Current and emerging strategies for nutritional management of dry and fresh cows

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Transition period goals

- High milk production
- Maintain/minimize loss of BCS
- Low incidence of metabolic disorders
- Minimize loss of immunocompetence
- Control/decrease days to first ovulation and maintain/enhance fertility
- Low stillborn rate and healthy calves

- Our high performing dairies achieve ALL of these
A few topics for today…

• Hypocalcemia – an old topic made new again

• Opportunities in energy and protein formulation and feeding management in dry cow/prefresh rations

• Fresh cow diets
  – Interactions of starch and fiber
  – Protein and AA supply

Why the renewed excitement about blood Ca status?

• High prevalence of subclinical hypocalcemia (SCH; ~ 40 to 80% of fresh cows)

• Associations with SCH:
  – Immune competence  (Kimura et al., 2006, Martinez et al. 2012)
  – Metabolic health  (Chamberlin et al., 2013, Martinez et al. 2012)
  – Milk production  (Chapinal et al., 2012)
  – Reproductive performance  (Martinez et al. 2012, Chapinal et al., 2012)
Calcium Status in the Transition Period


Prevalence of hypocalcemia by lactation number

Do we need to worry about subclinical hypocalcemia if milk fever rates are low?

Martinez et al., 2012. J. Dairy Sci. 95 :7158–7172

- Cows with low blood Ca concentrations (< 8.6 mg/dL) during d 1 to 3 postcalving had:
  - Decreased neutrophil function
    - Both phagocytosis and oxidative burst
  - Increased NEFA and BHBA concentrations
    - Likely lower dry matter intake
  - Higher metritis and endometritis
  - Lower subsequent reproductive performance
Chapinal et al., 2012. JDS 95:5676-5682

- 55 herds in US and Canada
- Herds with high proportions of cows with serum Ca < 8.4 mg/dl during wk 1 postcalving had
  - 2.4 X higher rates of DA
  - 3.8 kg/d less milk (all cows in the herd)
  - 30% decrease in conception rate at 1st AI

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**Increasing Blood Calcium**

- **PARATHYROID GLAND**
  - PTH secretion
  - PTH

- **BONE**
  - Release of Ca

- **KIDNEY**
  - Activation of Vitamin D
  - Calcium excretion

- **INTESTINE**
  - Ca absorption

Goff et al., 2008

Active Vitamin D
Low blood calcium
Improving Ca status via altering prepartum Dietary Cation Anion Difference (DCAD)

- Impact on calcium metabolism:
  - Improved sensitivity of PTH receptor to PTH stimulation
  - Decreased urine pH increases urinary Ca excretion = increased calcium flux
  - Systemic pH reduction may directly stimulate Ca resorption from bone

Cations:
- Sodium (+1)
- Potassium (+1)

Anions:
- Chloride (-1)
- Sulfate (-2)

More H+ in blood to maintain electroneutrality
Decreased blood pH
Increased H+ excretion

Strategies for application of DCAD for close-up dry cows

1) Low K ration + NO anion supplementation
   - Calculated DCAD ~+10 mEq/100 g DM
   - Urine pH = 8.3 – 8.5

2) Low K ration + PARTIAL anion supplementation
   - Calculated DCAD ~0 mEq/100 g DM
   - Urine pH = 7 – 8

3) Low K ration + FULL anion supplementation
   - Calculated DCAD ~-10 to -15 mEq/100 g DM
   - Urine pH = 5.5 – 6.0
   *Necessary to regularly monitor urine pH and adjust ration

*DCAD in mEq/100 g DM = (Na + K) - (Cl + S)
Day -31 to Day -25
Day -24 to Day 0
Day 0 to Day 63

Low K control
+17.4 mEq/100 g diet DM
n = 30

Low K control
+17.4 mEq/100 g diet DM
n = 30

Medium DCAD
+3.7 mEq/100 g diet DM
n = 30

Lactating Ration

Low DCAD
-10.5 mEq/100 g diet DM
n = 29


Prepartum Diets, lbs DM; Sweeney et al., 2015

<table>
<thead>
<tr>
<th>Ingredient (lbs DM/d)</th>
<th>Control</th>
<th>MedDCAD</th>
<th>LowDCAD</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMR Corn Silage</td>
<td>12.77</td>
<td>12.77</td>
<td>12.77</td>
</tr>
<tr>
<td>Wheat Straw</td>
<td>8.00</td>
<td>8.00</td>
<td>8.00</td>
</tr>
<tr>
<td>Amino Plus</td>
<td>2.30</td>
<td>2.30</td>
<td>2.30</td>
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<tr>
<td>Citrus Pulp</td>
<td>0.95</td>
<td>0.95</td>
<td>0.95</td>
</tr>
<tr>
<td>Soybean Hulls</td>
<td>0.66</td>
<td>0.66</td>
<td>0.66</td>
</tr>
<tr>
<td>Canola Meal</td>
<td>0.63</td>
<td>0.63</td>
<td>0.63</td>
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<tr>
<td>Molasses</td>
<td>0.19</td>
<td>0.19</td>
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<tr>
<td>Calcium diphosphate</td>
<td>0.13</td>
<td>0.13</td>
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<tr>
<td>Ground corn grain</td>
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<td>0.12</td>
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<tr>
<td>Salt</td>
<td>0.07</td>
<td>0.07</td>
<td>0.07</td>
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<tr>
<td>Vitamin Mix</td>
<td>0.04</td>
<td>0.04</td>
<td>0.04</td>
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<tr>
<td>Rumensin (mg)</td>
<td>318</td>
<td>318</td>
<td>318</td>
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<tr>
<td>Animate</td>
<td>-</td>
<td>0.56</td>
<td>1.14</td>
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<tr>
<td>Wheat Midds</td>
<td>0.92</td>
<td>0.74</td>
<td>0.55</td>
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<tr>
<td>Calcium carbonate</td>
<td>0.82</td>
<td>0.80</td>
<td>0.77</td>
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<tr>
<td>Corn Distillers Ethanol</td>
<td>0.63</td>
<td>0.37</td>
<td>0.11</td>
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<tr>
<td>Magnesium Oxide</td>
<td>0.16</td>
<td>0.12</td>
<td>0.07</td>
</tr>
<tr>
<td>Urea</td>
<td>0.12</td>
<td>0.06</td>
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</table>
### Experimental Diet: Analyzed (mean ± SD) Composition

