Final report

Real-Time Meat Eating Quality Probe: Technology Refinement

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Abstract

The project was undertaken to determine if MEQ Probe could develop their technology to be of sufficient accuracy and precision to be of value to the red meat industry, as well as robust and fit for purpose to be used in a red meat processing plant.

The project was performed by undertaking trials in lamb and beef plants to enable MEQ Probe's team to collect data and stress test its system for development. The key results from the project were that MEQ Probe has demonstrated its system is commercially fit for purpose and ready to seek AUS-MEAT accreditation for intramuscular fat percentage in lamb and marble score in beef.

The benefit to the industry is that the data provided is objective and at the earliest point possible in the processing workflow enabling earlier decisions. Additionally, intramuscular fat percentage measurement was not available under commercial processing conditions in the lamb industry prior to the MEQ Probe development, which now enables deployment of the MSA sheepmeat cuts-based model.

In beef, grading hot can unlock chiller efficiencies and energy optimisation—the broader industry benefits from greater consistency in the grading output and earlier decisions for the cut plan.

Executive summary

This project investigated whether MEQ Probe could develop a hot grading system in lamb and beef to deliver greater objectivity in the grading process, and new value-creation opportunities through brand development of processing efficiency. The beef and lamb industries currently lack objective measures for eating quality and grading. Crucial aspects of animal productivity include: (1) health, (2) reproduction, (3) eating quality and (4) lean meat yield. The last three compete against each other if one is preferentially selected. MSA is well established for beef carcase grading, however, it is based on a visual assessment by trained graders rather than objective measurement.

For lamb, MSA remains a mob-based pathway. There is no carcase grading for eating quality, in fact, for most lamb processors, the only objective carcase measurement is weight.

The target audience for the MEQ Probe is the processor community as this is the point of grading carcases; however, the information is also of great value to producers. The data is objective and, in the instance of lamb, new information to help drive carcase quality grading and better genetic selection and management decisions.

The MEQ Probe's outcome, which this project supports, is to develop its technology solution to enable it to be developed to a level where it is precise and accurate enough for industry use, and in a form factor that fits the processor environment.

Objectives

The project's goal was to further develop the MEQ Probe, refine, redesign, and fabricate a robust and ergonomic meat eating quality probe to predict marble score and pH in beef, and IMF in lamb in carcases; and for the probe to be scalable to processor's chain speed requirements for use in abattoirs.

The objective has been achieved as MEQ Probe has built a system that has demonstrated it can be used in a commercial processing environment and operate at chain speed. The technology is currently undertaking AUS-MEAT accreditation to measure IMF% in lamb and will be seeking accreditation in the coming months to measure marble score in beef.

Methodology

The methodology was to probe carcasses in the hot passage and then take an eye-muscle sample from those carcasses the following day. The sample was then processed according to the Sheep CRC guidelines and a NIR value of chemical IMF% was obtained from the sample. In the case of beef, the MSA expert grader's values were used to benchmark against MEQ Probe's marbling value.

This was then used for AI model development to develop the relationship between the probe's spectral reading and the benchmark values.

Results/key findings

The key results achieved throughout the project were:

- MEQ Probe can provide a measure of IMF% in a hot lamb carcase that is accurate and precise to proceed to seek AUS-MEAT accreditation
- MEQ Probe is approaching the stated accuracy and precision required to enable the technology to seek accreditation to measure marble score in hot beef carcases; this is expected within the next six months

Benefits to industry

The benefit to the industry is different between lamb and beef.

Lamb:

The Lamb industry does not have a measure at a carcase level for eating quality. However, the workflow of a lamb processor is such that a hot measure is essential for them to take advantage of the data and maintain the integrity of the data on a per carcase basis. Measuring IMF% enables producers to have a signal as to how they should optimise genetics and management of future mobs, and the processor can use this information to categorise lambs to ensure consumer expectations are met. It will also unlock the opportunity for the MSA cut based sheepmeat model to be utilised.

Beef:

Beef has a well-established and respected grading system; however, it is on the cold carcase. Being able to provide hot carcase measures helps to optimise the cut plan and use of chillers. Shifting from human graders to objective measures will provide greater consistency as well. It is hoped that in the IMF work planned for 2022, MEQ could provide an IMF% measure in the way it has in lamb.

Future research and recommendations

Given the outcomes achieved and the expertise developed, the opportunity to provide IMF% in the beef industry would be an exciting development. It would also be valuable to measure additional attributes that can perhaps objectively determine nutritional measures on an individual carcase basis.

