Field Testing Fatty Acid Metrics for Herd Management

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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.

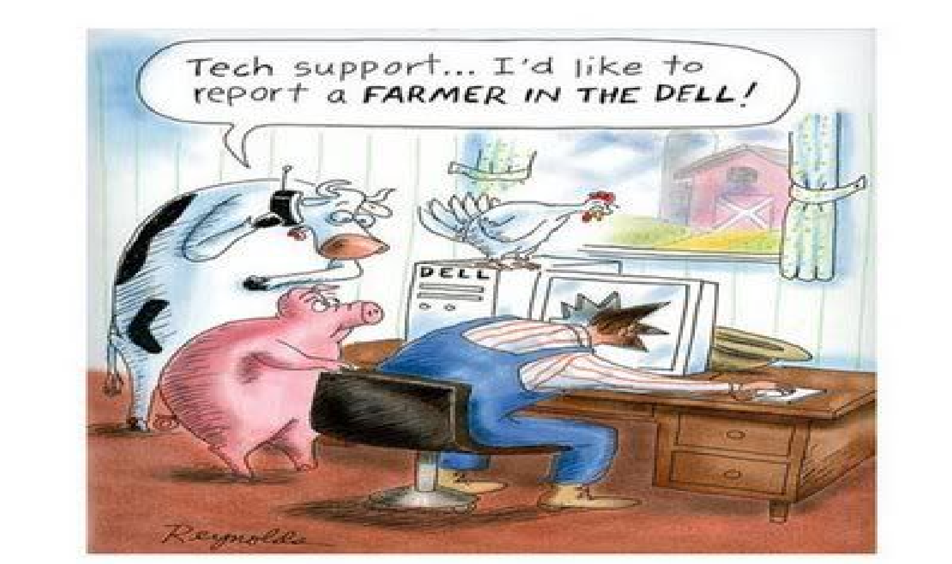
The success of farm management ultimately depends on correct decisions on an animal by animal basis. The challenge is to find the cow of interest, make a decision, and take action.

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.



What Do Dairy Farmers Want?

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”


www.MichaelEmerson.pl

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 – bulk tank

Connecting with Dairy Farmer Needs

- **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.

Infrared (mid-FTIR) Milk Analysis

Manual FTIR currently used at Cornell and Collaborator Laboratories - Delta Instruments Model FTA, The Netherlands

de novo, mixed origin, and preformed fatty acids

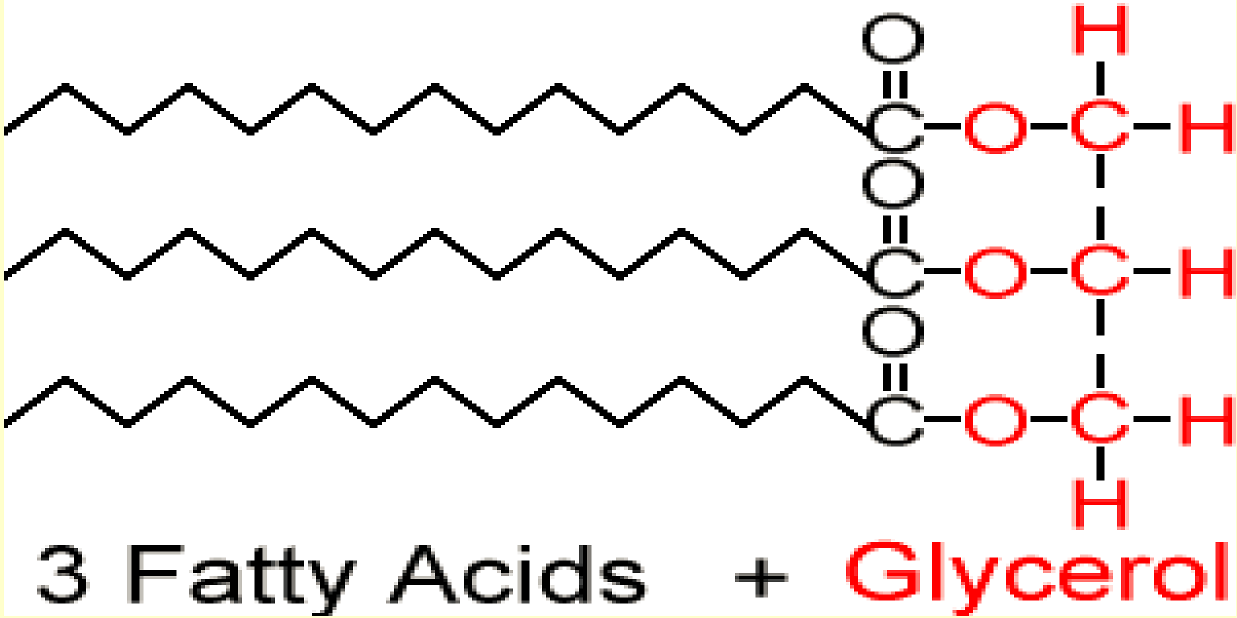
Fatty acid calibration was done once per month with reference milks produced at Cornell. The instrument tests about 50 to 70 samples per hour for all components, NPN/urea, and all fatty acid parameters. The automated model runs 600 samples per hour.

Connecting with Dairy Farmer Needs

Bulk Tank Milk Testing

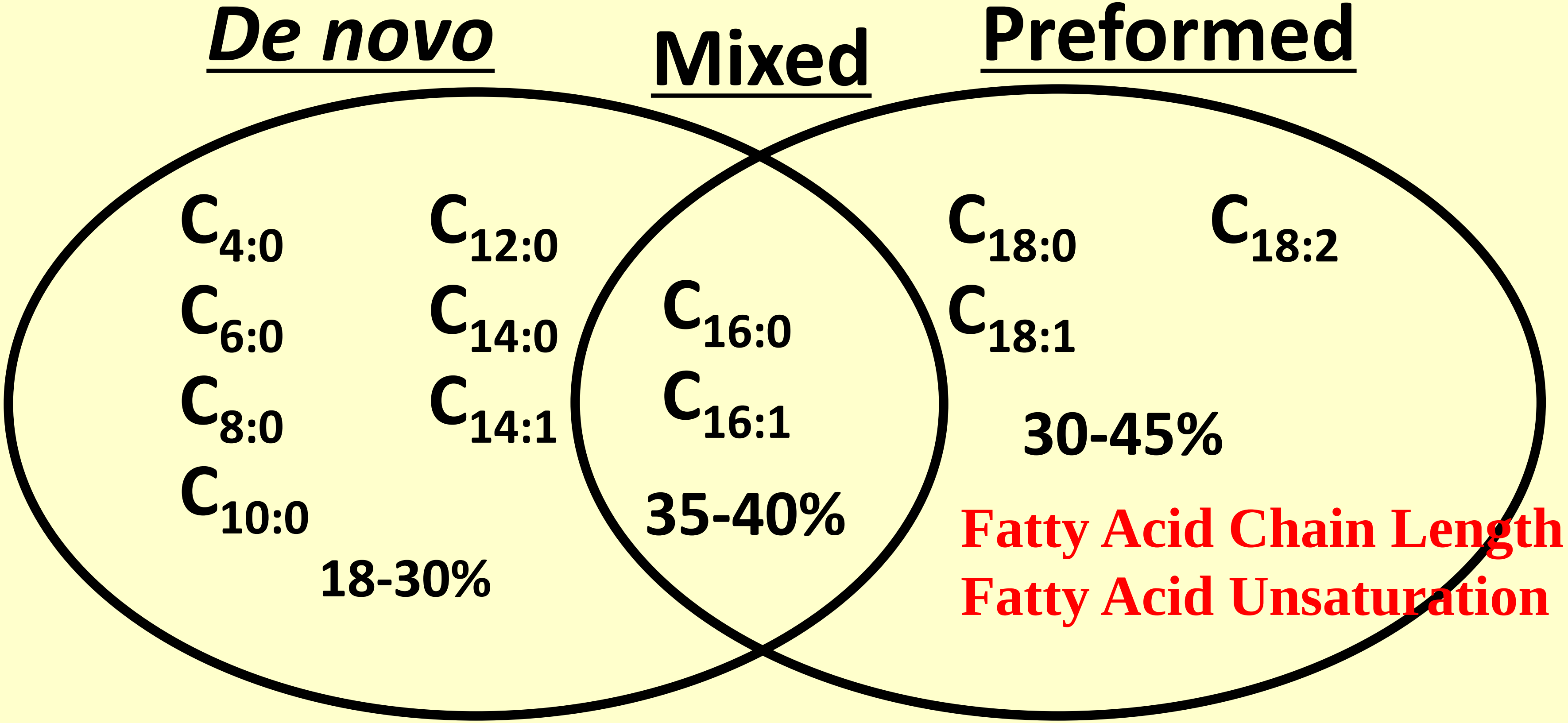
Efficiency of forage utilization (*de novo* fatty acids)