<table>
<thead>
<tr>
<th></th>
<th>CON</th>
<th>MedDCAD</th>
<th>LowDCAD</th>
<th>Lactating</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DM (%)</strong></td>
<td>46.3 ± 1.6</td>
<td>46.5 ± 1.3</td>
<td>46.4 ± 1.1</td>
<td>45.7 ± 1.8</td>
</tr>
<tr>
<td><strong>CP (%) DM</strong></td>
<td>13.0 ± 0.3</td>
<td>13.2 ± 0.4</td>
<td>13.2 ± 0.5</td>
<td>15.7 ± 0.2</td>
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<tr>
<td><strong>ADF (%) DM</strong></td>
<td>30.2 ± 0.7</td>
<td>30.5 ± 1.3</td>
<td>30.1 ± 1.3</td>
<td>20.6 ± 0.8</td>
</tr>
<tr>
<td><strong>NDF (%) DM</strong></td>
<td>44.3 ± 1.2</td>
<td>44.0 ± 2.1</td>
<td>43.2 ± 1.8</td>
<td>31.1 ± 1.0</td>
</tr>
<tr>
<td><strong>Starch (%) DM</strong></td>
<td>17.0 ± 0.5</td>
<td>16.0 ± 0.8</td>
<td>16.3 ± 0.9</td>
<td>26.0 ± 0.7</td>
</tr>
<tr>
<td><strong>NFC (%) DM</strong></td>
<td>33.6 ± 0.9</td>
<td>34.3 ± 2.5</td>
<td>35.0 ± 1.9</td>
<td>45.8 ± 1.2</td>
</tr>
<tr>
<td><strong>Fat (%) DM</strong></td>
<td>1.1 ± 0.1</td>
<td>1.3 ± 0.2</td>
<td>1.1 ± 0.3</td>
<td>2.3 ± 0.2</td>
</tr>
<tr>
<td><strong>Ca (%) DM</strong></td>
<td>1.54 ± 0.12</td>
<td>1.57 ± 0.14</td>
<td>1.57 ± 0.07</td>
<td>0.95 ± 0.03</td>
</tr>
<tr>
<td><strong>P (%) DM</strong></td>
<td>0.44 ± 0.01</td>
<td>0.43 ± 0.01</td>
<td>0.41 ± 0.01</td>
<td>0.41 ± 0.02</td>
</tr>
<tr>
<td><strong>Mg (%) DM</strong></td>
<td>0.47 ± 0.01</td>
<td>0.48 ± 0.03</td>
<td>0.50 ± 0.03</td>
<td>0.44 ± 0.02</td>
</tr>
<tr>
<td><strong>K (%) DM</strong></td>
<td>1.28 ± 0.07</td>
<td>1.26 ± 0.06</td>
<td>1.24 ± 0.07</td>
<td>1.37 ± 0.05</td>
</tr>
<tr>
<td><strong>S (%) DM</strong></td>
<td>0.20 ± 0.01</td>
<td>0.30 ± 0.02</td>
<td>0.41 ± 0.02</td>
<td>0.29 ± 0.01</td>
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<tr>
<td><strong>Na (%) DM</strong></td>
<td>0.13 ± 0.01</td>
<td>0.13 ± 0.01</td>
<td>0.14 ± 0.01</td>
<td>0.44 ± 0.02</td>
</tr>
<tr>
<td><strong>Cl (%) DM</strong></td>
<td>0.27 ± 0.03</td>
<td>0.47 ± 0.05</td>
<td>0.69 ± 0.04</td>
<td>0.40 ± 0.02</td>
</tr>
<tr>
<td><strong>DCAD (mEq/100g DM)</strong></td>
<td>18.3 ± 0.8</td>
<td>5.9 ± 3.4</td>
<td>-7.4 ± 3.6</td>
<td>25.0 ± 1.5</td>
</tr>
<tr>
<td><strong>Predicted MF (g/kg DM)</strong></td>
<td>93.8</td>
<td>93.23</td>
<td>92.26</td>
<td>116.56</td>
</tr>
</tbody>
</table>

