Feeding and managing for milk components

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Income Over Feed Cost (IOFC)

• Defined as milk income minus feed cost

• Consistently accounts for about 50% of the variability in dairy farm profitability
  – Karszes, Cornell Dairy Farm Business Summary and Analysis Program
Three factors account for ~ 85% of the variance in Income Over Feed Cost (IOFC)

- Milk / milk component yields (~ 50% of the variance)
- Feed efficiency (~25%)
- Cost per lb of TMR DM (~ 10%)
Dairy Profit Monitor -- www.dairyprofit.cornell.edu
Same 111 farms – September 2017 to August 2018

Milk fat is affected by many factors

**Nutritional Factors**
- Inhibited by “Classical” diet induced milk fat depression
  - Unsaturated fat
  - Fermentability
  - Acidosis
  - Feeding strategies
  - Ionophores
- Increased by additional substrate
  - Acetate
  - Fatty acids (Palmitic acid)
  - High NEFA

**Non-nutritional Factors**
- Genetics
- Season
- Stage of lactation/Level of production
- Parity

Slide courtesy Dr. Kevin Harvatine
Sources of milk fat

- "De novo" – made by the mammary cells
  - Short- and medium-chain fatty acids
  - Primary source ruminal acetate and butyrate
- "Pre-formed" – extracted from the blood by the mammary gland
  - Long-chain fatty acids from diet and body fat (early lactation)
- "Mixed" – both made in the mammary gland and extracted from the blood

- ~ 50% of milk fatty acids made in mammary gland and about 50% extracted from the blood
Bulk Tank – 430 farms – 15 months

Barbano and Mellili, 2016
Bulk Tank – 430 farms – 15 months

Barbano and Mellili, 2016

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Increased by additional substrate
- Acetate
- Fatty acids (Palmitic acid)
- High NEFA (fresh cows)

Slide courtesy Dr. Kevin Harvatine
Biohydrogenation-induced low milk fat

- Specific fatty acids produced during microbial biohydrogenation of unsaturated dietary fatty acids in the rumen are responsible for low milk fat.
- Very potent – 2 to 3 grams of these fatty acids flowing out of the rumen can decrease milk fat by 0.5% or more.
- Mechanism for all situations of diet-induced low milk fat appears to be the same, but get there in different ways.

Rumen Biohydrogenation

- Linolenic Acid: cis-9, cis-12, cis-15 C\text{18:3} → cis-9, trans-11, cis-15 C\text{18:3} → trans-11, cis-15 C\text{18:2} → trans-15 or cis-15 C\text{18:1} → trans-15 C\text{18:1} → Stearic Acid C\text{18:0}
- Linoleic Acid: cis-9, cis-12 C\text{18:2} → cis-9, trans-11 CLA → trans-10, cis-12 CLA → altered fermentation

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- Process extensive, but not complete
- All intermediates formed potentially pass to the small intestine
## Dietary components can impact the risk of MFD in 3 ways

1. **Increase C18 PUFA Precursors**
   - Linoleic acid (cis-9, cis-12 18:2)
   - Rumenic acid (cis-9, trans-11 CLA)
   - Vaccenic acid (trans-11 18:1)
   - Stearic acid (18:0)

2. **Alter BH pathways/ rumen environment**
   - trans-10, cis-12 CLA
   - trans-10 18:1

3. **Inhibit final step/ alter rates of BH**
   - Stearic acid (18:0)

### Increase C18 PUFA precursor supply and rumen availability

- Linoleic acid (C18:2) supply and availability in the rumen
  - Corn and corn-based sources high in linoleic acid
  - Oilseeds (whole soybeans or cottonseed) high in linoleic acid

- CNCPS predictions of linoleic acid intake from high corn silage-based lactating diets can approach or exceed 400 to 500 g/d

- Any processing method that will increase ruminal availability of unsaturated FA (e.g. finely ground or extruded full-fat soybeans)

- Despite high content of C18:2, whole cottonseed not frequently associated with low milk fat
  - Effect of hull on release of fatty acids into rumen environment
Factors that result in an altered ruminal environment

- Dynamics of rumen pH as a balance of
  - Acid production from ruminally fermentable CHO
    - Dietary CHO profile and Kd of fractions as affected by source, processing, and moisture
  - Buffer production from salivary and dietary sources
    - peNDF supply and source
  - Rate of removal of acids through absorption or passage
  - Feeding management and environmental/facility effects
    - Mixing, DM changes, feeding frequency, stocking density, heat stress, stall usage, etc.

