Technical Report

Program: Sub-program 1.3

Report Title: Summary and reporting on indirect LMY measurement technologies developed for commercial use in abattoirs

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Executive Summary

Non-destructive, objective methods of determining LMY that are cost effective and can operate at commercial line speeds are essential to enhance productivity and profitability of red meat supply chains. While X-ray based technologies such as DEXA offer excellent "direct measurement" of carcase composition, these can be prohibitively expensive for smaller abattoirs. Therefore, simpler and more cost effect technologies that predict carcase composition and therefore provide "indirect measurement" are also required. A microwave system designed and fabricated at Murdoch University has demonstrated excellent precision and accuracy in predicting single site fat depth in beef and cattle. The device is portable, simple to use and poses no risk to human operators or food safety. Similarly, a 3D imaging system for beef, designed at the University of Technology Sydney, and an imaging system for pork commercial known as PorkScan Plus offers robust prediction of lean meat yield.

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1 Subprogram 1.3 Indirect Carcase Measurement Technologies

1.1 3D Imaging

The portable 3D scanning rig designed at the University of Technology Sydney (based on RGB and depth cameras) was modified from the initial prototype to operate at chain speed of slaughter floor at beef abattoirs. This was primarily enabled by utilising alternative 3D cameras (which became available at commencement of ALMTech II), redesigning the scanning mechanism and improvements to the software. While the rig is portable, evaluation focused on acquiring hot carcass sides as they leave the slaughter floor for the chillers. This was deemed to have potential of providing early LMY information to optimise abattoir operations.

The largest software changes were in identifying consistently region of 3D digital carcass shape that was used for LMY estimation. Improvements in surface correspondence and shape morphing allowed more robust extraction of information from 3D data, which are essential precursor to formulating data-driven regression problems. These improvements were validated against medical CT data, shape of 3D CT reconstruction and volume of cuts.

The last deployment of 3D scanning rig at beef abattoir is reported in KPI 1.19, confirming the rig was able to perform at chain speed while scanning left beef carcass side at chiller entrance. Using 3D digital shape of all carcasses acquired thus far and combining curvature descriptor with HCW resulted in highest alignment with CT LMY (reported in KPI 1.19), consistent with results report in earlier KPI 7.6.1 “3D imaging measurement of beef carcase composition, and analysis of improvement to 3D modelling”.

The opportunity to increase the confidence in estimated LMY and evaluating portability of model to data acquired at different deployments is forthcoming. The 3D imaging scanner is awaiting deployment at a beef abattoir with consolidated validation utilising portable CT scanner part of Program 1 efforts in Q1 or Q2 of 2023. This validation is seen as an important precursor before a processor would consider fully integrating a 3D scanning rig within their plant.

In lamb, sole 3D information was determined not to be capable of discerning LMY. While C-site fat depth is a point measure, and LMY and overall quantity for carcass, estimation of subcutaneous fat depth could provide complimentary information of fat deposits that are not obtainable by any other technique. Hyperspectral imaging (near and short-wave infrared spectrum) has promise to estimate subcutaneous fat depth, the light penetrating into subsurface of carcass. The approach combination of 3D and hyperspectral data can capture surface shape and the light source origin, producing diffuse reflectance information which is related to subsurface fat depth.

A range of mid-loins from a commercial abattoir, collected by Program 2, covering a representative distribution of C-site fat were used. They were scanned by a small rig and thereafter CT subcutaneous fat depth ground truth also obtained. 3D shape and reflectance information from hyperspectral camera were used, coupled with machine learning methods that capture nonlinearities and spatial correlations, produced very accurate estimates of subcutaneous fat depth. The results are reported in KPI 1.20 “Capability of integrated hyperspectral and 3D imaging cameras to determine subcutaneous fat depth and cover”.

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While deployment at abattoir was not achieved, the validation against medical CT, and the status of beef 3D scanning rig, provides significant confidence translation to lamb abattoir is possible.

1.1.1 KPI 3.15 The commercial testing of a 3D imaging system (Frontmatec BCC3) in a beef abattoir.

1.1.2 KPI 3.18 The commercial use of a 3D imaging scanning rig in beef abattoirs.

1.1.3 KPI 3.19 The commercial viability of a 3D imaging scanning rig integrated with a hyperspectral camera, deployed in a lamb abattoir.

