Managing Energy Metabolism in Transition Cows

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2012 Dairy Cattle Nutrition Workshop

High-Producing, Healthy Fresh Cow with Good Legs and Ability to Reproduce
Components of Successful Transition Cow Programs

- Implementation of management practices that focus on...
  - Prevention of transition disorders
  - Optimization of nutrient intake
  - Removal of stressors
- Real-time monitoring and use of the information

Lactation Cycle:
The most rapid decrease in energy balance and negative energy balance nadir occur during early lactation

Goal: manage intake to optimize milk yield, efficiency of nutrient utilization, and animal health
A Return to Positive Energy Balance (PEB)

- Return to positive energy balance occurs quickly when fed nutritionally adequate diets
  - 20 published studies: mean of 45 DIM (SD = 21) with 90% reaching PEB by 63 DIM
- Energy balance is more likely to be related to energy intake than energy output (milk yield)
- Minimizing negative energy balance is most likely to be accomplished through successful metabolic adaptation and feeding rather than through decreasing or preventing a rapid increase in milk yield

Santos et al., 2009; Grummer et al., 2010

Metabolic Changes Associated with Onset of Lactation

<table>
<thead>
<tr>
<th>Physiological function</th>
<th>Metabolic change</th>
<th>Tissue involved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk synthesis</td>
<td>↑ synthetic capacity</td>
<td>Mammary</td>
</tr>
<tr>
<td></td>
<td>↑ blood flow</td>
<td></td>
</tr>
<tr>
<td></td>
<td>↑ nutrient uptake and use</td>
<td></td>
</tr>
<tr>
<td>Lipid metabolism</td>
<td>↑ lipolysis</td>
<td>Adipose</td>
</tr>
<tr>
<td></td>
<td>↓ lipogenesis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>↑ use of lipid as energy</td>
<td></td>
</tr>
<tr>
<td>Glucose metabolism</td>
<td>↑ gluconeogenesis</td>
<td>Liver</td>
</tr>
<tr>
<td></td>
<td>↓ use of glucose</td>
<td>Other body tissues</td>
</tr>
<tr>
<td>Protein metabolism</td>
<td>↑ protein mobilization</td>
<td>Muscle and other body tissues</td>
</tr>
<tr>
<td>Mineral metabolism</td>
<td>↑ absorption</td>
<td>Gut</td>
</tr>
<tr>
<td></td>
<td>↑ mobilization</td>
<td>Bones</td>
</tr>
<tr>
<td>Intake</td>
<td>↑ food consumption</td>
<td>Central nervous system</td>
</tr>
<tr>
<td>Digestion</td>
<td>↑ Hypertrophy of digestive tract</td>
<td>Digestive tract (incl. Liver)</td>
</tr>
<tr>
<td></td>
<td>↑ capacity for nutrient absorption</td>
<td></td>
</tr>
</tbody>
</table>

↓: decreasing; ↑: increasing.

Ingvartsen and Andersen, 2000; J. Dairy Sci. 83:1573-1597
Circulating NEFA and BHBA are a Normal Part of Transition if Lipid Mobilization is “Normal” and Non-Compromised

How Common is Elevated NEFA and BHB in Herds in the Northeast?

<table>
<thead>
<tr>
<th></th>
<th>% of herds with &gt;15% of samples</th>
<th>% of herds with &gt;35% of samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prepartum NEFA &gt; 0.3 mEq/L</td>
<td>74</td>
<td>37</td>
</tr>
<tr>
<td>Postpartum NEFA &gt; 0.7 mEq/L</td>
<td>65</td>
<td>35</td>
</tr>
<tr>
<td>Postpartum BHB &gt; 10 mg/dL (heifers)</td>
<td>38</td>
<td>12</td>
</tr>
<tr>
<td>Postpartum BHB &gt; 10 mg/dL (cows)</td>
<td>70</td>
<td>25</td>
</tr>
</tbody>
</table>

Overton and Nydam, 2009
**Ketosis**

- “It’s the #1 metabolic disease going on in cattle”  
  *Gary Oetzel, February 13, 2012*