Milk Fat Structure

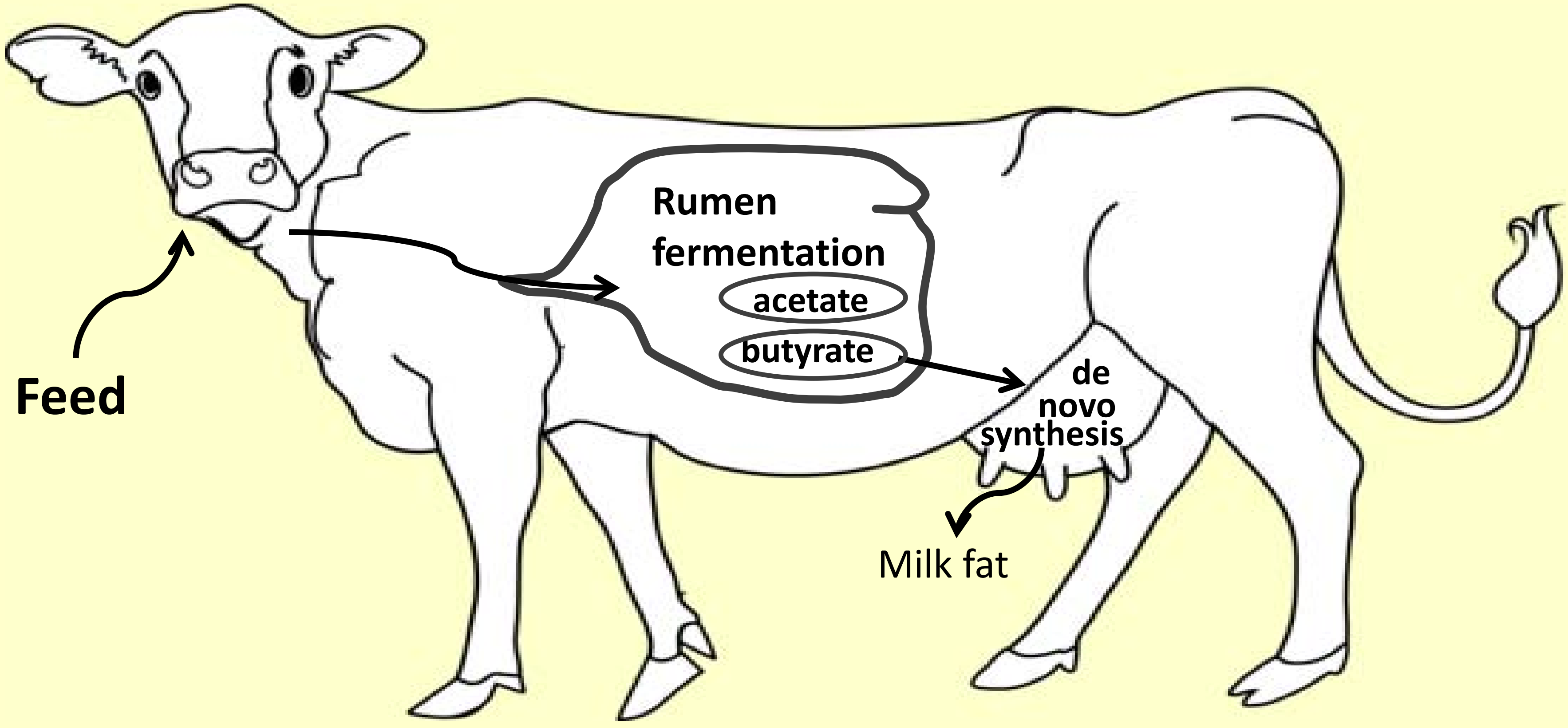


3 fatty acids per triglyceride

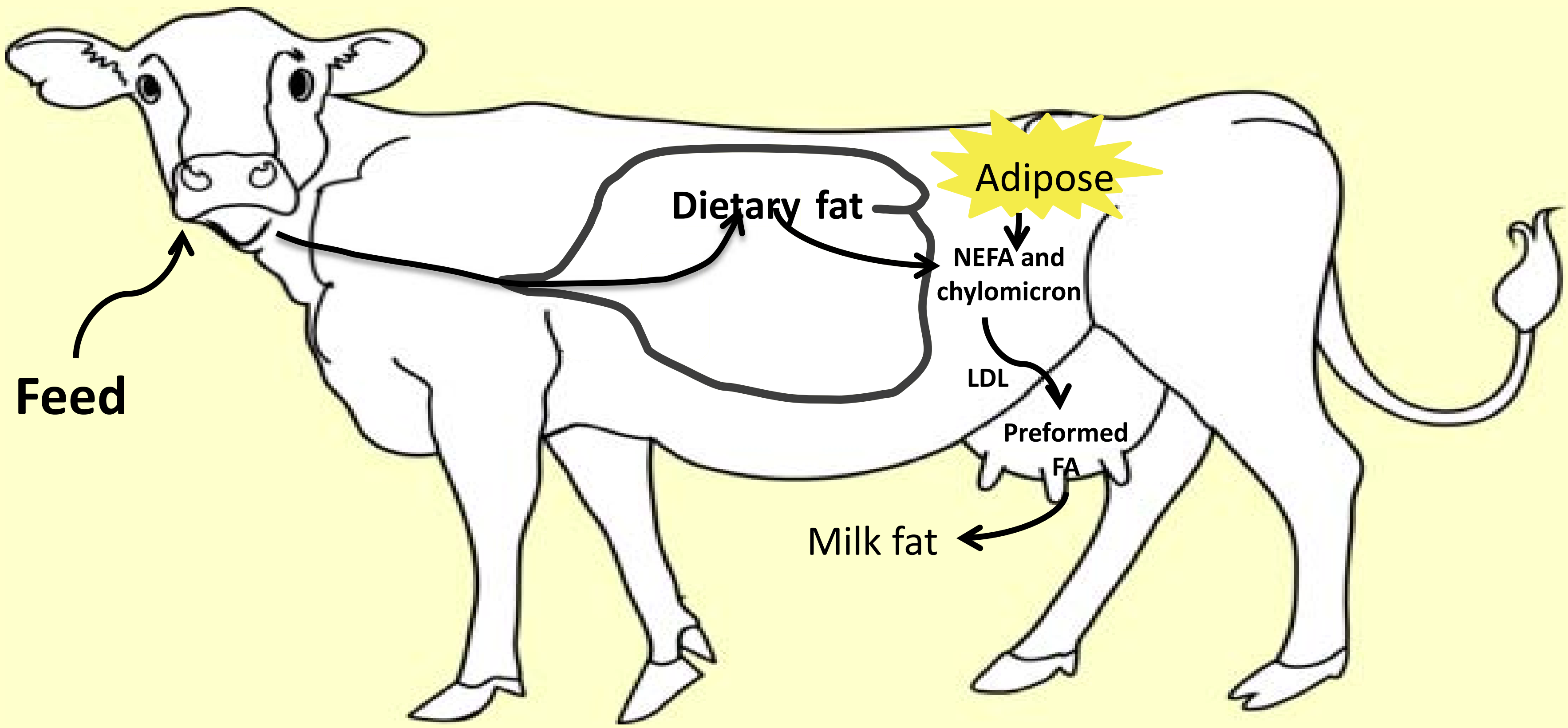
Milk Fatty Acid Origin



De novo Fatty Acid Synthesis



Preformed Fatty Acids



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.

