meat Sci., **13**, 137-149.
Lepetit, J. (1991). Meat Sci., **29**, (3), 271-283.
Mc Cormick, R.J. (1994). Meat Sci., **36**, 79-91.
Purslow, P.P. (1985). Meat Sci., **12**, 39-60.
Purslow, P.P. (1989). J. Biomechanics, **22**, (1), 21-31.
Purslow, P.P. and Trotter, J.A. (1994)..J. Muscle Research and Cell Motility, **15**, 299-308.
Rowe, R.W.D. (1974). J. of Food Technology, **9**, 501-508.
Totland, G.K., Kryvi, H. and Slinde, E. (1988).Meat Sci., **23**, 303-315.