Snapshot Report

AUSTRALIAN MEAT PROCESSOR CORPORATION

Ovine IMF Measurement Production Prototype

Project Code	Prepared by	Date Submitted
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Project Description

The objective of this project was to design and build a prototype system for non-invasive, automated, percentage intramuscular fat (IMF) measurement of lamb and to prove application in processor facilities. The equipment was installed near the end of the slaughter-floor, off-line in a location that allowed the measurement of hot carcases. The system measures carcass-specific IMF in the longissimus dorsi muscle near the 13th rib.

Project Content

A single-sided Nuclear Magnetic Resonance (NMR) sensor was designed and built for this project, called Marbl™. Sensor design considerations included carcase curvature, carcase length, length of the loin, eye muscle depth, eye muscle width, c-site fat, sampling volume, depth of measurement, magnetic field strength, design of the radio-frequency (RF) coil, signal to noise and enclosure shape. Further design considerations included the electronic and data-management requirements for automated measurements.

The sensor was integrated into carcass materials handling and locating equipment. Key features of the balance of equipment (BOE) included: 4-axis adjustability of the sensor, a walking rail, guarding and a pusher arm.

The resulting Production Prototype, i.e. Marbl™ sensor fitted into the BOE, was temporarily trialled with 100 hot carcases in a processing plant in New Zealand before being shipped to Australia.

Figure 1 – Production Prototype installed in the chiller. The pusher arm is in the centre of the photo. The Marbl™ sensor is partially obscured.

Figure 2 – View of measurement being made, with a lamb carcase being pressed up against the Marbl™ sensor by the pusher arm.

The unit was installed in a chiller adjacent to the end of the slaughter floor where it was used to make non-invasive, automated % IMF measurements of carcases. Operation of the equipment required manual loading of the carcases onto the walking rail then the operator pushed a go button that initiated the automation sequence of: advance all carcases along the walking rail, push the carcase in position against the sensor, acquire NMR data and reset the walking rail, release the carcase.

Carcases were redirected from the main chain into the chiller in batches of 8-25. The cycle time for operating the prototype equipment was 2 carcases per minute and a batch of 10-20 were typically measured in 15 minutes.

Notably, in initial testing the focus was on validating the sensor for hot carcases, so the measurement time was longer than what will be necessary under commercial operation.

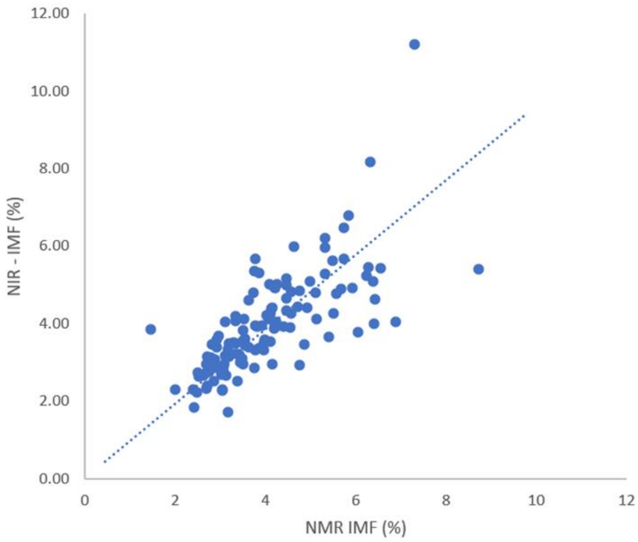
A wide range in carcase size, weight, shape and fattiness were deliberately chosen to explore the operational performance of the system (as compared to the design specification). Over 1000 hot carcases were measured that covered:

- Two different seasons (testing occurred in August and October 2022)
- Weights from 17.5 kg to 42 kg
- Fat score 2-5
- Breeds, including merino, first-cross, second-cross, and dorper

Building the validation data set involved the selection of reference carcases that spanned a wide range of IMF values. The right loin of the carcasses was tracked in the fabrication room the following day. The loins were characterized for c-site fat, eye muscle depth and were measured on-site using a bench top NMR (Oscar), and independently analysed by the University of New England using the proven NIR method [Anderson et al 2015, Harper & Pethick 2004, Perry et al 2001, Stewart et al 2021]. Using Oscar on the chilled loin sample provided immediate feedback while waiting for the NIR results. 65 loin samples were sent to UNE from the August trial, however, these samples degraded during transit. This was followed up with 142 sample from the October trial. Separate loin samples were provided for further measurements such as shear force, pH, and colour as available.

Project Outcome

A key outcome from the reference testing is summarised by this graph showing the linear relationship of Marbl™ NMR IMF (%) versus NIR-IMF (%); N=137 of the October dataset.



In analysing the data using the Scikit Learn python package, consideration was given to the impact of the wide variation in carcase size, weight, shape and fattiness, as extremes were deliberately chosen for this data set. By example, with C-site fat it was found that the operational limit was significantly higher than the design specification of 8-10mm due to compression of the fat during measurement. At the extremes, 5 carcases had around 3 times the design specification so these points were removed. By selecting carcases with wide-ranging attributes, the tests ascertained two limitations: carcases at the extreme end of c-site fat and very large carcases that don't fit well to the sensor.

The October data set was referenced against the AUSMeat accreditation requirements using a web app developed by Murdoch University. The data set (N=137) passed accreditation between 2-6 % IMF. Due to a lack of samples outside the 2-6% IMF range, it was not possible to test below 2% and above 6%.

This project successfully demonstrated the measurement of % IMF of hot lamb carcases using a magnetic resonance method that is non-invasive, automated and provides a direct measure of fat.

Benefit for Industry

The Australian meat industry seeks objective measurement devices capable of determining key traits that form the basis of the MSA eating quality grading system for lamb. The model that is currently being commercialised includes intramuscular fat, the trait that is the focus here. The details of the value that the MSA grading system provides to the Australian meat industry is captured in the MSA annual outcomes report. In the 2020-21 annual outcome report, it was noted that in preparation for the next evolution of the MSA sheepmeat model, 57% of the total lambs processed in Australia were processed through MSA-licenced processing plants that follow processes to improve eating quality.

This project successfully demonstrated automated measurement of % IMF of hot lamb carcases. Measuring carcases hot, at the end of the slaughter floor will provide processors with the opportunity to sort into chillers followed by batch manufacture of similarly graded product. This should provide efficiencies in manufacturing.

Processors will also gain efficiencies since the measurement method is automated and once calibrated the first time, no further calibrations are required. The one-off calibration results from the magnetic resonance measurement method are a direct measurement of fat, whereas some other fat measurement methods require frequent recalibration.

Farmers and producers can also benefit from the % IMF data, informing decisions on finishing on-farm and genetics.

Over the course of this project, the Marbl™ technology was advanced from a sensor used on a workshop bench to a fully functional automated measurement unit that was successfully trialled on site. This pushes the technology down the path to commercialisation. With the improvements identified from this project, reaching cycle times of six carcases a minute with a single sensor, and twelve carcases per minute with a dual sensor system, seem achievable. These cycle times are in line with processor chain speeds. Therefore, in the next year, the technology development plan includes in-line installations in processing facilities. These will be located at the end of the slaughter floor and will measure hot carcases.

Acknowledgement

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Useful resources

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