MEASUREMENT OF TEMPERATURE DECLINE IN SHEEP CARCASSES

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SUMMARY
An experiment which followed the temperature decline during chilling of 116 lamb and hogget carcasses showed that the industry standard measurement; surface temperature is prone to fluctuations indicating the need for careful measurement. Despite a medium chill < 6°C in the loin after 8 hours of chilling the predicted deep butt temperature was 18.1°C at a surface temperature of 7°C. Measurement of temperature at the site (Ltemp) used for the sheep meat eating quality grading scheme (at the caudal end of the m. longissimus thoracis et lumborum, LL) was 2.3°C less than measurement at the deep butt. Importantly measurement of temperature at the 12th/13th rib in the middle of the LL was less than at the Ltemp site. This indicates that the measurement site must be specified for the grading scheme even if temperature is measured in the same muscle with implications for pH/temperature window specifications.

Keywords: lamb, chilling, temperature

INTRODUCTION
With the development of an eating quality scheme for sheepmeat it is likely that processors will need to monitor temperature and pH decline during chilling so as to ensure that the meat enters rigor at target temperatures as occurs in the Meat Standards Australia scheme for beef (Thompson 2000). The site for the measurement of temperature in lamb carcasses was changed in 1995 with the launch of the Australian standards endorsed by ARMCANZ. These state that the surface temperature must be reduced to 7°C within 24 hours of stunning and before transport (Anon. 1995). A quick and effective method of measuring these temperatures is by use of an infrared non-contact thermometer (Anon. 1996). Usually temperature would be measured by a probe that penetrates into carcass meat, but if surface temperature could be used this would allow quicker and easier screening measurements allowing targeted pH measurement. This paper presents some preliminary data on the relationship between temperature decline measured at several different sites on lamb and hogget carcasses.

MATERIALS AND METHODS

Carcass types and measures
Carcass data were obtained for 120 animals representing first and second cross lambs; Merino lambs and first cross hoggets of mixed sexes. These genotypes were equally represented across 2 slaughter days and 4 slaughter groups (2 per day). All animals were electrically stunned (head only) in a commercial abattoir and trimmed according to the specifications of AUS-MEAT (Anon. 1992). Two carcasses were unsuitable for sampling, due to disease and 2 were trimmed during dressing (leaving 116 from the 120 killed). Hot carcass weights were recorded and the GR measured (total tissue depth over the 12th rib 110 mm from the midline) using a GR knife. GR is used as an indicator of subcutaneous fat depth from which 5 fat classes are defined.

Sampling and meat quality measurements
At regular intervals after the commencement of chilling pH and temperature (Ltemp) were measured in the left-hand portion of the m. longissimus thoracis et lumborum (LL) at the caudal end over the lumbar/sacral joint. A section of subcutaneous fat and the m. gluteus medius was cut away to expose the LL and after measurement the area was resealed with the overlaying tissue. pH was measured using a WPS meter with temperature compensation (TPS, WP-80, PTS Pty Ltd) and a polypropylene spear-type gel electrode (Ionode IJ 44), calibrated at ambient temperature. Six measurements were taken as the pH fell. Temperature decline (Ptemp) was determined on 10 carcasses per slaughter group using Cox recorders (Belmont, NC, USA). Probes were inserted into the centre of the (LL) at the 12th/13th rib and recorded temperature every 10 mins. Temperature decline in the m. semimembranosus (SM; to the depth of the femur, Dtemp) was recorded in every carcass, 4 times during chilling (Comark C9001 thermometer with 250 mm x 11 mm probe). At the same time the
surface temperature (Stemp) was measured with an infrared gun (non-contact thermometer; Raynger PM plus, Raytek inc.) on the opposite side of the LL to the pH measurement site. Thus from the commencement of chilling and the first measurements, temperature was monitored in each carcass for 5-6 hours, during the period of rapid temperature decline. On the first slaughter day the chiller was filled with non-experimental lamb carcasses, but on the second kill day this was not the case and only experimental lambs were placed in the chiller.

Statistical analysis
Ltemp, Dtemp, Stemp and Ptemp were regressed against each other (GENSTAT 5.4.1, 2000) and the effect of carcass weight or GR on these relationships was also examined.

The rate of temp decline (Ltemp and Ptemp) relative to chilling time from the first pH measurement post-mortem for each carcass was described using data for 7 different sample points for Ltemp and up to 132 for Ptemp using the following non-linear equation and a non-linear procedure (GENSTAT 5.4.1, 2000):

\[ \text{Tempt} = \text{Temp}_f + (\text{Temp}_i + \text{Temp}_f) \exp^{-kt} \]

where \( \text{Tempt} \) = Temperature at time \( t \), \( \text{Temp}_f \) = the final temperature, \( \text{Temp}_i \) = temperature at \( t = 0 \), \( k \) = rate constant of temperature decline and \( t \) = the time in hours.

RESULTS
Carcasses were chilled at 2-3°C and 86% humidity. During the first slaughter day the introduction of non-experimental lambs which filled the chiller to capacity resulted in a rise in the surface temperature of 14 carcasses from the first slaughter group (Figure 1). Surface temperature data for these carcasses were not used for analysis, but this does illustrate a need for caution when using surface temperatures.

