MEASURING MARBLING FAT IN BEEF CARCASES USING THE HENNESSY GRADING PROBE

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SUMMARY

The ability of the Hennessy Grading Probe (HGP) to measure intramuscular (marbling) fat was determined by probing 266 carcases from grain-fed cattle. The probe was inserted between the 10th and 11th ribs measuring the amount of marbling within M. longissimus thoracis et lumborum (eye muscle). These measurements were compared with chemically determined intramuscular fat percentage (chemical fat percentage) and visual marbling scores of AUS-MEAT’s Chiller Assessment Scheme which range from 1 (minimal marbling) to 12 (very highly marbled). Visual marbling scores were also compared with chemical fat percentage.

The best combination of HGP measurements was only weakly correlated with chemical fat percentage ($r^2 = 0.14$, standard error of estimate (SEE) = 2.12, $P < 0.01$). Visual marbling score and chemical fat percentage were also weakly correlated ($r^2 = 0.22$, SEE = 2.01, $P < 0.01$). Measurements with the HGP and visual marbling scores were not significantly correlated.

These results indicate that the HGP marbling fat measurements were poor estimators of chemical fat percentage and visual marbling scores.

Keywords: beef carcases, marbling, measurement, grading probe.

INTRODUCTION

In Japan, meat with high levels of intramuscular (marbling) fat attracts higher premiums (Longworth 1983) because the Japanese believe that marbling enhances flavour, juiciness and tenderness. Australia exported 195,733 tonnes of beef and veal to Japan in 1992, representing 34% of the total value of beef and veal exports (AMLC 1992).

It is difficult and expensive to produce cattle that yield well marbled meat. It is also difficult to quantify the degree of marbling accurately. Commercially, marbling is visually scored at the cut surface of M. longissimus thoracis et lumborum (eye muscle) using the marbling standards of the AUS-MEAT Chiller Assessment Scheme. However, while visual assessment is conveniently made on quartered carcases, Taylor and Johnson (1992) showed that visual marbling scores were poorly correlated with chemical intramuscular fat percentage. If the Hennessy Grading Probe (HGP) could accurately quantify intramuscular fat, the technique might be used as a basis of payment in preference to visual marbling score.

Currently, there is no objective method of measuring marbling on the slaughter floor, so producers receive a direct financial reward for producing well marbled meat when the payment is adjusted following chiller assessment. An objective marbling assessment system is required that is accurate and commercially practical. Such a system would provide industry with a product description system on which to base differential payments and it would enhance forward marketing. A device which objectively measures marbling on the slaughter floor would assist the Australian beef industry to maintain a competitive edge in these markets.

The HGP, an electronic probe, is approved in Australia and overseas for the commercial measurement of fat thickness in cattle (Phillips et al. 1987), and fat and muscle thicknesses in pigs (Cook et al. 1989). It operates on the principle that muscle and fat have different light reflectance properties and it is capable of measuring fat and muscle thicknesses to within 0.4 mm. It could conceivably be used to measure marbling fat in conjunction with the measurement of fat and muscle thickness.

MATERIALS AND METHODS

The programming of the HGP was modified to incorporate marbling measurements. The HGP was then used to collect marbling data for 266 Japanese grain-fed beef carcases slaughtered at 2 abattoirs.

One person probed the left side of each carcase on the slaughter floor at chain speed. Marbling was measured within the eye muscle between the 10/11th ribs. Carcases were probed at the following 2 sites:

1. dorso/ventrally at a point half the distance from the medial edge to the lateral edge of the eye muscle; and
2. dorso/ventrally at a point three quarters of the distance from the medial edge to lateral edge of the eye muscle.

After overnight chilling the carcases were re-probed between the 10/11th ribs, where Japanese grain-fed carcases are commonly assessed in Australia. Following quartering between these 2 ribs, marbling was assessed by trained AUS-MEAT officers using AUS-MEAT’s Chiller Assessment Scheme visual marbling scores (Anon. 1990). The scale ranged from 1 (minimal marbling) to 12 (highly marbled). AUS-MEAT’s Chiller Assessment Scheme was in the developmental stage at the time of the project and the assessors were not AUS-MEAT accredited; however they were experienced in using the visual marbling scores.

A slice (approximately 5 to 10 mm thick) of the eye muscle at the 10/11 th ribs was removed from one side of each carcase and chemically analysed for intramuscular fat content at the CSIRO Meat Research Laboratory, Cannon Hill, using a standard ether extraction procedure (AOAC 1984).

Using regression analysis, HGP marbling measurements and visual marbling scores were used as independent variables (x) to predict the dependent variable, chemical fat percentage (y), and their accuracies were compared using a one-way analysis of variance. The HGP measurements (x) were also used to predict visual marbling scores (y). The data were analysed using the SYSTAT statistical package (Wilkinson 1990) and the value of predictors was determined from their coefficient of determination ($R^2$) and standard error of estimate (SEE).

**RESULTS**

The means and standard deviations of chemical fat percentage and visual marbling scores are reported in Table 1.

<table>
<thead>
<tr>
<th>Abattoir</th>
<th>Number of carcases</th>
<th>Chemical fat percentage</th>
<th>Visual marbling scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>100</td>
<td>4.7 (2.4)</td>
<td>2.1 (0.5)</td>
</tr>
<tr>
<td>2</td>
<td>166</td>
<td>5.5 (2.2)</td>
<td>2.4 (0.6)</td>
</tr>
<tr>
<td>Combined</td>
<td>266</td>
<td>5.2 (2.3)</td>
<td>2.3 (0.6)</td>
</tr>
</tbody>
</table>

*Standard deviations shown in parenthesis.

