**Sulfate induced polioencephalomalacia (PEM) in feedlot cattle**

Dr. Mary Drewnoski

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**Sulfur and ethanol co-products**

- **Ethanol co-products**
  - 0.3 to 2 % S
  - Ethanol plants - sulfuric acid added
    - Control fermentation
    - Cleaning agent
- **NRC maximum tolerable level of S**
  - 0.4 % on high forage diet
  - 0.3 % on high concentrate diets

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**Polioencephalomalacia (PEM)**

- **Terminology**
  - Polio = gray matter
  - Encephalo = brain
  - Malacia = tissue death
- **Clinical signs**
  - Subacute – head pressing, circling, ataxia, staggering, blindness, depression, stupor
  - Acute – blindness, seizures, comatose
- Can be caused by thiamine deficiency, lead or salt poisoning and high sulfur diets

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**S induced PEM**

- Dose not appear to be caused by thiamine or copper deficiency
  - No alterations of thiamine or its mono- and diphosphate esters in whole blood, brain, cerebrospinal fluid, or liver (Sager et al., 1990; Gould et al., 1991)
- Thiamine treatment can help reduce symptoms
  - Increase energy availability to the brain
  - Plays a key role in the tri-carboxcylic acid cycle and pentose shunt
  - Thiamine-supplemented groups also manifested PEM, even though clinical signs were not observed (Olkowski et al., 1992).

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**PEM in feedlots with high S water**

- McAllister: JAVMA 1997, 211:1275

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**Graph**

- Loneragan: Bov Pract 2005, 39:18
### Rumen H₂S on high sulfate diet

- **Dietary sulfate:** 60% of ruminal gas that is eructated is inhaled

- **Gas phase:**
  - H₂S
  - CO₂
  - H₂

- **Ruminal fluid:**
  - H₂S⁻

- **Pka of HS⁻:** 7.04

<table>
<thead>
<tr>
<th>Diet</th>
<th>d on diet</th>
<th>Hay</th>
<th>DDGS</th>
<th>Corn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hay+ DDGS</td>
<td>10</td>
<td>57</td>
<td>43</td>
<td>0</td>
</tr>
<tr>
<td>TMR 1</td>
<td>7</td>
<td>47</td>
<td>40</td>
<td>13</td>
</tr>
<tr>
<td>TMR 2</td>
<td>7</td>
<td>32</td>
<td>40</td>
<td>28</td>
</tr>
<tr>
<td>TMR 3</td>
<td>7</td>
<td>17</td>
<td>40</td>
<td>43</td>
</tr>
<tr>
<td>TMR 4</td>
<td>-</td>
<td>10</td>
<td>40</td>
<td>50</td>
</tr>
</tbody>
</table>

- **Dietary chemistry:**
  - 4% of diet DM
  - Hay: 10, DDGS: 57, Corn: 43
  - TMR 3: 7, Hay: 17, DDGS: 40, Corn: 43
  - TMR 4: 10, Hay: 40, Corn: 50

- **Frequency of FER events:**
  - Days since arrival at feedlot

- **Hydrogen sulfide concentration:**
  - 0 - 30

- **Rumen HRumen H₂S on high sulfate diet**
  - 60% of ruminal gas that is eructated is inhaled
  - Burping can be deadly!

- **Pka of HS⁻:** 7.04

- **Burping can be deadly!**
S-induced PEM mechanism

- Toxic effects of H$_2$S
  - Make brain energy deficient?
    - Inhibits cytochrome C oxidase
  - Oxidative injury?
    - Inhibit superoxide dismutase and glutathione peroxidase

Conclusions

- High rumen H$_2$S is associated with S-induced PEM
- The precise microbial, animal physiological and dietary factors that come together to cause PEM remain to be elucidated.
- But…. research is underway!!

What can we do?

- Sample water and evaluate for sulfate concentration.
- Sample all co-product feed ingredients and analyze for sulfur.
  - Make certain total (water plus feed) dietary sulfur intake expressed as a percentage of dry matter intake is less than 0.40%.
- Currently, there are no dietary modifications that have been shown to effectively control PEM
  - Supplementing thiamine may reduce symptoms
  - Including higher roughage levels may reduce risk
  - Manage for acidosis
- Take the sulfur survey