SNAPSHOT

MUSCLE STRUCTURE AND WATER RETENTION IN FRESH AND COOKED MEAT PRODUCTS

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Project Description

Raw meat is cooked to achieve a palatable and safe product. However, meat shrinks upon cooking due to protein denaturation which results in reduced yield by loss of liquid (cook loss). The moisture content of meat is also linked to the perceived juiciness by consumers. Therefore, it is important to understand the structural mechanisms behind the shrinkage and mass loss during cooking and subsequent storage, to retain a high yield as well as juiciness. Furthermore, muscle structure and water-holding capacity in relation to processing and cooking were identified as being a shared strategic priority for AMPC, MLA and CSIRO.

The objectives of this project were to determine the underlying structural events that cause shrinkage of beef upon cooking, resulting in reduced yield by the loss of liquid, and investigate interventions to manipulate/minimise this. Moreover, the development of mathematical models for mass loss during cooking were to be investigated. Furthermore, use of new investigative tools for meat quality assessment such as confocal laser scanning microscopy, computer modelling and process engineering were at the core of the project and also to create capability for future projects for the Australian meat industry.

Project Content

Meat is sold by weight and up to 15% of weight loss can occur during storage, and up to 40% during cooking, both consequences of mostly liquid loss. This project has focused on the basic mechanisms responsible for the mass loss during meat cooking and subsequent storage, and has characterised structural changes that occurs in meat during cooking. A series of six experiments was undertaken to elucidate the structural basis of mass loss. A mechanistic understanding of mass loss from cooking was developed by determining mechanical properties (Warner-Bratzler shear force) together with mathematical modelling of factors influencing mass loss.

The project also focused on identifying the basic mechanisms responsible for mass loss during cooking of meat and investigated the relative importance of each structural change that occurred. These mechanisms were studied in a variety of ways, including the effect of microstructural changes (shrinkage in width and length at different length scales), the effect of physiological properties such as pH, ratio of *Bos indicus* cross-breed or intramuscular fat content and the impact of different processing interventions (pulsed electric field (PEF) and high pressure thermal processing (HPTP)). The impact of cooking temperature, cooking time, ageing and muscle type on mass loss, structure, texture and colour of beef muscle was investigated. The information resulting from this project complements, and adds, to existing knowledge and will enable beef processors to predict product performance.

Project Outcome

Denaturation of myofibrillar proteins were the primary source of structural changes and, hence, of the mass loss during heating, with only minor influence of connective tissue denaturation. The major factors influencing mass loss were cooking temperature and time. The ultimate pH (final muscle pH after slaughter) did influence the characteristics of raw and cooked meat with high pH displaying higher moisture content and lower mass loss than low pH meat. Neither *Bos indicus* nor intramuscular fat content affected the total mass loss and did not influence the dimensional changes of meat samples during cooking in this study.

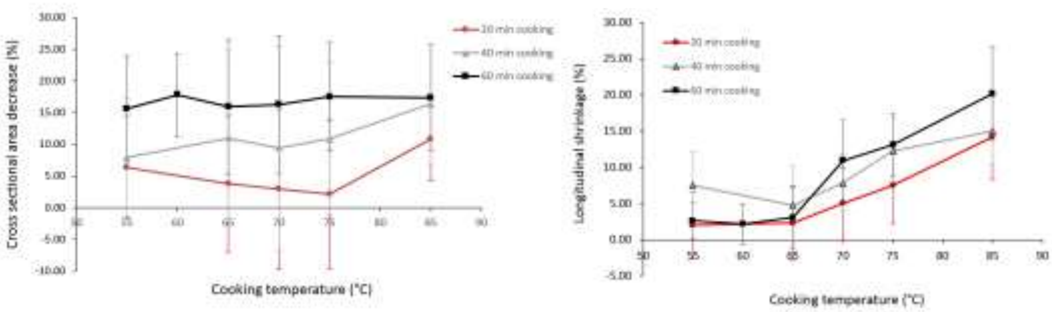

Figure 1. *Cross-sectional area and length decrease of eye round blocks cooked for 20, 40 or 60 minutes at various temperatures. Error bars show standard deviation. No difference in cross sectional area for blocks cooked between 55 and 85 °C was observed. A decrease in length with cooking temperature was seen above 65 °C.*

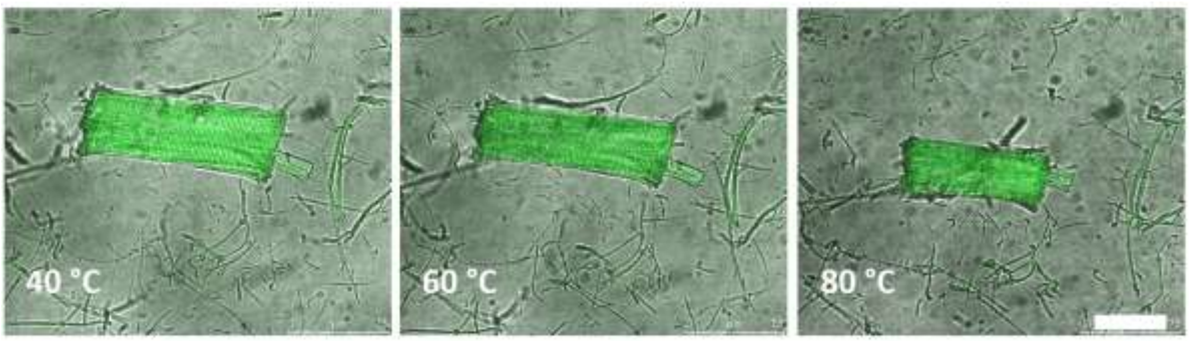

Figure 2. *Microscopy images of a single muscle fibre fragment (eye round) captured during heating to study structural changes. The width has clearly decreased at 60 °C and the length at 80 °C. Scale bar: 50 µm*

When cooking in a water bath, the most tender meat was achieved at temperatures ranging between 65 and 70 °C. In this study, meat with higher pH (>6.0) retained more moisture in the structure upon cooking, which increased the tenderness in some cases. With an increase in intramuscular fat (marbling score 4-5, compared to 0-3) the tenderness of some muscles (*e.g.* striploin) increased up to 32%, most likely due to a reduction in force required to split fat tissue compared to muscle fibres.

