New Milk Analysis Technologies to Improve Dairy Cattle Performance

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H. M. Dann and R. J. Grant - Miner

NYS Cheese Makers Meeting
March 6, 2017
Outline

• Current Status of Precision Management Milk Testing.
• What Do Farmers Want?
• An example of connecting analytical measures to meet dairy farmer needs.
• Future Directions
  • Farm management and sustainability
Precision Management Milk Testing

- AfiMilk – Near IR – fat and protein combined with milk weight. Built into the milking system.
- Antibiotic testing (rapid milk testing).
- Mid-IR for milk components and milk SCC: done on some large farms with traditional laboratory testing equipment. Normally manual instruments are used.
What Do Dairy Farmers Need?

Dairy farmers need analytical results that will help them manage the efficiency of feed utilization, metabolic health during the transition period, mammary infection, animal welfare, environmental impact, and reproduction to improve economic performance and sustainability.

The success of farm management ultimately depends on correct decisions on an animal by animal basis. The challenge is to find the cow of interest, make a decision, and take action.
What Do Dairy Farmers Want?

Farms are getting larger, more technology (satellite technology, cloud based internet tools and information) and new tools are becoming available every day.

It is easy to be a bit overwhelmed by all of this.

In the end, milk production is all about the sum of the performance of all the individual cows. The farmer needs information upon which to make decisions, not data.
In the end, milk production is all about the sum of the performance of all the individual cows. The farmer needs information upon which to make decisions, not data.

So how can today’s new technology be better harnessed to manage each individual cow?

Each cow needs to be a “Cow of Interest”
An interesting TV Program
“Person of Interest”
What Do Dairy Farmers Want?

Each cow needs to be a “Cow of Interest”

A tool that integrates diverse sources of data (e.g., milk analysis, activity monitors, cow side tests, etc.) to produce management information focused on optimization of the performance and economic return of each individual cow.
Outline

• Current Status of Precision Management Milk Testing.

• What Do Farmers Want?

• An example of connecting analytical measures to dairy farmer needs.
  • Milk fatty acid composition
Overall Vision

Develop new tools in milk analysis for bulk tank and individual cow milks that will provide information to support decision making for management of feeding, health, and reproduction in dairy cows.
Objectives

1. To develop a new rapid analysis tool to measure fatty acid composition in a format that is useful for farm management.
Manual FTIR currently used at Cornell and Collaborator Laboratories - Delta Instruments Model FTA, The Netherlands

deco novo, mixed origin, and preformed fatty acids

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

Bulk Tank Milk Testing

Efficiency of forage utilization

(de novo fatty acids)
Milk Fat Structure

3 fatty acids per triglyceride
Milk Fatty Acid Origin

**De novo**
- $C_{4:0}$
- $C_{6:0}$
- $C_{8:0}$
- $C_{10:0}$
  - 18-30%
  - Shorter chain

**Mixed**
- $C_{12:0}$
- $C_{14:0}$
- $C_{14:1}$
- $C_{16:0}$
- $C_{16:1}$
  - 35-40%

**Preformed**
- $C_{18:0}$
- $C_{18:1}$
- $C_{18:2}$
  - Longer chain
  - 30-45%
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

LDL

Preformed FA

Milk fat
Objectives

1. To develop a new rapid analysis tool to measure milk fatty acid composition in a format that is useful for farm management.

2. To determine how to use the milk fatty acid composition data on bulk tank and individual cow milk samples for feeding and health management of dairy cows.

Conclusions from Preliminary Work: 430 farm survey of milk fatty acid composition for 2 years at the St Albans Cooperative in St Albans, Vermont. As de novo fatty acids in the bulk tank milk increased, the fat and protein concentration increased.
1. Sort all 430 farm data from low to high values for de novo fatty acids as a percentage of total fatty acids within the Jersey group of farms and within the Holstein group of farms for a field study in 2014.

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

3. Select 10 Holstein farms with low de novo and 10 Holstein farms that have high de novo fatty acids.

4. In 2015, we repeated the study with 40 Holstein farms: 20 high de novo and 20 low de novo farms.
Mean relative milk fatty acid composition for each group of 10 farms for the 15 month period: *de novo*, mixed origin, and preformed fatty acids

<table>
<thead>
<tr>
<th>Breed</th>
<th>Group</th>
<th>St Albans</th>
<th>June 2012 through August 2013</th>
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<tr>
<td></td>
<td></td>
<td>% Fat</td>
<td>% True Protein</td>
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<tr>
<td>Holstein</td>
<td>Low <em>DeNovo</em></td>
<td>3.623</td>
<td>2.993</td>
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<tr>
<td>Holstein</td>
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<tr>
<td>Jersey</td>
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<td>Jersey</td>
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<td>4.804</td>
<td>3.616</td>
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</table>
If you want a fat test > 3.75% fat in bulk tank with Holsteins, then the de novo fatty acids in grams per 100 grams of milk needs to be > 0.85 g/100 milk.