Plasma Calcium

Prepartum
Trt P=0.52
Day P=0.0003
Trt x Day P=0.64

Postpartum
Linear P=0.002
Trt P=0.005
Day P<.0001
Trt x Day P=0.06


Postpartum Plasma Calcium Treatment by Parity Interaction

Control
MedDCAD
LowDCAD
Trt x Parity P=0.06

### Dry Matter Intake

<table>
<thead>
<tr>
<th>Variable</th>
<th>Prepartum Diet</th>
<th>P-values</th>
<th></th>
<th></th>
<th></th>
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<th></th>
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<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>CON</td>
<td>Med</td>
<td>Low</td>
<td>SEM</td>
<td>Linear</td>
<td>Quad</td>
<td>Trt×Wk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prepartum</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DMI, kg/d</td>
<td>14.55</td>
<td>15.08</td>
<td>14.08</td>
<td>0.23</td>
<td>0.15</td>
<td>0.007</td>
<td>0.45</td>
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<tr>
<td>DMI, % of BW</td>
<td>1.87</td>
<td>1.89</td>
<td>1.80</td>
<td>0.03</td>
<td>0.16</td>
<td>0.22</td>
<td>0.38</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Postpartum (wk 1 to 3)</td>
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<td></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>DMI, kg/d</td>
<td>20.99</td>
<td>21.74</td>
<td>22.30</td>
<td>0.50</td>
<td>0.07</td>
<td>0.88</td>
<td>0.24</td>
<td></td>
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</tr>
<tr>
<td>DMI, % of BW</td>
<td>2.94</td>
<td>3.04</td>
<td>3.15</td>
<td>0.07</td>
<td>0.03</td>
<td>0.99</td>
<td>0.37</td>
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</tbody>
</table>


### Milk Production: Weeks 1 to 3

<table>
<thead>
<tr>
<th>Variable</th>
<th>Prepartum Diet</th>
<th>P-values</th>
<th></th>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td>CON</td>
<td>Med</td>
<td>Low</td>
<td>SEM</td>
<td>Linear</td>
<td>Quad</td>
<td>Trt×Wk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Milk yield, kg/d</td>
<td>40.54</td>
<td>42.13</td>
<td>43.79</td>
<td>1.05</td>
<td>0.03</td>
<td>0.97</td>
<td>0.35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fat, %</td>
<td>4.38</td>
<td>4.36</td>
<td>4.24</td>
<td>0.08</td>
<td>0.21</td>
<td>0.63</td>
<td>0.10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>True protein, %</td>
<td>3.54</td>
<td>3.49</td>
<td>3.27</td>
<td>0.07</td>
<td>0.005</td>
<td>0.33</td>
<td>0.36</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lactose, %</td>
<td>4.64</td>
<td>4.67</td>
<td>4.69</td>
<td>0.03</td>
<td>0.25</td>
<td>0.94</td>
<td>0.38</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Solids, %</td>
<td>13.63</td>
<td>13.61</td>
<td>13.27</td>
<td>0.10</td>
<td>0.01</td>
<td>0.20</td>
<td>0.10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ECM, kg/d</td>
<td>46.12</td>
<td>48.04</td>
<td>49.50</td>
<td>1.35</td>
<td>0.08</td>
<td>0.89</td>
<td>0.39</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MUN, mg/dL</td>
<td>10.32</td>
<td>9.72</td>
<td>9.44</td>
<td>0.30</td>
<td>0.04</td>
<td>0.67</td>
<td>0.17</td>
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<tr>
<td>SCS</td>
<td>2.62</td>
<td>3.26</td>
<td>2.73</td>
<td>0.25</td>
<td>0.75</td>
<td>0.06</td>
<td>0.27</td>
<td></td>
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</tr>
</tbody>
</table>

What about length of time fed a low DCAD diet?

Weich et al., 2013. J. Dairy Sci. 98:5780-5792

– 60 Holstein and Holstein-cross cows

– Three prepartum treatments
  • Control: +12 mEq/100 g DM
  • 21 d: - 16 mEq/100 g DM for last 21 d
  • 42 d: - 16 mEq/100 g DM for last 42 d

– Cows fed negative DCAD
  • Increased postpartum DMI 2.1 kg/d
  • Increased postpartum milk yield 4.4 kg/d
  • Slight rebound in urine pH for cows fed negative DCAD for 42 d
  • No production advantage (or disadvantage) for 42 d vs. 21 d of feeding
Other mineral feeding considerations

• **Magnesium** – Excellent consensus
  - Necessary for PTH release and signaling
  - Take advantage of passive absorption at higher feeding rates
  ➡️ Target: 0.40-0.50% of DM

• **Phosphorous** – Good consensus
  - No detrimental effects as low as 0.25% of DM
  - Higher diet P (>0.55%) may predispose to hypocalcemia (inhibits absorption)
  ➡️ Target: 0.35 to 0.42% of DM

• **Vitamin D** - Good consensus
  ➡️ Target: 25,000 to 30,000 IU of Vitamin D (cholecalciferol)

Other mineral feeding considerations

• **Calcium** – Lack of consensus
  - Meta-analysis suggests lower milk fever risk at low (<0.60%) or high (>2.0%) Ca content (Lean et al., 2006)
  - Studies in conjunction with low DCAD:
    • Chan et al. (2006) saw no difference in Ca status, intake or performance when 0.99 or 1.50% Ca was fed with anion supplemented diet
    • Liesegang et al. (2007) no difference at high/moderately low DCAD for either 0.30% or 0.70% Ca

  - **Current recommendations** (Overton, personal communication)
    ➡️ No anionic supplementation: 0.9 to 1.0%
    Full anionic supplementation: 1.4 to 1.5%
Urine pH monitoring – a great way to monitor implementation and overall feeding management when herds are feeding anionic diets

Guidelines for Urine pH Monitoring

• Weekly....