40 Farm Studies (2014 & 2015)

Collaboration: Cornell, Miner Institute, St. Albans Cooperative, Delta Instruments

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.**

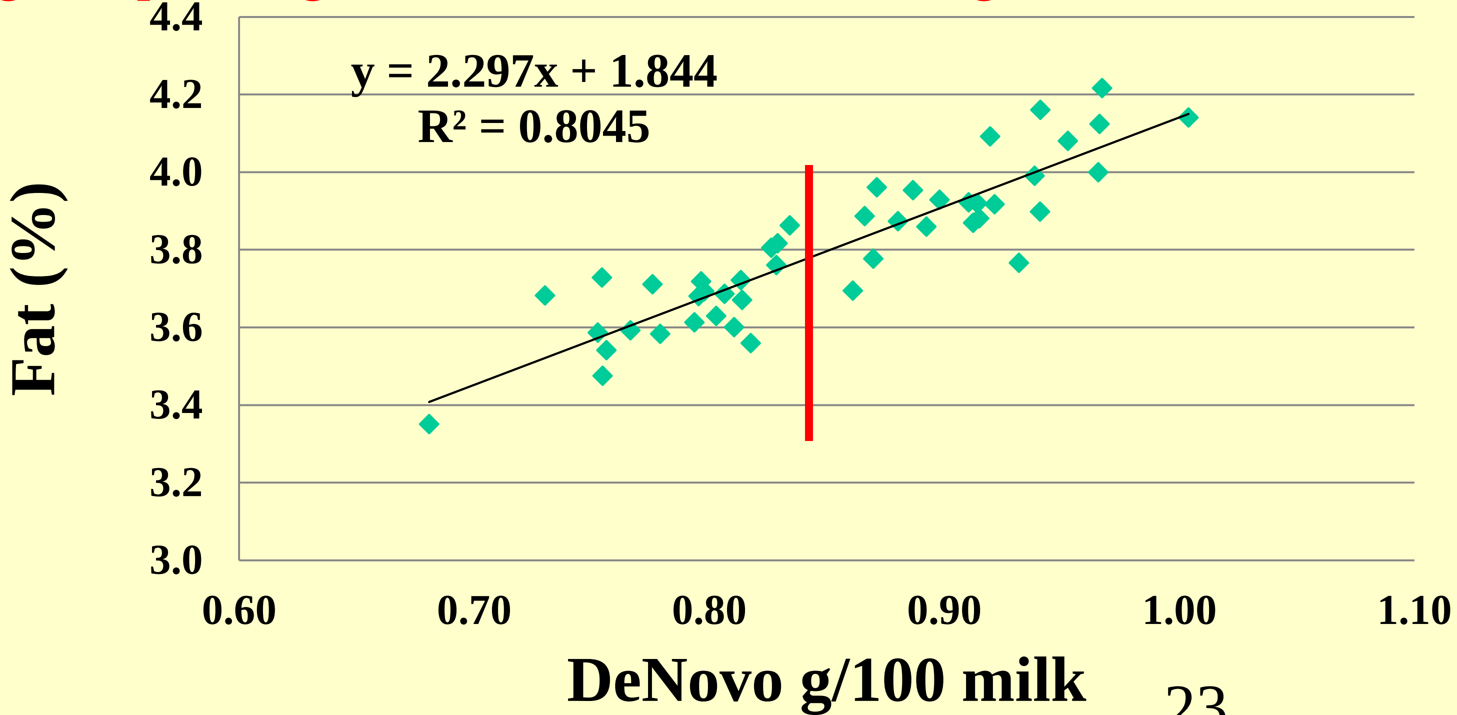
Milk Composition:June 2012 – August 2013

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

		St Albans	June 2012 through August 2013			
		%	%	g/100 g FA	g/100 g FA	g/100 g FA
Breed	Group	Fat	True Protein	Denovo	Mixed	Preformed
Holstein	Low *DeNovo*	**3.623**	**2.993**	**24.08**	**33.97**	**41.95**
Holstein	High *DeNovo*	**3.975**	**3.148**	**26.08**	**35.08**	**38.84**
Jersey	Low *DeNovo*	**3.917**	**3.093**	**25.04**	**33.35**	**41.61**
Jersey	High *DeNovo*	**4.804**	**3.616**	**27.41**	**34.62**	**37.96**

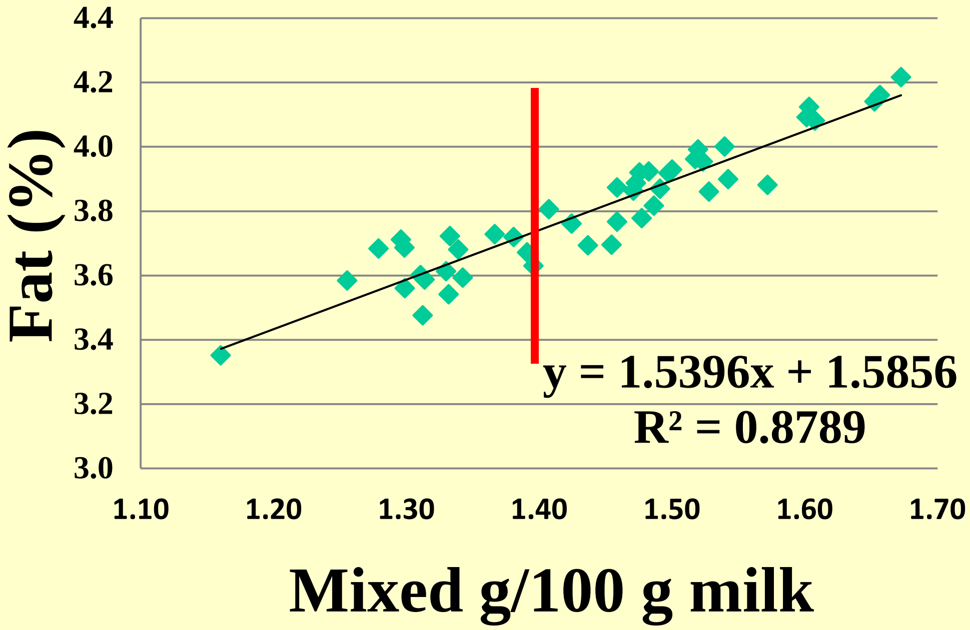
40 Holstein Farms 2015
St Albans - Fat

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



40 Holstein Farms 2015
St Albans - Fat

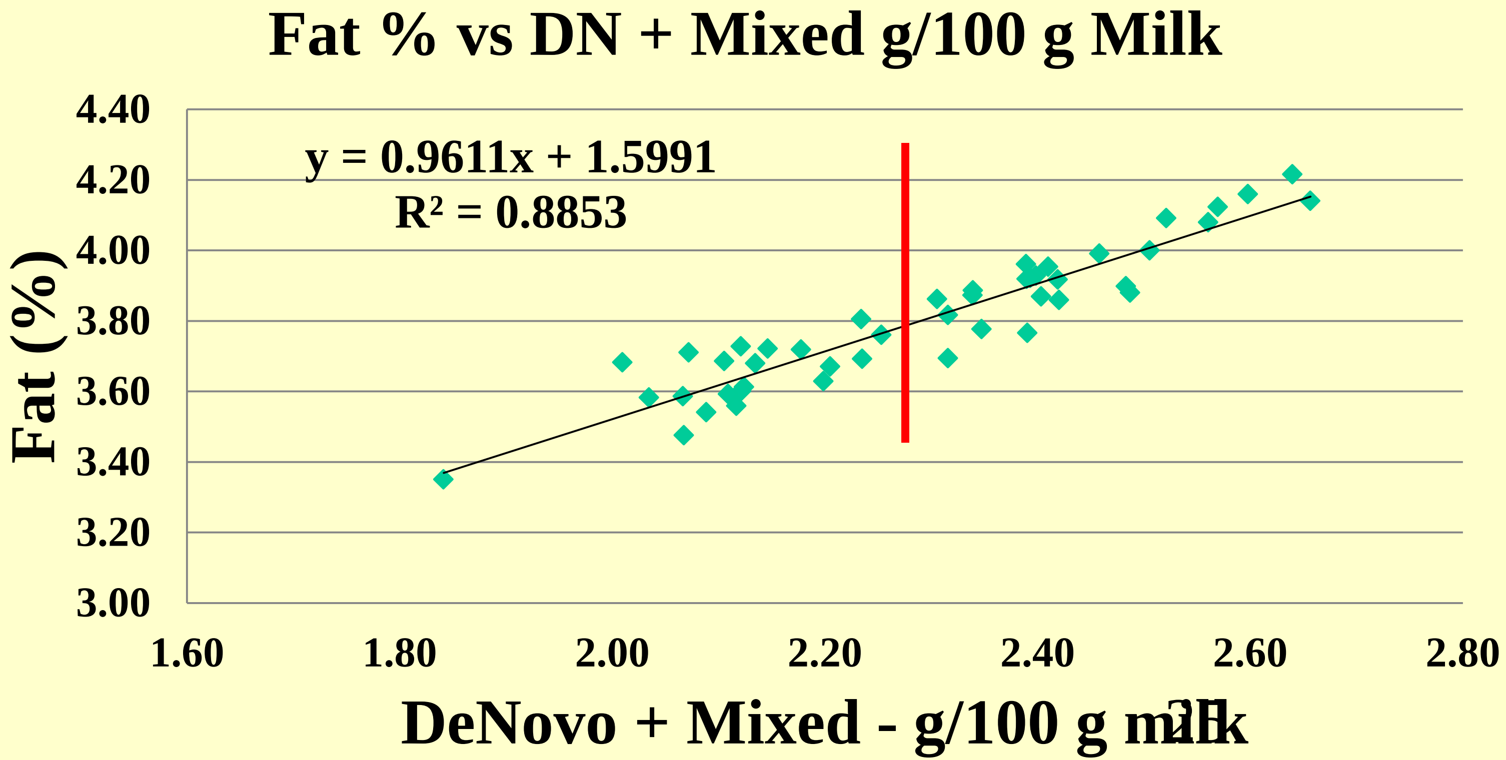
If you want a fat test > 3.75% fat in bulk tank with Holsteins, then the mixed origin fatty acids in grams per 100 grams of milk needs to be > 1.40 g/100 milk



