final report

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Beef DEXA Supply Chain Grading – LMY (TEYS Rockhampton – Construct scanning platform)

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Executive summary

The Red Meat Industry is seeking to improve Objective Carcase Measurement using Dual Energy X-Ray Absorptiometry to calculate Lean Meat Yield compositions for beef sides.

The project has constructed a DEXA system at TEYS Rockhampton which scans beef sides at line speed producing very stable images. The software analyses the DEXA images using a Murdoch University Algorithm to produce Lean Meat Yield compositions for Lean Meat, Fat, and Bone.
The data and images associated by the RFID are stored in a shared network drive, and this data is directly available to the processor.

The DEXA Lean Meat Yield composition accuracy will only be quantifiable upon the completion of the stage 3 DEXA analysis accuracy improvements being undertaken by Murdoch University. The improvements include calibrating against Computational Tomography (CT) composition.

The industry will be able to evaluate the calibrated Lean Meat Yield composition as a tool for Objective Carcase Measurement.

Future projects may use the DEXA platform to develop regional LMY compositions for beef side sectors, and robotic cutting developments.

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1 Background

1.1 Future of DEXA Lean Meat Yield (LMY)

The Red Meat Industry have an interest to advance Objective Carcass Measurements (OCM). Dual Energy X-Ray Absorptiometry (DEXA) systems providing LMY composition values are one of these measurements. These DEXA systems are intended to determine LMY compositions in-line, at production rates.

The LMY data determined in line with production will assist to develop:

i. More informed business decisions.
ii. Improve on-farm efficiency.
iii. Improve processing efficiency.
iv. Provide a product that which is more preferred by consumers.

There are many participants in the Red Meat Industry assisting with the development of OCM to meet the industry's targets for:

A. Optimised Data-based decisions
B. Commercial benefits
C. Increasing Industry value

This Beef DEXA LMY project has progressed in parallel with multiple other OCM industry projects being sponsored by Meat & Livestock Australia and other Australian Government programs.
The project equipment located at Teys Rockhampton Beef Processing site is intended to provide the first step towards the red meat industry gaining DEXA LMY data obtained in-line with production.

Murdoch University's development of the DEXA analysis software is intended to increase the LMY accuracy comparable to the gold standard Computed Tomography (CT) analysis for values of lean meat, fat, bone compositions of beef sides.

Scott wishes to thank the major participants in this project including the Australian Federal Government's Rural R&D for profit program, Meat & Livestock Australia, TEYS Australia, Murdoch University, and other Australian Red Meat processing entities either directly or indirectly supporting this project.

2 Project objectives

The Research Organisation will achieve the following objective(s) to MLA's reasonable satisfaction:

1. Verifying the correlation of DEXA to CT LMY composition that has been determined in P.PIP.0431 Teys Beef DEXA development stage 2.
2. Verify the effect that a range of product and processing variables has on the accuracy of the DEXA result relative to CT LMY composition.
3. Develop an algorithm to correlate DEXA values to LMY
4. Construct a system that is capable of delivering LMY information to underpin a producer feedback scheme currently being developed by the MLA rural research for profit program.

The outcomes of this project are to:

1. Construct a system that is capable of scanning a full side of beef using dual energy X-ray absorptiometry at line speed.
2. Develop software to capture and store the DEXA images and is able to be further developed to meet the outcomes of a stage 3, full producer feedback integration, in a subsequent project.

Additional details

It is expected that the in-plant system can, as a later stage development, be taken on-line and for results to start driving producer feedback and process optimisation. It is expected also that a mobile CT unit (constructed under a separate MLA project) will have application in verifying DEXA results and further algorithm refinement.

Fig. 1: Excerpt from V.TECH.1701 project objectives

2.1 The required outcomes of this project

2.1.1 Required Outcome 1

Construct a system that is capable of scanning a full side of beef using dual energy X-Ray absorptiometry at line speed.

2.1.2 Required Outcome 2

Develop software to capture and store the DEXA images and is able to be further developed to meet the outcomes of a stage 3, full producer feedback integration, in a subsequent project.

3 Methodology

3.1 Product Conveyance

3.1.1 Overhead chain conveyors

The Project has completed the construction of the X-Ray room and conveyors such that the machine can transfer Beef sides through the X-Ray system. The system scans beef sides at line speed producing X-Ray Low and High energy images.

