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A GR/Impedance probe proves unsuitable for measuring GR depth in
Australian lamb carcases
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Abstract

Multiple studies were conducted at 3 abattoirs to determine the potential of a dual function GR/Impedance probe to measure GR soft-tissue depth (depth at the 12th rib, 110 mm from the mid line of the carcase) of typical lamb carcases processed in Australia. Lamb carcases (1016) were measured approximately 25 min post slaughter with the probe and a GR knife as the most commonly used measurement. Modelling indicated that variation in the measurement using the probe compared to the measurement using the knife occurred with increasing carcase weight and fatness as well as between different abattoirs. Consequently, the probe in its current design cannot provide the repeatable measurement required by industry.

Keywords: lamb, carcase assessment, carcase yield, fat depth

1. Introduction

Profitability of the lamb supply chain is driven, in part, by the suitability of carcases in meeting value-based market specifications and the lean meat yield of carcases when retail cuts are fabricated. Given this importance, and the shift towards value based marketing in the Australian lamb supply chain, there has been increasing focus on accurately measuring lean meat yield at production speed in abattoirs (Pearce, 2016). However, there are currently few tools available to processors to determine the percentage of saleable meat. Consequently, processors rely on hot carcase weight (HCW) and a measurement of fat depth to determine market suitability and predict carcase yield.

There are currently two methods used to determine fat depth; palpated fat scores where scores vary from 1 (leanest) to 5 (fattest) which represent GR knife depths of approximately 0 – 5mm, 6 – 10 mm, 11 – 15 mm, 16 – 20mm and 20 + mm for fat scores 1 – 5 respectively and measurement using a GR (Greville) knife (AUSMeat, 2013). While both AUS-MEAT methods measure at the GR site (110 mm from the mid-line over the 12th rib), the measurement completed by palpation with HCW has a reduced accuracy in predicting lean meat yield (20%) when compared to the prediction accuracy using HCW and GR soft-
tissue depth measured to the nearest mm with a knife (35%) (Pearce, 2016). This is unsurprising given that it is completed by a person manipulating the carcase using their fingertips; however a GR knife is unable to be used accurately at fast chain speed.

In recent decades these limitations have been addressed by the use of the AUS-MEAT Sheep Probe (ASP) (Hopkins, Anderson, Morgan & Hall, 1995, Hopkins, Safari, Thompson & Smith, 2004), which is no longer available. The Hennessy Grading Probe (HGP) has also been investigated, but proved unsuitable (Hopkins, Toohey, Boyce & de Ven, 2013). Consequently, palpated fat scores is the most common method used by sheep and lamb processors in Australia to estimate the tissue depth at the GR site, despite its low accuracy in predicting saleable meat yield. Therefore, industry requires a more accurate and robust method for the measurement of GR tissue depth (Toohey & Hopkins, 2015).

The aim of this study was to determine the potential for a dual purpose GR/Impedance probe to measure GR depths of lamb carcases in commercial processing plants.

2. Materials and Methods

Experiments were conducted at 3 commercial abattoirs, measuring 1016 randomly selected lamb carcases which were typical of carcases processed in Australia. Lamb carcases were measured approximately 25 – 30 min post slaughter with the dual purpose GR/Impedance probe and the GR knife at the GR site. The GR probe electronically measures the tissue depth via displacement of a perspex plate relative to the needles used for the impedance function, which penetrate the tissue until they hit the rib bone.

Carcase weight, palpated fat score (if available), the day of measurement (Date), configuration of the perspex plate on the front of the probe (flat or round), carcase temperature (hot or cold) and operator were also recorded.

Regression models to predict the GR knife measurements using the GR probe were completed using asreml (Butler, Cullis, Gilmour & Gogel, 2009) under R software (R Core Team, 2015). The model included an average fixed effect regression for GR knife on GR probe and allowed the regressions to vary across the 3 abattoirs. In addition, the model
included random Date effects and allowed the error variance to differ for the three abattoirs. A model was also generated to include HCW as a covariate.