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1. Background

The project sought to address gaps in place to measure eating quality traits in red meat; in lamb, there is no measure, and in beef, most measures are undertaken by trained graders on a cold carcase.

The main question being asked was whether MEQ Probe could deliver hot measures that would add value to the red meat industry. The project's research outcomes were to demonstrate that technology could be built to adhere to the constraints within a processor environment. The second outcome for the project was for the technology to be sufficiently accurate and precise to be of value for carcase grading. The primary audience was the processor community within the red meat industry; however, the data is of importance through the supply chain. The use of the data in lamb has shown that producers find the data to be helpful.

This project is different from others as it aimed to deliver a hot carcase measure in an cut-cut carcase. Other technologies at an advanced stage aim to provide a surface measure for lamb or beef and are a cold carcase measure.

2. Objectives

The original objectives were as follows:

A tested meat-eating-quality probe ready for commercial piloting.

- A probe that is capable of being scalable to processors' chain-speed requirements.
- Software and statistical model that is ready for independent validation to seek approval for AUS-MEAT and MSA grading.

The objective has been achieved as MEQ Probe has built a system that has demonstrated it can be used in a commercial processor environment and operates at chain speed. The technology is currently undertaking accreditation in lamb and will be undertaking accreditation in the coming months in beef.

In further evidence of achieving the outcomes, MEQ Probe's lamb partner is using the data from the probe commercially by paying its consigning producers on a value-based pricing grid, a first using IMF in the lamb industry.

3. Methodology

3.1 Methodology Probe outputs and use

3.1.1 Probe outputs

Summary of experimental steps:

1. Measurement of IMF on the kill Floor by the MEQ Probe

Lambs were probed on the kill floor by the MEQ Probe. IMF% measurements were made by the MEQ Probe. These values were compared to laboratory IMF% values.

2. Collection of samples for laboratory analysis

Samples required for IMF% measurement were collected and processed as per industry standard methods and protocols outlined in the ALMTech Trait Manual.

3. Measurement of laboratory IMF

The laboratory IMF% was measured by Soxhlet calibrated NIR.

4. Lab value is compared to the value from the probe for model development

The lab value is compared to the output from the probe; the model is further developed on the basis of this performance to further enhance the performance of predictions.

In beef, the steps undertaken are the same to train the MEQ Probe to estimate IMF%. However, for AUS-MEAT and MSA marble score the probe is benchmarked against an expert grader.

3.1.2 Operating the probe

To perform a scan using the MEQ Probe, the following actions are taken:

1. The carcass about to be scanned is identified using the abattoir's identification method of choice.

2. For lamb, the operator reaches into the carcase with their non-probe hand, identifies the 13th rib, and stabilises the carcase. For beef, they identify the correct position but do not need to stabilise the carcase before probing.

3. The operator inserts the MEQ Probe into the loin at the 12/13th rib

4. Once the MEQ Probe has been fully extracted from the loin the operator releases the button, which completes the scan.

4. Results

4.1 Performance of the system in Lamb and Beef

4.1.1 Outcomes in Lamb

Following are the results of the probe for both lamb and beef.

Lamb

MEQ Probe undertook a validation project in June 2021 as it prepared for an accreditation trial. The results of the validation project provide a current summary of the performance of the probe.

IMF Distribution

A total population of 2053 carcases were selected over a period of 14 days. The proposed guidelines for accreditation require a minimum of 20 carcasses for each IMF percentage. The IMF range captured in this population of lambs covered a range from 2.06% IMF to 9.46% IMF. The distribution of the population's IMF is shown in Figure 1. Buckets from 2% IMF - 9% IMF were filled with at least 20 samples. The number of carcasses in each individual bucket can be seen below in Table 1.

Table 1: Number of carcasses in each IMF bucket, in increments of 1% IMF

IMF% Level	0 - 1	1 - 2	2 - 3	3 - 4	4 - 5	5 - 6	6 - 7	7 – 8	8 - 9	9 - 10	10 - 11	11 - 12
Number of carcasses required	20	20	20	20	20	20	20	20	20	20	20	20
Actually Captured	0	0	106	607	635	422	183	77	22	1	0	0