• 12 to 15 cows that have been fed the diet for at least a week

• If possible, 4 to 6 hours postfeeding
  – More important to be consistent within a herd

• Can be a terrific monitor of feeding management in herds feeding anionic diets
# Low DCAD (-13 mEq/100 g DM) Urine pHs

**Sweeney et al., unpublished**

**Diagram: Low DCAD (-13 mEq/100 g DM) Urine pHs**

**Table: Low DCAD (-13 mEq/100 g DM) Urine pHs**

<table>
<thead>
<tr>
<th>Date</th>
<th>Median</th>
<th>MEAN</th>
<th>StDev</th>
<th>CV</th>
<th>Ration K, % of DM</th>
<th>Ration Anionic Suppl, % of DM</th>
<th>Expected DCAD, mEq/100 g ration DM (Na + K - Cl - S)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4/30/2015</td>
<td>6.40</td>
<td>6.47</td>
<td>0.60</td>
<td>0.09</td>
<td>1.24</td>
<td>1.62%</td>
<td>-3.3</td>
</tr>
<tr>
<td>5/7/2015</td>
<td>6.20</td>
<td>6.49</td>
<td>0.67</td>
<td>0.10</td>
<td>1.24</td>
<td>1.62%</td>
<td>-3.3</td>
</tr>
<tr>
<td>5/14/2015</td>
<td>6.00</td>
<td>6.18</td>
<td>0.50</td>
<td>0.08</td>
<td>1.18</td>
<td>1.60%</td>
<td>-3.3</td>
</tr>
<tr>
<td>5/21/2015</td>
<td>7.50</td>
<td>7.16</td>
<td>0.81</td>
<td>0.11</td>
<td>1.22</td>
<td>1.54%</td>
<td>-3.3</td>
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<tr>
<td>5/28/2015</td>
<td>7.60</td>
<td>7.45</td>
<td>0.71</td>
<td>0.08</td>
<td>1.09</td>
<td>1.82%</td>
<td>-3.3</td>
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<tr>
<td>6/4/2015</td>
<td>7.20</td>
<td>7.04</td>
<td>0.64</td>
<td>0.10</td>
<td>1.25</td>
<td>1.97%</td>
<td>-3.3</td>
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<tr>
<td>6/11/2015</td>
<td>6.80</td>
<td>6.77</td>
<td>0.66</td>
<td>0.08</td>
<td>1.26</td>
<td>2.13%</td>
<td>-3.3</td>
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<td>6/19/2015</td>
<td>6.60</td>
<td>6.82</td>
<td>0.68</td>
<td>0.09</td>
<td>1.25</td>
<td>2.25%</td>
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<td>6/25/2015</td>
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<td>6.51</td>
<td>0.58</td>
<td>0.09</td>
<td>1.24</td>
<td>2.25%</td>
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<td>6.50</td>
<td>6.61</td>
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<td>0.11</td>
<td>1.24</td>
<td>2.25%</td>
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<td>7.20</td>
<td>6.81</td>
<td>0.77</td>
<td>0.08</td>
<td>1.24</td>
<td>2.25%</td>
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<td>7.11</td>
<td>6.99</td>
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<td>2.25%</td>
<td>-3.3</td>
</tr>
</tbody>
</table>

**Table: Median, MEAN, StDev, CV, Ration K, % of DM, Ration Anionic Suppl, % of DM, Expected DCAD, mEq/100 g ration DM (Na + K - Cl - S)**

**Courtesy: Dairy Health and Management Services**
Overall benefits of improving calcium status via more aggressive prepartum DCAD

- Evidence shows:
  - increased postpartum intake and milk production for cows with improved plasma calcium as a result of low DCAD feeding

- Potential for:
  - Reduced incidence of infectious and metabolic disease
  - Improved reproductive performance

A few topics for today…

- Hypocalcemia – an old topic made new again

- Opportunities in energy and protein formulation and feeding management in dry cow/prefresh rations

- Fresh cow diets
  - Interactions of starch and fiber
  - Protein and AA supply
Why worry about dry cow energy and protein?

- Effects on milk production
- Incidence of metabolic diseases
- Effect on immune system
- Effect on reproductive success
- Colostrum quality?

The energy challenge...

The challenge: minimize NEB and maximize DMI postpartum
If any or all are out of balance (too much, too little): effects on milk, health and reproduction

**Energy**: If out of balance (too much, too little): effects on milk, health and reproduction
Manipulating energy supply in the dry period (Mann et al., 2015)

Parity ≥ 1, ad libitum intake, individual tie-stall with feed buckets, 5% refusals

DIET FORMULATION (LBS DM)

CONTROLLED
- Corn silage: 8.0
- Wheat straw: 10.0
- Concentrate (Controlled): 10.1
- Total: 28.12

INTERMEDIATE
- Corn silage: 12.7
- Wheat straw: 7.2
- Concentrate (Controlled): 5.4
- Concentrate (High): 4.8
- Total: 30.1

HIGH
- Corn silage: 18.0
- Wheat straw: 4.0
- Concentrate (High): 10.2
- Total: 32.2
Analysis of TMR composition

<table>
<thead>
<tr>
<th>Variable</th>
<th>Controlled</th>
<th>I-med</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>ME (Mcal/kg)(^a)</td>
<td>1.98</td>
<td>2.12</td>
<td>2.23</td>
</tr>
<tr>
<td>Energy balance(^b) (% of req.)</td>
<td>112</td>
<td>126</td>
<td>153</td>
</tr>
<tr>
<td>Total MP Available(^b) (g/day)</td>
<td>1492</td>
<td>1523</td>
<td>1518</td>
</tr>
<tr>
<td>MP(^b) (% of req.)</td>
<td>124</td>
<td>123</td>
<td>118</td>
</tr>
<tr>
<td>NDF (% DM)(^a)</td>
<td>48.4</td>
<td>42.2</td>
<td>41.0</td>
</tr>
<tr>
<td>Starch (% DM)(^a)</td>
<td>15.0</td>
<td>20.1</td>
<td>23.7</td>
</tr>
</tbody>
</table>

\(^a\)average of 10 monthly composites, \(^b\)average of DMI last seven weeks a.p., CNCPS

Overfeeding prepartum compared with restricted feeding:

NEFA concentration postpartum
Mann et al. 2015; Dann et al., 2006; Douglas et al., 2006; Janovick et al., 2011; Zhang et al., 2015

BHB concentration postpartum
Mann et al. 2015; Dann et al., 2006; Douglas et al., 2006; Janovick et al. 2011; Nowak et al., 2014
Why do we worry about this?

