Minerals and Vitamins

Macrominerals
- Ca
  - Always feed adequate Ca
  - Milk fever
- P
  - P runoff is associated with alga blooms and Pfiesteria
  - Bottom Line: Don’t overfeed P
- Na
  - Common to add 0.5 lb/cow/d in early lactation

Micro (Trace)
- expressed as ppm (mg/kg DM)
  - Co, Cu, Fe, I, Mn, Se, Zn

Water soluble
- Synthesized in rumen and abundant in feeds
  - Niacin - blocks fat mobilization

Fat soluble
- Physiological requirement
  - A, D, E

Mineral Content
- Accurate determination of the mineral content of feeds
- Book values deviate 30 to 100% of the average value
- Bioavailability
  - Inorganic vs Organic
  - Maturity
  - Type of feed

Even small deficiencies or imbalances can develop into reproductive, health, and milk production problems

<table>
<thead>
<tr>
<th>Deficiency</th>
<th>Adequacy</th>
<th>Toxicity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Death</td>
<td>Death</td>
</tr>
</tbody>
</table>

Macrominerals
- Cl
  - Heat Stress – 0.30 to 0.35% DM
  - Salt - cows will consume if deficient
- K
  - Heat stress – 1.2 to 1.8% DM
- Mg
  - Feed 0.4 – 0.45% of diet DM with fat
  - Grass Tetany – Lush pastures high passage rate, high pH, low Na, and high K
### Dietary Mineral Concentrations

<table>
<thead>
<tr>
<th>Milk</th>
<th>Ca</th>
<th>P</th>
<th>Na</th>
<th>Cl</th>
<th>K</th>
<th>Mg</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>lb/d</td>
<td>% of Diet DM</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>100</td>
<td>0.60</td>
<td>0.37</td>
<td>0.21</td>
<td>0.26</td>
<td>1.04</td>
<td>0.19</td>
<td>0.20</td>
</tr>
<tr>
<td>90</td>
<td>0.58</td>
<td>0.36</td>
<td>0.21</td>
<td>0.25</td>
<td>1.04</td>
<td>0.19</td>
<td>0.20</td>
</tr>
<tr>
<td>80</td>
<td>0.57</td>
<td>0.35</td>
<td>0.21</td>
<td>0.25</td>
<td>1.03</td>
<td>0.18</td>
<td>0.20</td>
</tr>
<tr>
<td>70</td>
<td>0.56</td>
<td>0.34</td>
<td>0.21</td>
<td>0.24</td>
<td>1.02</td>
<td>0.18</td>
<td>0.20</td>
</tr>
<tr>
<td>60</td>
<td>0.54</td>
<td>0.32</td>
<td>0.21</td>
<td>0.23</td>
<td>1.01</td>
<td>0.17</td>
<td>0.20</td>
</tr>
<tr>
<td>50</td>
<td>0.52</td>
<td>0.31</td>
<td>0.21</td>
<td>0.22</td>
<td>1.00</td>
<td>0.16</td>
<td>0.20</td>
</tr>
</tbody>
</table>

### Trace Minerals

- **Cu**
  - Jerseys should not be fed >25 mg/kg DM

- **I**
  - Overfeeding results in higher milk concentrations

- **Fe**
  - Normally very high levels in diets (200 PPM)

- **Se**
  - FDA max is 0.3 PPM supplemental Se

### Trace Minerals Requirements

<table>
<thead>
<tr>
<th>Micromineral</th>
<th>PPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Co</td>
<td>0.11</td>
</tr>
<tr>
<td>Cu</td>
<td>15</td>
</tr>
<tr>
<td>I</td>
<td>0.5</td>
</tr>
<tr>
<td>Fe</td>
<td>15</td>
</tr>
<tr>
<td>Mn</td>
<td>15</td>
</tr>
<tr>
<td>Se</td>
<td>0.3</td>
</tr>
<tr>
<td>Zn</td>
<td>60</td>
</tr>
</tbody>
</table>

### Vitamins

- **Vitamin A**
  - Grains low and unstable during storage of forages

- **Vitamin E**
  - Role in immunity and sparing effect on Se

### General Comments

- **Lab analysis**
  - Important to determine macromineral levels
  - Important to determine if a trace mineral(s) is too high

