THE EFFECTS OF FASTING AND COLD STRESS ON DARK-CUTTING AND BRUISING IN CATTLE

R.D. WARNER*, G.A. ELDRIDGE*, J.L. BARNETT*, C.G. HALPIN** and D.J. CAHILL*

SUMMARY

Fifty Angus x Shorthorn heifers (mean body weight, 384 kg) were used to investigate the effects of a 72 h pre-slaughter fast and cold environmental conditions (accentuated by wetting down) on meat colour, muscle ultimate pH (pHu) and susceptibility to bruising. Cattle fasted outdoors and wet down had a higher muscle pHu than cattle fasted in a shed (5.51 vs 5.37; P < 0.05) and a darker meat colour score than control cattle grazed at pasture (5.47 vs 4.56; P < 0.05). These treatments however, had no effect on the susceptibility to bruising as assessed by an experimentally induced bruise. (Keywords: dark-cutting, bruising, fasting, cold stress, cattle).

INTRODUCTION

During the marketing process in southern Australia, cattle may be deprived of feed for several days whilst, at certain times of the year, simultaneously being exposed to low environmental temperatures: these stressors may lead to a chronic stress response and increased susceptibility to bruising (Barnett et al. 1984). These stressors have also been implicated in an increase in the ultimate pH (pHu) of muscles in a carcass and dark-cutting meat. Wythes and Underwood (1980) found that fasting cattle for 96 h compared to 72 h prior to slaughter significantly increased the mean pHu. Ashmore et al. (1973) considered that feed deprivation alone is insufficient to raise muscle pHu but combined with other stressors such as excessive exercise or sudden changes in temperature, the incidence of high muscle pHu may increase. Furnival et al. (1977) found a relationship between the pre-slaughter ambient temperature and subsequent muscle pHu in lambs: pHu increased by 0.25 units with decreasing temperature over the range (13 to -1ºC).

This experiment was designed to examine the effects of fasting-and cold environmental conditions on tissue damage following a standard bruising procedure and muscle pHu and subsequent meat colour of slaughter cattle.

MATERIALS AND METHODS

The trial was timed to coincide with the onset of cold environmental conditions. In June 1983, 50 Angus x Shorthorn heifers were allotted at random within liveweight strata to three treatments, one of which was returned to pasture (C) while the other two were withdrawn from feed and held in an enclosed shed (S) or in open yards (Y) for 60 h. Water was provided throughout. Environmental stress was accentuated in the cattle fasted outdoors (Y) by twice daily spraying of the group with 900 l of water over 10 min (Bell 1976). At the end of the treatment period, all cattle were bruised by a standardised technique (Barnett et al. 1984). Immediately prior to bruising, while cattle were in the race, a blood sample was taken from the caudal blood supply, a mild electric shock (66V, 0.85–2.2 mA) applied over the withers for 30 sec and a second blood

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sample taken to estimate adrenal responsiveness to a standard stressor (Barnett et al. 1984). After the treatment period, all cattle were withheld from food and water for 12 h, transported 18 km to an abattoir and slaughtered within 4 h of arrival.

The temperature, wind-speed (yard and paddock) and rainfall were monitored throughout. Additional weather information was obtained from a nearby weather station.

Within 30 min post-mortem, samples of liver (caudal lobe) and muscle (M. longissimus dorsi, 11/12 rib site) were taken, frozen and stored in liquid nitrogen. Experimentally bruised tissue was dissected from the carcass and weighed. The bruise score of the carcass was assessed as described by the Australian Bruise Scoring System (Anderson and Horder 1979) and the trimmed hot weight of the carcass recorded.

At 24 h post-mortem, carcasses were quartered (10/11 rib) and the pH (spear electrode, Watson-Victor 5003 pH meter) and subjective colour (scale: 1 = very pale, 10 = very dark) of the LD were recorded. The cold fat depth was measured at the 12/13 rib site using a Toland probe (Anderson and Truscott 1982). Glycogen and glucose determinations were made on liver and muscle samples as described by Halpin and Warner (1985). Free plasma corticosteroid concentration was determined as described by Barnett et al. (1981) using the mean affinity constant of transcortin for cortisol of $11.91 \times 10^7$ l/mol (J. Barnett, unpublished data). Adrenal responsiveness was calculated as the difference between the log10 of free plasma corticosteroid concentrations before, and 12 min after, the mild electric shock (J. Barnett, unpublished data).

One way analysis of variance was used to compare treatments, except the Behrens-Fisher test (Fisher and Yates 1963) for non-normal distribution was used for the pHu data. Differences between means determined by least significant difference. Correlation coefficients ($n = 50$) were obtained for pHu vs muscle colour score, muscle glycogen concentration and liver glycogen concentration using linear regression.

RESULTS

The only rainfall was 0.6 mm on the final day of the trial. The average maximum and minimum temperatures for the month of the trial were 11.7°C and 4.4°C, for the week preceding the trial 16.7°C and 5.4°C, and during the trial were 11.4°C and 5.0°C. Average wind speed during the trial was $1.78(\pm 0.49)$ km/hr in the yard and $2.67(\pm 1.09)$ km/hr in the paddock.

The mean liveweight, blood measurements prior to slaughter and carcass measurements post-slaughter for the three treatments are presented in Table 1. Free corticosteroid levels were similar between treatments but the adrenal responsiveness of fasted cattle was higher than that of control cattle ($P < 0.05$).