- 30% incidence...may be higher
- 43% (26-56%) SCK incidence on 4 large commercial dairies (McArt et al., 2011)
- $67 ($33-109) per case of SCK (Oetzel, 2012)

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**Incidence of Subclinical Ketosis** *(BHBA = 1.2 to 2.9 mmol/L)*

- Peak incidence occurs early (5 DIM) in herds that group cows and feed a TMR
- Resolution of SCK is ~5 d

McArt et al., 2012; J. Dairy Sci. 95:5056
Cow-Level Testing for Ketosis
(Oetzel, 2012)

- Blanket testing
  - M-W-F protocol
  - Use in high prevalence (snapshot) herds
    - Incidence is 2.2-2.4 X the prevalence
- Selective testing
  - Based on attitude, appetite, and milk
    - Low milk alone will delay diagnosis
  - Use selective testing in lower prevalence herds

Early Detection and Propylene Glycol Treatment (300 mL/ 10 oz.)
(Oetzel, 2012; McArt et al., 2012)

- 1.5X more likely to resolve ketosis by 16 DIM
- 0.54X less likely to develop BHBA ≥ 3.0 mmol/L
- 0.63X less likely to develop a DA ≤ 30 DIM
- 0.48X less likely to be removed by ≤ 30 DIM
- 3.2 lb more milk
- 1.3X more likely to conceive at 1st service

Rather Prevent than Treat!
Impact of Negative Energy Balance and Subclinical Ketosis

- **Reduced milk yield: 4 - 7%** (Dohoo and Martin, 1984; Duffield et al., 2009; Ospina et al., 2010; Chapinal et al., 2012)

- **Severity of loss is associated with magnitude of elevation in BHBA at 1st diagnosis and DIM at 1st diagnosis** (McArt et al., 2012)
  - Each additional 0.1 mmol/L increase in BHBA above 1.2 mmol/L was associated with 1.1 lbs more lost milk in 1st 30 DIM
  - Great loss at 3 to 7 DIM vs. 8 to 16 DIM

Impact of Negative Energy Balance and Subclinical Ketosis

- **Increased risk (3-7x) for DA** (Duffield et al., 2009; Ospina et al., 2010)

- **Increased risk (3x) for early removal from herd in 1st 30 DIM** (McArt et al., 2012)

- **Increased risk (2-3x) for metritis** (Duffield et al., 2009; Ospina et al., 2010)

- **Impaired fertility** (Walsh et al., 2007; Ospina et al., 2010; McArt et al., 2012)
Energy Metabolism & Immunity  (Sordillo, 2012)

- **Body condition score**
  - Alters cytokine production (O’Boyle et al., 2006)
  - Reduces lymphocyte function (Lacetera et al., 2005)

- **Negative energy balance**
  - Reduces antibody formation (van Kregsel, 2007)
  - Reduces neutrophil function (Hammond et al., 2006)

- **Elevated NEFA**
  - Compromises lymphocyte function (Lacetera et al., 2004)

- **Ketosis (elevated BHBA)**
  - Impairs neutrophil function (Grinberg et al., 2008)
**Dry Period Energy Formulation...a Balancing Act**

- If cows consume insufficient energy before calving...more metabolic problems after calving
- If cows consume excessive energy before calving...more metabolic problems after calving
- Major influence of non-nutritional factors on amount and uniformity of energy intake
- Dictates different approaches on different farms to achieve same goal

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**Common Observations with Prepartum Overfeeding/Excessive Insulin Resistance**

- Large decreases in DMI as cows approach calving
- Low/sluggish increases in DMI in fresh cows
- Rapid BW/BCS loss during postpartum period
- Higher incidence of subclinical and clinical ketosis and DA
- Sometimes lower colostrum yield

*Slide from T. R. Overton*
Nutrition for the Fresh Cow

- Should feed diets that
  - Provide nutrients to accelerate the postpartum increase in intake and milk
  - Support noncompromised lipid mobilization
  - Optimize rumen function
  - Minimize health problems
  - Prepare cows for conception

