

# Changes in meat produced by cooking

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## INTRODUCTION

Cooking of meat produces two major changes as a result of the heat denaturation of the muscle proteins, these in turn have a marked influence on the texture of the cooked meat;

- 1) there is a loss of water binding capacity producing cooking loss
- 2) the meat shrinks

There is a reasonable amount of data available in the literature on the heat denaturation of the isolated muscle proteins both sarcoplasmic and myofibrillar (myosin and actin). There have, however, been few studies of the structural changes taking place *in situ* in whole meat in the environment in which the proteins exist during cooking.

We have been studying the structural and dimensional changes produced in meat on heating to see how these might relate to the textural differences produced on cooking. This paper outlines the ultrastructural changes produced in muscle during cooking, and the relationship of the dimensional changes occurring at the myofibrillar level to those observed in the whole meat.

## MATERIALS AND METHODS

Four beef muscle (semimembranosus, panniculus, psoas and pectoralis) were studied using heating periods of 10 to 140 minutes at 60° and 70° C.

Samples were prepared for electron microscopy by fixation in glutaraldehyde, followed by post fixation with osmic acid, staining with uranyl acetate, embedding in Araldite and post staining with lead citrate.

All measurements of sarcomere length, A band length and I band length were carried out on micrographs of the muscle sections.

Shrinkage of whole muscle strips was measured using a modified collagen shrinkage apparatus.

## RESULTS

The ultrastructural changes observed with the different muscles showed no significant variation under the same conditions. The results from the different muscles will therefore be described collectively.

### *Shrinkage of whole meat strips at 60° and 70° C*

The longitudinal shortening observed as a function of heating period when muscle strips were heated at 60° and 70° C are shown in Figure 1. It can be seen that there is only a slight shrinkage at 60° C, but a progressive shortening at 70° C, reaching a constant value of about 20 % after 100 minutes heating.

### *Ultrastructural changes in samples heated at 60° C*

Heating at 60° C caused some alteration in the ultrastructure of the meat myofibrils, but the main features of the sarcomere were still visible after 100 minutes heating.

After 20 minutes heating, the normal triplet M line structure of the A band (myosin filament region) had disappeared. Instead a light band, the pseudo H zone, appeared with an unstructured dark line, the remains of the M line, visible at the centre. At longer heating times this band became less clear. The thick myosin filaments in the A band could still be seen fairly easily after 20 minutes at 60° but could only just be discerned after 100 minutes.

The edges of the A band became increasingly ragged at the longer cooking times, and a lightly stained zone appeared at the A band — I band junction.

No fine structure could be seen in the I filaments after 20 mins heating, indicating that denaturation of the actin had begun. The filaments became increasingly coagulated at the longer heating times, but the filamentous organisation was still apparent. The Z line lost all trace of fine structure after 20 minutes heating.

Measurement of the sarcomere length and A band length showed evidence of slight shortening (Fig. 2) as was observed with the whole strips of meat (Fig. 1).

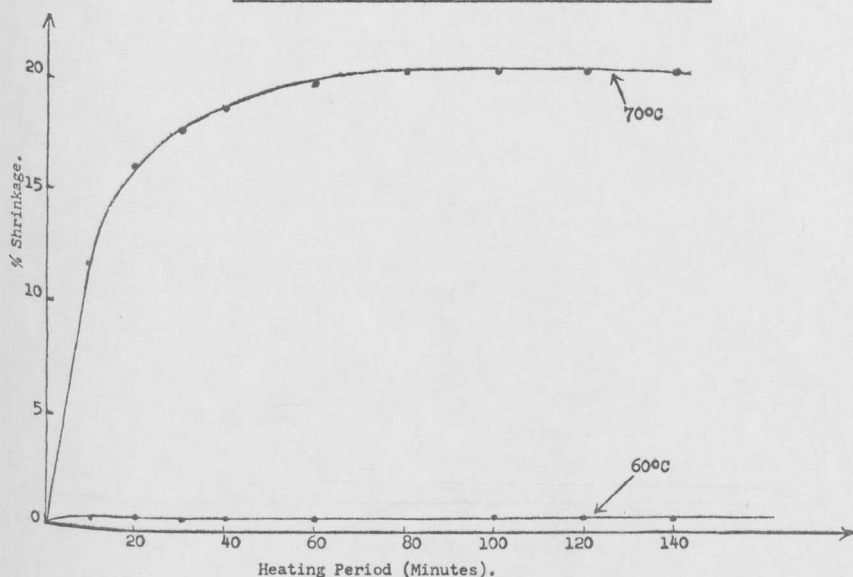
Striated collagen fibrils (exhibiting fine structure and 640 Å periodicity) were observed in the endomysium and perimysium throughout the heating periods.