Facility/cow/management factors that contribute to low milk fat

- Stocking density (slug feeding/eating patterns)
- Time budget (slug feeding/eating patterns)
- Cooling/heat stress (slug feeding/feeding patterns)
- Feeding to an empty bunk? (slug feeding/feeding patterns)
Forage/TMR factors contributing to low milk fat

- Wet corn silages (high total VFA?)
- Starch availability in corn silage
- High mold and yeast counts in corn silage or high-moisture cereals
- Mycotoxins
- Particle size (of TMR)

Changes in silage microbiology

- Denmark study of 20 corn silage piles (Storm et al., 2010)
  - Samples collected about 3 feet in from face every 2 months
  - Counts of various yeast species increased over time
  - Peaked at 5 to 7 months post-ensiling

- Protection against yeasts
  - Good silage management (pack, moisture, chop, etc.)
  - Good face management (defacer helps)
  - Low oxygen permeability plastics
  - Silage inoculants based upon Lactobacillus Buchneri or acid-based preservatives
Factors that influence biohydrogenation rate

- Anything that slows rates of biohydrogenation at different steps may result in more passage of FA intermediates that cause MFD from the rumen
- These do not cause milk fat problems, but will amplify the effect of an existing ruminal condition on milk fat
  - Monensin
  - Fish fatty acids (last step of biohydrogenation)
  - High load of unsaturated FA (C18:1 and/or C18:3?)

Factors that influence rate of passage

- DMI (higher producing, higher intake herds more risk)
- Ration particle size (especially middle screen and pan if using 3-part Penn State Particle Separator)
Common risk factors for low milk fat

- Factors that result in high availability of linoleic acid
  - Unsaturated fat source, amount, and processing

- Factors that cause altered ruminal biohydrogenation
  - Low rumen pH
  - Forage/feed quality issues (mycotoxins, spoilage yeasts)
  - Management-related changes in feeding behavior

- Factors that slow rates of biohydrogenation
  - Fish fatty acids
  - Ionophores
  - High C18:1 intake

- Factors that result in high rates of passage
  - High production/DMI

- Most often not one factor, but an INTERACTION AMONG SEVERAL FACTORS, responsible for milk fat problems

Should we think about risk factors for low milk fat based upon the severity of the issue?

2.9 to 3.4%

3.4 to 3.7%
If acutely low milk fat (< 3.4%) ....

• Linoleic acid issues
• Yeasts on silage or high moisture cereals
• Mycotoxins
• EPA/DHA
• Severe rumen pH issues

If subacutely low milk fat (3.4 to 3.7%) ....

• Could be a lesser version of issues that cause acute low milk fat

• Could also be
  – C18:1 (oleic acid)
  – Overstocking/feedbunk mgt/factors that alter feeding patterns
  – Particle size/passage rate/DMI
What might we do nutritionally to increase milk fat percentage and yield when milk fat content is “normal”??

TABLE 1  Effect of acetate infusion on intake, milk yield, and milk composition in lactating dairy cows\textsuperscript{1}

<table>
<thead>
<tr>
<th>Variable</th>
<th>Acetate infusion,\textsuperscript{2} mol/d</th>
<th>( \text{SE} )</th>
<th>( p )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Intake, kg/d</td>
<td>26.6</td>
<td>26.5</td>
<td>27.3</td>
</tr>
<tr>
<td>Milk yield, kg/d</td>
<td>37.7</td>
<td>38.2</td>
<td>39.2</td>
</tr>
<tr>
<td>Milk fat</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yield, kg/d</td>
<td>1.37</td>
<td>1.47</td>
<td>1.59</td>
</tr>
<tr>
<td>Percentage</td>
<td>3.71</td>
<td>3.94</td>
<td>4.05</td>
</tr>
<tr>
<td>Milk protein</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yield, kg/d</td>
<td>1.16</td>
<td>1.19</td>
<td>1.24</td>
</tr>
<tr>
<td>Percentage</td>
<td>3.14</td>
<td>3.17</td>
<td>3.20</td>
</tr>
</tbody>
</table>

\textsuperscript{1} Values are least-squares means and mean SEs, \( n = 8 \). L, linear; Q, quadratic. Trt, treatment.
\textsuperscript{2} Treatments included 4 d of continuous rumen infusion of acetate adjusted to pH 6.1.
\textsuperscript{3} Probability of a fixed effect of treatment, time, and treatment \text{x} time interaction and probability of a linear or quadratic effect of acetate dose with the use of polynomial contrasts.

Specific nutritional supplements and additives that may increase milk fat percentage and yield

- Many nutritional supplements and feed additives exert their effects on milk fat yield through effects on milk yield rather than on milk fat percentage per se
- Some additives can have effects on milk fat percentage and yield
  - Buffers
  - DCAD (increasing using potassium or sodium)
  - Yeast/yeast culture
  - AA analogs
  - Certain added fat sources (especially those high in palmitate C16:0)

What about milk protein?
Protein metabolism in cows

Schwab, 2005

Lysine Plot (NRC, 2001)
Methionine Plot (NRC, 2001)

Weighted average responses of cows to additional Met provided by experimental infusion or feeding protected forms or a Met analog