Manage for a Rapid Increase in Intake

Eating behavior and feed intake are the result of neural integration of numerous signals.
Model of Intake Regulation

Intake

At high NDF concentrations in diets, rumen fill limits DMI whereas, at low NDF concentrations energy intake feedback inhibitors limit DMI

Low Forage to Concentrate Ratio High
High NEL Density Low
Low Gut Fill (NDF) High

Recommendations for Fresh Cows
(Low insulin, insulin resistant, high NEFA)

- Maintain rumen fill during transition period
  - Forages with long ruminal retention time (grass, straw)
- Avoid feeding highly fermentable diets to fresh cows (may be ~7 to 21 d)
  - Rapid production and absorption of propionate will suppress intake (Allen and Bradford, 2011)
    - But depends on NEFA status
  - Ground corn is good choice...moderate ruminal fermentability, high small intestinal digestibility
  - Use of nonforage fiber sources
Optimizing Rumen Function in Transition Cows to Drive Intake and Energy Balance

- Rumen dysfunction affects rumen microbes...
  - Less efficient digestion
  - Decreased feed intake
  - Exacerbating the negative energy balance

Risk of Ruminal Acidosis (SARA) is Increased in Fresh Cows

- SARA increased dramatically after calving (Fairfield et al., 2007; Penner et al., 2007)

<table>
<thead>
<tr>
<th>Item</th>
<th>-5 to -1 d</th>
<th>1 to 5 d</th>
<th>17-19 d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum pH</td>
<td>5.74</td>
<td>5.38</td>
<td>5.37</td>
</tr>
<tr>
<td>Mean pH</td>
<td>6.32</td>
<td>5.96</td>
<td>5.95</td>
</tr>
<tr>
<td>SARA, h/d</td>
<td>1.1</td>
<td>7.3</td>
<td>9.0</td>
</tr>
</tbody>
</table>

- Why?
  - Abrupt change in fermentable carbohydrate intake after calving
  - Feeding behavior changes associated with grouping and pen movement strategies
    - Heifers may be more susceptible
Minimize the Risk of SARA

- Prevent depression in intake before calving
  - Negatively affects ruminal epithelial function
- Proper formulation of diets to optimize intake of fermentable carbohydrates, peNDF, and endogenous buffering capacity
- Consistent delivery of diets with minimal variation in composition
- Continuous access to feed so meals are small and regular...avoiding slug feeding
- Inclusion of appropriate feed additives that mitigate low ruminal pH

The Power of Rumination – Early Disease Prevention

- Facilitate digestion, particle size reduction, and subsequent passage from the reticulo-rumen...allowing high levels of feed intake
- Increase saliva secretion...improving rumen function by buffering
Rumination Should Rapidly Increase After Calving
(Soriani et al., 2012)

Prepartum Rumination is Related to Postpartum Health
(Soriani et al., 2012)
Daily Rumination Time of Health and (later diagnosed) Diseased Cows in the 1st Week

T. Breunig, 9/14/12 www.progressivedairy.com

Fresh Heifer with Low Rumination Time
Fresh Cow with Floating DA

Strategies for Feeding Early Lactation Cows

- Increasing the dietary nutrient (energy/protein) density
  - Increase starch, protein or fat components at expense of forage
  - Implications for rumen function, milk composition, nutrient partitioning, and metabolic hormones
- Altering the source of fermentable carbohydrates
  - Implications for acidosis risk and intake
- Changing the availability of glucogenic nutrients relative to lipogenic nutrients
  - Implications for reproductive performance
- Targeting use of specific fatty acids
  - Implications for immunity and reproductive performance
- Changing amount and source of metabolizable protein and amino acids
Miner Study

- 72 multiparous Holstein cows
- 40-d dry period
  - Controlled-energy, high-straw diet
- 91-d lactation period
  - 21% (low), 23% (medium), and 26% (high) starch diets