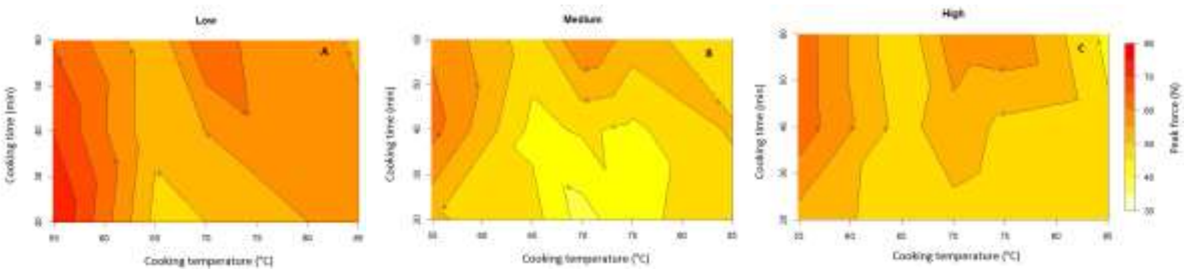

Figure 3. *Peak force of low, medium and high pH meat (eye round) cooked at different temperatures (55, 65, 70, 75 and 85 °C) and time intervals (20, 40 or 60 min).*

In this study, HPTP (300-650 MPa, 60-89 °C, 5 min) of brine injected samples showed that only processing temperature had a significant effect on tenderness and mass loss, not the applied pressure nor brine concentration. Higher processing temperatures resulted in tougher meat and larger mass losses. All HPTP samples showed lower mass losses and higher tenderness than corresponding samples cooked in a water bath.

Benefit for Industry

To limit mass loss and retain juiciness, it is important to avoid excessive shrinkage of meat. Therefore, it is crucial to keep core temperatures of meat under 70 °C during cooking. The ideal tenderness of cooked meat was achieved when the meat was cooked to a core temperature between 65 °C and 70 °C.

Medium pH (5.71 – 5.93) and high pH (>6.00) meat retained more moisture when cooked at high temperatures (above 75 °C) than low pH (5.37 – 5.55) meat. Therefore, medium and high pH meat has greater potential to be sold as pre-cooked meat products.

Meat from cattle with high *Bos indicus* content was slightly less tender (by 13% when cooked at 70 °C for 60 min) than that derived from animals with low *Bos indicus* content, despite having the same mass loss. Therefore, it is recommended to keep the cooking temperature below 70 °C for meat with high *Bos indicus* content, since the cooking temperature had larger influence than the *Bos indicus* content.

We recommend the use of HPTP (60 °C, 550 MPa) with brine injections (10% of total mass of either 0.2% PPi or 1.0% NaCl) as a treatment for meat tenderisation, which will result in increased juiciness. This process is suitable for manufacturing ready-to-eat based meat products.

We recommend further research into PEF processing as a method of value adding for the meat industry. So far, the results from various studies are divergent and more knowledge is needed in this area of novel processing to deliver practical solutions to the industry.

The model developed in this project can be used to simulate the cooking process of meat as a function of cooking conditions (both temperature and time) which minimises cook loss. It is flexible enough to account for other phenomena and extensible enough for other geometries in complex shaped systems. During cooking of meat, significant structural changes occur. We recommend coupling of a mechanical model to the mass and heat model for the prediction of meat tenderness and mass loss. In addition, modelling the cooking process in a way that incorporates the prediction of other food qualities (*i.e.*, sensorial, functional and nutritional) would be important to enable the manipulation and control of meat quality to achieve desired attributes/value added meat products.

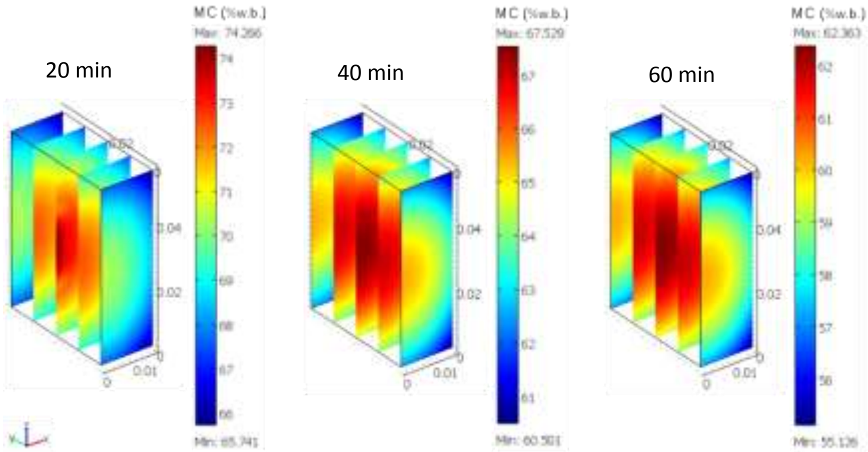

Figure 4. *Predicted moisture content distribution of blocks (55 x 35 x 40 mm) of meat after 20, 40 and 60 min of cooking time at 75 °C from the mass-heat model developed in this project.*