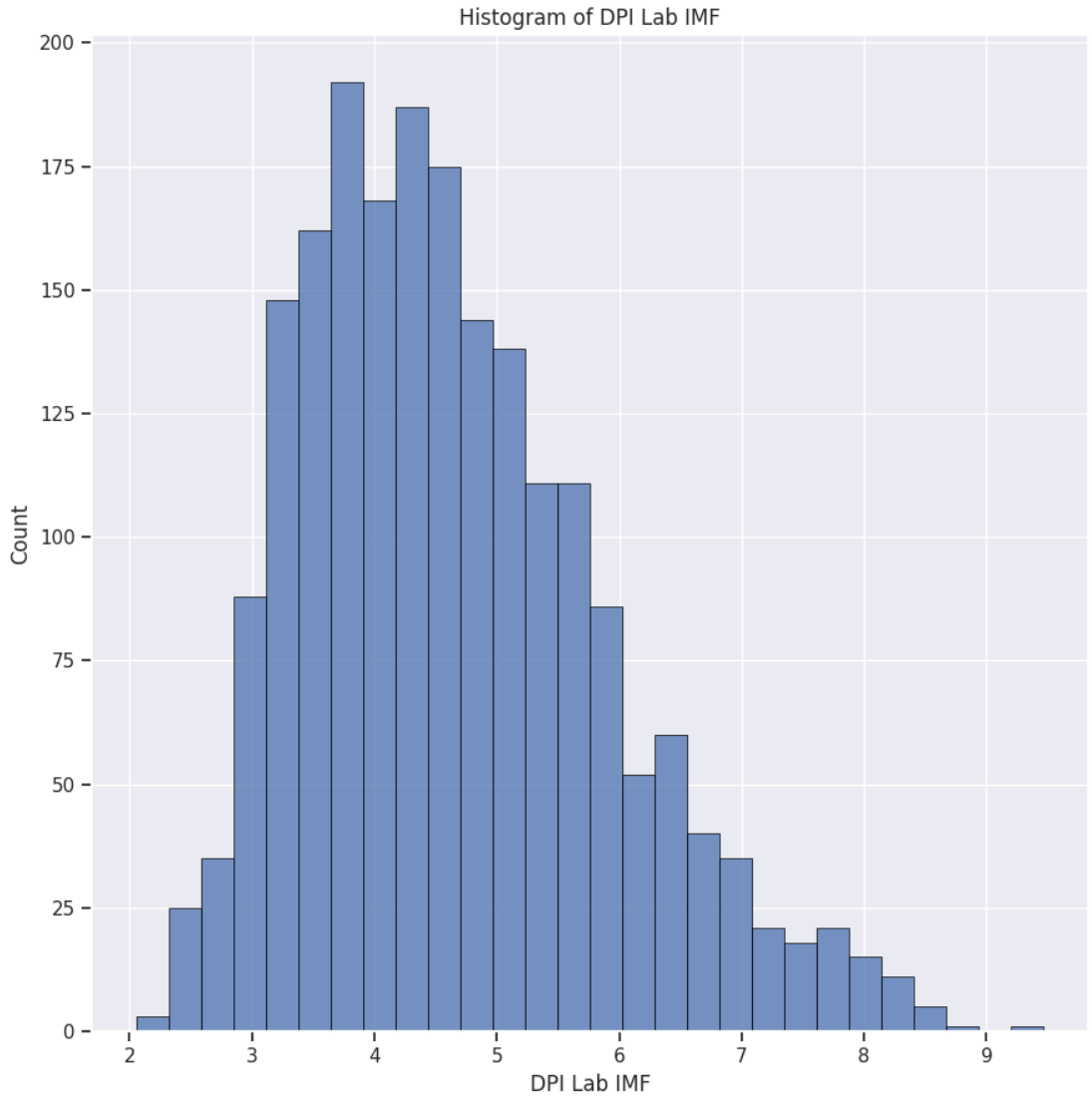

Figure 1: Distribution of DPI Lab IMF (UNE Corrected) in the sample population ranging from 2.06% IMF to 9.46% IMF.

HSCW Distribution

The population of carcass weights sampled during validation covers a wide and, approximately, normally distributed range. Figure 2 shows the distribution of HSCW with a minimum carcass weight of 15.3kg and a maximum carcass weight of 33.7kg. This indicates that the MEQ Probe is suitable for use across a wide carcass weight range.