- **Levels 2-5x requirement not uncommon for some trace minerals**

- **High levels of a trace mineral can result in deficiencies of another**

### Mineral Interactions
Method of Delivery
- Force feeding - recommended method
  - eliminates
    - palatability problems
    - daily variation in intake
    - over-consumption
  - determine amount of supplements based on forage and grain mineral levels and milk production

Method of Delivery
- Free choice - cafeteria style
  - supplying unmixed supplements of Dical, salt, limestone and trace mineral
  - only mineral supplement a group of animals will consume and perform at optimum levels is salt

Water
- Water comprises about 55 to 65% BW of mature cows
- Consequences of limited intake are more severe than any other nutrient
- Milk 87% water
- Lactating cattle require the greatest amount of water in proportion to their size than any other farm animal

Estimated Water Consumption
<table>
<thead>
<tr>
<th>Animal</th>
<th>Consumption (gal/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heifer, 250 lbs.</td>
<td>2 – 3</td>
</tr>
<tr>
<td>Heifer, 500 lbs.</td>
<td>6 – 8</td>
</tr>
<tr>
<td>Heifer, 1,000 lbs.</td>
<td>8 – 10</td>
</tr>
<tr>
<td>Cows, 1,300 lbs.</td>
<td></td>
</tr>
<tr>
<td>Dry</td>
<td>12 – 15</td>
</tr>
<tr>
<td>50 lbs. milk</td>
<td>20 – 23</td>
</tr>
<tr>
<td>75 lbs. milk</td>
<td>24 – 30</td>
</tr>
<tr>
<td>100 lbs. milk</td>
<td>30 – 35</td>
</tr>
</tbody>
</table>

Water Prediction Equation
- Free water intake (kg/d) = 15.99 + 1.58 x DMI, kg/d + 0.90 x milk yield, kg/d + 0.05 x Na intake, g/d + 1.20 x min temp, °C
- Avg 3.2±0.6 lb H₂O/lb milk

Factors Affecting Water Intake
- Body weight
- Dry matter intake
- Environmental temperature
- Physiological state
- Water quality
Effect of Temp and Yield on $H_2O$ Intake

Water Quality
- Especially important if consuming from natural sources
- Samples should be taken yearly and analyzed - chemical and bacteriological
- Salinity - above 1% toxic to young animals
- Nitrate levels over 150 ppm and nitrite over 4 ppm
- Trace mineral interactions

General Comments
- Water and dry matter intake are highly correlated
- Water should be available as cows exit parlor
- 2 linear feet of water space per 15 to 20 cows in freestall barns
- Cheapest nutrient so don’t limit it!

Forages

Forage Utilization by Region*

<table>
<thead>
<tr>
<th>Forage</th>
<th>NE</th>
<th>NW</th>
<th>MW</th>
<th>SE</th>
<th>SW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa Hay</td>
<td>37</td>
<td>83</td>
<td>80</td>
<td>42</td>
<td>63</td>
</tr>
<tr>
<td>Alfalfa Silage</td>
<td>41</td>
<td>27</td>
<td>69</td>
<td>18</td>
<td>20</td>
</tr>
<tr>
<td>Corn Forage</td>
<td>83</td>
<td>60</td>
<td>54</td>
<td>67</td>
<td>40</td>
</tr>
<tr>
<td>Grass Hay</td>
<td>50</td>
<td>10</td>
<td>34</td>
<td>28</td>
<td>70</td>
</tr>
<tr>
<td>Grass Silage</td>
<td>50</td>
<td>33</td>
<td>27</td>
<td>18</td>
<td>27</td>
</tr>
<tr>
<td>Rye Forage</td>
<td>7</td>
<td>7</td>
<td>3</td>
<td>30</td>
<td>0</td>
</tr>
<tr>
<td>Sorghum Forage</td>
<td>13</td>
<td>10</td>
<td>10</td>
<td>33</td>
<td>30</td>
</tr>
</tbody>
</table>

*Percent of cows receiving forage

Annual Requirements for a Cow Producing 20,000 lbs. Milk

<table>
<thead>
<tr>
<th>Item</th>
<th>Total for Yr.</th>
<th>% from Forage</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM (lbs.)</td>
<td>16,000</td>
<td>56</td>
</tr>
<tr>
<td>CP (lbs.)</td>
<td>2,350</td>
<td>49</td>
</tr>
<tr>
<td>NEL (Mcal)</td>
<td>11,750</td>
<td>52</td>
</tr>
<tr>
<td>ADF (lbs.)</td>
<td>3,600</td>
<td>75</td>
</tr>
<tr>
<td>NDF (lbs.)</td>
<td>4,720</td>
<td>79</td>
</tr>
<tr>
<td>Chewing (hrs.)</td>
<td>4,792</td>
<td>90</td>
</tr>
</tbody>
</table>
Three Forms of Forage

