MINERALS IN FORAGES: COW CONSIDERATIONS

Jim Linn
University of Minnesota
FOCUS OF PAPER AND PRESENTATION

• MACRO MINERALS (Ca, P, K, Mg, Na, Cl, S)
  ✓ Forage mineral content
    • Quantity
    • Availability
  ✓ Lactating and transition cow requirements
  ✓ Feeding considerations
FORAGE MINERAL CONTENT

- Are ‘book values’ accurate?
  - 2001 Dairy NRC updated information
  - Legume and grass forages listed by NDF and not species
  - Grain silages
- Analysis better than book values
  - Wet chemistry better than NIR
Ash analysis important

- Inverse of organic matter (energy)
- Soil contamination
- Soil microorganisms
  - Molds, Mycotoxins
- High levels may decrease feed intake (>9% diet)
HOW MUCH EXTRA “MINERAL” ARE COWS GETTING?
ABILITY OF FORAGES TO MEET MINERAL REQUIREMENTS

• QUANTITY
  (Total Amount)

• AVAILABILITY
  (Amount cows can absorb from the digestive tract)
Calcium (Ca) in Forages

- Legumes
- Grasses
- Oatlage
- Corn Silage
## Ca Availability

<table>
<thead>
<tr>
<th>Feed</th>
<th>Factor, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forages</td>
<td>30</td>
</tr>
<tr>
<td>Grains</td>
<td>60</td>
</tr>
<tr>
<td>Mineral supplements</td>
<td>50 - 95</td>
</tr>
</tbody>
</table>

**Alfalfa @ 1.6% Ca = Available Ca 0.39%**  
\( (1.6 \times 0.3) \)
## Calcium and Cow Considerations
### Transition Cow

<table>
<thead>
<tr>
<th>Feed</th>
<th>Lb DM</th>
<th>% Ca</th>
<th>Avail %</th>
<th>Avail g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>11</td>
<td>1.7</td>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td>Corn Silage</td>
<td>11</td>
<td>0.3</td>
<td>30</td>
<td>5</td>
</tr>
<tr>
<td><strong>Total diet</strong></td>
<td>22</td>
<td>1%</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td><strong>275 d Preg req't</strong></td>
<td></td>
<td></td>
<td></td>
<td>21</td>
</tr>
<tr>
<td>Requirement</td>
<td></td>
<td></td>
<td></td>
<td>50</td>
</tr>
<tr>
<td>30 lb colostrum</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Calcium and Cow Considerations

• Ca only 30% available from forages
  ❖ Lactating cow diets with alfalfa may need Ca supplementation

• Availability
  ❖ Grains (60%)
  ❖ Supplements (50 – 95%)

• Balance diets to meet Ca requirements
  ❖ Lactating cows - .75 - .9%
  ❖ Closeup cows - 1 – 1.5%
Phosphorus (P) Facts

• Availability
  • Forages - 64%
  • Concentrates - 70%

• P content of most forages - 0.25 to 0.35%

• Phosphorus requirements - amounts not % of diet

• High phosphorus diets do not improve milk production or reproduction
Milk Production Responses to Dietary Phosphorus (Satter et al. 1999)

Milk, lb/d

Study 1  Study 2  Study 3  Study 4

% P
- 0.32 to .39
- 0.45 to .51
- 0.65

0 20 40 60 80 100
# P Requirements and Excretion

<table>
<thead>
<tr>
<th></th>
<th>275 day Preg 22 lb DMI</th>
<th>100 lb milk 55 lb DMI</th>
</tr>
</thead>
<tbody>
<tr>
<td>P requirement, g/d</td>
<td>32</td>
<td>69</td>
</tr>
<tr>
<td>Diet availability, %</td>
<td>67</td>
<td>67</td>
</tr>
<tr>
<td>Dietary Req’t, %</td>
<td>0.48</td>
<td>0.41</td>
</tr>
<tr>
<td>Excretion at Req’t, g/d</td>
<td>16</td>
<td>33</td>
</tr>
<tr>
<td>Yearly excretion/cow</td>
<td></td>
<td>24 lb/cow – unavoidable</td>
</tr>
<tr>
<td>60 d dry, 305 d lactation</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Magnesium in Forages