1.2 Microwave

As described in Sub-program 1.1, the prototype ultra-wideband microwave system (MiS) was significantly modified to improve its robustness and tolerance to water (splash proof) and dust, enhancing its readiness for slaughter floor use. This coupled with the improved calibration system required the acquisition of new calibration data and the training of new algorithms (see "KPI 1.16 Continued improvement of the MiS operating system and algorithm"). In this case two approaches were taken, the first acquiring the measurement directly over the GR tissue depth site to predict this trait (see "KPI 2.17 Report on the ability of a prototype microwave device to predict multiple traits in lamb"). In the second approach, measurements from the MiS system were taken at the C-site to predict C-site fat depth and eye-muscle depth, but also to extrapolate this prediction to the GR site and to the prediction of whole carcase fat, lean, and bone% (see "KPI 2.17 Report on the ability of a prototype microwave device to predict multiple traits in lamb"). After establishing and validating these prediction equations we attempted AUS-MEAT accreditation for measuring GR tissue depth and carcase fat, lean, and bone percentage. For GR tissue depth, only the measurement taken over the GR site was accurate enough to meet accreditation standards. The process of accreditation is partly completed, with a requirement to measure more carcases that are extremely lean, and more that are extremely fat. Accreditation for carcase fat, lean, and bone percentage is also underway, extrapolated from measurements taken at the C-site. Similarly, the process of accreditation is partly completed, with a requirement to measure more carcases in the lighter and medium weight ranges. In both cases we expect to complete this accreditation process prior to the conclusion of ALMTech, and we anticipate that this accreditation step will be crucial to the subsequent commercial demand for this technology.

In beef we have undertaken similar activities, retraining the algorithms for the prediction of rib fat depth and P8 fat depth (see "KPI 2.17 Report on the ability of a microwave device to predict rib fat and P8 fat depth in beef carcases"). This work has been heavily focused around Australian Country Choice (ACC) abattoir and aligned with the accreditation experiments for technologies predicting rib-eye traits that were taking place within Program 2. The precision and accuracy of these predictions were similar to those reported for the earlier MiS prototype. AUS-MEAT accreditation for measuring P8 fat depth has not commenced as we have been advised that the auditing standards require amendment for technologies to predict them.

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To test the commercial viability of this device, a processor-partner that processes both beef and lamb through the same abattoir has been enlisted to test the MiS. Dardanup Butchering Company (DBC) employees have utilised this system on both their beef and lamb chains, providing feedback on speed of measurement and suitability for deployment within their business. Similarly, feedback has been received from the key testing sites at WAMMCO and ACC. Once accredited for GR, DBC have a contract to install the microwave system within their processing plant.

To date no processor has fully installed and integrated a microwave system within their plant. However, based on the testing undertaken by processor partners to date we can say that the KPIs have been met.

1.2.1 KPI 3.16 the commercial utilisation of microwave technology in abattoirs to detect beef carcase fatness at the rib and P8 sites

1.2.2 KPI 3.17 the commercial utilisation of microwave technology in abattoirs to detect lamb carcase fatness at the GR and C-sites

1.3 PorkScan Plus

Work demonstrating the suitability of the PorkScan Plus system has progressed well in ALMTech 2. Two systems are installed in pork processing plants, and calibration and validation work has been completed demonstrating the suitability of this device for measuring ultrasound P2 fat depth in pork carcases (see “KPI 1.14 PorkScan Plus predicting ultrasound P2”). An additional study co-funded between ALMTech and Australian Pork Limited then benchmarked the lean meat yield predictions of PorkScan Plus versus computed tomography. This was also done for two other lean meat yield measurement technologies, the Hennessy Probe that measures P2 fat depth, and the Frontmatec AUTOFOM which predicts lean meat yield using an array of ultrasound sensors. This study clearly demonstrated the superior predictive performance of the AUTOFOM with respect to its alignment with CT lean% (see “KPI 3.14 PorkScan AutoFom Hennessy CT report”). These activities satisfy the following KPI:

1.3.1 KPI 3.14 The commercial utilisation of PorkScan-Plus for predicting LMY and P2 in two abattoirs.

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