New milk mid-FTIR metrics for dairy cattle management

Dave Barbano\textsuperscript{1}, Caterina Melilli\textsuperscript{1}, Tom Overton\textsuperscript{1}, Melissa Woolpert\textsuperscript{2}, Heather Dann\textsuperscript{2}, and Rick Grant\textsuperscript{2}

\textsuperscript{1}Cornell University, Ithaca, NY
\textsuperscript{2}W. H. Miner Agricultural Institute, Chazy, NY

ICAR Meeting
Krakow, Poland
June 2015
Outline

• Overall Vision
• Milk fat synthesis (*denovo*, mixed origin, preformed)
• Milk fatty acid analysis
• Objectives of our current work
• Survey results June 2012 – August 2013
  • *Milk fat and fatty acid composition*
  • *Milk protein and fatty acid composition*
• Next: 40 farm field study
• Future Directions
Outline

• Overall Vision
  Develop new tools in milk analysis for bulk tank and individual cow milks that will support decision making for management of feeding, health and reproduction in dairy cows.
Outline

- Overall Vision
- Milk fat synthesis (*denovo*, mixed origin, preformed)
3 fatty acids per triglyceride
Fatty Acid Categories

De novo | Mixed | Preformed

Short chain
- \( C_{4:0} \)
- \( C_{6:0} \)
- \( C_{8:0} \)
- \( C_{10:0} \)

18-30%

Long chain
- \( C_{18:0} \)
- \( C_{18:1} \)
- \( C_{18:2} \)

30-45%

35-40%
De Novo Fatty Acid Synthesis

Feed → Rumen fermentation → acetate, butyrate → De novo synthesis → Milk fat
Preformed Fatty Acids

Feed -> Dietary fat

Adipose

NEFA and chylomicron

LPL

Preformed FA

Milk fat
Outline

- Overall Vision
- Milk fat synthesis (*denovo*, mixed origin, preformed)
- Milk fatty acid analysis
  - Groups of fatty acids
    - *Denovo*, mixed origin, and preformed
Outline

- Milk fat synthesis (\textit{denovo}, mixed origin, preformed)
- Milk fatty acid analysis
- Objectives of our work
Objectives

1. To measure fatty acid composition of milk fat for 430 individual herds in the St. Albans Cooperative using new advanced calibration methods for infrared milk analysis over a 15 month period.

2. To determine if there is a correlation between milk fatty acid composition and bulk tank milk fat and protein concentration.
Data from 430 farms

Bulk tank milk samples tested 3 up to 20 times per month per farm

Infrared milk analysis for components and fatty acid composition. GLC analysis of selected samples for periodic validation of the IR calibration.

Means for each farm calculated by month

Farm Data Organized in 2 groups:

   Jersey and Other (almost totally Holstein)
Infrared milk analysis

Manual FTIR currently used at St. Albans - Delta Instruments Model FTA, Drachten, The Netherlands

Fatty acid calibration was done once per month with samples produced at Cornell. The instrument about 50 to 70 samples per hour for components, NPN/urea, and all fatty acid parameters. The automated model runs 600 samples per hour.
Outline

- Milk fat synthesis (*denovo*, mixed origin, preformed)
- Milk fatty acid analysis
- Objectives of our work
- Survey results June 2012 – August 2013
  - Milk fat and fatty acid composition
Survey Results June 2012 – August 2013

*DeNovo Fatty Acids*
Survey Results June 2012 – August 2013

Holstein Farms

\[ y = 2.165x + 1.8969 \]

\[ R^2 = 0.6156 \]
Survey Results July 2012 – August 2013

Mixed Origin Fatty Acids
Survey Results June 2012 – August 2013

Holstein Farms

\[ y = 1.834x + 1.5584 \]
\[ R^2 = 0.6791 \]
Preformed Fatty Acids
Holstein Farms

\[ y = 1.218x + 2.0219 \]

\[ R^2 = 0.3445 \]
Outline

• Milk fat synthesis (*denovo*, mixed origin, preformed)
• Milk fatty acid analysis
• Objectives of our work
• Survey results June 2012 – August 2013
  • *Milk fat and fatty acid composition*
  • *Milk protein and fatty acid composition*
Holstein Farms

\[ y = 1.1839x + 2.0083 \]

\( R^2 = 0.5437 \)

DeNovo fatty acids g / 100 g milk
Main Conclusions from Survey

The strongest correlation between milk fatty acid composition and the concentration of fat and protein in milk was with DeNovo fatty acids production.

Thus, feeding and farm management strategies that produce an increase in synthesis of DeNovo fatty acids may produce an increase in milk fat and milk protein percentage and possibly output of fat and protein per cow per day.
Outline

- Milk fat synthesis (denovo, mixed origin, preformed)
- Milk fatty acid analysis
- Objectives of our work
- Survey results June 2012 – August 2013
  - Milk fat and fatty acid composition
  - Milk protein and fatty acid composition
- Next: 40 farm field study
1. Sort all 430 farm data from low to high values for DeNovo as a percentage of total fatty within the Jersey group of farms and within the Holstein group of farms.