40 Farms Holstein Farms 2015

St Albans - Fat

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



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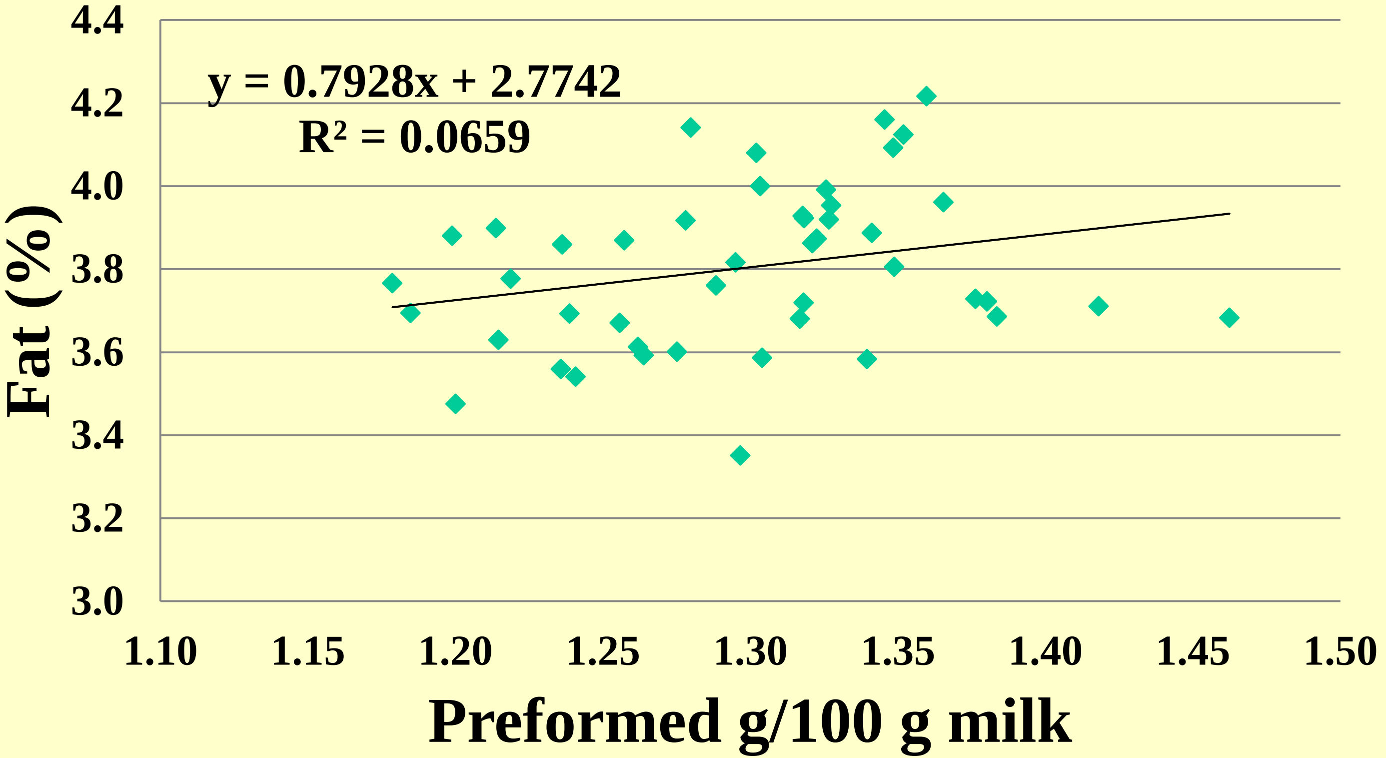
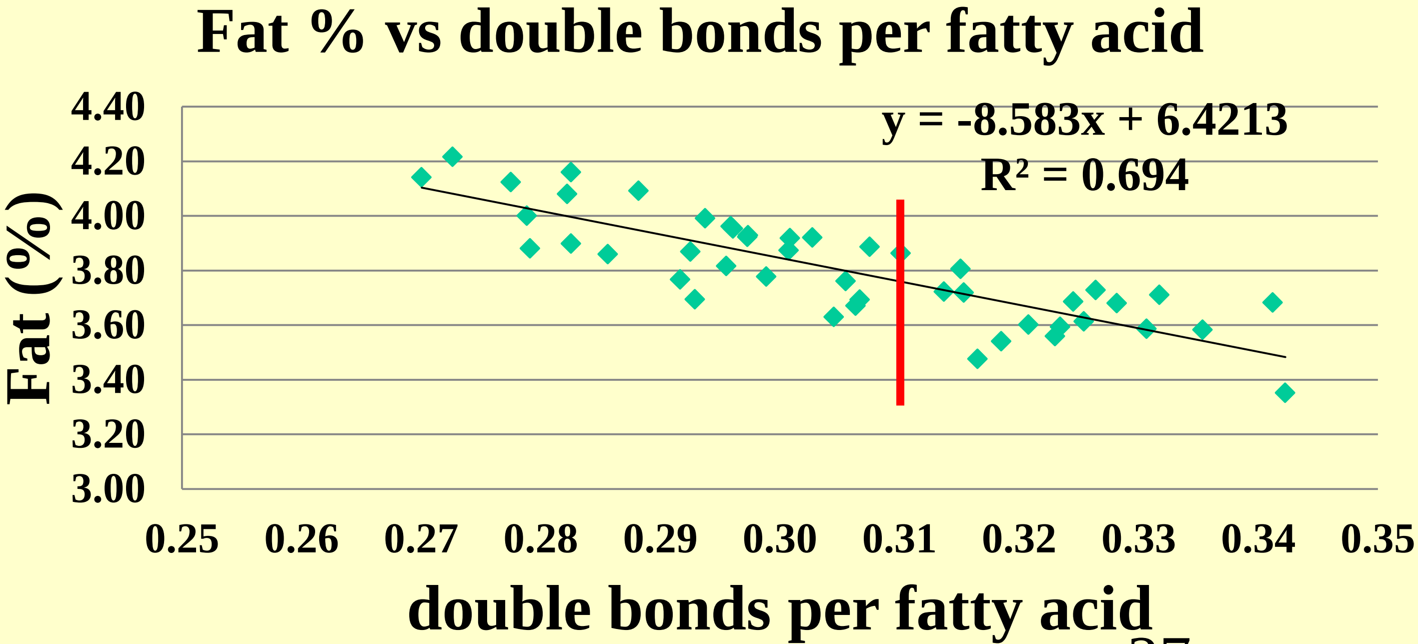
St Albans - Fat