<table>
<thead>
<tr>
<th>Treatment</th>
<th>1-21 DIM</th>
<th>22-91 DIM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low (LL)</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Medium-High (MH)</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>High (HH)</td>
<td>High</td>
<td>High</td>
</tr>
</tbody>
</table>

### Ingredient Composition of Diets (% of Dry Matter)

<table>
<thead>
<tr>
<th>Item</th>
<th>Dry</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn silage</td>
<td>30.7 ± 0.3</td>
<td>34.6 ± 0.1</td>
<td>34.6 ± 0.1</td>
<td>34.6 ± 0.1</td>
</tr>
<tr>
<td>Haylage</td>
<td>11.0 ± 1.0</td>
<td>11.4 ± 0.4</td>
<td>11.7 ± 0.3</td>
<td>11.4 ± 0.4</td>
</tr>
<tr>
<td>Wheat straw</td>
<td>24.9 ± 0.9</td>
<td>4.1 ± 0.1</td>
<td>4.1 ± 0.1</td>
<td>4.1 ± 0.1</td>
</tr>
<tr>
<td><strong>Corn meal</strong></td>
<td><strong>-</strong></td>
<td><strong>6.9 ± 0.4</strong></td>
<td><strong>11.1 ± 0.1</strong></td>
<td><strong>16.7 ± 0.4</strong></td>
</tr>
<tr>
<td>Soybean meal</td>
<td>8.6 ± 0.5</td>
<td>11.4 ± 0.1</td>
<td>11.9 ± 0.1</td>
<td>11.9 ± 0.1</td>
</tr>
<tr>
<td>Soybean hulls</td>
<td>9.3 ± 0.1</td>
<td>9.7 ± 0.1</td>
<td><strong>6.5 ± 0.2</strong></td>
<td><strong>3.2 ± 0.1</strong></td>
</tr>
<tr>
<td>Wheat middlings</td>
<td>-</td>
<td><strong>6.1 ± 0.1</strong></td>
<td><strong>3.9 ± 0.1</strong></td>
<td><strong>1.8 ± 0.1</strong></td>
</tr>
<tr>
<td>Canola meal</td>
<td>-</td>
<td>3.1 ± 0.1</td>
<td>6.1 ± 0.1</td>
<td>6.1 ± 0.1</td>
</tr>
<tr>
<td>DDGS</td>
<td>-</td>
<td>3.2 ± 0.1</td>
<td>3.1 ± 0.1</td>
<td>3.1 ± 0.1</td>
</tr>
<tr>
<td>AminoPlus</td>
<td>-</td>
<td>2.5 ± 0.1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Other</td>
<td>15.5 ± 1.2</td>
<td>7.0 ± 0.3</td>
<td>6.9 ± 0.3</td>
<td>7.1 ± 0.3</td>
</tr>
</tbody>
</table>
## Analyzed Chemical Composition of Diets (% of Dry Matter)

<table>
<thead>
<tr>
<th>Item</th>
<th>Dry</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM, %</td>
<td>52.9 ± 1.1</td>
<td>49.5 ± 0.7</td>
<td>50.1 ± 0.9</td>
<td>49.6 ± 0.7</td>
</tr>
<tr>
<td>CP, %</td>
<td>13.4 ± 0.2</td>
<td>17.3 ± 0.1</td>
<td>17.0 ± 0.2</td>
<td>16.7 ± 0.2</td>
</tr>
<tr>
<td>ADF, %</td>
<td>34.2 ± 0.3</td>
<td>22.9 ± 0.2</td>
<td>21.8 ± 0.2</td>
<td>20.3 ± 0.3</td>
</tr>
<tr>
<td>NDF, %</td>
<td>50.7 ± 0.3</td>
<td>35.7 ± 0.3</td>
<td>33.9 ± 0.4</td>
<td>31.9 ± 0.3</td>
</tr>
<tr>
<td>Starch, %</td>
<td>13.5 ± 0.4</td>
<td>21.0 ± 0.3</td>
<td>23.2 ± 0.3</td>
<td>25.5 ± 0.3</td>
</tr>
<tr>
<td>RFS, %</td>
<td>11.5 ± 0.5</td>
<td>16.8 ± 0.5</td>
<td>18.9 ± 0.6</td>
<td>20.2 ± 0.5</td>
</tr>
<tr>
<td>Sugar, %</td>
<td>4.5 ± 0.1</td>
<td>6.1 ± 0.1</td>
<td>5.8 ± 0.1</td>
<td>5.9 ± 0.1</td>
</tr>
<tr>
<td>Fat, %</td>
<td>2.6 ± 0.1</td>
<td>4.0 ± 0.1</td>
<td>4.1 ± 0.1</td>
<td>4.2 ± 0.1</td>
</tr>
</tbody>
</table>