### *Ultrastructural changes in samples heated at 70° C*

After heating at 70° the myofibrils showed considerably more disruption than at 60°.

Thick filaments could still just be discerned in the A band after heating for

FIG. I. Shrinkage of strips of beef muscle at 60° and 70°C.



45 minutes, although the A band was much more densely stained as a result of changes in the reactivity of the myosin and actomyosin due to the heat denaturation. After the longer heating periods the myosin filaments in the A band became very indistinct. Little trace remained of the M line, and the pseudo H zone became indistinct.

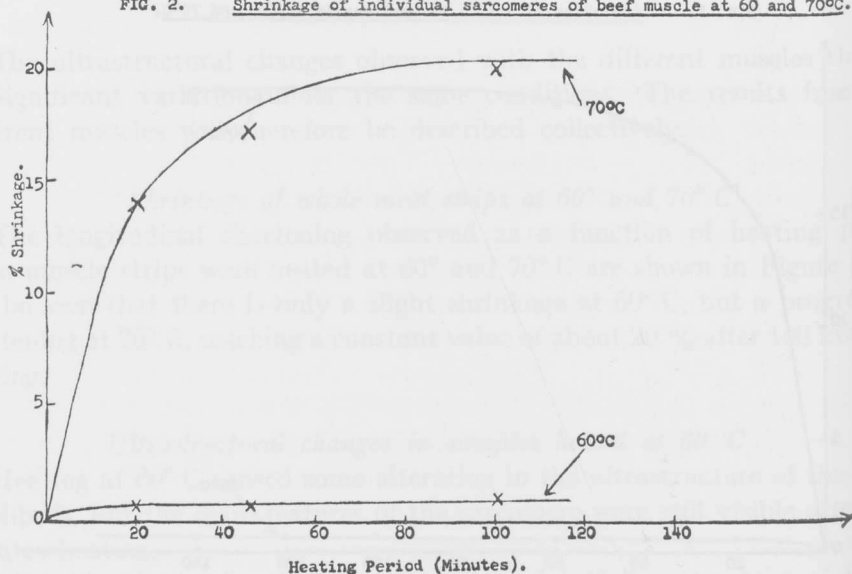
The Z line — I band junction and the A band — I band junctions appeared to be the regions of greater heat sensitivity than the rest of the I band. After 20–45 minutes heating the A band — I band junction showed discontinuities, and after 100 minutes heating break also occurred at the I band — Z line junction. Throughout the heating period the I filaments became more and more coagulated and progressively lost their filamentous structure and continuity.

The Z lines lost their fine structural details immediately at 70° and became more ill defined and disorganised at the longer heating times.

The collagen in the endomysium and perimysium was gradually denatured at 70°, shown by the loss of the fine cross striations and 640 Å periodicity. At the longer heating times the remaining striated collagen fibrils were mixed with lengths of swollen denatured unstriated collagen.

Distinct shortening of the sarcomere took place at 70° (Fig. 2). A shrinkage of about 15 % took place in the sarcomere length during the first 20 minutes heating, increasing to 20 % after 100 minutes. Both the A band and I band

FIG. 2. Shrinkage of individual sarcomeres of beef muscle at 60 and 70°C.



showed the same degree of shortening as the sarcomere as a whole. The shrinkage of the sarcomere closely followed that of the whole strips of meat as can be seen by comparing Figures 1 and 2.

### CONCLUSION

The shrinkage of meat is the result of shrinkage of the individual sarcomeres which make up the myofibrils of meat.

The A band (myosin and actomyosin) retained its structural integrity throughout the heat treatments at 60° and 70° C. It formed a dense band of denatured protein. The I band (actin) on the other hand became disrupted at 70° producing gaps in the sarcomere structure. This could indicate regions of mechanical weakness in the cooked muscle fibres.