40 Holstein Farms 2015
St Albans - Fat

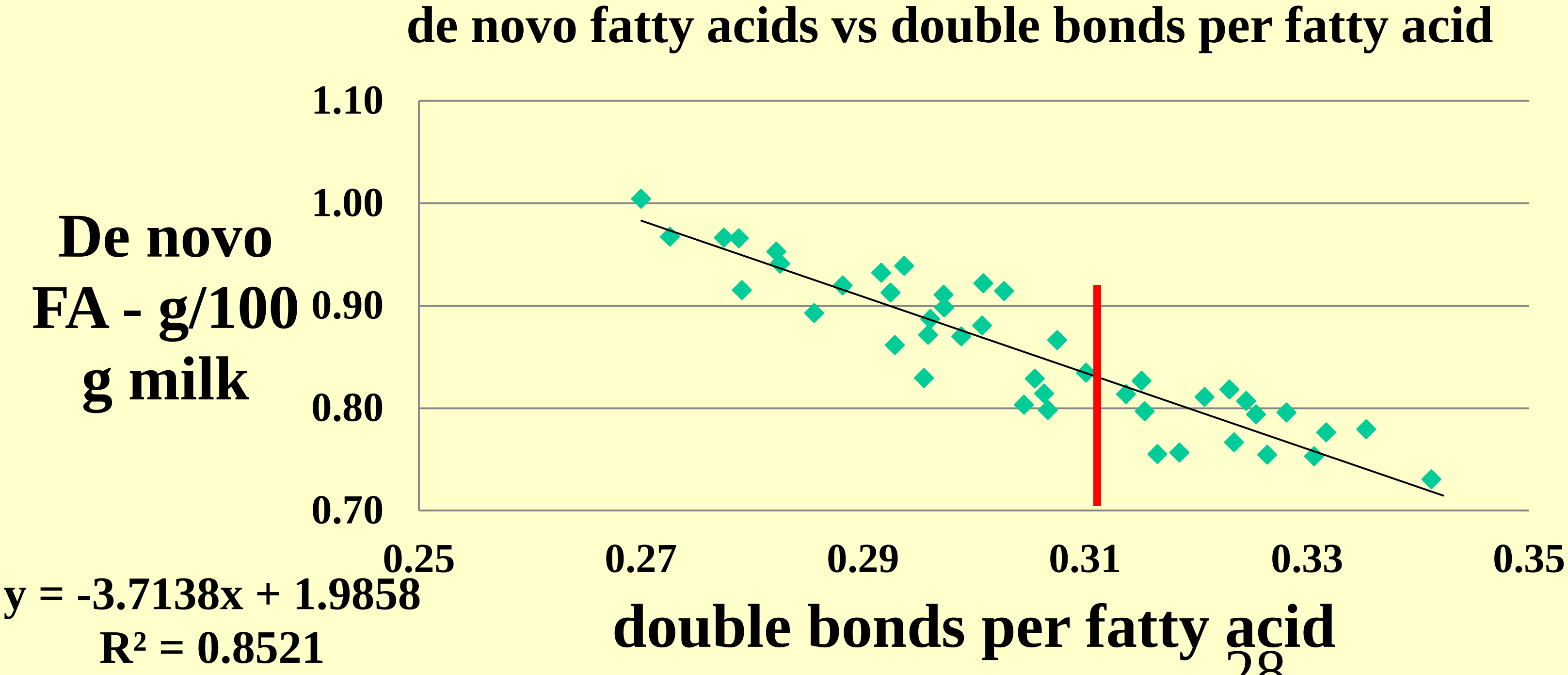
If you want a fat test > 3.75% fat in bulk tank with Holsteins, then the double bonds per fatty acid in milk fat needs to < 0.31.



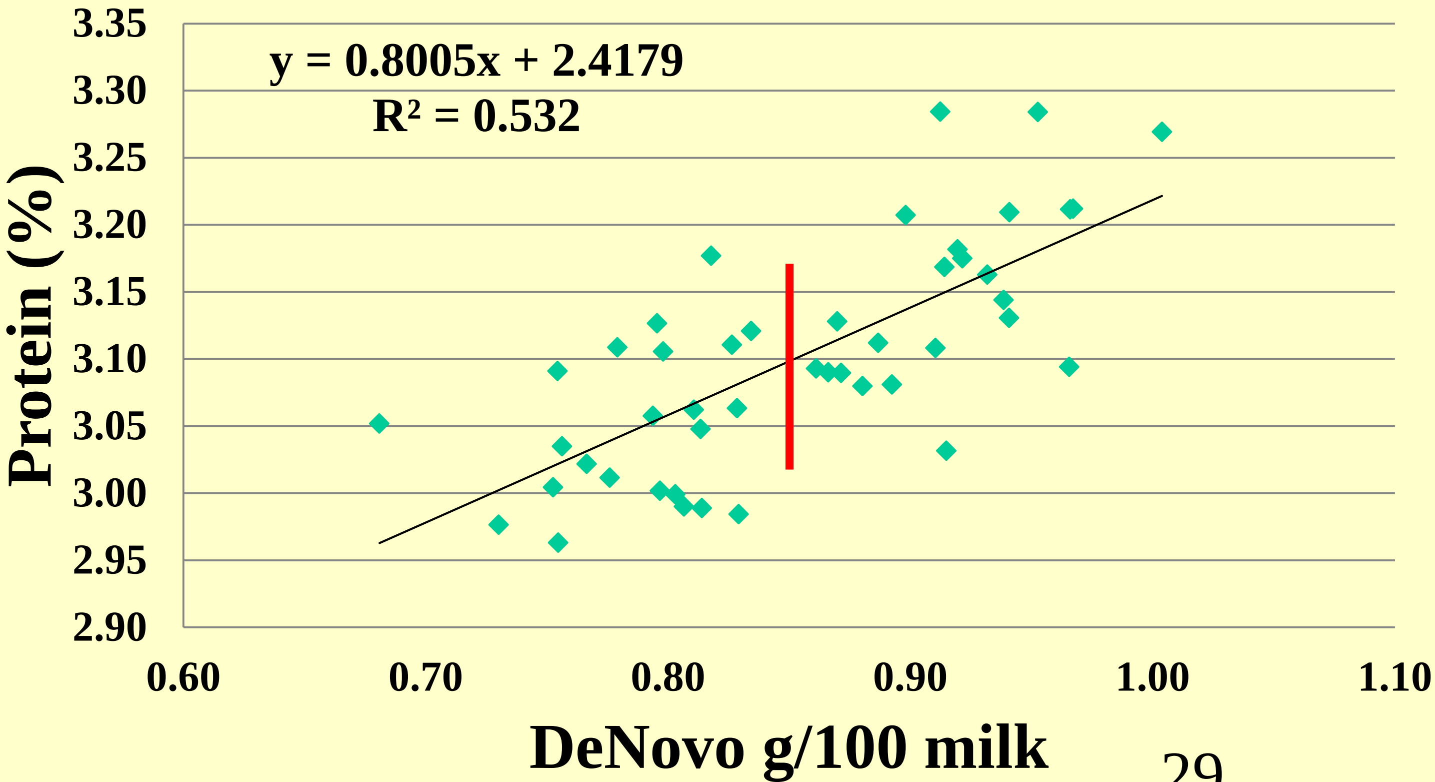
40 Holstein Farms 2015

St Albans – Milk Fat Depression

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



40 Holstein Farms 2015
St Albans - Protein



Results of 40 Farm Study Year 1

- ***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.**

Results of 40 Farm Study Year 2

- **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

1. St. Albans Cooperative (400 farms), AgriMark Cooperative (1200 farms), and Cayuga Milk Ingredients (30 large farms). Fatty acid testing is done as part of the process of milk payment testing at their laboratories.

2. Farm bulk tank and pen samples tested at Cornell. Sampling done by the tank truck driver or farm staff (research project).
   - Every other day pick (3 pick up samples and ship to Cornell)
   - Every day pick up (5 or 7 days of bulk tank samples and ship to Cornell
   - Direct tanker load large farms – sample from each tanker for 3 days and ship to Cornell
   - Very large farms – pen or feeding group samples

Current Field Work with Nutritionists

3. **W. H. Miner Institute in Chazy, NY tests herd milk and is taking over this testing of individual farm milk (fee charged). Contact Heather Dann (Dann@whminer.com)**

4. **Sterns County DHIA and Zumbrota DHIA laboratories in Minnesota start testing bulk tank milk samples for fatty acids (fee charged).**

Current Field Work with Nutritionists

1. The milk samples need to be representative (i.e., well mixed tank), preserved (with the correct preservative and correct amount). One Microtab II tablet per 2 or 3 ounce vial.
2. The milk samples need to be held refrigerated at the farm.
3. The milk samples need to kept cold during shipment and be less than 2 weeks old when tested.
4. Samples cannot be frozen.
5. Strip samples for individual cows will not give correct results. A representative sample from complete milking of a cow is needed.

