Low ruminal pH in feedlot cattle

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Why Worry About Ruminal Acidosis?

- Animal welfare concern
- Decreases performance/increases variability
  - Severe rumen scores were associated with reduced ADG (0.03 kg) and carcass weight (2.20 kg) (Rezac et al., 2014; JAS)
- Associated disorders
  - 42% of cattle with liver abscesses have poor rumen scores (Jensen et al., 1954)
- Mortalities
  - 10.4% due to digestive disorders (USDA, 2011)
Prevalence Rates during Grain Adaptation

![Graph showing prevalence rates and dietary intake over time.](image)

- **Prevalence (n = 18)**
- **DMI, kg/d**
- **Barley grain intake, kg/d**

<table>
<thead>
<tr>
<th>Diet</th>
<th>100%</th>
<th>60%</th>
<th>40%</th>
<th>25%</th>
<th>15%</th>
<th>8%</th>
<th>8%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Days</td>
<td>1-4</td>
<td>5-8</td>
<td>9-12</td>
<td>13-16</td>
<td>17-20</td>
<td>21-24</td>
<td>25-28</td>
</tr>
</tbody>
</table>

G.B. Penner, J.R. Aschenbach and M. Oba, Unpublished
Prevalence Rates during Finishing

Weirrenga et al., 2010; JAS

<table>
<thead>
<tr>
<th>Diet</th>
<th>Prevalence Rate, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>85% barley, 10% silage</td>
<td>65% barley, 10% silage</td>
</tr>
<tr>
<td>n=16</td>
<td></td>
</tr>
</tbody>
</table>
Evaluating the incidence and severity of low ruminal pH

- 30 ruminally cannulated steers mixed with 250 steers
- Divided into 1 of 8 pens distributing cannulated steers
  - Total of 35/pen
    - 3 to 4 cannulated/pen
- Fed twice daily
  - 09:00 and 16:00 h
- Fed for ad libitum intake

Castillo-Lopez et al., 2014; JAS
Evaluating the incidence and severity of ruminal acidosis

- BW and feed intake every 2 wk

- Rumen pH

- At slaughter
  - Liver score

Castillo-Lopez et al., 2014; JAS
Evaluating the incidence and severity of low ruminal pH

<table>
<thead>
<tr>
<th>Item</th>
<th>Backgrounding</th>
<th>Step 1</th>
<th>Step 2</th>
<th>Step 3</th>
<th>Step 4</th>
<th>Finishing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration, d</td>
<td>21</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>102</td>
</tr>
<tr>
<td>Ingredient inclusion rates, % DM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barley silage</td>
<td>45.7</td>
<td>34.3</td>
<td>25.5</td>
<td>17.0</td>
<td>10.5</td>
<td>5.0</td>
</tr>
<tr>
<td>Barley grain</td>
<td>41.6</td>
<td>51.3</td>
<td>60.8</td>
<td>69.3</td>
<td>75.7</td>
<td>81.2</td>
</tr>
<tr>
<td>Canola meal</td>
<td>4.2</td>
<td>5.9</td>
<td>5.1</td>
<td>5.0</td>
<td>5.0</td>
<td>4.9</td>
</tr>
<tr>
<td>Pellet</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
<td>8.0</td>
</tr>
<tr>
<td>Limestone</td>
<td>0.5</td>
<td>0.5</td>
<td>0.6</td>
<td>0.7</td>
<td>0.8</td>
<td>0.9</td>
</tr>
</tbody>
</table>

All diets contained Monensin (33 mg/kg) and Tylan (11 mg/kg)

Castillo-Lopez et al., 2014; JAS
Evaluating the incidence and severity of low ruminal pH

Castillo-Lopez et al., 2014; JAS
Evaluating the incidence and severity of low ruminal

Castillo-Lopez et al., 2014; JAS
Mean ruminal pH and pen DMI in feedlot cattle

Castillo-Lopez et al., 2014; JAS
Severity of low ruminal pH

Days on feed

Duration ruminal pH < 5.5, min/d

Castillo-Lopez et al., 2014; JAS
Prevalence of Ruminal Acidosis (pH < 5.5 for > 3 h/d)

