Fatty Acid Nutrition and Milk Fat Depression

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2015 Herd Health and Nutrition Conferences

Milk Fat Affected by Many Factors

<table>
<thead>
<tr>
<th>Nutritional Factors</th>
<th>Non-nutritional Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>fiber in the diet</td>
<td>genetics</td>
</tr>
<tr>
<td>specific feeds</td>
<td>stage of lactation</td>
</tr>
<tr>
<td>feeding strategy</td>
<td>season</td>
</tr>
<tr>
<td>ionophores</td>
<td>parity</td>
</tr>
</tbody>
</table>

Diet Induced Milk Fat Depression (MFD) = Specific inhibition of milk fat

Rumen Biohydrogenation

linoleic acid (cis-9, cis-12 C_{18:2})
\downarrow
rumenic acid (cis-9, trans-11 CLA)
\downarrow
vaccenic acid (trans-11 C_{18:1})
\downarrow
stearic acid (C_{18:0})

Altered pathways

Alternate CLA isomers trans-10, cis-12 CLA
\downarrow
trans - C_{18:1} isomers trans-10 C_{18:1}
\downarrow
stearic acid (C_{18:0})

Grimari and Bauman, 1999

The Mammary Gland is Acutely Responsive to CLA

![Diagram showing milk fat levels over time with infusions of different CLA isomers](image-url)
Dietary Risk Factors

- Associative Effects
  - Dietary fatty acid level and profile
  - Availability of fatty acids
  - Rumen modifiers - ionophore
  - Dietary carbohydrate profile
  - Rate and extent of fermentation
  - Effective fiber
  - Ruminal N balance
  - Feeding strategies / management
  - Silage fermentation / quality
  - Forage types
  - Individual cow effect (level of intake etc)

RUFAL: Rumen Unsaturated Fatty Acid Load (but C18:2 most important)

Risk Factors Cause Milk Fat Depression

- Rarely is low milk fat caused by a single factor on a farm

- We can’t eliminate all the risk factors

- We don’t want to eliminate all the risk factors!!

There is a Continuum From “High” to “Low” Milk Fat

Each herd and each cow is somewhere on this continuum!!

Variation in an Example Herd Group
What is the Time-Course of Induction of and Recovery from Milk Fat Depression?

- When MFD occurs...........when did the problem originate?
- When correcting the diet......when do we expect to see improvements???

Characterizing Recovery From MFD

- TMR diets:
  1) Low forage/High Oil (LF/HO)
     29.5% NDF, 27% starch, 6.9% FA (including 3% soy oil)
  2) Control
     36.9% NDF, 18% starch, 2.6% FA
- Milk sampled every other day

Rico and Harvatine, 2013

Time Course of Induction of MFD

- Normal Pathway cis-9,trans-11 CLA
- Alternative Pathway trans-10, cis-12 CLA

Rico and Harvatine, 2013

Time Course of Recovery of MFD

- Normal Pathway cis-9,trans-11 CLA
- Alternative Pathway trans-10, cis-12 CLA

Rico and Harvatine, 2013
Time Course of Milk Fat Depression: Key Messages

- Following a dietary adjustment-
  A lag of 7 to 10 days is expected to see milk fat depression

- Following diet corrections-
  It will take 10 to 14 days to rescue milk fat synthesis

Can We Accelerate Recovery?

Is it more important to change diet fermentability or unsaturated fat level?
Correcting Unsaturated Fat vs Diet Fermentability During Recovery

- Milk fat reduced with low NDF and high oil diet (26% NDF, 31.3% starch, 7.1% FA, 3.3% C18:2)
- Recovery diets tested
  1) Control
     31.8% NDF, 24.0% starch, 4.2% FA, and 1.7% C18:2
  2) High Oil (HO)
     31.3% NDF, 21.6% starch, 6.7% FA, and 3.0% C18:2
  3) Low NDF (LF)
     28.4% NDF, 29.0% starch, 4.3% FA, and 1.7% C18:2

Rico et al., Unpublished
Do you have to remove Rumensin to Recover?

- **Milk fat reduced with low NDF and high oil diet** (25.3% NDF, 30.6% starch, 6.9% FA, 3.2% C18:2)

- **Recovery diet**
  31.2% NDF, 24.6% starch, 4.3% FA, and 1.7% C18:2
  1) Control
     Rumensin removed
  2) Monensin (MN)
     Rumensin remained in diet

Correcting PUFA vs NDF: Key Messages

- Dietary unsaturated fatty acids are the most important factor to correct.