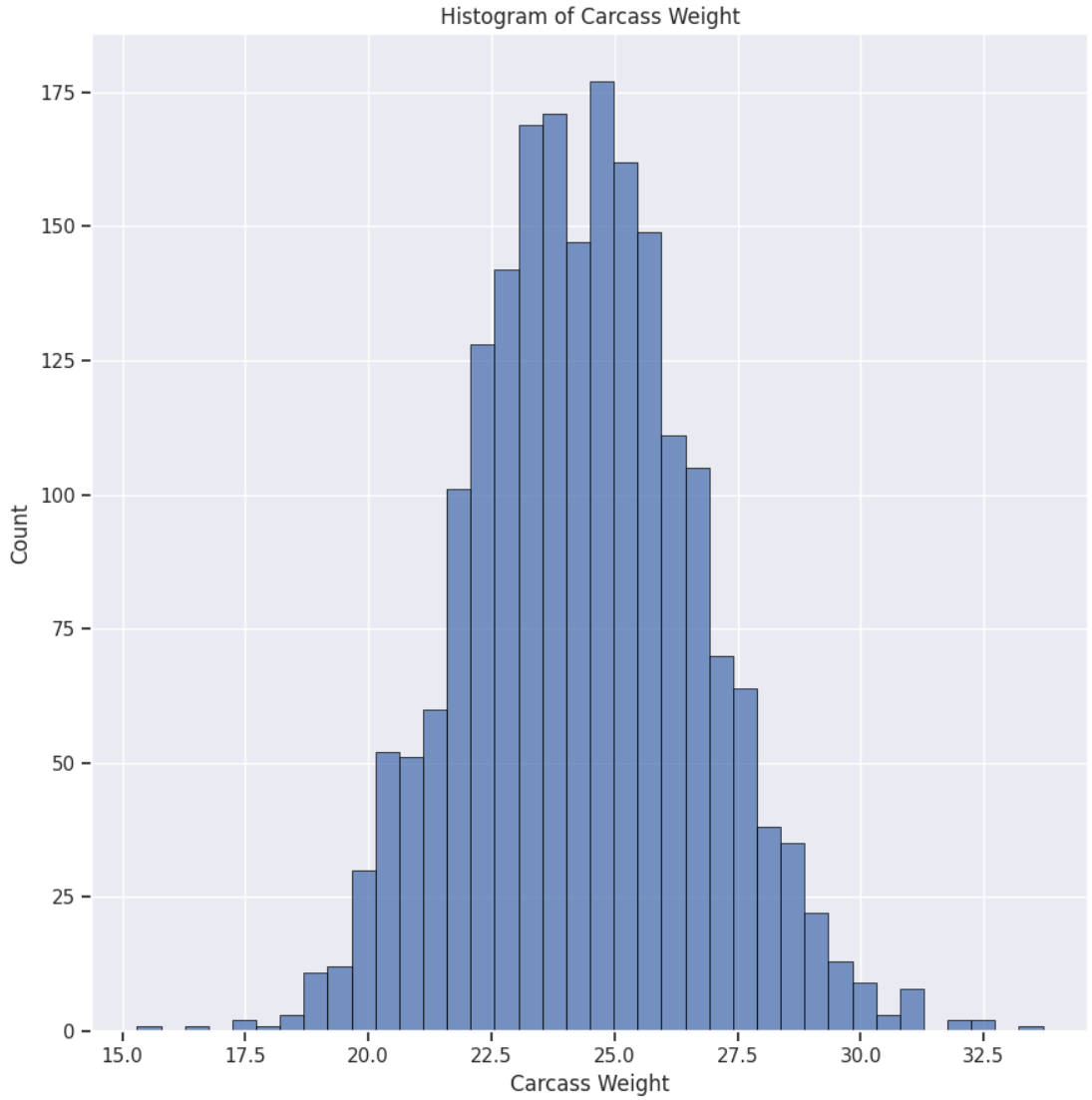

Figure 2: Distribution of carcass weight in the sample population ranging from 15.3kg to 33.7kg

Statistical Metrics

Precision and Accuracy

Statistical metrics have been calculated as per the guidelines described in the industry document *"Accuracy and accreditation standards for IMF% devices in lamb"*. Table 2 outlines the key statistical metrics used to determine model performance. The results show a +/- 1% IMF of 71.5% (higher than required) and +/- 2% IMF of 95.6% (higher than required).

Table 2: Statistical measures of model performance

Metric	Value
R^2	0.49
RMSEP	0.99
Bias	0.39
Slope	0.80
+/- 1% IMF	71.5%
+/- 2% IMF	95.6%
# Samples	2053

Figure 3 shows a scatter plot of real value (y-axis, DPI Lab IMF (UNE Corrected)) vs predicted (x-axis, MEQ Probe IMF%). A black line passing through [0, 10], [0, 10] shows an ideal fit. Grey lines at +/-1 % IMF and +/-2 % IMF are used to visualise the allowable thresholds.