- **Pasture**
  - +labor, palatability, vitamins
  - -DM yield, variable nutrient content
- **Silage**
  - +Preserve more DM and nutrients per acre
  - +Lower field loss, less weather risk
- **Hay**
  - +Less Weight, Market Value, Rumen Buffer
  - - Weather Risk

Silage

- A feedstuff resulting from anaerobic fermentation of moist forage and by preservation with the formation of acids

Silage Comparison

<table>
<thead>
<tr>
<th></th>
<th>Good</th>
<th>Poor</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>3.8</td>
<td>5.3</td>
</tr>
<tr>
<td>Acids</td>
<td></td>
<td></td>
</tr>
<tr>
<td>lactic</td>
<td>4.2</td>
<td>0.2</td>
</tr>
<tr>
<td>acetic</td>
<td>3.3</td>
<td>6.4</td>
</tr>
<tr>
<td>butyric</td>
<td>0.02</td>
<td>3.6</td>
</tr>
<tr>
<td>Ammonia N</td>
<td>5.8</td>
<td>38.3</td>
</tr>
</tbody>
</table>

Factors Necessary for Successful Silage Production

- Harvest at proper stage of maturity
- Air tight structures
- Rapid filling
- Available carbohydrates
  - lactate production - pH reduction

Where Problems Arise

- Dry matter content
  - too wet - (<25% DM) butyric acid fermentation
  - too dry - (>40% DM) - poor packing and too much oxygen, too much heat, protein bound to lignin (Maillard reaction)

- Carbohydrate content
  - Too much - very acid silage high acetic acid, poor palatability, very bitter
  - Too little - insufficient acid produced to preserve the crop, Molds!

Corn and Small Grain Silage
### Desired Nutrient Concentration

<table>
<thead>
<tr>
<th></th>
<th>DM %</th>
<th>CP %</th>
<th>ADF %</th>
<th>NEL</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn Silage</td>
<td>30 - 40</td>
<td>8</td>
<td>&lt;25</td>
<td>&gt;0.69</td>
<td></td>
</tr>
<tr>
<td>Barley Silage</td>
<td>30 - 40</td>
<td>12</td>
<td>&lt;35</td>
<td>&gt;0.63</td>
<td></td>
</tr>
<tr>
<td>Sorghum Silage</td>
<td>30 - 40</td>
<td>10</td>
<td>&lt;35</td>
<td>&gt;0.61</td>
<td></td>
</tr>
<tr>
<td>Wheat Silage</td>
<td>30 - 40</td>
<td>10</td>
<td>&lt;32</td>
<td>&gt;0.63</td>
<td></td>
</tr>
</tbody>
</table>

### Evaluating Corn Maturity

- **Examine the ear**
  - count percent of kernels which are dented - 95% dented
- **Look at milk line**
  - closer milk line is to tip of kernel, more mature and less moisture - 1/2 milk line
- **Plant color**
  - hybrids differ, not a reliable of maturity

### Evaluating Corn Maturity

- **Break kernel in half**
  - milky - 65 to 70% moisture
  - starch like cheese - 50 to 55% moisture
  - starch is hard - 45% moisture
- **Determine dry matter content**
  - chop 10 whole plants from field
  - use microwave

### Harvest at Correct Stage of Maturity

- **Dry Matter - 30 to 40% DM**
  - Bunker 28-32
  - Upright - 32 - 37
  - 1/3 to 1/2 milk line
    - <1/3 - high fiber, low starch
    - >1/2 - high starch, but starch and fiber low digestibility
- **Chop at 1/4" - 1/2" (3/8") theoretical length of chop and fill rapidly**

### Processed Corn Silage

- **Kernel (crop) processor breaks up corn kernels and cobs into smaller particles and shears stover**
- **Improves fermentation, increase starch digestion - increase milk production**

### Processed Corn Silage

- **Best if cut at 1/2 to 2/3 milk line**
- **Increase theoretical length of chop to 3/4"**
  - result in 1/3" length after processing
- **Dry matter still most important**
- **2 – 5 lb/cow/day milk production response**
Legumes and Grasses