Incidence rate for severe liver abscesses
10.7% and 14.1% for cannulated and non-cannulated steers

Castillo-Lopez et al., 2014; JAS
Evaluating the incidence and severity of low ruminal pH

Mean rumen pH

Duration pH < 5.5, min/d

BCKGD
TRAN
FIN 1
FIN 2

Castillo-Lopez et al., 2014; JAS
Prevalence of Ruminal Acidosis

Castillo-Lopez et al., 2014; JAS
Rumen pH decreases with advancing days on feed

$\text{r} = -0.60$

$P < 0.001$

$\text{r} = -0.50$

$P < 0.001$

Castillo-Lopez et al., 2014; JAS
Rumen pH and Performance

r = 0.194
P < 0.001

ADG, kg/d vs Rumen pH

Castillo-Lopez et al., 2014; JAS
Rumen pH and Feed Conversion

$r = -0.342$

$P < 0.001$

Castillo-Lopez et al., 2014; JAS
Evaluating the Impact of Pen Conditions

- 8 pens in a commercial feedlot
  - 3 to 4 hd/pen with pH measurement (n = 30)
  - ~250 to 300 hd/pen

- Steers were received in fall, adapted to a finishing diet and used at the time of spring thaw (April 2 – May 7, 2014)

- Corresponded to the last 5 wk of the feeding period
Evaluating the Impact of Pen Conditions

- **Pen mud depth**
  - Measured twice weekly

- **Feeding behavior**
  - 12 h measurement
  - Measured twice
  - Pre-mud
  - Peak mud

- **Environmental data**
Evaluating the Impact of Pen Conditions:
Results for Cohort Steers (n = 30)

- DMI = 10.3 kg/d
- ADG = 1.81 kg/d
- G:F = 0.18
- Final BW = 668 kg
- Hot carcass = 376 kg
- 28% AA, 72% AAA
Evaluating the Impact of Pen Conditions: Results

Average temperature, C

Maximum pH

Mean pH

Minimum pH

Temperature

Rumen pH

PRE-MUD

MUD

3-Apr  5-Apr  7-Apr  9-Apr  11-Apr  13-Apr  15-Apr  17-Apr  19-Apr  21-Apr  23-Apr  25-Apr  27-Apr  29-Apr  1-May  3-May  5-May  7-May

4.0  4.5  5.0  5.5  6.0  6.5  7.0  7.5  8.0

-10  -8  -6  -4  -2  0  2  4  6  8  10
Evaluating the Impact of Pen Conditions: Results

- Mud depth, cm
- Meals, no./12 h
- Meal duration, min
Evaluating the Impact of Pen Conditions: Results