*RFS = rumen fermentable starch*

## Dry Matter Intake (DMI)

\[ \text{DMI, kg/d} \]

\[ \text{DMI, % BW/d} \]

- **Trt:** Trt: $P = 0.06$
  Time: $P < 0.001$
  Trt x Time: $P = 0.09$
  LL > HH: $P \leq 0.10$
- **n:** n = 72 cows
Starch Intake

![Graph showing Starch Intake over time with different treatments (LL, MH, HH).](image1.png)

- Trt: $P < 0.001$
- Time: $P < 0.001$
- Trt x Time: $P < 0.001$
- LL < MH, HH: $P \leq 0.05$

Neutral Detergent Fiber (NDF) Intake

![Graph showing Neutral Detergent Fiber (NDF) Intake over time with different treatments (LL, MH, HH).](image2.png)

- Trt: $P < 0.001$
- Time: $P < 0.001$
- Trt x Time: $P = 0.85$
- LL > MH, HH: $P \leq 0.05$
Milk Yield

Week Relative to Parturition

Trt: $P = 0.04$
Time: $P < 0.001$
Trt x Time: $P = 0.75$
MH > HH: $P \leq 0.05$

Milk Yield and Composition for 13 wk of Lactation

<table>
<thead>
<tr>
<th>Item</th>
<th>Treatment</th>
<th>$P$-value</th>
<th>TRT</th>
<th>Time</th>
<th>TRT x Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.5% FCM, kg/d</td>
<td>LL</td>
<td>51.9</td>
<td>52.2</td>
<td>47.4</td>
<td>1.7</td>
</tr>
<tr>
<td>SCM, kg/d</td>
<td>MH</td>
<td>47.4</td>
<td>47.9</td>
<td>43.5</td>
<td>1.5</td>
</tr>
<tr>
<td>Fat, %</td>
<td>HH</td>
<td>3.88x</td>
<td>3.64y</td>
<td>3.79xy</td>
<td>0.08</td>
</tr>
<tr>
<td>Fat, kg/d</td>
<td>SE</td>
<td>1.91x</td>
<td>1.86y</td>
<td>1.71y</td>
<td>0.06</td>
</tr>
<tr>
<td>True protein, %</td>
<td>TRT</td>
<td>2.90</td>
<td>2.92</td>
<td>2.97</td>
<td>0.04</td>
</tr>
<tr>
<td>True protein, kg/d</td>
<td>HH</td>
<td>1.42ab</td>
<td>1.50a</td>
<td>1.34b</td>
<td>0.04</td>
</tr>
<tr>
<td>MUN, mg/dL</td>
<td>SE</td>
<td>15.2a</td>
<td>12.7b</td>
<td>11.9b</td>
<td>0.3</td>
</tr>
</tbody>
</table>

