NON-INVASIVE PREDICTION OF MEAT QUALITY FOR INDIVIDUAL ANIMALS AT SLAUGHTER

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I. INTRODUCTION

The conversion from muscle to meat is driven by energy metabolism pathways that normally sustain muscle function. Post-mortem energy metabolism regulates the calpain proteolytic system which plays a central role in tenderising meat by degrading myofibril and cytoskeletal proteins, and influences juiciness. Calpains also interact with caspase proteolytic systems in post-mortem muscle. Key considerations are the events and factors that influence the rate to rigor mortis, and the protection of proteolytic enzymes from degradation after rigor. Fat and metabolites such as residual glycogen, inosine and hypoxanthine also affect meat quality.

The meat industry needs technologies to manage variation and to improve current predictions of meat quality in order to enhance its quality assurance systems. The factors influencing tenderness, juiciness, and flavour are multifaceted [1-3], and thus prediction of meat quality requires a holistic approach. An integrative model that considers the interactions between multiple metabolites, proteases and other factors would enhance the prediction of meat quality. Crucial to this project would be the identification and benchmarking of key biochemical markers that influence meat quality attributes. Since tenderness results from cumulative protease activity, dynamical modelling is needed to quantify this. The technologies providing inputs to this model must be non-invasive and fast, to be practical for industry use, and able to penetrate inside muscle.

We describe a project to deliver predictive technology by rapid, non-invasive measurement of key factors in muscle at time of slaughter, combined with mathematical modelling of processes underlying meat quality. This will give processors key information to make early grading and streaming decisions, by reliably identifying quality carcasses and marginal ones that could be improved by post slaughter treatment. Success in this work would provide a step-change in prediction of end-product meat quality from non-invasive analysis at point of slaughter by sophisticated modelling of fundamental biological processes that are happening post-mortem. Discovery mapping of these processes will tighten grading and increase information for product streaming decisions, as well as increasing profitability through minimising chilled storage costs for meat ageing and maximising shelf life. The end point of this project are technologies that revolutionise quality control, processing and profitability in the meat industry. The pathway to this will be guided by mathematical modelling based on existing knowledge and experience in meat science, with the incorporation of new data and understanding in a series of structured, established and testable steps.

II. MATERIALS AND METHODS

The first year of this project will involve two key stages: mathematical modelling to identify key factors and interactions, followed by time-course measurement of these factors in muscle, to provide calibration data. In Stage 1, we will develop dynamic mathematical models of how post-mortem energy metabolism modulates the calpain system and subsequent protease cascades to drive tenderisation, how these processes respond to temperature and electrical stimulation of energy metabolism, and how outcomes combine with other factors to affect flavour and texture. This will use a mechanistic approach to exploit the conceptual knowledge and understanding of a team of experts combined with information from the literature and previous models [e.g.

4, 5]. In Stage 2 we will perform slaughter experiments to perform time-course measurements of key energy and flavour metabolites, proteases and other factors that determine quality during the conversion of muscle to meat. This will involve a combination of analytical techniques, for example wet chemistry, LC-MS/MS, gas chromatography, and novel proteomic and metabolomics approaches developed in-house in AgResearch. Additionally standard measures such as dimension, weight and intramuscular fat content will be measured.

Subsequently we will measure physical and sensory attributes using the meat from the same slaughter trial (Stage 3). Physical attributes of the meat will be measured using colour meters, tenderometers, and texture analysers. Sensory attributes (visual, tactile, olfactory and masticatory) would be determined using projective mapping which has a high degree of similarity to maps obtained by trained panel descriptive analysis and by consumer testing. In Stage 4, we will parameterise the model to obtain a calibration between the initial profiles of metabolites, proteases and other key factors, and the physical and sensory attributes of meat, allowing detailed investigation of how meat quality can be modulated by process controls.

Later we will investigate a range of alternative technologies to non-invasively measure the key factors identified in the previous objectives. These could include NMR, Raman spectroscopy, NIR and microwave devices. Chemometric models will be used in calibrations to quantify the concentration of factors of interest from the spectral information from these devices. The technology will be tested in meat plants to gauge performance, and for fine tuning calibration to produce a prototype technology for commercialisation.

III. RESULTS AND DISCUSSION

This project will advance meat science by developing quantitative frameworks to integrate and understand how different dynamical processes interact in the conversion of muscle to meat, and providing data that relate how physical and sensory attributes are related to key metabolic, protease and other processes. This knowledge will identify sources of variation between animals and how to increase consistency of products through improved management of animals for optimal meat quality, both on- and off-farm. Combined with the adaption of non-invasive technology to measure inside muscles, this will allow prediction of meat quality of individual animals before/at time of slaughter allowing streaming of carcasses to processing treatments.

IV. CONCLUSION

This is a new area of research, which if successful would provide a step change to the industry by developing next generation meat processing tools, which would be made available to the industry through the commercialisation route.

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