• Quantity
  - Legumes - 0.25 to 0.3%
  - Grasses – 0.20 to 0.25%
  - Grain silage – 0.15 to 0.20%

Availability 16% for all forages
Magnesium and Cow Considerations

Absorbed from the rumen

Magnesium sources must be soluble in rumen

Factors affecting Mg solubility/absorption

» Rumen pH - better below 6.5
» High K diets (>1.5%) decrease solubility
» K:Mg ratio < 4:1 for good absorption
» Low solubility/absorption of Mg in most feedstuffs (10 to 30%); Supplements - 5%
# Mg Requirements

<table>
<thead>
<tr>
<th></th>
<th>275 day Preg</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>22 lb DMI</td>
</tr>
<tr>
<td>Mg requirement, g/d</td>
<td>2.5</td>
</tr>
<tr>
<td>Diet availability, %</td>
<td>16</td>
</tr>
<tr>
<td>Dietary Req’t, %</td>
<td>0.16</td>
</tr>
<tr>
<td>Diet Recommend, %</td>
<td>0.3 to 0.4%</td>
</tr>
<tr>
<td></td>
<td>100 lb milk</td>
</tr>
<tr>
<td></td>
<td>55 lb DMI</td>
</tr>
<tr>
<td>Mg requirement, g/d</td>
<td>9</td>
</tr>
<tr>
<td>Diet availability, %</td>
<td>16</td>
</tr>
<tr>
<td>Dietary Req’t, %</td>
<td>0.23</td>
</tr>
<tr>
<td>Diet Recommend, %</td>
<td>0.3 to 0.35%</td>
</tr>
</tbody>
</table>
Cations and Anions

“Electrolytes”

Cations
Positive charge
Sodium (Na)
Potassium (K)

Anions
Negative charge
Chloride (Cl)
Sulfur (S)

Dietary Cation Anion Difference

\[(\text{Na} + \text{K}) - (\text{Cl} + \text{S})\]
Potassium (K) in Forages

• Quantity
  ➢ Legumes – 2.0 to >3%
  ➢ Grasses – 1.5 to >3%
  ➢ Corn sil – 1.0 to 1.5%
  ➢ Grain sil – 1.5 to >3%

Availability 85 to 90% for all forages
## Minerals in Milk

<table>
<thead>
<tr>
<th>Mineral</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potassium</td>
<td>0.13</td>
</tr>
<tr>
<td>Calcium</td>
<td>0.12</td>
</tr>
<tr>
<td>Chloride</td>
<td>0.09</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>0.09</td>
</tr>
<tr>
<td>Sodium</td>
<td>0.05</td>
</tr>
<tr>
<td>Sulfur</td>
<td>0.03</td>
</tr>
<tr>
<td>Magnesium</td>
<td>0.01</td>
</tr>
</tbody>
</table>
# K Requirements

<table>
<thead>
<tr>
<th></th>
<th>275 day Preg 22 lb DMI</th>
<th>100 lb milk 55 lb DMI</th>
</tr>
</thead>
<tbody>
<tr>
<td>K requirement, g/day</td>
<td>53</td>
<td>256</td>
</tr>
<tr>
<td>Diet availability, %</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>Dietary Req’t, %</td>
<td>0.60</td>
<td>1.14</td>
</tr>
<tr>
<td>K feeding period, weeks</td>
<td>3 Low</td>
<td>45 High</td>
</tr>
</tbody>
</table>
Potassium and Cow Considerations

Potassium - lactating cows
- Milk
- Heat stress – cows sweat K
- >1.5% K in diet

Potassium – closeup cows
- Factor in milk fever
- High levels reduce Mg absorption
- < 1% if possible
Sodium (Na) in Forages