Effect of Alfalfa Maturity on Yield

- 1st cutting: 80 lb/d
- 2nd cutting: 112 lb/d

Yield (T DM/A) vs. Time of Cutting

Effect of Alfalfa Maturity on ADF

- 1st cutting: 0.4 pt/d
- 2nd cutting: 0.33 pt/d

% ADF vs. Time of Cutting

Effect of Alfalfa Maturity on CP

- 1st cutting: 0.2 pt/d
- 2nd cutting: 0.34 pt/d

% CP vs. Time of Cutting

Nutrient Content of Alfalfa at Different Stages of Maturity

<table>
<thead>
<tr>
<th>Stage of Mat.</th>
<th>% CP</th>
<th>% ADF</th>
<th>% NDF</th>
<th>NE_L Mcal/lb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Bloom</td>
<td>26</td>
<td>24</td>
<td>33</td>
<td>0.72</td>
</tr>
<tr>
<td>Early Bloom</td>
<td>23</td>
<td>28</td>
<td>39</td>
<td>0.68</td>
</tr>
<tr>
<td>Mid-Bloom</td>
<td>20</td>
<td>31</td>
<td>40</td>
<td>0.65</td>
</tr>
<tr>
<td>Full Bloom</td>
<td>17</td>
<td>35</td>
<td>46</td>
<td>0.61</td>
</tr>
</tbody>
</table>

Time of Cutting

- We have known plant sugars increase throughout the day, and drop at night
- Time forage is cut in the day influences animal preference and intake
- Dairy cows have been shown to eat 8% more TMR when it contains 40% afternoon cut alfalfa than morning cut and produce 8% more milk
Alfalfa vs Grasses

- Protein is more digestible than grasses
- Mature more slowly than grasses
- Lower cell wall content than grasses (lower NDF). Overall digestibility?
- Lower digestibility of cell wall - more lignin
- Generally greater intake of alfalfa vs grasses at equal NDF

Relative Feed Value (RFV)

- % Digestible DM (DDM) = 88.9 - (0.779 x %ADF)
  DDM = 67.1% at 28% ADF
- DMI (% of BW) = 120 / %NDF
  DMI = 3.43% at 35% NDF
- RFV = (%DDM + % DMI) / 1.29
  RFV = 178

Alfalfa Hay Guidelines

<table>
<thead>
<tr>
<th></th>
<th>% ADF</th>
<th>% CP</th>
<th>RFV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supreme</td>
<td>&lt;27</td>
<td>&gt;22</td>
<td>&gt;180</td>
</tr>
<tr>
<td>Premium</td>
<td>27 – 30</td>
<td>20 – 22</td>
<td>150 – 180</td>
</tr>
<tr>
<td>Good</td>
<td>30 – 32</td>
<td>18 – 20</td>
<td>125 – 150</td>
</tr>
<tr>
<td>Fair</td>
<td>32 – 35</td>
<td>15 – 18</td>
<td>100 – 125</td>
</tr>
</tbody>
</table>

Recent Alfalfa Prices ($/T)

<table>
<thead>
<tr>
<th></th>
<th>OR/WA</th>
<th>CA*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supreme</td>
<td>150-165</td>
<td></td>
</tr>
<tr>
<td>Premium</td>
<td>105-115</td>
<td>125-135</td>
</tr>
<tr>
<td>Good</td>
<td>85-90</td>
<td>115-125</td>
</tr>
<tr>
<td>Fair</td>
<td>70-80</td>
<td>95-100</td>
</tr>
</tbody>
</table>

*Delivered

Commodities: Grains and By-products

- Source of most concentrates for dairy cattle?
  - corn
  - soybean meal
  - wheat midds
  - brewers grains
  - distillers grains
  - hominy feed

The cow is a garbage disposal
Factors to Evaluate
- Cost - DM basis, cost/unit of nutrient
- Variability
- Palatability
- Handling, storage, feed facilities
- Storage losses, length to store
- Management and labor required
- Potential contaminants
- Dependable supply

Traditional Energy Supplements
- Grains
  - Corn
  - Barley
  - Sorghum
  - Wheat
  - Soybeans
  - Animal/Vegetable Fat