Cattle in the fasted treatments tended to decrease in liveweight, mainly due to reduced gut-fill, and had a higher ($P < 0.05$) dressing percentage. Carcass fat depth and carcass weight were not significantly different between treatments. Fasted cattle had a higher liver glycogen concentration than cattle not fasted ($P < 0.05$). However, muscle glycogen concentration, liver glucose concentration, bruise score and the experimental bruise weight did not differ between treatments. The pHu for carcasses in treatment Y was higher than for treatment S ($P < 0.05$). The average carcass muscle colour score of cattle in treatment Y was higher ($P < 0.05$) than for treatment C; treatment S was not significantly
different from either. Two animals in treatment Y (n=6) had a pHu greater than 6.0 and these animals also had low levels of muscle (<1.3 mg/g) and liver (<12 mg/g) glycogen.

There were significant correlations between pHu and colour score (r = 0.65, P < 0.05), muscle glycogen (r = -0.55, P < 0.05) and liver glycogen (r = -0.29, P < 0.05).

TABLE 1  The effects of fasting and wetting down on the mean (standard error) for liveweight, blood and carcass measurements

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Control (C) (Fed on pasture)</th>
<th>Fasted Indoors (S)</th>
<th>Fasted Outdoors and wet down (Y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of animals</td>
<td>17</td>
<td>17</td>
<td>16</td>
</tr>
<tr>
<td>#pHu</td>
<td>5.41±0.01</td>
<td>5.37±0.01</td>
<td>5.5±0.05</td>
</tr>
<tr>
<td>#Colour Score</td>
<td>4.56±0.17</td>
<td>4.81±0.15</td>
<td>5.47±0.26</td>
</tr>
<tr>
<td>#Muscle glycogen (mg/g)</td>
<td>5.82±0.33</td>
<td>6.48±0.49</td>
<td>5.15±0.67</td>
</tr>
<tr>
<td>#Brusle Score</td>
<td>3.0±0.8</td>
<td>3.0±0.6</td>
<td>3.5±0.7</td>
</tr>
<tr>
<td>#Blood weight (g)</td>
<td>300±31.6</td>
<td>318.3±54.3</td>
<td>229.6±24.8</td>
</tr>
<tr>
<td>#Liver glycogen (mg/g)</td>
<td>12.5±1.2</td>
<td>21.4±2.1</td>
<td>17.9±2.2</td>
</tr>
<tr>
<td>#Liver glucose (mg/g)</td>
<td>39.3±1.8</td>
<td>38.2±2.2</td>
<td>34.7±2.1</td>
</tr>
<tr>
<td>#Adrenal responsiveness</td>
<td>0.183±0.023</td>
<td>0.326±0.064</td>
<td>0.376±0.030</td>
</tr>
<tr>
<td>#Free corticosteroids (ng/ml)</td>
<td>3.59±0.35</td>
<td>2.91±0.71</td>
<td>3.21±0.36</td>
</tr>
<tr>
<td>+Liveweight (kg) - Initial</td>
<td>383.3±9.2</td>
<td>386.0±8.9</td>
<td>383.3±9.0</td>
</tr>
<tr>
<td>- Change</td>
<td>+3.8±2.5</td>
<td>-29.9±2.6</td>
<td>-32.8±2.9</td>
</tr>
<tr>
<td>#Carcass weight (kg)</td>
<td>203.1±4.7</td>
<td>192.7±4.9</td>
<td>192.7±4.5</td>
</tr>
<tr>
<td>#Dressing %</td>
<td>52.7±1.5</td>
<td>54.2±0.4</td>
<td>55.0±0.4</td>
</tr>
<tr>
<td>#Fat Depth (mm)</td>
<td>10.2±0.8</td>
<td>9.1±0.7</td>
<td>9.5±0.8</td>
</tr>
</tbody>
</table>

ab different letters in rows denote a significant difference (P < 0.05)
# measured after slaughter (>72h from start of trial)
* measured at end of trial period (60h)
+ measured at beginning (0h) and end (60h) of trial period

DISCUSSION

The 72 h pre-slaughter fast and cold environmental conditions imposed on the cattle in treatment Y resulted in a raised carcass pHu and an indication of reduced muscle glycogen compared to the cattle similarly fasted indoors. The cattle fasted outdoors and wet down had darker meat than the control cattle. The weather prior to and during the trial produced conditions similar to those suggested to be a cause of dark-cutting meat, i.e. changing seasonal conditions and the onset of cold weather (Lister et al. 1979). The environmental conditions (temperature and wind-speed) encountered in this experiment were not extreme but cattle are more susceptible to cold stress under conditions of feed deprivation (Alexander, 1979) and coat-wetting (Bell, 1976).

Fasting prior to transport has been associated with a trend for increased levels of bruising in slaughter cattle (Dodt et al. 1979) while both a chronic stress response and loss of liveweight can increase susceptibility to bruise (Barnett et al. 1984 and unpublished). In the present experiment there was no evidence for a chronic stress response due to fasting for 60 h as post-treatment...
free corticosteroid concentrations were similar in all treatments, or evidence of a loss of body weight/condition as carcass weight and fat depth were similar in all treatments. However, fasting appeared to increase adrenal responsiveness to the stressors involved in handling and electric shock. Fasting for a period of 72 h affected neither bruising per se nor susceptibility to bruise: however the results may have differed if weight loss occurred for a longer period of time and this aspect requires clarification.

There was an acute effect due to withdrawal of feed for 12 h prior to slaughter in the control treatment, as evidenced by the lower liver glycogen concentration. In the two fasted treatments, 72 h was sufficient time to allow liver glycerogen to be partially repleted (Ganong 1967) although levels were still below those reported for non-dark-cutting bulls (27.7 mg/g; Warriss and Lister 1983).

These results suggest that cattle exposed to cold and wet environmental conditions and fasted prior to slaughter are at risk to exhibit a dark-cutting carcass. Further research is required to define the optimal facilities required for slaughter cattle at abattoirs during high risk periods.

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REFERENCES