- Correcting fermentability provides an additional benefit, but may lose milk.

Effect of Monensin on Recovery: Milk Fat

<table>
<thead>
<tr>
<th>Time, d</th>
<th>Control</th>
<th>MN</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>3</td>
<td>2.8</td>
<td>2.6</td>
</tr>
<tr>
<td>6</td>
<td>2.6</td>
<td>2.4</td>
</tr>
<tr>
<td>9</td>
<td>2.4</td>
<td>2.2</td>
</tr>
<tr>
<td>12</td>
<td>2.2</td>
<td>2.0</td>
</tr>
<tr>
<td>15</td>
<td>2.0</td>
<td>1.8</td>
</tr>
<tr>
<td>18</td>
<td>1.8</td>
<td>1.6</td>
</tr>
</tbody>
</table>

* = P < 0.05
† = P < 0.1
Trt: 0.02
Trt x time: 0.15
SEM: 0.74

Rico et al., 2014
Effect of Monensin on Recovery: Preformed FA

- Control
- MN

* $= P < 0.05$
† $= P < 0.1$

Rico et al., 2014

Key Messages

- Milk fat synthesis can be rapidly rescued in Rumensin supplemented diets by correcting unsaturated fatty acid concentration and diet fermentability.

- In some cases, milk fat can be rescued before you run out of the current mineral?

- Monensin is a risk factor and its removal may help if you cannot correct other things!

Can Rumen Available Methionine Decrease Risk of MFD

- 15 high and 15 low producing cows fed Alimet (25 g/d) or Control (No Alimet)

- Three Dietary Phases

  1) Low Risk Diet
  - 33.5% NDF and no added oil

  2) Moderate Risk Diet
  - 31% NDF and 0.75% soybean oil

  3) High Risk Diet
  - 28.5% NDF and 1.5% soybean oil

Baldin et al., 2014 Unpublished
**Effect of Alimet on Risk of MFD:**

**Milk Yield**

Low Cows | High Cows
---|---

**Fat %**

Low Cows | High Cows
---|---

**trans-10 C18:1**

Low Cows | High Cows
---|---

**Alimet and Risk of MFD:**

**Key Messages**

- High producing cows are generally at the highest risk for MFD
- Alimet appears to reduce the risk of MFD in high producing cows and while feeding high risk diets
- Many cows in a “normal” milk fat herd are milk fat depressed
- This may take some of the “bumps out of the road”
What is the Mechanism??

- We don’t have the answer yet!!
- Definitely strong rumen mechanism, but cannot exclude a post-absorptive mechanism
- Most likely due to stabilizing rumen environment or altering rumen microbial population
  - Increased microbial mass may allow more biohydrogenation
  - May stabilize or increase microbial populations important to biohydrogenation

What are the Sources of Variation in Corn FA Profile?

- Environment
  - Seems to be a very small impact of environmental factors on fatty acid profile of corn grain
- Genetics
  - Greatest impact
  - Literature is not near as deep as soybean FA profile
  - There was some interest in high oil and oleic corn ~15 years ago

Why are High Corn Silage Diets Higher Risk for Milk Fat Depression??

- More rapidly fermented starch?
- Lower effective fiber?
- Difference in fiber digestibility/rates?
- Level and rate of C18:2 availability??
- Low in fat, but cows eat a large amount

Where are the PUFA in Corn Silage?

<table>
<thead>
<tr>
<th></th>
<th>DM</th>
<th>Total FA</th>
<th>C18:1</th>
<th>C18:2</th>
<th>C18:3</th>
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<tbody>
<tr>
<td>Kernels</td>
<td>44.0</td>
<td>80.3</td>
<td>96.8</td>
<td>92.4</td>
<td>17.1</td>
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<tr>
<td>Leaves</td>
<td>13.3</td>
<td>11.9</td>
<td>0.9</td>
<td>2.0</td>
<td>71.3</td>
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<tr>
<td>Stalk</td>
<td>31.4</td>
<td>5.1</td>
<td>0.7</td>
<td>3.3</td>
<td>9.7</td>
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<tr>
<td>Cob</td>
<td>7.6</td>
<td>1.7</td>
<td>1.1</td>
<td>1.6</td>
<td>1.0</td>
</tr>
<tr>
<td>Husk&amp;Shank</td>
<td>3.6</td>
<td>1.0</td>
<td>0.6</td>
<td>0.8</td>
<td>0.9</td>
</tr>
</tbody>
</table>
67 Corn Silages from Two Test Plots (2013)