**NEFA and BHB** = Markers of negative energy balance (**NEB**)
- Normal increase postpartum
- Excessive increase associated with
  - Adverse health, reproduction, production outcomes
    (Ospina et al. 2010 a,b,c, Chapinal et al., 2011, McArt et al. 2012, Suthar et al. 2013, McArt et al., 2015)
  - Recent estimate of total cost per case of hyperketonemia: $289 (McArt et al. 2015)

Excessive NEFA and BHB concentrations = failure of successful adaptation to lactation

---

Effects on immune system

- Excessive drop in dry matter intake associated with metritis (Huzzey et al., 2007)

- High concentrations of NEFA and BHB postpartum are associated with immune dysfunction (Ingavartsen and Moyes, 2013)

- Glucose is needed for proper immune cell function
  - Glucose postpartum higher in cows fed controlled energy prepartum (Mann et al. 2016, Cardoso et al. 2013)
Reproduction

• Negative energy balance associated with reduced reproductive performance (Cardoso et al., 2013)

• Longer days to pregnancy (167 vs. 157) in prepartum overfed cows compared with controlled (Cardoso et al., 2013)

• Higher plasma glucose postpartum in controlled energy fed dry cow associated with shorter days to pregnancy (Cardoso et al., 2013)

What is the effect on milk?

P = 0.98

P = 0.49
Overfeeding: It’s not all about the dry period

- Lactation length and BCS at dry-off
- Energy balance in late lactation?
- BCS lacks sensitivity for assessing visceral fat depots (Drackley, 2014)
- Cows with long lactations and/or long dry periods are at increased risk for postpartum metabolic disorders

Protein: How much is needed in the dry period to prevent negative effects on milk, health and reproduction? And can it be too much?
The role of protein

More reasons to keep an eye on MP supply?

- Particularly with controlled energy dry cow approach, less ruminal microbial protein supply
- Protein insufficiency associated with inflammatory response and immune system dysfunction
Summary of responses to transition period AA

<table>
<thead>
<tr>
<th>Study</th>
<th>Treatment</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overton et al., 1996</td>
<td>RPMet</td>
<td>↑ 2.7 kg/d FCM</td>
</tr>
<tr>
<td>Socha et al., 2005</td>
<td>Met, Met+Lys</td>
<td>↑ 2.9 kg/d ECM for Met + Lys</td>
</tr>
<tr>
<td>Piepenbrink et al., 2004</td>
<td>HMTBa (13 g pre; 28 g post)</td>
<td>↑ 3.0 kg/d milk</td>
</tr>
<tr>
<td></td>
<td>HMTBa (27 g pre; 44 g post)</td>
<td>NS</td>
</tr>
<tr>
<td>Preynat et al., 2009; 2010</td>
<td>RPMet w/wo folic acid + B12</td>
<td>NS – milk yield</td>
</tr>
<tr>
<td></td>
<td></td>
<td>↑ milk CP (2.94 vs. 3.04%)</td>
</tr>
<tr>
<td>Ordway et al., 2009</td>
<td>HMBi</td>
<td>No effect on milk yield</td>
</tr>
<tr>
<td></td>
<td>RPMet</td>
<td>Both trts ↑ milk protein %</td>
</tr>
<tr>
<td>Osorio et al., 2013</td>
<td>HMBi</td>
<td>↑ 3.8 kg/d ECM</td>
</tr>
<tr>
<td></td>
<td>RPMet</td>
<td>↑ 4.0 kg/d ECM</td>
</tr>
</tbody>
</table>

MP and AA recommendations prefresh

- Target 1200 to 1400 g/d MP
- Lysine ≥ 6.8 to 7.2% of MP (CNCPS 6.5 biology)
- Methionine ≥ 2.6 – 2.8% of MP (CNCPS 6.5 biology)
- Dr. Patrick French systematic review of literature and regression analysis (2012):
  - Suggests 1,300 g/d MP, 30 g/d Met, and 90 g/d Lys prepartum

- Focus protein supplementation pre-fresh on RUP sources with additional AA supplemented
  - Meet MP requirements more efficiently (feed less supplemental protein)
  - Cow metabolically does not handle excess N well at time of calving
COLOSTRUM

Sources:
- Antibodies (IgG)
- Nutrients
- Growth factors (Insulin)

Effect of dry cow energy on colostrum (Mann et al., 2016)

Need to control MP supply
Summary guidelines -- dry period nutritional strategies

• Far-off
  – Keep energy down (0.59 to 0.63 Mcal/lb; 1.30 to 1.39 Mcal/kg of NEL; 110 to 120% of energy requirements; < 13% starch
  – Macromineral balances not important (within reason)

• Close-up (if same ration fed to heifers and older cows)
  – Low to moderate energy (0.64 to 0.66 Mcal/lb; 1.40 to 1.45 Mcal/kg of NEL; 110 to 130% of energy requirements; 16 to 18% starch
  – Supplement with RUP (MP for Holsteins 1200 to 1400 g/d)
  – Macromineral relationships (K, Mg, Na, S, Cl; maybe Ca) critically important; Vitamins D and E; trace elements

General recommendations – one-group nutritional strategies

• Low to moderate energy (1.35 to 1.40 Mcal/kg -- ~ 0.63 Mcal/lb of NEL; 110 to 130% of energy requirements; 14 to 16% starch)

• Supplement with RUP (MP for Holsteins ~ 1200 g/d)

• Formulate minerals like close-up ration

• *Always a bit of a compromise (performance, health, cost) compared to two-group systems, but most practical option on some farms*
What about feeding management of dry cow TMR?

