Technical Report

Program: Sub-program 1.2

Report Title: Compilation of final reports for direct carcase 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.

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1.1 Lamb carcase DEXA

A total of seven lamb dual energy X-ray absorptiometry (DEXA) scanners have been installed into abattoirs around Australia. These include 6 by Scott Automation and Robotics at JBS Bordertown, JBS Brooklyn, TFI Frewstall, TFI Tamworth, WA Meat Marketing Cooperative (WAMMCO) and Gundagai Meat Processors (GMP), and 1 by Nuctech at Wagstaff. Work has primarily focused upon the Scott installations given the direct role of ALMTech in development of this system and its predictive algorithm.

A crucial enabler of lamb DEXA has been establishing carcase composition as a new industry language for trading. Initially this involved developing the standardised methodology for measuring the bone, muscle, and fat percentage of a carcase using computed tomography (see "KPI 3.11 Standardised methodology for sampling & image analysis, & validation resource data for CT as the calibrating standard for LMY measurement"), and then establishing this within the industry language enabling supply chains to trade upon this trait. This was done initially within ALMTech's Industry Calibration Working Group, followed by significant industry consultation through on-line workshops, and lastly a submission and presentation to the Australian Meat Industry Language and Standards Committee (see "KPI 3.6 A carcase composition trait for sheep meat grading technologies").

The DEXA algorithm itself has undergone significant improvements, enabling more precise prediction of carcase fat, lean, and bone percentage. In part this is due to enhanced bone prediction methodology described in "KPI 3.11 DEXA Bone detection algorithm for lamb carcases", as well as improved calibration of the DEXA values referencing a plastic phantom described in "KPI 3.11 AUS-MEAT accredited lamb DEXA Algorithm Performance". This has led to the establishment of an industry-wide DEXA algorithm for predicting the new carcase trait for fat, lean, and bone percentage, and its subsequent accreditation for use by the Australian Meat Industries Language and Standards Committee (see "KPI 3.11 Lamb DEXA accreditation submission to AMILSC on behalf of Scott Automation and Robotics"). The commercial implications of this are substantial, enabling supply chains to publicly trade upon lean meat yield values derived from DEXA.

We also attempted to accredit DEXA to predict GR tissue depth (see "KPI 3.11 Initial analysis of lamb DEXA predicting GR tissue depth"), but this was shown to require composition estimates specifically from the loin region – a value not routinely available without the installation of a second detector which is installed to direct automated cutting.

Lastly, cut weight prediction algorithms linked to DEXA were developed from an updated cut weight data set that was acquired using the new DEXA calibration methodology. These predictions are being benchmarked at sites around Australia, as described in Program 5, and in "KPI 3.13 DEXA Rack Weight prediction at WAMMCO Katanning". These algorithms are crucial to processors, enabling carcase sorting prior to fabrication to optimise the allocation of carcases to target markets based upon maximised profit. Furthermore, these predictions allow boning rooms to benchmark their throughput based upon more accurate estimates of carcase saleable meat yield.

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In all cases, these new algorithms are being tested through another ALMTech initiative - the installation of on-site research PCs. These systems sit peripherally to the main processor operating systems but allow external researchers to interrogate production data acquired from the DEXA in real-time. This has enabled the parallel testing of new DEXA equations, and the subsequent side-by-side comparison of these predictions with pre-existing forms. This is crucial when transitioning a plant across to an upgraded equation form, providing confidence that there will be no commercial impact, or quantifying the impact if present. It also enables the real-time testing of other research equations that predict composition within the hind, saddle, and fore carcase sections, the weight of cuts, and potentially the eating quality of those cuts stemming from bone R value estimates described in Program 2. This provides a data interface for the research team to discuss potential commercial opportunities with the processor, enabling them to further differentiate carcases and the quality of cuts dissected from them. These commercial decisions are already being tested at sites such as GMP and Frewstall, as described in Program 5.