<table>
<thead>
<tr>
<th>C18:2 (% DM)</th>
<th>C18:2 (% FA)</th>
<th>total FA (% DM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>90.0%</td>
<td>90.0%</td>
<td>90.0%</td>
</tr>
<tr>
<td>75.0%</td>
<td>75.0%</td>
<td>75.0%</td>
</tr>
<tr>
<td>50.0%</td>
<td>50.0%</td>
<td>50.0%</td>
</tr>
<tr>
<td>25.0%</td>
<td>25.0%</td>
<td>25.0%</td>
</tr>
<tr>
<td>10.0%</td>
<td>10.0%</td>
<td>10.0%</td>
</tr>
<tr>
<td>0.87%</td>
<td>0.87%</td>
<td>0.87%</td>
</tr>
<tr>
<td>Quantiles</td>
<td>Quantiles</td>
<td>Quantiles</td>
</tr>
<tr>
<td>1.60384</td>
<td>52.2013</td>
<td>3.10991</td>
</tr>
<tr>
<td>1.4064</td>
<td>50.2998</td>
<td>2.79108</td>
</tr>
<tr>
<td>1.2167</td>
<td>48.875</td>
<td>2.53337</td>
</tr>
<tr>
<td>1.0954</td>
<td>46.89</td>
<td>2.3032</td>
</tr>
<tr>
<td>0.93576</td>
<td>45.2388</td>
<td>2.05506</td>
</tr>
</tbody>
</table>

Intake of C18:2 in diets that contain 30, 42, or 54% corn silage (% DM) from hybrids that contain 0.9, 1.2, or 1.6% C18:2 (% of DM)

Nutrition is best practiced as an “Experiment in Progress”!!

- When milk fat is Acceptable
  - Inclusion of risk factors acceptable and may be advantageous to production and efficiency

- When milk fat is Low: Look For a Reason
  - When did it start and what happened ~7-10 d prior?
  - Is it a certain string or group of cows?
    - High Producing cows are normally more susceptible
  - What season is it?
  - Is the sample a daily average?
The Experiment in Progress

1. Diet Polyunsaturated Fatty Acids
   – Concentration of C18:2
   – Source of C18:2
     Very different rates of rumen release
     • Ca Salts are more slowly released, but are not inert

   **Best First Step- Reduce diet PUFA
   - Least risk of losing milk in the short-term
   - Replace unsaturated fat supplements with saturated fat supplements
     - Monitor milk yield and milk fat over time

2. Diet Fermentability
   – Analyze carbohydrate profiles and effective fiber
   – Experience with similar diets in the region is important

   – Start to titrate down starch and increase fiber
   – Switch rapidly fermentable sources for less rapidly fermentable sources
   – Increase forage NDF and effective fiber

   **Careful..... May Lose Milk!!

3. Rumen Modifiers
   – Rumensin
     • Risk factor, but does not cause MFD by itself
     • Can be synergistic with other risk factors for induction
   – Yeast & Direct Fed Microbials
     • May reduce incidence of MFD in some cases
     • Have not tested their effect on recovery
   – DCAD
     • Increases DCAD decreases MFD
   – HMTBa
     • Reduces the risk of MFD

   **Remember we are dealing with many interactions!

4. Feeding Strategies
   – Number of feeding times per day
   – Slick bunks before feeding?
   – Feeding times
     * You can slug feed TMR!

5. Saturated Fat Supplements
   - No risk for induction of milk fat depression
   - High palmitic acid (C16:0) supplements may increase milk fat in some cases
   - Milk fat depression will reduce the effectiveness of high palm supplements

   Monitor milk yield and milk fat over time!!

**Set Expectations for the Time Required
Conclusions

- MFD is caused by unique fatty acids originating from ruminal biohydrogenation.
- Rumen environment is critical and involves interactions of numerous dietary, cow, and environmental factors.
- Induction occurs in ~7 to 10 d and recovery requires 10 to 18 d.
- Unsaturated FA are the 1st issue to consider.
- Alimet reduces risk of MFD in high risk situations.

Constant “Experiment in Progress” to maximize energy intake, milk yield, and milk fat yield.

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Collaborator:
Dr. Dale Bauman, Cornell University

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Thank You