3. Results

Overall the lambs measured in this study represented those which are typically processed in Australian lamb abattoirs. Carcase weights ranged from 10.7 – 33.3 kg (mean = 21.6kg, s.d. = 3.3), while GR knife measurements ranged from 1.5 – 25 mm (mean = 11.0, s.d. = 4.0) and fat scores ranged from 2 – 5 (mean = 3).

The model to predict GR knife measurements using the GR probe excluding HCW for the population of abattoirs which these ones were selected from yielded the equation:

\[ \text{Predicted(GR Knife)} = 3.35 \text{ (s.e = 0.77)} + 0.70 \text{ (s.e. = 0.048)} \text{ GR probe} \]

However, if this model was being used to predict the ability of the probe to measure GR depth at an abattoir different to those in the current study, the standard errors in the regression increase to 1.63 and 0.13, for the intercept and slope respectively. Which is not unexpected given this involves predicting in a different population and that more sampling would be required to reduce the error for translating purposes.

Abattoir was also a source of variation within the model as highlighted by Fig. 1. Subsequently, the regression equations for the data collected from each abattoir are:

Abattoir 1: \( \text{Predicted(GR Knife)} = 2.83 \text{ (± 1.47)} + 0.66 \text{ (± 0.132)} \text{ GR probe} \)

Abattoir 2: \( \text{Predicted(GR Knife)} = 5.76 \text{ (± 0.818)} + 0.52 \text{ (± 0.042)} \text{ GR probe} \)

Abattoir 3: \( \text{Predicted(GR Knife)} = 1.46 \text{ (± 1.321)} + 0.91 \text{ (± 0.026)} \text{ GR probe} \)

Insert Fig 1 here.

When HCW was included in the models indicates it was highly significant \( (P<0.001) \). Furthermore, the intercept for the regression model demonstrated an increase in GR tissue depth of 0.49 mm \( \text{(s.e. = 0.039)} \) with each kilo increase in HCW. The regression equation for
this model (adjusted to the mean carcase weight of 21.5 kg including data from all abattoirs) is equal to:

\[
\text{Predicted(GR Knife)} = 3.04 \text{ (s.e. = 1.54)} + 0.56 \text{ (s.e. = 0.19)} \text{ GR probe}
\]

Using the GR probe to allocate carcases into fat scores when the GR knife are in the ranges 0 – 5mm, 6 – 10 mm, 11 – 15 mm, 16 – 20mm and 20 + mm (Table 1) for carcases measured at one abattoir, indicates that prediction without including HCW resulted in 269 carcases being correctly classified according to fat score. Of the remainder, 326 were misclassified by one fat score, while 81 were misclassified by two or more fat scores. Including HCW marginally improved the classification resulting in 297 correctly classified, 315 misclassified by 1 fat score and 64 misclassified by two or more fat scores.

**Insert Table 1 here.**

4. **Discussion**

Overall, the results found in this study indicate that the GR probe is unable to totally account for the differences in GR knife measurements introduced with varying fat scores and carcase weights. Furthermore, the probe was also unable to totally account for the differences in GR knife measurements associated with measurement at alternative abattoirs.