The equation for the regression line is:

\[ y = 2.297x + 1.844 \]

With an R² value of 0.8045.
If you want a fat test > 3.75% fat in bulk tank with Holsteins, then the mixed origin fatty acids in grams per 100 grams of milk needs to be > 1.40 g/100 milk

\[ y = 1.5396x + 1.5856 \]

\[ R^2 = 0.8789 \]
If you want a fat test > 3.75% fat in bulk tank with Holsteins, then the denovo + mixed fatty acids in grams per 100 grams of milk needs to be > 2.25 g/100 milk.
40 Holstein Farms 2015
St Albans - Fat

$y = 0.7928x + 2.7742$

$R^2 = 0.0659$
If you want a fat test > 3.75% fat in bulk tank with Holsteins, then the double bonds per fatty acid in milk fat needs to < 0.31.

### Fat % vs double bonds per fatty acid

\[ y = -8.583x + 6.4213 \]

\[ R^2 = 0.694 \]
As double bonds per fatty acid increases in milk fat, the output of de novo fatty acids decreases. This metric seems to indicate the overall level of milk fat depression.

\[ y = -3.7138x + 1.9858 \]

\[ R^2 = 0.8521 \]
40 Holstein Farms 2015
St Albans - Protein

\[ y = 0.8005x + 2.4179 \]

\[ R^2 = 0.532 \]
Half Holstein Herds and Half (Jersey – mixed breed)

De novo FA as a % of total fatty acids (25.6 vs 23.7% relative %, \(P<0.01\))

Milk (26.3 vs 22.7 kg/d, \(P=0.06\)),

Fat (4.33 vs 4.14%, \(P=0.10\)),

True protein (3.41 vs 3.22%, \(P<0.01\))

MUN (11.4 vs 11.3 mg/dL, no significant difference)

These differences for fat and protein between HDN and LDN herds at 25 kg of milk per 100 cows per year would result in a gross income difference of $8,544 for fat and $15,695 for protein.
All herds were Holstein

*De novo* FA as a % of total fatty acids (26.0 vs 23.8% relative, significant $P < 0.01$)

Milk (31.9 vs 32.1 kg/d, no significant difference),

Fat (3.98 vs 3.78%, $P<0.01$),

True protein (3.19 vs 3.08 %, $P<0.01$)

MUN (12.1 vs 12.9 mg/dL, no significant difference)

These differences for fat and protein between HDN and LDN herds at 30 kg of milk would result in a gross income difference of $9,125 for fat and $6,935 for protein per 100 milking cows per year.
Factors Related to De novo Fatty Acid Synthesis

Less feed bunk space per cow (i.e., < 46 cm, or < 18 inches) was related to lower de novo fatty acids and lower fat and protein test.

Higher stall stocking density in pens (i.e., > 1.1 cows per stall) was related to lower de novo fatty acids and lower fat and protein test.

Higher average ether extract in the ration for lower de novo fatty acid farms.

Higher peNDF as a % of DM for the high de novo fatty acid farms (26.8 vs 21.4%) \((P < 0.01)\)
Main Conclusions from Bulk Tank Milks

The strongest correlation between milk fatty acid composition and the concentration of fat and protein in milk was with *de novo* fatty acid production.

*De novo* fatty acid level seems to be barometer of rumen health and proper rumen function.

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

Even more information may be gained by measuring the fatty acid composition of milk from individual cows.
Current Field Work with Nutritionists

Progress on one 1800 cow Holstein farm in Northern NY

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<tr>
<th>Holstein</th>
<th>Farm #1 lbs</th>
<th>SCC</th>
<th>Fat D</th>
<th>Lactose</th>
<th>Protein</th>
<th>MUN</th>
<th>Denovo g/100 g</th>
<th>Mixed g/100 g</th>
<th>Preformed g/100 g</th>
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<table>
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<th>fatty acids per 100 g milk</th>
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<tr>
<td>Denovo g/100 g</td>
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<tr>
<td>-----------------</td>
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<tr>
<td>May-16</td>
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<td>DB/FA</td>
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<td>FA Unsat</td>
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<tr>
<td>Milk lbs per day g/day</td>
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<td>Denovo</td>
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<td>Protein</td>
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| May-16     | 14.59 | 0.324 | 92 | 350 | 493 | 531 | 1940 | 1472 | 1316 |
| Sep-16     | 14.90 | 0.342 | 91.3 | 300 | 497 | 544 | 1911 | 1433 | 1284 |
| Nov-16     | 14.54 | 0.302 | 92 | 380 | 587 | 560 | 1927 | 1626 | 1358 |
## New Format Fatty Acid Data at St. Albans