**Mean pH**

- **PRE-MUD**: 6.00
- **MUD**: 6.50

**Duration, min/d**

- **PRE-MUD**: 40
- **MUD**: 80

**Statistical Significance**

- **P < 0.01**
- **P = 0.07**
Severity of low ruminal pH

Duration ruminal pH < 5.5, min/d

Days on feed

Castillo-Lopez et al., 2014; JAS
# Role of dietary transition

<table>
<thead>
<tr>
<th>Variable</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6H</th>
<th>6S</th>
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<tbody>
<tr>
<td>Days fed, no.</td>
<td>7</td>
<td>7</td>
<td>5</td>
<td>8</td>
<td>5</td>
<td>9</td>
<td>9</td>
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<tr>
<td>Corn silage</td>
<td>30.0</td>
<td>30.0</td>
<td>31.5</td>
<td>31.5</td>
<td>23.5</td>
<td>9.5</td>
<td>9.5</td>
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<tr>
<td>Alfalfa silage</td>
<td>16.5</td>
<td>8.5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Barley grain</td>
<td>37.6</td>
<td>46.5</td>
<td>45.0</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Wheat grain</td>
<td>-</td>
<td>-</td>
<td>8</td>
<td>55.32</td>
<td>66.22</td>
<td>78.9</td>
<td>78.9</td>
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<tr>
<td>DDGS</td>
<td>15</td>
<td>14</td>
<td>12</td>
<td>12</td>
<td>9</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Limestone</td>
<td>0.8</td>
<td>0.9</td>
<td>1.1</td>
<td>1.1</td>
<td>1.2</td>
<td>1.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Mineral and vitamin premix²</td>
<td>0.055</td>
<td>0.055</td>
<td>0.055</td>
<td>0.055</td>
<td>0.055</td>
<td>0.055</td>
<td>0.055</td>
</tr>
<tr>
<td>Chemical§</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DM %</td>
<td>67.6</td>
<td>68.2</td>
<td>70.1</td>
<td>72.8</td>
<td>73.6</td>
<td>81.6</td>
<td>81.6</td>
</tr>
<tr>
<td>CP</td>
<td>14.0</td>
<td>14.6</td>
<td>12.6</td>
<td>15.8</td>
<td>14.8</td>
<td>14.3</td>
<td>14.3</td>
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<tr>
<td>NDF</td>
<td>35.1</td>
<td>32.1</td>
<td>29.4</td>
<td>25.3</td>
<td>23.3</td>
<td>16.3</td>
<td>16.3</td>
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<tr>
<td>Starch</td>
<td>29.3</td>
<td>35.0</td>
<td>35.8</td>
<td>39.0</td>
<td>45.3</td>
<td>52.6</td>
<td>52.6</td>
</tr>
<tr>
<td>Ether extract</td>
<td>3.35</td>
<td>3.71</td>
<td>3.37</td>
<td>3.16</td>
<td>2.89</td>
<td>2.93</td>
<td>2.93</td>
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<tr>
<td>Ash</td>
<td>6.16</td>
<td>4.84</td>
<td>4.79</td>
<td>3.27</td>
<td>3.96</td>
<td>2.51</td>
<td>2.51</td>
</tr>
</tbody>
</table>
Is low pH a problem?

- Liver abscesses are one of the most well regarded sequelae of ruminal acidosis
- Reported prevalence of 30% at slaughter in Canada (BCRC 2012)
- Negative effect on ADG, cost of condemned livers (Wiese, unpublished)
# Results

**Table 1. Distribution of rumen and liver pathology found in 28 cannulated steers at slaughter.**

<table>
<thead>
<tr>
<th>Liver Score&lt;sup&gt;2&lt;/sup&gt;</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>Total steers</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>A</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>6</td>
</tr>
<tr>
<td>A+</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Total Steers</td>
<td>7</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>28</td>
</tr>
</tbody>
</table>

<sup>1</sup>Rumen lesions are scored as follows: 0 = healthy rumen with large papillae and normal colouration; 1 = hyperemia/discolouration, clumped papillae; 2 = erosion or regeneration from previous erosion; 3 = evident ulceration or appearance of stellate scars.

<sup>2</sup>Livers were scored as follows: 0 (no abscesses); A (abscess scars or 1 to 4 well organized abscesses less than 2.5 cm in diameter); or A+ (1 or more large active abscesses with inflammation of surrounding liver tissue).
Figure 1. Box and whisker plots of the time spent below rumen pH 5.2 (top panel), 5.5 (middle panel) and 5.8 (bottom panel) by steers with and without rumen and liver pathology at slaughter. Measurements were collected daily during the final 5 weeks of finishing and averages of these values were used. The finishing diet was composed of 5:95 F:C (%DM). Horizontal line within each box represents the median, boundaries of the box indicate the 25\textsuperscript{TH}- and 75\textsuperscript{TH} - percentile, and the whiskers indicate the highest and lowest values of the results. Outliers’ are represented by circles.
Figure 2. Box and whisker plots of serum amyloid A (top panel) and serum Haptoglobin (bottom panel) concentrations of steers with and without rumen and liver pathology at slaughter. Samples were collected weekly during the final 5 weeks of finishing and averages of these values were used. Horizontal line within each box represents the median, boundaries of the box indicate the 25\textsuperscript{th}- and 75\textsuperscript{th} - percentile, and the whiskers indicate the highest and lowest values of the results.
Conclusions

- Feedlot cattle are at high risk for low ruminal pH
  - Late in the feeding period may be of greatest risk
- Variation in feed intake and altered meal pattern increases risk
Funding Sources
Team Rumen!