- Minimize sorting
  - Particle size of straw/hay
    - Longest particles < 1.5 in (4 cm)
  - Moisture content of TMR
    - Target 46 to 48 DM % -- add water if necessary

You HAVE to chop the %(* #@&# straw/hay

3.5 lbs straw in 26 lb DM package   6 lbs straw in 27 lb DM package
### Particle size recommendations using Penn State Particle Separator

<table>
<thead>
<tr>
<th>Screen</th>
<th>Lactating cow TMR</th>
<th>Dry cow or heifer TMR</th>
<th>Corn silage</th>
<th>Hay crop silage</th>
<th>Straw/dry hay for TMR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Top (&gt; 0.75” sieve)</td>
<td>6 to 10%</td>
<td>10 to 20%</td>
<td>5 to 10%</td>
<td>10 to 20%</td>
<td>33%</td>
</tr>
<tr>
<td>Middle (0.31 to 0.75 in sieve)</td>
<td>45 to 55%</td>
<td>50 to 60%</td>
<td>45 to 65%</td>
<td>45 to 75%</td>
<td>33%</td>
</tr>
<tr>
<td>Bottom (&lt; 0.31 in sieve)</td>
<td>&lt; 50%</td>
<td>&lt; 40%</td>
<td>30 to 40%</td>
<td>20 to 30%</td>
<td>33%</td>
</tr>
</tbody>
</table>

Recommendations and particle size distributions for 74 prefresh TMR samples using the Penn State Particle Separator (n=72 farms; Lawton et al., 2015)
Most common areas where dry cow programs “break”

- Not catching mineral changes in forages/other feeds through analysis
- Feeding management/sorting of diets – too long chop length of bulky forage and/or too low moisture of diet (target ~ 46% DM)
- Overfeeding energy to far-off cows
- Overdoing the controlled energy approach – too bulky/too low
- Not providing adequate metabolizable protein precalving
- Nonnutritional factors can break great diets pretty easily!!

A few topics for today…

- Hypocalcemia – an old topic made new again
- Opportunities in energy and protein formulation and feeding management in dry cow/prefresh rations
- Fresh cow diets
  - Interactions of starch and fiber
  - Protein and AA supply
Fresh cow diets – common themes

• Frequently based upon high cow diet
• Some common “tweaks”
  – Lower starch
  – Higher physically effective fiber
    • Usually less than 1 lb of chopped straw/hay
  – Additional RUP/AA
  – Additional fat
  – Strategic addition of other nutrients (e.g., RP-choline)
• Success usually gauged by farm-level outcomes

Some questions

• How fermentable should fresh cow diets be?
  – do we need to feed lower starch diets to fresh cows?

• How important is physically effective NDF in fresh cow diets?
  – “High bulk, high fermentability” fresh cow diets?

• Are there opportunities related to protein and amino acid nutrition in fresh cows?
To starch, or not to starch?

Three experiments conducted by groups at Miner Institute and Cornell

• Starch level in fresh diet
  – Dann and Nelson, 2011 Cornell Nutrition Conference
  – Williams et al., 2015 ADSA-ASAS Joint Annual Meeting

• Starch level in fresh diet and peripartal monensin
Dann and Nelson, 2011 Cornell Nutrition Conference

- 72 Holstein cows (2\textsuperscript{nd} and greater lactation)

- Fed high straw controlled energy diet for 40-d dry period

- At calving, one of three starch regimens
  - Low starch (~21\%) for first 91 DIM
  - Medium starch (~23\%) for first 21 d followed by high starch (~25.5\%) until 91 DIM
  - High starch (~25.5\%) for first 91 DIM

<table>
<thead>
<tr>
<th>Item</th>
<th>Low-low</th>
<th>Medium-High</th>
<th>High-High</th>
<th>SEM</th>
<th>P, Trt</th>
<th>P, Trt x wk</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMI, kg/d</td>
<td>25.2\textsuperscript{x}</td>
<td>24.9\textsuperscript{xy}</td>
<td>23.7\textsuperscript{y}</td>
<td>0.5</td>
<td>0.06</td>
<td>0.09</td>
</tr>
<tr>
<td>Milk, kg/d</td>
<td>47.9\textsuperscript{ab}</td>
<td>49.9\textsuperscript{a}</td>
<td>44.2\textsuperscript{b}</td>
<td>1.6</td>
<td>0.04</td>
<td>0.75</td>
</tr>
<tr>
<td>SCM, kg/d</td>
<td>47.4</td>
<td>47.9</td>
<td>43.5</td>
<td>1.5</td>
<td>0.09</td>
<td>0.39</td>
</tr>
<tr>
<td>NEFA, uEq/L (wk 1-3)</td>
<td>452\textsuperscript{aby}</td>
<td>577\textsuperscript{ax}</td>
<td>431\textsuperscript{by}</td>
<td>43</td>
<td>0.03</td>
<td>0.11</td>
</tr>
<tr>
<td>BHBA, mg/dL (wk 1-3)</td>
<td>9.3</td>
<td>8.8</td>
<td>7.8</td>
<td>1.1</td>
<td>0.15</td>
<td>0.97</td>
</tr>
</tbody>
</table>

\textsuperscript{ab} Least squares means within a row without a common superscript differ \((P \leq 0.05)\).