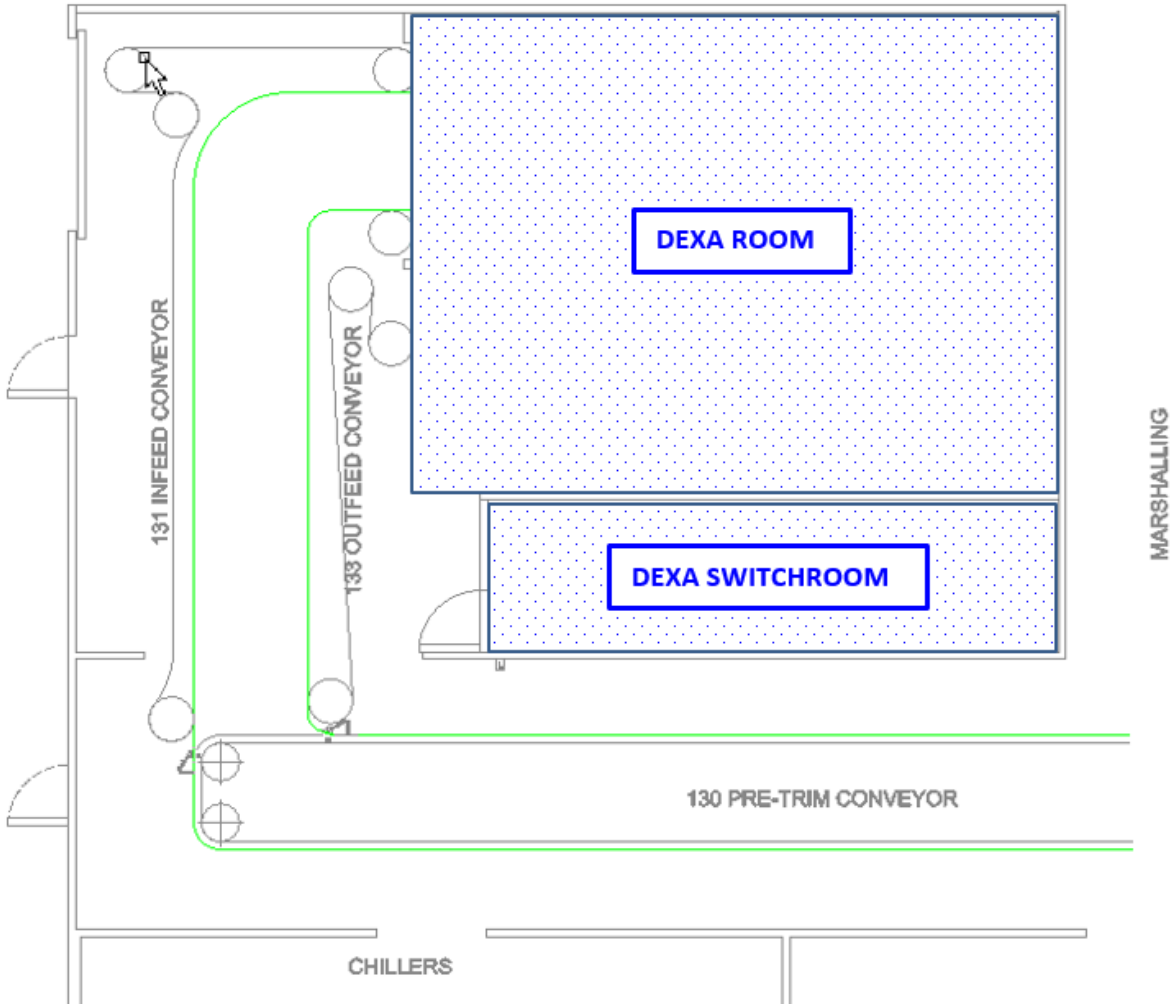

Fig. 2: DEXA Layout diagram

The overhead chain conveyors are of a standard design to transfer the beef sides from the existing customer's Pre-Trim conveyor through the DEXA system and back onto the Pre-Trim conveyor.

Fig. 3: Standard overhead chain conveyance of beef sides.