Nutrient Concentration
<table>
<thead>
<tr>
<th>NFC % of DM</th>
<th>Starch % of DM</th>
<th>Fat</th>
<th>NEL Mcal/lb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Barley</td>
<td>65</td>
<td>59</td>
<td>2.2</td>
</tr>
<tr>
<td>Corn</td>
<td>77</td>
<td>69</td>
<td>4.3</td>
</tr>
<tr>
<td>Sorghum</td>
<td>61</td>
<td>55</td>
<td>3.1</td>
</tr>
<tr>
<td>Wheat</td>
<td>71</td>
<td>64</td>
<td>2.0</td>
</tr>
<tr>
<td>Soybeans</td>
<td>25</td>
<td>22</td>
<td>19</td>
</tr>
<tr>
<td>Fat</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
</tbody>
</table>

Nontraditional Energy Supplements
- Hominy feed
- Bakery waste/Candy
- Whole cottonseed
- Apple pomace
- Vegetable waste
- Characteristics of these feeds
  - some high soluble CHO (sugar)
  - some high in fat

Nutrient Concentration
<table>
<thead>
<tr>
<th>ADF % of DM</th>
<th>Starch % of DM</th>
<th>Fat</th>
<th>NEL Mcal/lb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple pomace</td>
<td>30</td>
<td>50</td>
<td>3</td>
</tr>
<tr>
<td>Carrots</td>
<td>14</td>
<td>55</td>
<td>3</td>
</tr>
<tr>
<td>Candy</td>
<td>7</td>
<td>55</td>
<td>24</td>
</tr>
<tr>
<td>Cottonseed</td>
<td>29</td>
<td>2</td>
<td>21</td>
</tr>
<tr>
<td>Hominy</td>
<td>13</td>
<td>23</td>
<td>7</td>
</tr>
</tbody>
</table>

Nonforage fiber sources
- Replace concentrates for high producing cows
- Fermentability
- Physical effectiveness as fiber replacement
Nutrient Concentrations

<table>
<thead>
<tr>
<th>Feed</th>
<th>% NDF</th>
<th>% NDF digested/24 h</th>
<th>NEL Mcal/lb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beet Pulp</td>
<td>56</td>
<td>69</td>
<td>0.77</td>
</tr>
<tr>
<td>Peanut Hulls</td>
<td>75</td>
<td>13</td>
<td>0.68</td>
</tr>
<tr>
<td>Soy Hulls</td>
<td>65</td>
<td>38</td>
<td>0.83</td>
</tr>
<tr>
<td>Wheat Midds</td>
<td>35</td>
<td></td>
<td>0.87</td>
</tr>
</tbody>
</table>

Protein supplements

- Soybean meal - 44 vs. 48%
- Distillers grains - light vs. dark
- Brewers grains (dry vs wet)
- Canola meal
- Blood meal, fish meal
- Poultry by-product meal
- Ruminant meat and bone meal banned!

Nutrient Composition

<table>
<thead>
<tr>
<th>Supplement</th>
<th>CP, %</th>
<th>ADF, %</th>
<th>NEL, Mcal/lb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soybean meal</td>
<td>55</td>
<td>4</td>
<td>0.88</td>
</tr>
<tr>
<td>Brewers</td>
<td>23</td>
<td>23</td>
<td>0.68</td>
</tr>
<tr>
<td>Canola</td>
<td>36</td>
<td>16</td>
<td>0.77</td>
</tr>
<tr>
<td>Distillers</td>
<td>29</td>
<td>17</td>
<td>0.92</td>
</tr>
<tr>
<td>Whole cottonseed</td>
<td>29</td>
<td>29</td>
<td>1.01</td>
</tr>
<tr>
<td>Fish meal</td>
<td>70</td>
<td></td>
<td>0.78</td>
</tr>
</tbody>
</table>

Commodities vs. Commercial

- Commodities
  - Purchasing agent
  - Quality control
  - Facilities - mixing, grinding, storage? $$$
  - Labor
  - Formulation knowledge
  - Risk
  - Plus is flexibility

Commodities vs. Commercial

- Commercial concentrates
  - Quality control assumed by company
  - Free up labor and management for other duties
  - Service
    - Technical support/ration balancing
    - Free up capital
    - Minus is Flexibility

Summary

- Use concentrates to supplement forages
- Seek economic source of needed nutrients
- Know what you need
  - Test forages regularly
  - Balance rations carefully
Summary

- Dairy cattle are very adaptable - will eat most anything - if adjusted gradually
- Consider anything, but remember
  - Palatability
  - Handling
  - Variability
  - Reliable supply
  - Cost/nutrient
- Get out of your box!