\textsuperscript{xy} Least squares means within a row without a common superscript differ \((P \leq 0.10)\).
• 70 Holstein cows (1st and greater lactation)
• Fed high straw, moderate energy diet during close-up
• At calving, fed one of two rations
  • Low starch (~ 21.5% starch)
  • Higher starch (~ 26.2% starch)
  • Beginning at 22 DIM, all cows fed higher starch ration
• Also fed either 0 mg/d monensin or 400 mg/d prepartum/450 mg/d postpartum

Summary results – McCarthy et al., 2015a; 2015b

• Cows fed higher starch diets during fresh period
  • Faster increase in milk yield
  • Trend for higher DMI postcalving
  • Lower plasma NEFA and BHBA postcalving
  • OPPOSITE results to Miner study

• Cows fed monensin precalving and postcalving
  • Higher milk yield (~ 5 lbs)
  • Higher DMI postcalving
  • No effect on plasma NEFA but decreased BHBA
So why the differences?

<table>
<thead>
<tr>
<th>Study &amp; Group</th>
<th>Starch, %DM</th>
<th>Fermentable Starch, %DM</th>
<th>Total Fermentable Starch, %DM</th>
<th>Total Fermentable CHO, %DM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miner Dry</td>
<td>13.5</td>
<td>11.5</td>
<td>29.7</td>
<td>39.4</td>
</tr>
<tr>
<td>Miner Low</td>
<td>21.0</td>
<td>16.8</td>
<td>40.1</td>
<td>42.4</td>
</tr>
<tr>
<td>Miner High</td>
<td>25.5</td>
<td>20.2</td>
<td>50.3</td>
<td>44.1</td>
</tr>
<tr>
<td>Cornell Close-up</td>
<td>17.4</td>
<td>15.3</td>
<td>36.3</td>
<td>42.2</td>
</tr>
<tr>
<td>Cornell Low</td>
<td>21.5</td>
<td>16.8</td>
<td>42.1</td>
<td>39.9</td>
</tr>
<tr>
<td>Cornell High</td>
<td>26.2</td>
<td>21.5</td>
<td>53.2</td>
<td>40.4</td>
</tr>
</tbody>
</table>

Slide courtesy of H.M. Dann, Miner Institute

Ruminal adaptations during the transition period

- Relatively poorly studied
- Early focus was on ruminal papillae development from feeding higher energy close-up rations (myth)
  - Supported by only one study (Dirksen et al., 1985)
  - More applicable studies indicated minimal papillae changes during the transition period (Andersen et al., 1999; Reynolds et al., 2004)
- Potential benefits of modulating ruminal microbial populations
  - Microbial adaptation
  - Increase supply of propionate
  - Increase microbial protein yield
Severity of ruminal acidosis during the transition period (RA total area – pH x min)

Penner et al., 2007

Fresh cow starch levels and acute phase response (Miner Institute and Zennoh)

- Randomized design with 16 multiparous Holstein cows
- 55-d dry period and fed close-up diet fed starting 21 d before expected calving
- Treatments from calving to 21 DIM
  - Lower starch diet (21% starch, 37% NDF)
  - Higher starch diet (27% starch, 32% NDF)

Rumen pH and time below pH 5.8 for cows fed high and low starch fresh diets


Acute phase proteins in cows fed high and low starch fresh diets

Adequate physically effective NDF in rations is probably very important in fresh cows

A case study

• Cornell T&R study evaluating high or low starch diets for fresh cows

• Controlled energy/high straw dry cow approach starting 28 to 35 days before calving

• At calving, one of two fresh diets until 21 DIM

• First cows that calved onto either ration developed significant health problems
Table 2. Health events for cows fed either high or low starch diets for the first 3 wk postpartum before and after postpartum ration changes.

<table>
<thead>
<tr>
<th>Item</th>
<th>Postpartum ration1</th>
<th>Parity</th>
<th>P-values2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HSLF</td>
<td>LSLF</td>
<td>HSHF</td>
</tr>
<tr>
<td>Multiparous, n</td>
<td>3</td>
<td>8</td>
<td>27</td>
</tr>
<tr>
<td>Primiparous, n</td>
<td>4</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td>Clinical ketosis3</td>
<td>4</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>DA4</td>
<td>4</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>RP5</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Total disorders</td>
<td>9</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>

1. HSLF = high starch, low fiber (pre-change); LSLF = low starch, low fiber (post-change); HSHF = high starch, high fiber (post change); LSHF = low starch, high fiber (post-change).
2. S = effect of starch; F = effect of fiber; P = effect of parity.
3. Clinical ketosis defined as rapidly decreased milk production and DMI and blood BHBA ≥ 2.6 mmol/L using Precision Xtra, displaced abomasum by auscultation.
4. Displaced abomasum diagnosed by auscultation.
5. Placenta retained for ≥ 24 h postcalving.

Table 3. Ingredient and chemical composition of diets (± SD) before and after postpartum ration changes (DM basis).