3.1.2 Beef side stability through X-Ray beam

The beef sides are stabilised through the X-Ray beam. The image clarity and lack of distortion demonstrates the stabilisation method is suitable for this DEXA application.

3.2 Operator Interface and Software

3.2.1 Operator Interface

The operator interface screen is located at the exit of the DEXA room as shown below.
The operator interface is also available for read access by any customer supervisor or management PC connected to the customer network.

Fig. 4: Operator interface in the outfeed area

The Operation screen has been simplified to a 'run' and 'stop' button for normal operation.

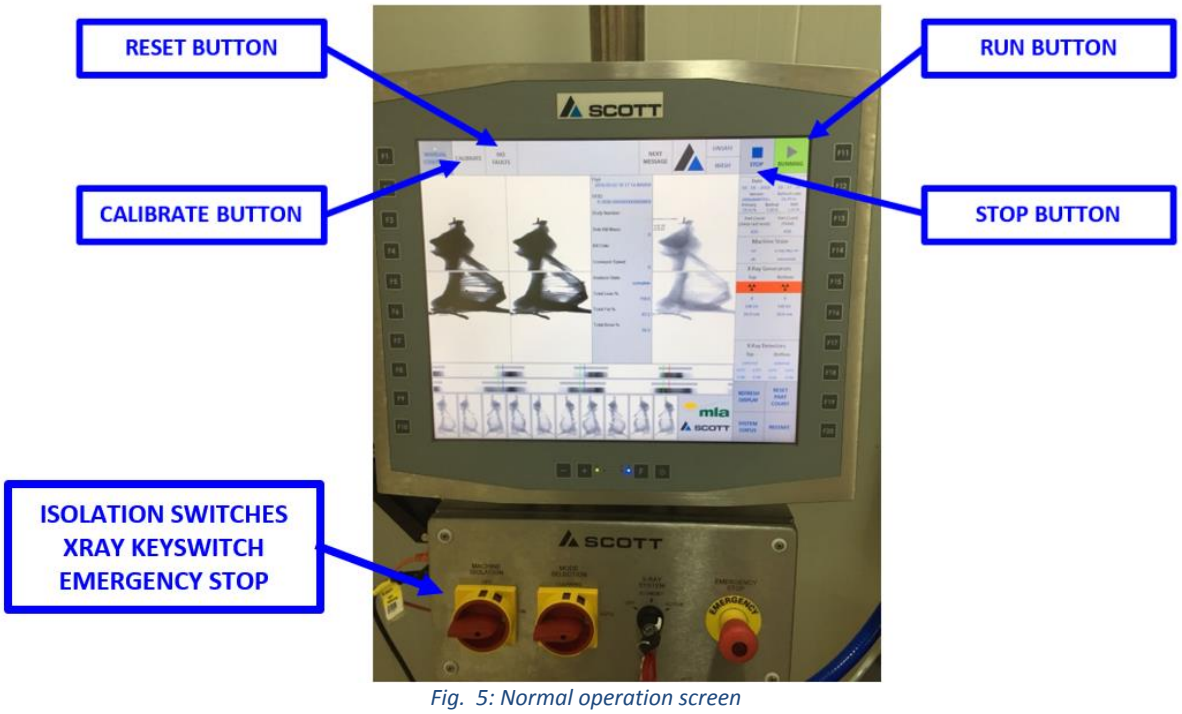

Fig. 5: Normal operation screen

The current side Images data and results are displayed on the screen at the machine console. The previous 10 sides can be selected to display by selecting the icon image at the bottom of the screen.