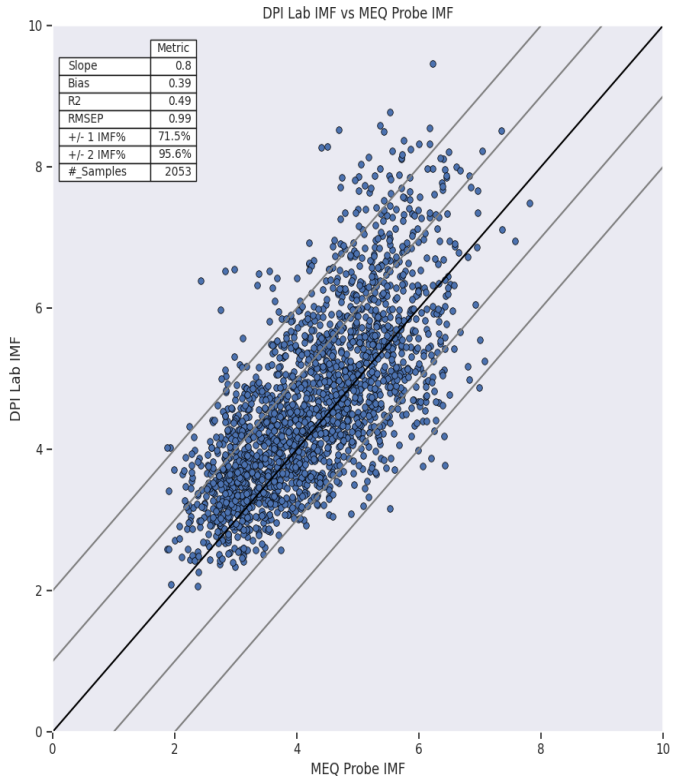

Figure 3: Scatter plot of real (y axis) vs predicted (x axis), where real is the DPI Lab IMF % (UNE Corrected) data. Predicted is the MEQ Probe measurement of the IMF%.

4.1.2 Outcomes in Beef

MEQ Probe has been developing its system to provide MSA Marbling as standards were created for technologies to be accredited to provide this output. The work undertaken has led to MEQ Probe being very close to the stated guidelines. The results are provided below.

Figure 1 shows the MEQ Probe MSA Prediction vs Expert Grader MSA Grade for 257 carcasses. The carcasses in this dataset were not used for training the probe thereby providing an independent dataset to validate the performance of the MEQ Probe. We use the expert graded carcasses for this purpose because they are the graders that the MEQ Probe will be accredited against.