<table>
<thead>
<tr>
<th>Item</th>
<th>DL-Met</th>
<th>HMTBa</th>
<th>RPM M</th>
<th>RPM S</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMI, kg/d</td>
<td>+0.12&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>+0.15&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.25&lt;sup&gt;b&lt;/sup&gt;</td>
<td>+0.31&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.012</td>
</tr>
<tr>
<td>Milk, kg/d</td>
<td>-0.34</td>
<td>+0.28</td>
<td>+0.31</td>
<td>-0.13</td>
<td>0.055</td>
</tr>
<tr>
<td>Milk protein, g/d</td>
<td>+19&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>+13&lt;sup&gt;b&lt;/sup&gt;</td>
<td>+35&lt;sup&gt;a&lt;/sup&gt;</td>
<td>+19&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Milk protein, %</td>
<td>+0.08&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.00&lt;sup&gt;b&lt;/sup&gt;</td>
<td>+0.07&lt;sup&gt;a&lt;/sup&gt;</td>
<td>+0.07&lt;sup&gt;a&lt;/sup&gt;</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Milk fat, g/d</td>
<td>+12&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>+45&lt;sup&gt;a&lt;/sup&gt;</td>
<td>+35&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>+6&lt;sup&gt;b&lt;/sup&gt;</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Milk fat, %</td>
<td>+0.08&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>+0.13&lt;sup&gt;a&lt;/sup&gt;</td>
<td>+0.05&lt;sup&gt;b&lt;/sup&gt;</td>
<td>+0.04&lt;sup&gt;b&lt;/sup&gt;</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>(Protein+fat)/DMI</td>
<td>+0.78&lt;sup&gt;b&lt;/sup&gt;</td>
<td>+1.70&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>+3.88&lt;sup&gt;a&lt;/sup&gt;</td>
<td>-0.42&lt;sup&gt;b&lt;/sup&gt;</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Zanton et al., 2014. J. Dairy Sci. 97:7085-7101
Optimum AA concentrations in MP in CNCPS 6.55 biology

<table>
<thead>
<tr>
<th>AMTS/NDS (CNPS 6.5 biology)</th>
<th>Lysine</th>
<th>Methionine</th>
<th>Optimal Lys/Met</th>
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</thead>
<tbody>
<tr>
<td>2015</td>
<td>7.00</td>
<td>2.60</td>
<td>2.7</td>
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</table>

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<thead>
<tr>
<th>AMTS/NDS (CNCPS 6.5 biology)</th>
<th>milk protein %</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>6.77 2.85 2.4</td>
</tr>
</tbody>
</table>

Van Amburgh (2015)

Other considerations for AA balancing

- How digestible are your RUP sources?
  - Plant-based RUP sources (bypass soy/canola) usually good
  - Distillers grains can vary substantially
  - Animal protein sources (blood) can vary substantially

- What about interactions with energy status?
  - Protein synthesis is energy driven
Let’s go back to milk fatty acid profiles

<table>
<thead>
<tr>
<th>August</th>
<th>Lactose</th>
<th>Protein</th>
<th>MUN</th>
<th>Butterfat</th>
<th>MIXED FA</th>
<th>DENOVO FA</th>
<th>PREFORMED FA</th>
</tr>
</thead>
<tbody>
<tr>
<td>05/21/18</td>
<td>4.70</td>
<td>4.70</td>
<td>3.02</td>
<td>3.04</td>
<td>11.47</td>
<td>11.26</td>
<td>3.66</td>
</tr>
<tr>
<td>05/22/18</td>
<td>4.70</td>
<td>4.70</td>
<td>3.02</td>
<td>3.04</td>
<td>11.47</td>
<td>11.26</td>
<td>3.66</td>
</tr>
<tr>
<td>05/23/18</td>
<td>4.69</td>
<td>4.71</td>
<td>3.05</td>
<td>3.09</td>
<td>12.30</td>
<td>10.50</td>
<td>3.69</td>
</tr>
<tr>
<td>05/24/18</td>
<td>4.68</td>
<td>4.71</td>
<td>3.05</td>
<td>3.09</td>
<td>12.30</td>
<td>10.50</td>
<td>3.69</td>
</tr>
<tr>
<td>05/25/18</td>
<td>4.69</td>
<td>4.70</td>
<td>3.03</td>
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<td>11.70</td>
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<td>12.50</td>
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</tr>
</tbody>
</table>
Dann recommendations

Bulk Tank “Alarms” for Holstein Herds that Want >3.8% Milk Fat

<table>
<thead>
<tr>
<th>Milk Component</th>
<th>Units</th>
<th>Alarm Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fat</td>
<td>%</td>
<td>&lt;3.8</td>
</tr>
<tr>
<td>De Novo FA</td>
<td>g/100 g milk</td>
<td>&lt;0.8</td>
</tr>
<tr>
<td>Mixed FA</td>
<td>g/100 g milk</td>
<td>&lt;1.3</td>
</tr>
<tr>
<td>Preformed FA</td>
<td>g/100 g milk</td>
<td>&lt;1.3</td>
</tr>
<tr>
<td>FA Unsaturation</td>
<td>double bonds/FA</td>
<td>&gt;0.31</td>
</tr>
</tbody>
</table>
Summary and conclusions

- Milk component yields are major drivers for maximizing Income Over Feed Cost
- Many factors (nutritional and nonnutritional) affect milk components
- Strategies exist to troubleshoot milk fat issues when it is low and potentially boost it to increase milk revenue
- Protein and amino acid nutrition can be optimized to increase milk protein yields, increase the efficiency of nitrogen use, and capture increased margin
- New milk analytics are available to help identify opportunities for improved milk components

Thanks!!

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