Current Field Work with Nutritionists

Progress on one 1800 cow Holstein farm in Northern NY

				Anhyd	True P		fatty acids per 100 g milk		
Holstein		X1000	%(m/m)	%(m/m)	%(m/m)		Denovo	Mixed	Preformed
Farm #1	lbs	SCC	Fat D	Lactose	Protein	MUN	g/100 g	g/100 g	g/100 g
May-16	92	182	3.52	4.65	3.15	10.8	0.84	1.18	1.27
Sep-16	91.3	207	3.46	4.61	3.10	11.2	0.72	1.20	1.31
Nov-16	92	147	3.89	4.61	3.25	9.7	0.91	1.40	1.34

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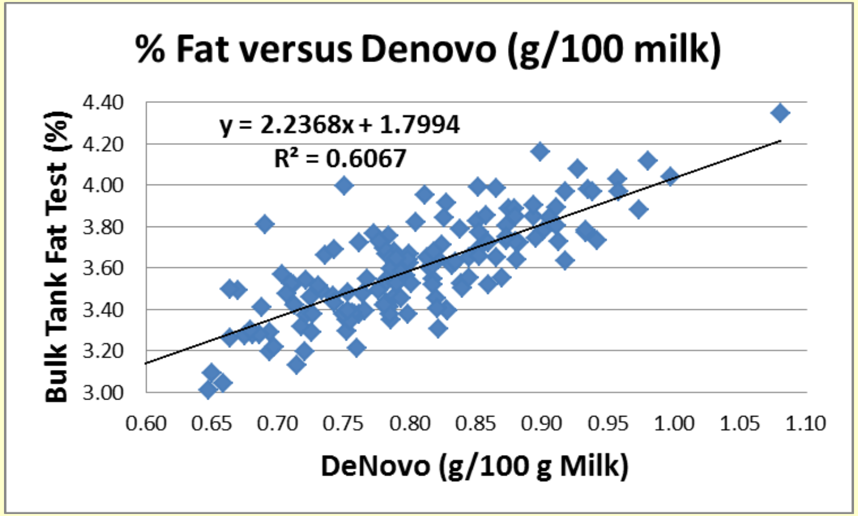
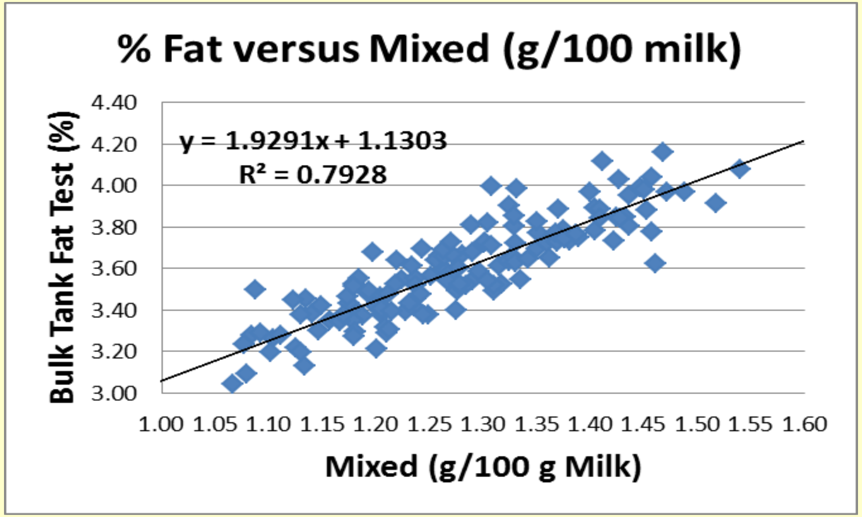
				fatty acids					
	carbon #	DB/FA	Milk lbs	Denovo	Mixed	Preformed	Lactose	Fat	Protein
	FA CL	FA Unsat	per day	g/day	g/day	g/day	g/day	g/day	g/day
May-16	14.59	0.324	92	350	493	531	1940	1472	1316
Sep-16	14.90	0.342	91.3	300	497	544	1911	1433	1284
Nov-16	14.54	0.302	92	380	587	560	1927	1626	1358

Current Field Work with Nutritionists





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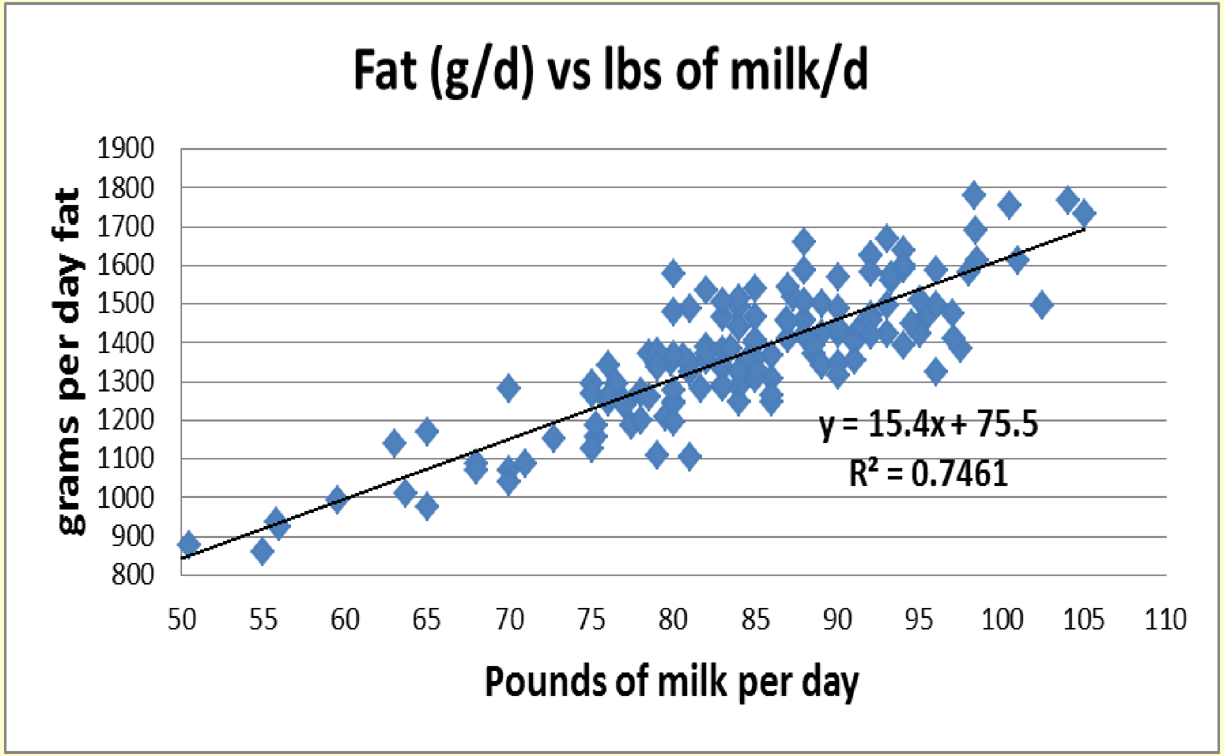

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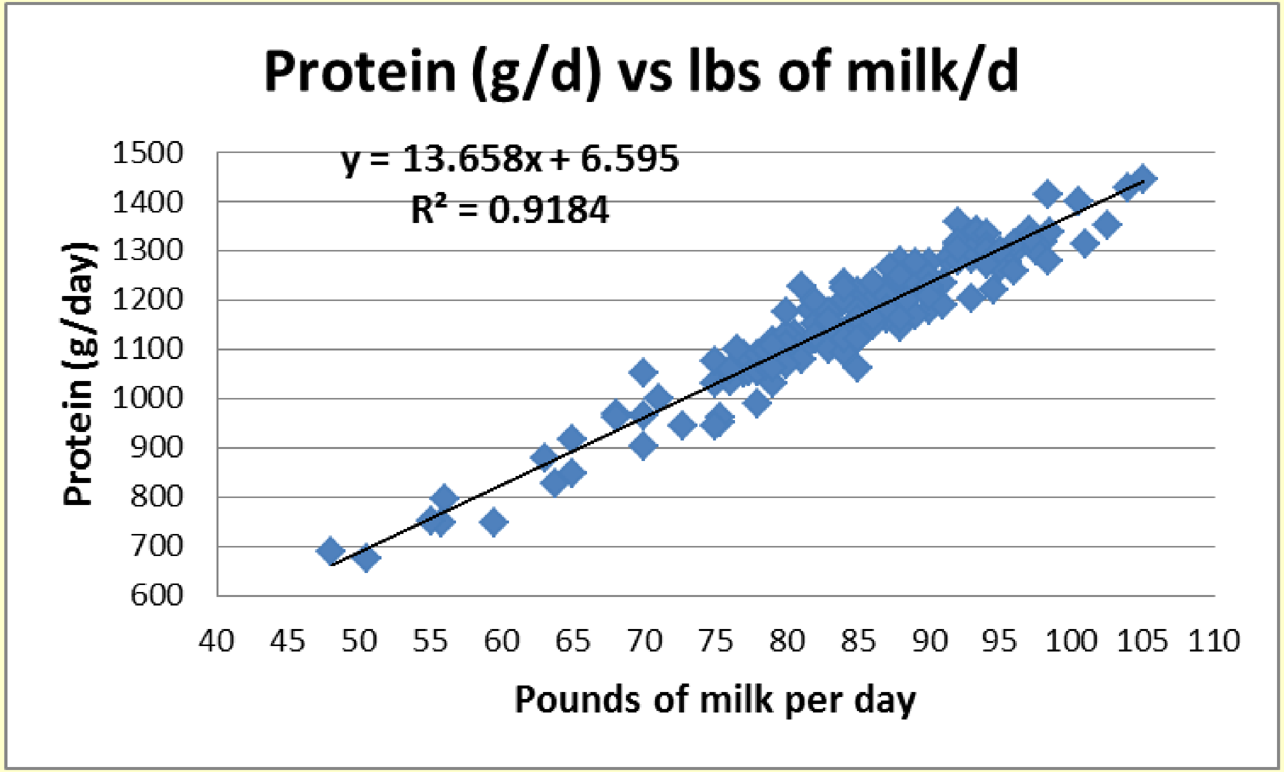