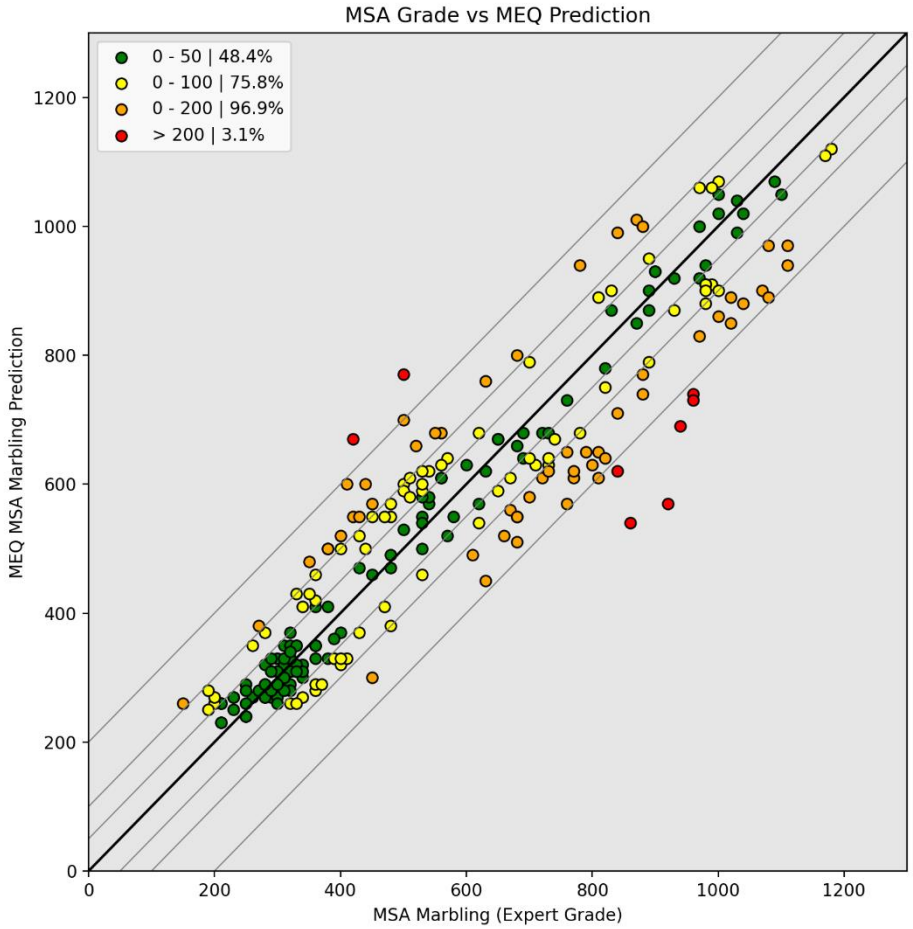

Figure 1: A scatter plot of the MEQ Probe performance vs Expert grader on a independent dataset of 257 carcasses

The industry language for recommended accuracy standards for technology have been revised slightly to make the standards less ambiguous. These changes have been reflected in the data below. Table 1 reports the current performance of the MEQ Probe. Further development is planned with the intent to seek AUS-MEAT accreditation.

Table 1: A table showing the MEQ Probe performance against the required parameters for accreditation.

Error Range (MSA Marbling)	Range for accreditation	Latest Model (September 2021)
<= 50	>= 49%	**48.4%**
0 - 100	>= 79%	**75.8%**
0 - 200	>= 97%	**96.9%**

5. Conclusion

The project's objective was to build a solution that could work within the processor environment with the accuracy and precision that would deliver value to the industry—a technology developed to a sufficient level to be ready for validation in preparation to seek Australian Meat Industry Language and Standards Committee approval as an accredited grading device.

These objectives have been achieved. Over the course of the project, MEQ Probe has developed its technology in lamb and beef to be ready for validation. As a result, MEQ Probe has undertaken an accreditation trial to measure IMF% in hot lamb carcases, which is currently being finalised; and is positioned to undertake an accreditation trial to measure MSA marble score in hot beef carcases in the coming months.

Through its deployments in both lamb and beef plants, the technology has shown that it is suitable for the processing environment and can operate at commercial chain speeds. In the case of lamb, it is currently being used by its processor partner to be an input for a value-based pricing grid; this is a first.

5.1 Key findings

The key findings are that the MEQ Probe has been demonstrated its capability to:

- Estimate IMF% in uncut lamb carcases, enabling the MSA cut based sheepmeat model to be introduced to industry
- Estimate MSA marble score in uncut beef carcases
- Deliver both IMF% and MSA marble score in hot carcase measures, thereby enabling new lamb grading opportunities, earlier boning run planning, improved carcase handling and marshalling efficiency and optimisation of chillers
- New carcase value feedback to lamb producers to improve genetic selection and management decisions

5.2 Benefits to the Industry

The practical implications of the project's outcomes are that the industry has the opportunity to adopt a technology providing new grading opportunities for lamb and beef processors. Furthermore, the data from this technology is objective, enabling a more consistent measure of IMF% and marbling.

The benefit to the lamb industry is that a key eating quality trait can be measured and, therefore, inform improved brand development and on-farm management. The establishment of IMF% also enables brand owners to be able to categorise their products with greater certainty. In beef, a hot measure will open the opportunity to optimise cut plans given more time to determine the plan with an earlier marbling measure. A hot measure in beef also unlocks the potential for optimising the use of chillers and energy reduction and efficiencies in the boning room.

At a broader level, data at this point of processing opens the opportunity to greater collaboration between producers and processors through either new data (lamb) or earlier data (beef). An additional benefit in lamb is the opportunity to implement the MSA cut based sheepmeat model.

6. Future research and recommendations

The MEQ Probe is a platform technology meaning it has the capacity to measure other attributes. This will be a focus of future R+D, where a key area of interest is tenderness and nutritional attributes. In the immediate future IMF% for beef will be a focus; given the work undertaken by MEQ Probe in lamb with IMF% it is well placed to deliver an IMF output for beef.

MEQ Probe is working closely with groups such as the MLA, ALMTech, AMPC and MSA to ensure that the outcomes of work are distributed to the industry. It will also be independently reaching out to the processor community to brief them on the technology and attending major industry conferences as they happen.