2. Select 10 Jersey farms with low DeNovo and 10 Jersey farms that have high DeNovo fatty acids.

3. Select 10 Holstein farms with low DeNovo and 10 Holstein farms that have high DeNovo fatty acids.
**St Albans June 2012 through August 2013**

Mean Relative Milk Fatty Acid Composition for each Group of 10 farms for the 15 month period: *DeNovo*, Mixed Origin, and Preformed Fatty Acids

<table>
<thead>
<tr>
<th>Breed</th>
<th>Group</th>
<th>%m/m Fat</th>
<th>%m/m True Protein</th>
<th>Rel % Denovo</th>
<th>Rel % Mixed</th>
<th>Rel % Preformed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holstein</td>
<td>Low <em>DeNovo</em></td>
<td>3.623</td>
<td>2.993</td>
<td>24.080</td>
<td>33.971</td>
<td>41.949</td>
</tr>
<tr>
<td>Holstein</td>
<td>High <em>DeNovo</em></td>
<td>3.975</td>
<td>3.148</td>
<td>26.076</td>
<td>35.082</td>
<td>38.842</td>
</tr>
<tr>
<td>Jersey</td>
<td>Low <em>DeNovo</em></td>
<td>3.917</td>
<td>3.093</td>
<td>25.037</td>
<td>33.352</td>
<td>41.611</td>
</tr>
<tr>
<td>Jersey</td>
<td>High <em>DeNovo</em></td>
<td>4.804</td>
<td>3.616</td>
<td>27.414</td>
<td>34.623</td>
<td>37.963</td>
</tr>
</tbody>
</table>
**Milk Composition: June 2012 – August 2013**

Mean Relative % *Denovo* Fatty Acids within each Group of 10 Farms average for the 15 month period

**DeNovo Fatty Acids as Percent of Total Fatty Acids**

<table>
<thead>
<tr>
<th>Farm</th>
<th>LDN - H</th>
<th>HDN - H</th>
<th>LDN - J</th>
<th>HDN - J</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>24.13</td>
<td>27.00</td>
<td>26.11</td>
<td>27.11</td>
</tr>
<tr>
<td>2</td>
<td>21.89</td>
<td>25.67</td>
<td>24.70</td>
<td>27.97</td>
</tr>
<tr>
<td>3</td>
<td>24.43</td>
<td>25.83</td>
<td>23.75</td>
<td>26.86</td>
</tr>
<tr>
<td>4</td>
<td>24.27</td>
<td>25.28</td>
<td>23.80</td>
<td>27.43</td>
</tr>
<tr>
<td>5</td>
<td>24.81</td>
<td>26.22</td>
<td>26.50</td>
<td>28.50</td>
</tr>
<tr>
<td>6</td>
<td>23.48</td>
<td>26.83</td>
<td>25.42</td>
<td>27.51</td>
</tr>
<tr>
<td>7</td>
<td>24.74</td>
<td>25.68</td>
<td>25.46</td>
<td>26.89</td>
</tr>
<tr>
<td>8</td>
<td>23.62</td>
<td>25.46</td>
<td>26.44</td>
<td>26.85</td>
</tr>
<tr>
<td>9</td>
<td>24.67</td>
<td>25.60</td>
<td>22.73</td>
<td>27.12</td>
</tr>
<tr>
<td>10</td>
<td>24.82</td>
<td>27.21</td>
<td>25.47</td>
<td>27.89</td>
</tr>
</tbody>
</table>

**Mean**

<table>
<thead>
<tr>
<th>LDN - H</th>
<th>HDN - H</th>
<th>LDN - J</th>
<th>HDN - J</th>
</tr>
</thead>
<tbody>
<tr>
<td>24.08</td>
<td>26.08</td>
<td>25.04</td>
<td>27.41</td>
</tr>
</tbody>
</table>
Pre-study data: June 2012 – August 2013

\[ y = 2.9037x + 1.1675 \]
\[ R^2 = 0.9125 \]
Pre-study data: June 2012 – August 2013

% Milk PROTEIN - all groups -

\[ y = 1.7755x + 1.426 \]
\[ R^2 = 0.8069 \]
Results of First 40 Farm Study

- Milk (26.3 vs 22.7 kg/d, SE=1.3, $P=0.06$), fat (1.1 vs 0.9 kg/d, SE=0.1, $P<0.01$), true protein (0.9 vs 0.7 kg/d, SE<0.1, $P<0.01$), and de novo FA (25.6 vs 23.7 relative %, SE=0.2, $P<0.01$) were higher for high versus low DeNovo farms, respectively.

- The gross difference in farm income from milk between the low and high DeNovo fatty acid farms was approximately $30,000 per year per 100 cows with higher income for the high DeNovo fatty acid farms.
Outline

- Overall Vision
- Milk fat synthesis (*denovo*, mixed origin, preformed)
- Milk fatty acid analysis
- Objectives of our current work
- Survey results June 2012 – August 2013
  - *Milk fat and fatty acid composition*
  - *Milk protein and fatty acid composition*
- Next steps – field study of management and feeding
- Future Directions
Future Directions

Bulk Tank Milk Testing

feed utilization (fatty acids)
milk fat depression index
Future Directions

Individual cow “real-time” milk testing for precision farm management of feeding, health, and reproduction.
Future Directions

Blood Chemistry Measures (done on MILK!!! Every milking???)
  Blood NEFA
  Blood BHB
  Milk NPN/MUN

Use: Predict Ketosis, DA, acidosis, and reproductive performance

Management Indices on Individual Cows
Future Directions

Efficiency of Feed Utilization and Rumen Function

*DeNovo* fatty acid synthesis

Proportion of C16:0 from *DeNovo* vs Preformed C16:0

Total trans fatty acid level

Ratio of C18:1 *trans* 10 to C18:1 *trans* 11 fatty acid

Targeted, automated, feeding of concentrates to individual cows based on need to support each cow’s unique nutritional requirements based on production output.
The lab staff at St. Albans Cooperative for running the infrared testing of fatty acid composition of the milk fat for the milks from 430 farms.

Delta Instruments for technical support in development of fatty acid calibration models and equipment trouble shooting.

The USDA Federal Milk Markets for support of the development of improved milk testing methods.

Miner Institute for collaboration in farm field studies.

Larry Chase for advice, insight, and encouragement.