Lastly, an attempt has been made to estimate the value of improved cut weight prediction to a processor (see “KPI 3.13 The value of precise cut weight prediction in the optimisation of lamb carcase processing”). We modelled an abattoir with a set of market opportunities that are common in Australia, and then utilised the optimiser package described in program 5 to allocate carcases to these markets. This was applied to a simulated dataset where cut weights were predicted from either Carcase weight alone or cut weight predictions enhanced by GR tissue depth or DEXA, and clearly demonstrated the improved allocation through DEXA, and thus the commercial value that this represented.

These activities have enabled the full delivery of the following KPIs.

1.1.1 KPI 3.11 The commercial utilisation of new DEXA systems in five lamb abattoirs

1.1.2 KPI 3.13 Demonstrate the value of improved LMY measurement precision to an abattoir.

1.2 Beef carcase DEXA

The installation of the first commercial beef DEXA system was completed by Scott Automation and Robotics at Teys Lakes Creek abattoir (Rockhampton, Queensland) in 2018. Work within the early phase of ALMTech demonstrated that this system had excellent robustness, repeatability, and showed excellent potential for predicting CT composition and retail cut weights with high accuracy and precision when scanning beef sides at line speed.

A key constraint to this early work was that the system at Rockhampton acquired two DEXA images, one focused upon the hind-section, and one focused on the fore-section with an overlapping region within each image. The reason for this was that a single X-ray tube and detector, as used in the lamb system, was not sufficient to capture the full length of the beef carcase. Therefore, work was undertaken to assess different methods for bridging these two images so that a single DEXA value per side of beef could be used to predict CT carcase composition. The resulting method was shown to have prediction accuracy and precision

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that matched the results previously achieved in earlier reports when carcase sections were scanned individually using a single DEXA system (see “KPI 3.12 Bridging of beef DEXA images to provide LMY feedback”). To facilitate Teys use of the installed DEXA an additional report was written detailing the capacity to deploy this new method and the associated DEXA equation through their existing DEXA hardware at Rockhampton (see “KPI 3.12 Potential for applying DEXA prediction as feedback at the Teys Rockhampton abattoir”). This report focused upon the substantial improvement in precision and accuracy that this would achieve relative to their existing prediction of carcase composition.

To further expand the diversity of outputs from the beef DEXA system, an algorithm was developed to predict the mass of trim dissected from each carcase during bone-out, delivering predictions of 3 separate categories: 65%CL, 85%CL, and 90%CL. These equations were trained upon fore and hind section data, as well as whole carcase side data, with the best performed describing as much as 91% of the variation in the weight of 85 and 90%CL combined lean trim (see “KPI 3.12 DEXA prediction of lean beef trim”).

The final phase in development and testing of the beef DEXA system was to be its calibration against computed tomography across a larger number of carcases of varying carcase phenotype and breed. This is to be done in parallel with other beef carcase lean meat yield measurement technologies including the microwave tissue depth scanner and the 3D carcase imaging system described in Program 1, section 1.3, and also in parallel with the E+V whole carcase scanner. This would enable side-by-side comparison between all of these technologies. A key enabler of this activity is the construction of a portable CT scanner, installed within a shipping contain that could be deployed on-site at Teys Rockhampton. This activity is funded by a project peripheral to, but strongly aligned with ALMTech activities. The construction of this scanner has been heavily delayed, largely due to supply-chain disruption through COVID. The final phase of its construction and government licencing is underway, and the complete dataset stemming from this activity should be acquired by mid-year. None-the-less the signalling of these outcomes, and an expansion of the use of commercial lean meat yield measurement system will rely on continued support by industry RDCs and commercial partners after the completion of ALMTech.

Irrespective of this valuable additional work, the KPI linked to the commercial testing of the new beef DEXA system has been met.

1.2.1 KPI 3.12 The commercial testing of new DEXA systems in one beef abattoir.

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