Less than .05% in all forages

Availability 90%+ for all feeds

Major sources of Na

- Salt
- Buffers – Na bicarb/carbonate
## Na Requirements

<table>
<thead>
<tr>
<th></th>
<th>275 day Preg 22 lb DMI</th>
<th>100 lb milk 55 lb DMI</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Na requirement, g/d</strong></td>
<td>12</td>
<td>52</td>
</tr>
<tr>
<td><strong>Diet availability, %</strong></td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td><strong>Dietary Req’t, %</strong></td>
<td>0.14</td>
<td>0.23</td>
</tr>
<tr>
<td><strong>Diet Recommend, %</strong></td>
<td>&lt;0.2% Factor in milk fever</td>
<td>0.3 to 0.5% Milk response</td>
</tr>
</tbody>
</table>
Chloride (Cl) in Forages

Legume/Grass forages - 0.5 to 1.0%
Corn silage – 0.2 to 0.4%

Availability – 90%

Major source
- Salt
- Legumes and grass forages
- Supplements
## Cl Requirements

<table>
<thead>
<tr>
<th></th>
<th>275 day Preg 22 lb DMI</th>
<th>100 lb milk 55 lb DMI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cl requirement, g/d</td>
<td>16</td>
<td>66</td>
</tr>
<tr>
<td>Diet availability, %</td>
<td>90</td>
<td>90</td>
</tr>
<tr>
<td>Dietary Req’t, %</td>
<td>0.18</td>
<td>0.27</td>
</tr>
<tr>
<td>Diet Recommend, %</td>
<td>&gt; 0.5% Factor in milk fever</td>
<td>&lt; 0.5% Milk response</td>
</tr>
</tbody>
</table>
Na and Cl Feeding Considerations

Cl content of forages?
Accurate analysis (.5 – 1% forages)
Availability

Buffers supply Na
Excess of Na requirement

Cows appear to require salt
» Lactating – 4 oz/day
» Dry – 1 oz/day
Sulfur (S) in Forages

Related to protein content
- Legumes – 0.25%
- Corn silage - 0.1 to 0.15%

Requirement is for rumen microbes

Nitrogen (N) to S ration
10 to 12:1 in diet
# S Requirements

<table>
<thead>
<tr>
<th></th>
<th>275 day Preg 22 lb DMI</th>
<th>100 lb milk 55 lb DMI</th>
</tr>
</thead>
<tbody>
<tr>
<td>S req’t to support yield of microbial protein, g/d</td>
<td>20</td>
<td>54</td>
</tr>
<tr>
<td>Diet availability, %</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Dietary Req’t, %</td>
<td>0.2</td>
<td>0.22</td>
</tr>
<tr>
<td>Diet Recommend, %</td>
<td>&lt;0.4%</td>
<td>0.2 to 0.3%</td>
</tr>
<tr>
<td></td>
<td>Factor in milk fever</td>
<td></td>
</tr>
</tbody>
</table>
Cations and Anions

“Electrolytes”

Cations

Potassium
• Culprit in milk fever
• Highest requirement in lactation (> 1.5%)

Sodium
• Milk production may be enhanced by feeding above requirement (~ 15%)

Anions

Chloride
• Transition ~ .5%
• Lactation - excess may reduce milk in hot weather (> .5%)

Sulfur
• Requirement ~ .2%
• Toxicity ~ .5%
**DCAD Balances**

**Lactating cows**
- +30 meq/100g DM

**Closeup Cows**
- No salts
- < 10 meq/100 g DM
- Salts
- -10 or greater meq/100g DM
- Measure urine pH < 6.5

Sanchez et al., 1994
SUMMARY

• Forages are an important source of macro minerals for dairy cattle

• Diet formulations must consider
  ✓ Amount
  ✓ Availability
  ✓ Interactions between minerals

• Excesses are as much of a concern as deficiencies