<table>
<thead>
<tr>
<th>Item</th>
<th>Prepartum</th>
<th>HSLF</th>
<th>LSLF</th>
<th>HSHF</th>
<th>LSHF</th>
<th>Postpartum2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ingredient (% of DM)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn silage, conv.</td>
<td>42.1</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>BMR corn silage</td>
<td>46.1</td>
<td>46.1</td>
<td>38.5</td>
<td>38.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheat straw</td>
<td>21.2</td>
<td>3.84</td>
<td>3.84</td>
<td>11.5</td>
<td>11.5</td>
<td></td>
</tr>
<tr>
<td>Corn meal, fine</td>
<td>4.28</td>
<td>21.0</td>
<td>10.3</td>
<td>21.0</td>
<td>10.3</td>
<td></td>
</tr>
<tr>
<td>Citrus pulp</td>
<td>7.23</td>
<td>1.01</td>
<td>7.15</td>
<td>1.01</td>
<td>7.15</td>
<td></td>
</tr>
<tr>
<td>Corn germ meal</td>
<td>2.52</td>
<td>5.56</td>
<td>2.52</td>
<td>5.56</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soybean hulls</td>
<td>7.08</td>
<td>---</td>
<td>3.58</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soybean meal</td>
<td>5.27</td>
<td>5.87</td>
<td>5.87</td>
<td>5.87</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canola meal</td>
<td>4.63</td>
<td>2.73</td>
<td>2.08</td>
<td>2.73</td>
<td>2.08</td>
<td></td>
</tr>
<tr>
<td>Blood meal</td>
<td>1.05</td>
<td>1.94</td>
<td>1.94</td>
<td>1.94</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expeller soy</td>
<td>1.78</td>
<td>1.70</td>
<td>2.34</td>
<td>1.70</td>
<td>2.34</td>
<td></td>
</tr>
<tr>
<td>Bypass fat</td>
<td>---</td>
<td>0.77</td>
<td>0.77</td>
<td>0.77</td>
<td>0.77</td>
<td></td>
</tr>
<tr>
<td>Anionic suppl</td>
<td>1.33</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>Sodium bicarbonate</td>
<td>0.86</td>
<td>0.86</td>
<td>0.86</td>
<td>0.86</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Minerals/vitamins</td>
<td>3.35</td>
<td>1.99</td>
<td>1.72</td>
<td>1.99</td>
<td>1.72</td>
<td></td>
</tr>
<tr>
<td>Chemical</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CP, %</td>
<td>13.0 ± 0.8</td>
<td>16.5</td>
<td>15.3</td>
<td>15.5</td>
<td>15.2</td>
<td>15.4 ± 0.8</td>
</tr>
<tr>
<td>ADF, %</td>
<td>28.2 ± 1.2</td>
<td>17.7</td>
<td>22.3</td>
<td>22.7 ± 1.2</td>
<td>25.2 ± 1.2</td>
<td></td>
</tr>
<tr>
<td>NDF, %</td>
<td>42.9 ± 2.0</td>
<td>26.4</td>
<td>31.5</td>
<td>34.3 ± 1.5</td>
<td>36.9 ± 1.5</td>
<td></td>
</tr>
<tr>
<td>Sugar, %</td>
<td>4.9 ± 0.8</td>
<td>3.1</td>
<td>3.9</td>
<td>3.5 ± 0.6</td>
<td>4.5 ± 0.4</td>
<td></td>
</tr>
<tr>
<td>Starch, %</td>
<td>17.4 ± 1.2</td>
<td>28.3</td>
<td>22.0</td>
<td>26.2 ± 1.2</td>
<td>21.5 ± 1.0</td>
<td></td>
</tr>
<tr>
<td>Fat, %</td>
<td>2.6 ± 0.2</td>
<td>3.2</td>
<td>3.1</td>
<td>4.0 ± 0.2</td>
<td>2.2 ± 0.6</td>
<td></td>
</tr>
<tr>
<td>uNDF40, % of DM</td>
<td>14.9</td>
<td>7.7</td>
<td>8.9</td>
<td>10.5</td>
<td>10.9</td>
<td></td>
</tr>
</tbody>
</table>

1. Chemical composition was analyzed on 4-wk composite samples (n = 1 for HSLF, n = 1 for LSLF, n = 7 for HSHF, and n = 0 for LSHF).
2. HSLF = high starch, low fiber (pre-change); LSLF = low starch, low fiber (post-change); HSHF = high starch, high fiber (post-change); LSHF = low starch, high fiber (post-change).
3. Determined using wet chemistry methods on a single-1 using wet chemistry methods on a single-composite sample from each diet (Cumberland Valley Analytical Services, Hagerstown, MD).
What about protein and AA supply to the fresh cow?
Increasing MP supply postpartum?

- 8 Holstein cows entering second lactation
- Received either water (control) or casein infused into the abomasum to meet approximate calculated deficit in MP
- Casein was planned to supply 360 g/d at 1 DIM, 720 g/d at 2 DIM, followed by daily reductions of 19.5 g/d ending at 194 g/d at 29 DIM.

Bell et al., 2000
Larsen et al., 2014. J. Dairy Sci. 97:5608–5622
Milk yield was increased (~ 7.2 kg/d) in cows receiving additional MP by casein infusion postpartum

From Larsen et al., 2014. J. Dairy Sci. 97:5608–5622

Implications – fresh cow diets

- Evolution in fresh cow feeding strategies over next few years
- Interactions appear to exist between prepartum and postpartum feeding strategies
- If low starch (< 15%) prepartum:
  - likely best fresh strategy 21 to 23% starch
- If higher starch (17 to 19%) prepartum
  - likely OK to go to 26 to 27% starch fresh diet
- Higher fiber/peNDF/uNDF240 diet postcalving may help cows adapt to higher starch diet
- There may be additional opportunities to improve performance of fresh cows through protein/AA nutrition
Overall conclusions and implications

• Transition cow success is attainable!!
• Learned a lot, still more to learn and need to work on consistency of adoption in the field
• Focus on
  – Management of hypocalcemia – even in herds with very low clinical rates
  – Controlling energy intake precalving and increasing DMI/energy intake postcalving
  – MP and AA supply
  – Feeding management
  – Fresh cow diets – these are going to evolve
• More emphasis on real-time monitoring at the herd and cow level using physiological markers and/or technology

Thanks!!

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