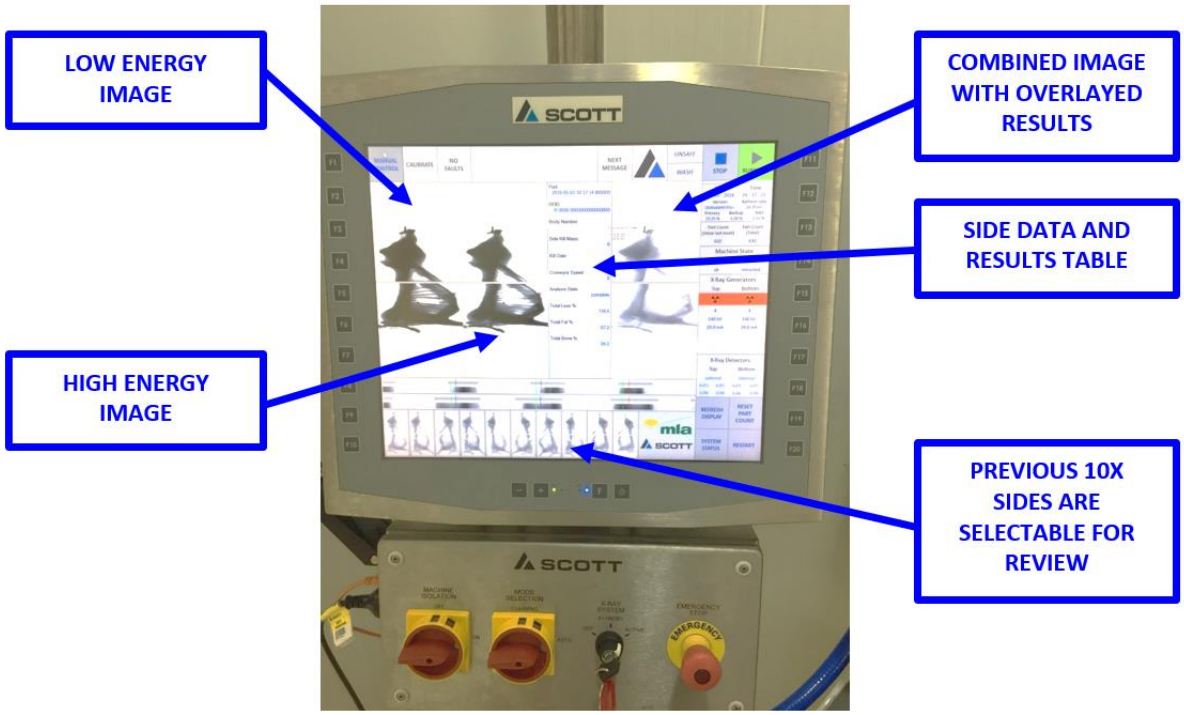

Fig. 6: X-Ray image and results display

4 Results

4.1 Product transfer

4.1.1 Physical product transfer

The Beef side transfer through the machine is suitable for the purpose of DEXA image capture.
An additional double hook detect sensor has been installed. This will detect if two sides (hooks) have been transferred to the Scott infeed conveyor from upstream on the Pre-Trim conveyor.

4.1.2 Product Stability

Scott have undertaken considerable time increasing the stability of the product whilst travelling past the X-Ray beam. Stable product give the most clarity for X-Ray images.

4.1.3 LMY DEXA value repeatability

Murdoch University have undertaken repeatability trials on this machine and found for a range of beef sides it is highly repeatable and suitable for scanning beef sides for the purpose of LMY DEXA analysis at the processors chain speed.

4.1.4 Stabiliser Clean In Place (CIP) system

Scott and TEYS have commissioned an automated CIP system for the stabilisation mechanism. The system now automatically cold washes, hot washes, alkaline foams, and sterilise sprays the stabiliser mechanism internally and externally.

4.2 Product tracking, Image capture and Analysis

4.2.1 Product tracking using Radio Frequency Identification (RFID)

Animal identification from the farm through the DEXA machine and throughout the plant is achieved using RFID tags. At the farm and part way through the slaughter process identification is by ear RFID tags.

Once the side is on a conveyor hook all prior data collected by the customer for that animal is associated with that hook RFID.

The hook RFID is read in many locations on a plant including at the DEXA machine. The RFID tag, readers are essential tools for product tracking and data transfer within a processing site.

4.2.2 Image capture

The images being captured by the DEXA system are of good quality with little product movement evident in X-Ray images. The Low and High X-Ray images are of suitable quality for DEXA analysis.