$ab \ P \leq 0.05; \ y \ P \leq 0.10$
Serum NEFA and BHBA During First 21 DIM

<table>
<thead>
<tr>
<th>Item</th>
<th>LL</th>
<th>MH</th>
<th>HH</th>
<th>SE</th>
<th>TRT</th>
<th>Time</th>
<th>TRT × Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEFA, uEq/L</td>
<td>452a</td>
<td>577b</td>
<td>431b</td>
<td>43</td>
<td>0.03</td>
<td>&lt;0.001</td>
<td>0.11</td>
</tr>
<tr>
<td>BHBA, mg/dL</td>
<td>9.3</td>
<td>8.8</td>
<td>7.8</td>
<td>1.1</td>
<td>0.15</td>
<td>0.46</td>
<td>0.97</td>
</tr>
</tbody>
</table>

ab $P \leq 0.05$

Body Weight and Body Condition Score

- Trt: $P = 0.99$
- Time: $P < 0.001$
- Trt x Time: $P = 0.59$

- Trt: $P = 0.46$
- Time: $P < 0.001$
- Trt x Time: $P = 0.37$
Energy Balance

Management - Focus on Minimizing Stress

n = 72 cows

Week Relative to Parturition
Use Management Strategies to Minimize Stressors

- Minimize overcrowding (bunk and stalls)
- Grouping
- Pen moves
- Time budget busters
- Cooling dry and fresh cows
Transition Period Stocking Density

- Overstocking during the far-off dry period affects energy metabolism (Huzzey et al., 2012)
- Competition at feedbunk (Insentec) changes behavior (Proudfoot et al., 2009)
  - Faster eating rate before and after calving
  - Less intake before calving

Competition at Feed Bunk Increased Displacements
(Proudfoot et al., 2009)

![Graph showing increased displacements and feeding rate](image)
Feeding Behavior of Fresh Cows at Different Feed Bin Stocking Densities (Krawczel et al., 2009)

- In absence of freestall overcrowding, feed bin stocking density did not affect dry matter intake, water intake, or standing behavior.
- Trends for increased feeding rate and altered feeding time suggest that overstocking feed bins may alter feeding behavior.

The Social “Support” Group
**Weekly Entrance Close-Up**

**Pen Vs. All-In-All-Out (AIAO)**

(Lobeck et al., 2012 JAM; Silva et al., 2012 JAM)

- Weekly pen: ~10 cows entered weekly @ 254 ± 7 d gestation (n = 308)
  - Stocking density: 100% stall & 92% headlocks (averaged 87% stalls)

- AIAO: groups of 44 cows for 5 wk max. (n = 259)
  - Stocking density: 100% to 7% (averaged 73%)

- Weekly entrance pen had 2X more displacements at feed bunk (agonistic interactions)

- No effect on BCS, lameness, NEFA, glucose, innate immune function, or milk yield

**Use of a Designated Fresh Cow Pen**

- Allows dairies to facilitate monitoring of health problems, minimize social stress, and provide a diet specifically formulated for fresh cows

- Use increased with herd size (Heuwieser et al., 2010)

- The optimal duration of stay in a fresh pen is unknown...it most likely varies among farms and cows
Grouping Fresh Cows – Are There Benefits of Separate Housing and Feeding?

- 1 mo separate housing vs. comingling with herd (Østergaard et al., 2010)
  - Primiparous cows, but not multiparous cows, produced ~230 kg more of energy-corrected milk from 0 to 305 DIM and had less ketosis treatments when housed separately
  - Did not use a “fresh cow diet”...probably see more benefits of separate groups

Use of High-Risk and Low-Risk Fresh Cow Pens

- Opportunity for large dairies
- Target specialized management time to cows that need it
- Decrease lock-up time for exam and treatment
- Decrease time away from stalls
  - Rest for lame and sick cows
- Milking frequency adjustment (2x vs. 3x)

http://thedairylandinitiative.vetmed.wisc.edu/tdi/ac_group_size.htm
Conclusions

- Successful transition cow programs implement management programs that manage energy metabolism
  - Subclinical ketosis is our challenge

- Minimize the drop in DMI before calving and promote rapid increases in DMI after calving through properly balanced diets to support metabolic adaptations

Conclusions

- No “one size fits all” approach but there are some common themes
- Do not overfeed during the dry period
- Formulate the fresh diet in the context of the dry and high group diets
- Optimize rumen function
- Monitor and adjust diets for forage changes (DM, chemical composition, digestibility, particle size)
- Provide appropriate fermentable carbohydrates and adequate peNDF in fresh diets
- Manage to minimize stressors