![Figure 1](image-url)

Figure 1. Relationship between surface temperature and time of chilling for carcasses which showed a rise in temperature (n = 14; ♦) as indicated and those that did not (n = 102; %)

A summary of the various temperature measurements for 102 carcasses is provided in Table 1. This shows that surface temperature was much lower than muscle temperatures, presumably because by the time of first measurement a lot of heat has been dissipated from the surface of the carcass. Complete probe data for temperature decline at the 12th rib was available for 38 carcasses. The mean time required for surface temperature to reach 7°C was 3.45 ± 0.81 h.
Table 1. Summary statistics for surface temperature (Stemp), deep butt temperature (Dtemp), loin temperature (Ltemp) and loin temperature at the 12th rib (Ptemp)

<table>
<thead>
<tr>
<th></th>
<th>Stemp (°C)</th>
<th>Dtemp (°C)</th>
<th>Ltemp (°C)</th>
<th>Ptemp (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>9.5</td>
<td>23.5</td>
<td>21.1</td>
<td>14.2</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>4.4</td>
<td>7.6</td>
<td>7.0</td>
<td>6.3</td>
</tr>
<tr>
<td>Coefficient of variation</td>
<td>46.9</td>
<td>32.4</td>
<td>33.1</td>
<td>44.5</td>
</tr>
<tr>
<td>Range</td>
<td>0-19.7</td>
<td>8.9-39</td>
<td>8.2-36.7</td>
<td>3.9-30.6</td>
</tr>
</tbody>
</table>

The coefficients for the regression models are shown in Table 2. All regression models were significant at the P = 0.001 level as was each coefficient in the models. These show that muscle temperatures measured by penetration (Dtemp and Ltemp) decrease at a faster rate than surface temperature and that temperature measured in the deep butt is consistently 2.3°C greater than temperature measured in the loin (Ltemp). Both carcass weight and fatness (GR) had a significant effect (P < 0.05) on the relationship between Dtemp and Ltemp with regression coefficients of 0.15 kg/degree and –0.1 mm/degree respectively. Of particular interest was the finding that prediction of Ltemp from Stemp was significantly effected by the GR level of the carcass such that at a constant Stemp the predicted value of Ltemp increased as GR increased with a regression coefficient of 0.14 mm/degree. Temperature measured at the 12th rib (Ptemp) declined at a similar rate to temperature at the pH measurement site (Ltemp), but had lower absolute levels throughout chilling. This relationship was independent of the carcass weight and fatness (GR) of the carcass. Using these models the predicted temperature in the loin (Ltemp) at a surface temperature of 7°C was derived and found to be 18.1°C. For Dtemp to be 10°C the surface temperature would need to be 1°C.

Table 2. Regression relationships between different measures of temperature where surface temperature (Stemp), deep butt temperature (Dtemp) and loin temperature (Ltemp)

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Intercept ± SD</th>
<th>Slope ± SD</th>
<th>R²</th>
<th>r.s.d.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ltemp</td>
<td>8.86 (± 0.46)</td>
<td>1.32 (± 0.04) Stemp</td>
<td>0.69</td>
<td>3.95</td>
</tr>
<tr>
<td>Dtemp</td>
<td>9.88 (± 0.48)</td>
<td>1.44 (± 0.05) Stemp</td>
<td>0.71</td>
<td>4.13</td>
</tr>
<tr>
<td>Dtemp</td>
<td>2.28 (± 0.46)</td>
<td>0.99 (± 0.02) Ltemp</td>
<td>0.85</td>
<td>2.93</td>
</tr>
<tr>
<td>Ltemp</td>
<td>7.61 (± 0.56)</td>
<td>0.97 (± 0.04) Ptemp</td>
<td>0.84</td>
<td>2.74</td>
</tr>
</tbody>
</table>

Using the non-linear models of Ptemp against time for each carcass the temperature at 8 hours was determined with the mean being 4.9°C compared with 8.5°C for Ltemp.

DISCUSSION

Based on the results of Shaw et al. (1995) and using data for Ptemp the chilling conditions in this experiment would be classified as medium ie <6°C after 8 hours of chilling even allowing for the fact that there was delay in measuring temperature after death in this experiment. The chiller temperature at 2-3°C in this experiment was probably at the colder end of the spectrum for domestic abattoirs Hopkins (1993). Given this temperature regime the target surface temperature of 7°C was achieved within 4 hours of the first measurement, well within the time scale to allow a night loadout. Despite this rate of decline the deep butt temperature (Dtemp) was much higher than suggested previously for a surface temperature of 7°C (Hopkins et al. 1996).

There was an obvious increase in surface temperature (Stemp) on the first slaughter day coinciding with the introduction of hot carcasses that filled the chiller, whereas Dtemp, Ltemp and Ptemp continued to decline. This highlights the greater sensitivity of measuring temperature on the surface of the carcass and suggests that using this measure, as a quick monitoring method to indicate when deeper muscle temperatures and pH should be measured would require very careful application. Further to this the precision of predictions of Ltemp from Stemp can be improved by consideration of the fatness of the carcass (ie r.s.d = 3.95 cf 3.89). The fact that fatness effects temperature decline is not new (eg Smith et al. 1976).
Of particular relevance to the development of an eating quality system was the difference in temperature between Ltemp and Ptemp. This indicates that when setting a pH/temperature window as per MSA (Thompson 2000) then the actual site of measurement must be specified even if measurement is in the loin.

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REFERENCES

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