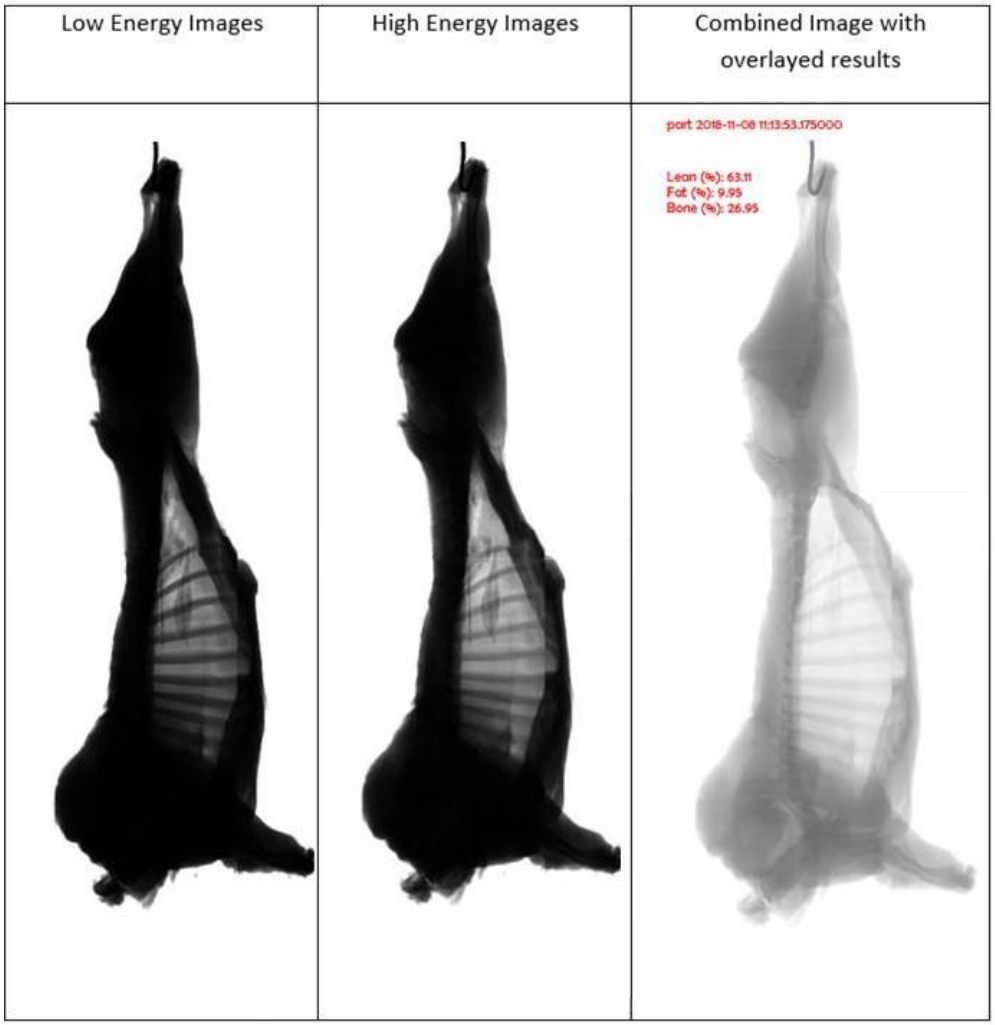

Fig. 7: Production beef side images (Note: the LMY values are nominal until the calibration with CT is completed).

4.2.3 DEXA Analysis

Scott software combines the Low and High Energy Images data to provide data inputs to the DEXA algorithm.

Scott uses the DEXA Value as an input into the Murdoch University DEXA Algorithm Calculations which results in LMY outputs of Lean Meat, Fat, and Bone composition values.

Scott then repopulates the database with the DEXA LMY results associated by the RFID identifier, and displays the results on the operator screen. The Database is available for the customer to retrieve the LMY data as required. MLA current and future DEXA Improvement projects can retrieve the data on approval from the customer.

4.3 Data transfer

The project has developed software to capture and store the DEXA images and is able to accommodate future Murdoch DEXA analysis changes as required. The Scott software stores the images and data outputs in a drive shared with the customer. The customer is able to retrieve the data from within the Scott database.

4.4 Lean Meat Yield composition accuracy

This project is to provide a LMY dataset for each beef side scanned and to record the results in a database matched by RFID with the customers kill information. This project does not have an objective for achieving a specific LMY accuracy for the individual beef side or against a population.