Although the range of visual marbling scores within the sample (1-4) was representative of the carcase population being exported to Japan (Browne and Beasley 1991), it may have been an inadequate distribution of marbling scores to ensure reliable regression analysis. The amount of variance in chemical fat percentage explained by the HGP ($R^2$ and SEE) are reported in Table 2.

**Table 2. Coefficients of determination ($R^2$) and standard errors of estimate (SEE) for the prediction of chemical fat percentage using Hennessy Grading Probe marbling measurements and visual marbling scores**

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Coefficient of determination ($R^2$)</th>
<th>SEE</th>
</tr>
</thead>
<tbody>
<tr>
<td>HGP marbling measurements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hot carcase, site 1</td>
<td>0.09</td>
<td>2.17</td>
</tr>
<tr>
<td>Hot carcase, site 2</td>
<td>0.07</td>
<td>2.21</td>
</tr>
<tr>
<td>Cold carcase, site 1</td>
<td>0.03</td>
<td>2.23</td>
</tr>
<tr>
<td>Cold carcase, site 2</td>
<td>0.11</td>
<td>2.14</td>
</tr>
<tr>
<td>Hot carcase, sites 1 + 2</td>
<td>0.14&lt;sup&gt;A&lt;/sup&gt;</td>
<td>2.12</td>
</tr>
<tr>
<td>Cold carcase, sites 1 + 2</td>
<td>0.13</td>
<td>2.12</td>
</tr>
<tr>
<td>Chiller Assessment Scheme</td>
<td>Visual marbling score</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0.22&lt;sup&gt;A&lt;/sup&gt;</td>
<td>2.01</td>
</tr>
</tbody>
</table>

<sup>A</sup>One-way analysis of variance comparing predictions using HGP measurements with predictions using visual marbling scores showed that there was no significant difference ($F = 0.626$, df = 1, $p > 0.05$) between the two techniques.
The HGP marbling measurements were poor predictors of chemical fat percentage ($R^2 = 0.14$, SEE = 2.12) and visual marbling scores ($R^2 = 0.07$, SEE = 0.60) (Tables 2 and 3). They also predicted chemical fat percentage less accurately than visual marbling scores, although the difference in accuracy was not statistically significant ($P < 0.05$).

Table 3. Coefficients of determination ($R^2$) and standard errors of estimate (SEE) for the prediction of visual marbling scores using Hennessy Grading Probe measurements

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Coefficient of determination ($R^2$)</th>
<th>SEE</th>
</tr>
</thead>
<tbody>
<tr>
<td>HGP marbling measurements</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hot carcass, sites 1 + 2</td>
<td>0.07</td>
<td>0.60</td>
</tr>
<tr>
<td>Cold carcass, sites 1 + 2</td>
<td>0.07</td>
<td>0.59</td>
</tr>
</tbody>
</table>

**DISCUSSION**

Some possible explanations for the poor relationship between the HGP marbling measurements and other marbling parameters are:

1. The HGP probes only a fraction of the entire cross-sectional area through which it passes. Marbling is not deposited homogeneously so a linear measurement (a sample) could misrepresent the actual amount of marbling within the entire eye muscle area. Combining sites 1 and 2 increased the amount of variation in chemical fat percentage explained by the HGP. Further investigations would determine if additional measurements improve the prediction of chemical fat percentage.

2. The HGP uses light reflectance to measure visible deposits of marbling fat. However, visual marbling is weakly correlated with chemically analysed marbling fat content and Savell et al. (1986) and Taylor and Johnson (1992) have demonstrated only a moderate relationship ($r = 0.44$) between the 2.

3. All HGP measurements were taken at the 10/11th ribs because of scapula interference at the 5/6th ribs where carcasses are often graded in Japan (Longworth 1983) and where Taylor and Johnson (1992) reported better relationships between visual marbling scores and chemical fat percentage. Improved predictions of chemical fat percentage may be achieved by measuring marbling at other sites on the carcass.

4. The ability of the HGP to identify and measure marbling deposits could have been a limiting factor. It was programmed to identify marbling using specific light reflectance values; however marbling deposits vary in size and reflected intensity, and sometimes they may not have been detected by the parameters used in the probe’s computer programme. The current version of the probe (GP4) with advanced programming capabilities, may achieve a better result.

Despite the findings of this study there are practical reasons to continue research with the HGP. It is already in commercial use, it interfaces with computer systems currently used on slaughter floors and it accurately measures fat depths which can be used to estimate saleable beef yield or lean meat yield (Ferguson 1989). The HGP has the potential to measure marbling prior to chilling and quartering, allowing the pre-selection of carcasses for markets with different quartering sites. It also has the potential to detect abnormal meat and fat colour (Anon. 1993).

Although visual marbling scores conveniently assess marbling at the quartering site, they have an error of ± 1 score based on chemical fat percentage (Taylor and Johnson 1992) over the narrow range of 4 scores commonly encountered in carcasses exported to Japan (Browne and Beasley 1991). The commercial convenience of subjectively estimating marbling at a quartering site should not preclude further efforts to provide industry with a more accurate measure of marbling.

Chemical fat percentage is an objective measurement of marbling fat in beef muscles which is useful for evaluating the accuracy of other methods. Neither the HGP used in this study nor visual marbling score accurately predicted chemical fat percentage. There remains a need to investigate objective methods of assessing marbling content in beef carcasses including the new HGP (GP4) and alternative programming methods.

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REFERENCES