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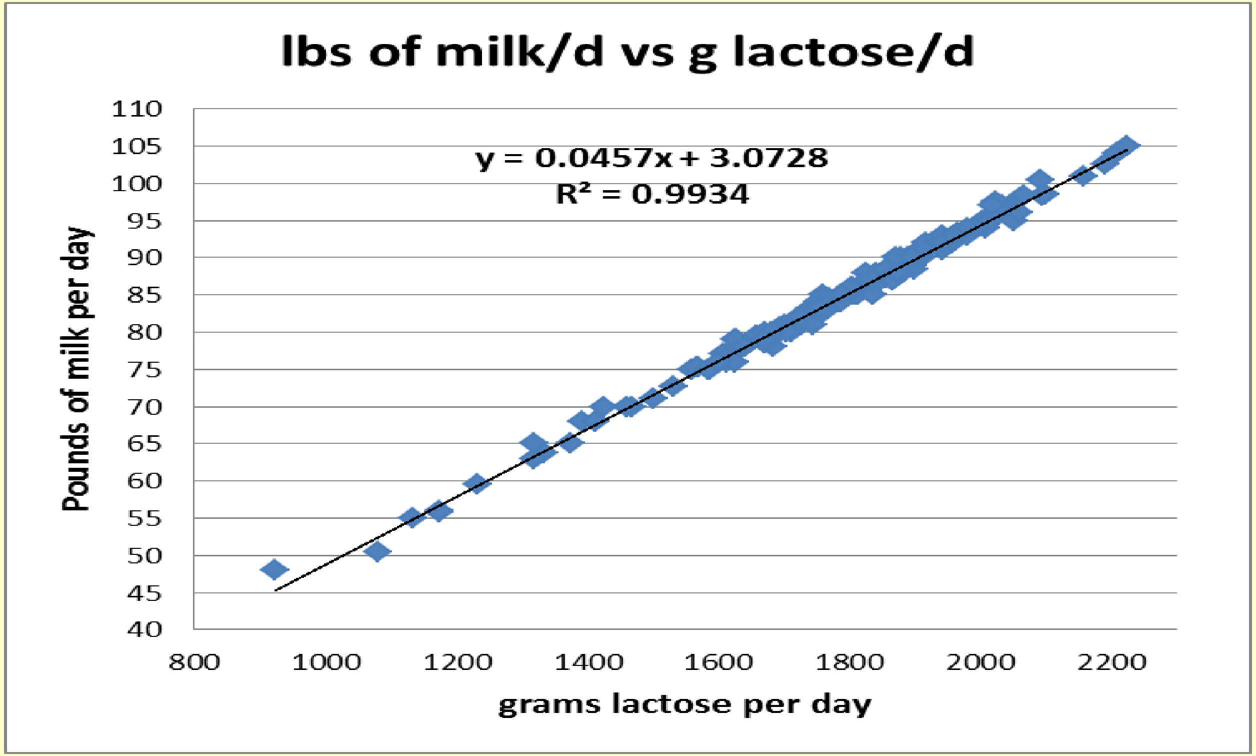


Factors Most Highly Associated with Welfare and Productivity

(Popescu et al., 2013)

- **Comfortable, clean stalls**
- **Adequate nutrition and water**
- **Access to exercise**
- **Relationship with stockperson**

Status of all 4 factors may be reflected in milk MIR profiles

Fatty acid profiles provide insight…

- Proportions of de novo, mixed, and preformed fatty acids reflect:
  - Diet and dietary changes
    - CHO fermentability, RUFAL, forages…
  - Management environment
    - Rumen pH, turnover
  - Physiological state of cow
    - Energy balance
    - Stage of lactation

Fundamental importance of milk fatty acid profiles

- The FA profile reflects performance and health status of the cow:
  - Rumen function
  - Body adipose reserves
  - Risk of milk fat depression
- Assess bulk tank – whole herd or group status
- Future: individual cows; at each milking

Focus on de novo fatty acids…

- **De novo fatty acids reflect rumen function – especially fiber fermentation.**
  - **Acetate and butyrate are building blocks**
- **Rumen conditions that enhance microbial fermentation stimulate microbial protein production and increase milk protein content.**
- **Relative proportion of de novo fatty acids in milk fat tells us how well the cow is being fed and managed for optimal rumen fermentation conditions.**

Fiber fermentation is key: Acetate can boost milk fat – even when milk fat is normal

	Acetate (g/d)					
	0	300	600	900	SE	*P*
DMI, lb/d	59.9	62.2	60.0	59.5	2.2	NS
Milk, lb/d	84.9	86.3	88.9	85.6	6.2	NS
Milk fat						
% g	3.64 1382	3.87 1468	4.03 1582	4.10 1577	0.20 59	<0.001 <0.001

- 600 g/d of acetate increased milk fat by 200 g/d
- Mainly reflected greater de novo FA synthesis (short chain and C16)

(Urrutia and Harvatine, J. Nutr. 2017)

How Should We Use This Information?

1. Herd “snapshot” and troubleshooting
2. Evaluating changes over time
3. Need to understand natural variation
4. Place in context of stage of lactation

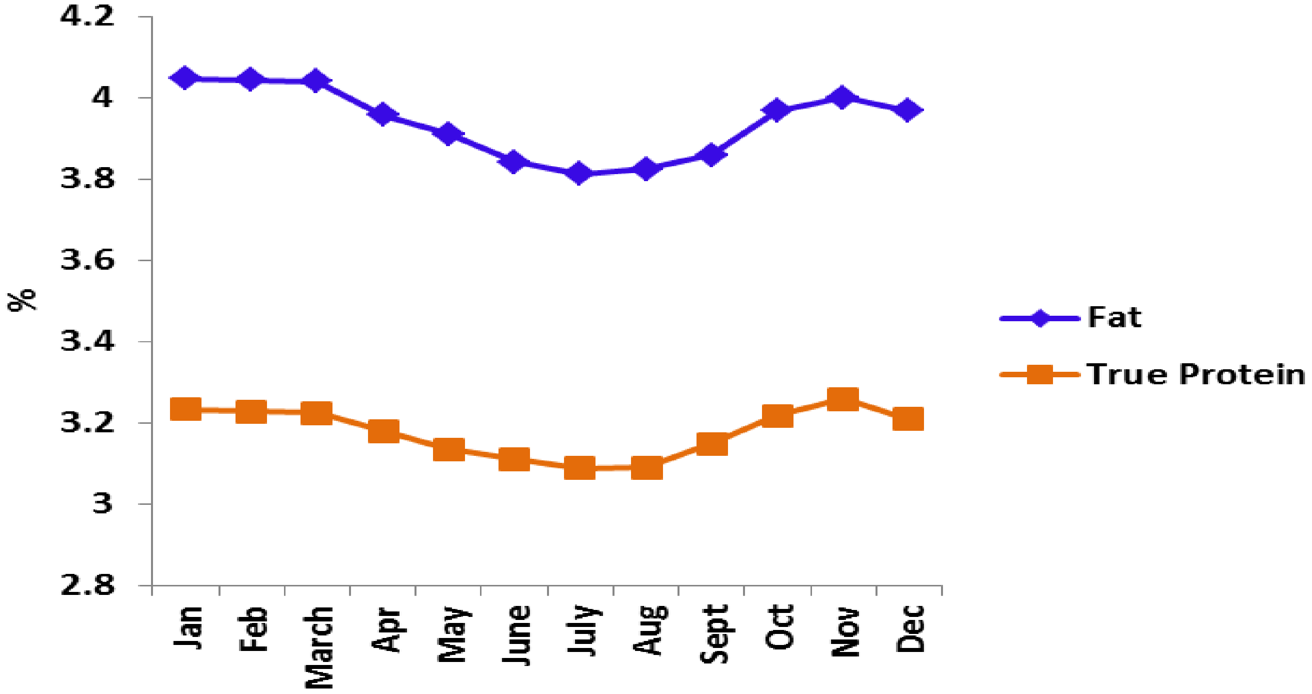
How best to use the FA information

- In conjunction with
    - Diet information
    - Management information, other systems
    - On-farm assessment
  - Don't use the milk FA information "in a vacuum"