The current algorithm in the TEYS BEEF DEXA machine located at Rockhampton is based on the Stage II Dexa In A Box {DIAB} calculations which are not calibrated against the CT 'gold standard'. The algorithm is a placeholder until further improvements are able to be implemented. The LMY outputs should not be evaluated with respect to accuracy until the improvements are implemented.

Stage III trials are intended to provide an output algorithm that is based on calculations calibrated and formulated by comparing to CT scanned products from diverse genotype carcase variables. This improved algorithm is intended to be tested and proven at the TEYS Rockhampton site.

4.5 Site Demonstrations

Fig. 8: Richard Norton (MLA Managing Director) and David Littleproud (Federal Minister for Agriculture and Water Resources) operating the machine during Beef week 2018.

Fig. 9: Brad Teys (TEYS CEO) and David Littleproud (Federal Minister for Agriculture and Water Resources) operating the machine during Beef week 2018.

There were several demonstrations during the “Rockhampton Beef Week 2018” including the following:

- Federal Minister for Agriculture and Water Resources, David Littleproud
- Meat and LiveStock Australia Management
- TEYS Management
- Other industry participants

5 Discussion

This project undertook to develop a first production prototype beef DEXA objective measurement platform with the ability to scan full sides of beef at line speed at TEYS Rockhampton for direct LMY measurement, and values available to be fed into industry designed and managed databases.

DEXA LMY was viewed as the only practical and accurate measurement of this key attribute, and this technology was assessed at the formation of this project as being commercially feasible for this application.

5.1 Machine operation.

The DEXA machine was designed and commissioned for ease of operation. In some cases the operators may not be familiar with computer interfaces or may not primarily be English speaking.

For this reason a simple interface was designed with a simple start/stop and fault reset button.

5.2 Primary requirement for image quality

Beef side stability is the primary requirement for accurate X-Ray capture. This project achieved stable product by designing the stabilisation mechanism with the design intent of the least amount of product movement over the X-Ray scanning area.

5.3 Achieving the outcomes

5.3.1 Outcome 1

Construct a system that is capable of scanning a full side of beef using dual energy X-Ray absorptiometry at line speed.

The project has achieved the outcome of designing, building, installing and commissioning a system that is capable of scanning a full side of beef using dual energy absorptiometry at the processing sites line speed.

5.3.2 Outcome 2

Develop software to capture and store the DEXA images and is able to be further developed to meet the outcomes of a stage 3, full producer feedback integration, in a subsequent project.

The project has achieved the outcome of designing the control and vision software systems to capture and store the DEXA images and data and is able to be further developed to meet the outcomes of stage 3, with full producer feedback integration, in a subsequent project.

6 Conclusions

The Beef DEXA Supply Chain Grading – LMY construct scanning platform project has successfully provided the required outcome of constructing a system that is capable of DEXA scanning and storing images of a full side of beef at line speed. The software calculates the DEXA LMY composition for the sides using the Murdoch University algorithm and stores the data in a shared database. The software is able to be further developed when the Murdoch University algorithm is calibrated against the CT compositions of a genetically diverse population.

The images captured are very stable and are suitable for DEXA analysis. The DEXA analysis will not be accurate until calibrated against CT compositions.

7 Key messages

7.1 DEXA system suitability

- The system as commissioned at TEYS Rockhampton produces very stable X-Ray images and as such is suitable for DEXA analysis.
- The Current DEXA composition results are not calibrated against CT compositions for a genetically diverse population. Murdoch University are leading the DEXA algorithm improvements including the CT calibrations with stage 3 developments.

7.2 DEXA system adaptation for future projects

- The system is in a good position to continue with DEXA progression for commercialisation for the red meat industries requirements.
- The system is in a good position to continue with further downstream automation for robotic cutting applications.

8 Bibliography

Sean Starling, Meat & Livestock Australia
MLA Factsheet – DEXA Technology (2016)

Honor Calnan, Andrew Williams, Jarno Peterse, Graham Gardner, Murdoch University;
ALMTech Report 4.3.3a : Tissue phantom scanning and base algorithm calculation (2018)
ALMTech Report 4.3.3b : Carcase DEXA value calculation and repeatability scanning (2018)