Variability in lamb carcase conformation is an ongoing challenge for the development of a technology to measure the GR tissue depth, particularly soon after slaughter when the carcases are still hot given they lack rigidity and are slippery to handle. The GR/Impedance probe used in this study was designed for pork and is a similar design to the Fat-o-Meater (Goenaga, Lloveras & Améndola, 2008). Consequently, the design of the probe is large and heavy and the front perspex plate does not sit entirely flat against the ribs of the carcase. This can result in an inaccurate measurement of GR knife measurements, as the displacement between the needles of the probe which penetrate the carcase to the 12th rib and the perspex plate which is intended to sit on the ribs is greater than the actual depth at the GR site. Therefore, future modifications of the technology need to include adaptions to better suit the smaller, rounder size and shape of lamb carcases.
The classification of carcases into fat scores measured with the GR knife using the GR probe data suggests that the variability in the regression due to carcase confirmation may be more pronounced for fatter carcases as carcases which had a GR knife measurement between 16 – 20 mm were most incorrectly classified. The same effect was found by Hopkins et al. (1995) during the development of the AUS-MEAT sheep probe. As carcases with a measured soft-tissue depth between 16 – 20 mm were most likely measured as a fat score 3 (between 11 – 15 mm), it is hypothesised that the size and the weight of the probe combined with the confirmation of fatter carcases resulted in the probe slipping from the rib during measurement resulting in an inaccurate fat measurement with the GR probe. While the probe may be incorporated into the chain in such a manner that the operator does not have to carry its weight, the size and number of needles which penetrate the carcase to the 12th rib are incorrectly distanced and orientated to sit along the rib of a lamb carcase hung on the chain. Consequently, when the probe is used with the needles parallel to the rib, the probe needs to be held rotated making it difficult to manoeuvre the probe into the correct position before pushing it firmly into the carcase to take the measurement. Alternatively, when the probe is used perpendicular to the rib, the distance between the needles results in the ribs of the carcase going between the needles. This finding supports the need for the development of a technology specialised to the application of measuring GR soft tissue depth of lamb and sheep carcases.

Carcase confirmation is not only affected by fat depth as a similar affect was also found for heavier carcases. As a result, GR knife measurements were increasingly underestimated as carcase weight increased, again suggesting size impacted on the operation of the probe. Consequently, over the 22.6 kg carcase weight range the underestimation of the GR probe equates to an 11.1 mm difference between the GR depth measured with the probe and the knife.

Several causes can be attributed to the variation associated between abattoirs including operator and chain speed. On a lamb processing chain there is not enough time to complete repeat measurements, therefore operator proficiency is required to make accurate measurements using a probe (Hopkins et al., 1995). Furthermore, the chain speed itself also contributes to this variation, given that the faster the chain speed the lower the accuracy of the GR measurement (Pearce, 2016). This is a result of the operator missing the GR site on a carcase which is moving at faster chain speeds. However, this variance emphasises the
significance of operator training and operator monitoring to ensure that suitable protocols for measurement are developed and employed, as the abattoir error includes the contributions to measurement error associated with operator.

5. Conclusion

Based on the findings from this study it is evident that the dual purpose GR/Impedance probe is unable to provide an accurate and repeatable measure of GR tissue depth which is required by industry. This is due to the variation between GR probe and GR knife measurements found as a result of increasing carcase weight and fatness as well as the variation present between abattoirs. However, this finding is limited to the current design of the probe as this study identified several modifications, including miniturisation of components, which may enable accurate measurements at chain speed.

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References

Fig. 1. The prediction of GR Knife measurements using the GR probe, for each abattoir where the dashed lines represent the standard error of the predicted average of the mean over the three abattoirs in the study (each abattoir is denoted by a single symbol), while the dotted lines represent the standard error of the predicted average over the total population of abattoirs.
Table 1.
The classification of carcases into fat scores measured with the GR knife using the GR probe with and without hot carcase weight.

<table>
<thead>
<tr>
<th>GR Knife measurement</th>
<th>Predicted Fat Score (without HCW)</th>
<th>Predicted Fat Score (with HCW)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>6 – 10 mm (2)</td>
<td>39</td>
<td>34</td>
</tr>
<tr>
<td>11 – 15 mm (3)</td>
<td>93</td>
<td>220</td>
</tr>
<tr>
<td>16 – 20 mm (4)</td>
<td>33</td>
<td>194</td>
</tr>
<tr>
<td>20 + mm (5)</td>
<td>1</td>
<td>47</td>
</tr>
</tbody>
</table>
Highlights

- A GR/Impedance probe was shown to be unsuitable to measure GR tissue depth in lambs
- Variation in GR tissue depth measures were associated with the weight of carcases
- Increasing fatness also reduced the ability to measure GR tissue depth with the probe