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Outline

• What Do Farmers Want?
• What Do Processors Want?
• An example of connecting analytical measures to dairy farmer needs.
  • Milk fatty acid composition
  • Blood NEFA estimated from milk analysis
Objective

To develop and validate a Fourier transform mid-IR-based milk analysis method to estimate blood NEFA concentrations for lactating dairy cows.
Connecting with **Dairy Farmer Needs**

- **Transition Cow**

  **Calving:** going from negative energy balance to positive energy balance (weeks 1 to 10 of lactation)

  **Measures:** feed composition, activity monitor data, milk fatty acid composition, blood NEFA, blood BHB, milk BHB, acetone, milk weight, body weight, automated video observation. New data available every day.

  **Challenge and Opportunity:** Integrate all of this into actionable information in real-time.
The NEFA concentration measured in blood represents the concentration at an instant in time. The level can vary with time and with the level of stress of the individual cow at the time of blood sampling.

It is hypothesized that the blood NEFA concentration estimated from milk represents the time average status of blood NEFA for full period of time between milkings.

Therefore, the estimate for blood NEFA based on milk analysis may be a more stable and integrated estimate of the status of a cow’s blood NEFA level for a period of time than the estimate obtained from a blood sample.
Cow with high body condition at calving with good liver function

Known values of de novo fatty acids and blood NEFA in the first 50 days postpartum:

- **Days in Milk**: 0, 10, 20, 30, 40, 50
- **Estimated Blood NEFA**
  - Initial value: 1000
  - Day 10: Decrease to 500
  - Day 20: Further decrease to 200
  - Day 30: Further decrease to 100
  - Day 40: Further decrease to 50
  - Day 50: Further decrease to 0
- **Blood NEFA**
  - Initial value: 1400
  - Day 10: Decrease to 1200
  - Day 20: Further decrease to 1000
  - Day 30: Further decrease to 800
  - Day 40: Further decrease to 600
  - Day 50: Further decrease to 400

% de novo fatty acids:
- Initial value: 26%
- Day 10: Decrease to 22%
- Day 20: Further decrease to 18%
- Day 30: Further decrease to 14%
- Day 40: Further decrease to 10%
- Day 50: Further decrease to 6%
Sample Individual Cow Data

Displaced Abomasum

Blood NEFA

Estimated Blood NEFA

Days in Milk

De novo fatty acids

Surgery

Blood NEFA

% de novo fatty acids
Sample Individual Cow Data

cow with ketosis

De novo fatty acids

Glycol

estimated blood NEFA

blood NEFA

Days in Milk

% de novo fatty acids

estimated blood NEFA

blood NEFA
The milk estimated blood NEFA and milk fatty acid data correlated well with documented ketosis and displaced abomasum (DA), but more data is needed.

Conclusion
Outline

• Current Status of Precision Management Milk Testing.
• What Do Farmers Want?
• An example of connecting analytical measures to meet dairy farmer needs.
• Future Directions
Future Directions – Dairy Processing

Improved Dairy Product Calibration and Standards for:

- WPC 80
- Vat Whey
- Concentrated Whey
- Condensed Milk
- Light Cream
- Heavy Cream

Completely New
Testing Cheddar cheese for:
- fat, protein, salt, and solids with a mid-IR milk analyzer
- Cheese aging indices?
Management Indices on Individual Cows

Blood Chemistry Measures (done on MILK!!! Every milking???)
  Blood NEFA
  Blood BHB
  Milk urea nitrogen (MUN)
  Stress/inflammation compounds?
  others – related to reproduction??

**Used:** Milk Fat Depression, Predict Ketosis, DA, acidosis, and reproductive performance

Rumen Function
  prediction of rumen pH?
Future Directions

What is next? Cow of Interest Season #2 the “Man in the Boots”?

Coming to a Dairy Nutrition Conference Near You!

October 2018

Riddle Number 1

What has roots as nobody sees,
Is taller than trees,
Up, up, up it goes,
And yet never grows?

Caladriel

Dandolf the White
The lab staff at **St. Albans Cooperative** for infrared milk testing of fatty acid composition of bulk tank milk of 430 farms over 4 years and **Miner Institute** (R. Grant, H. Dann, M. Woolpert and many others) for individual cow milk and blood samples.

**Delta Instruments** for technical support in development of calibration models.

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

**Shawn Landersz** for “Cow of Interest” video production.

[www.landersz.com](http://www.landersz.com)