- Can give you clues as to what is happening
  - More specific than milk fat or protein %
  - Low milk fat can be caused by different factors – MIR FA information allows you to identify what is wrong
  - May allow more rapid decision making

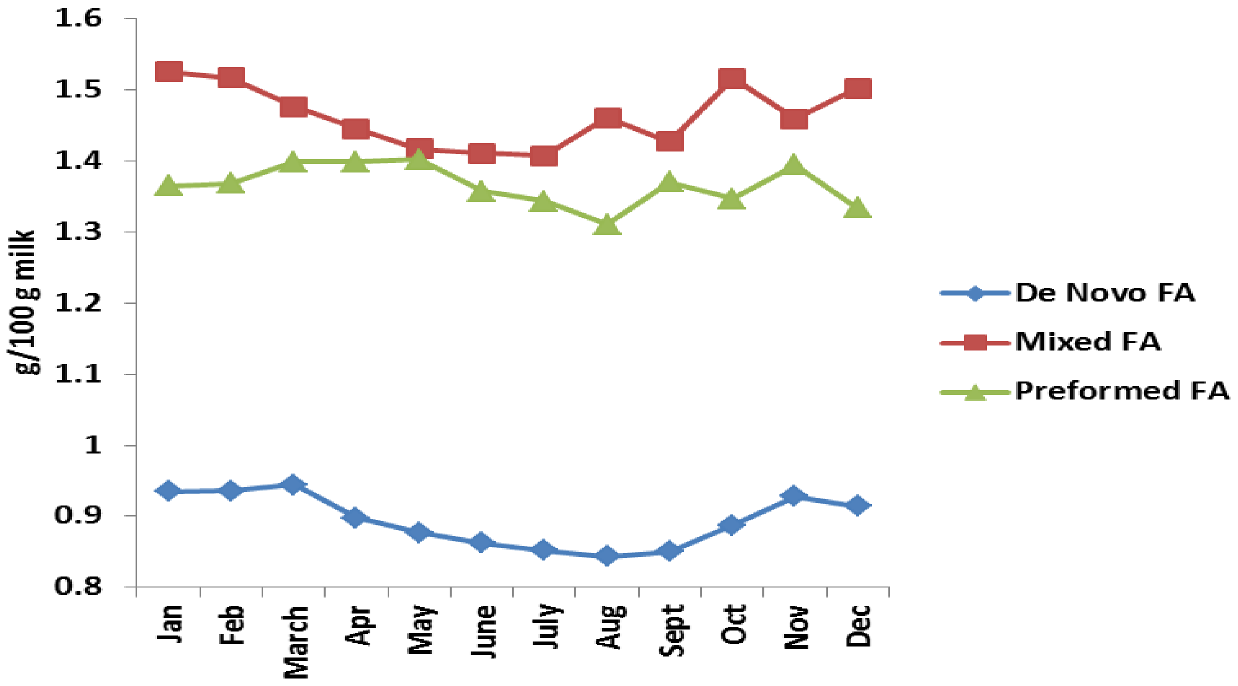
Need to understand changes in milk profiles with season and stage of lactation

Seasonal Changes in Milk Composition



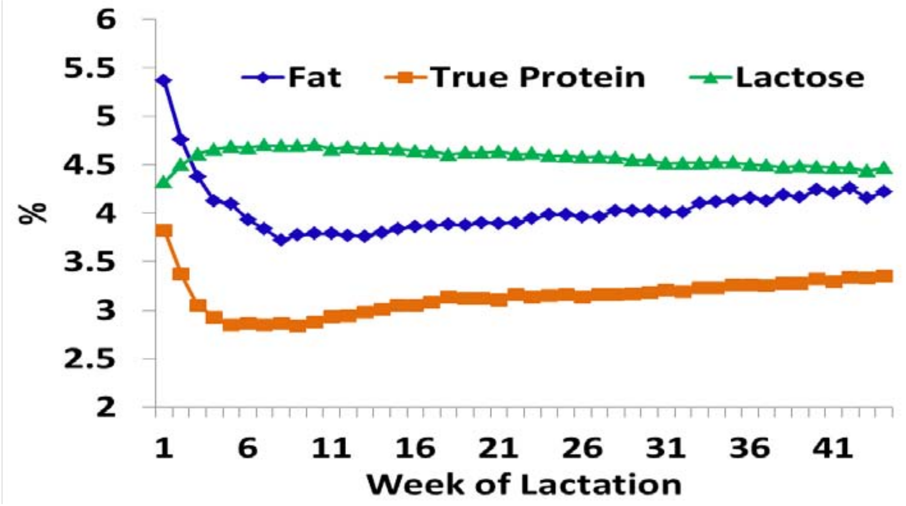
40 St. Albans Coop herds January 2014 to February 2016

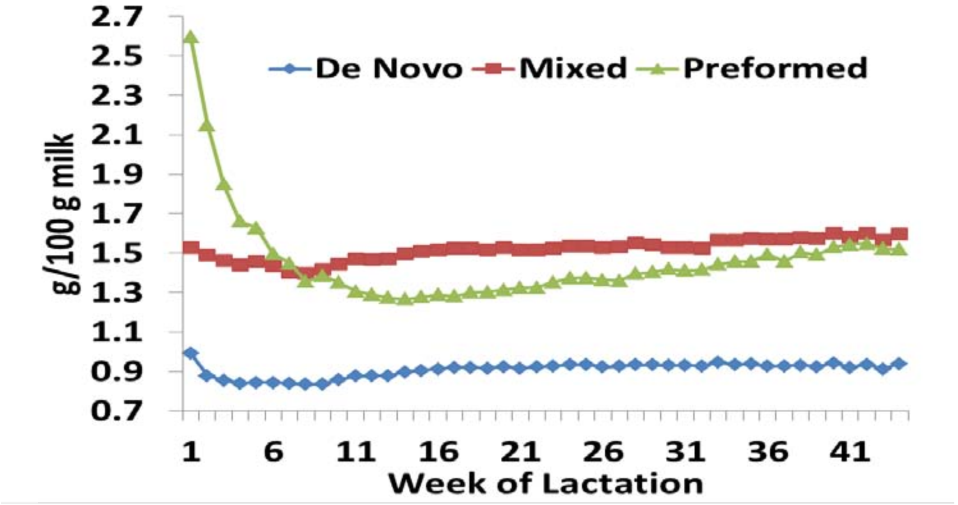
Seasonal Changes in Milk Composition



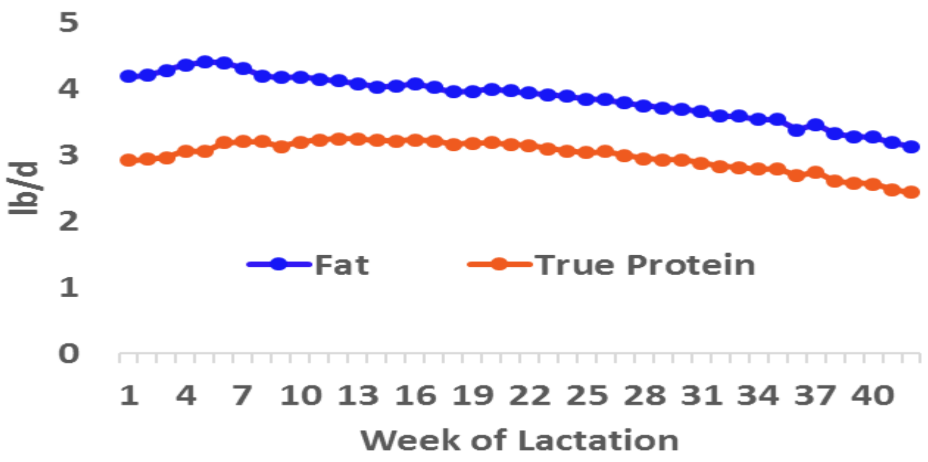
40 St. Albans Coop herds January 2014 to February 2016

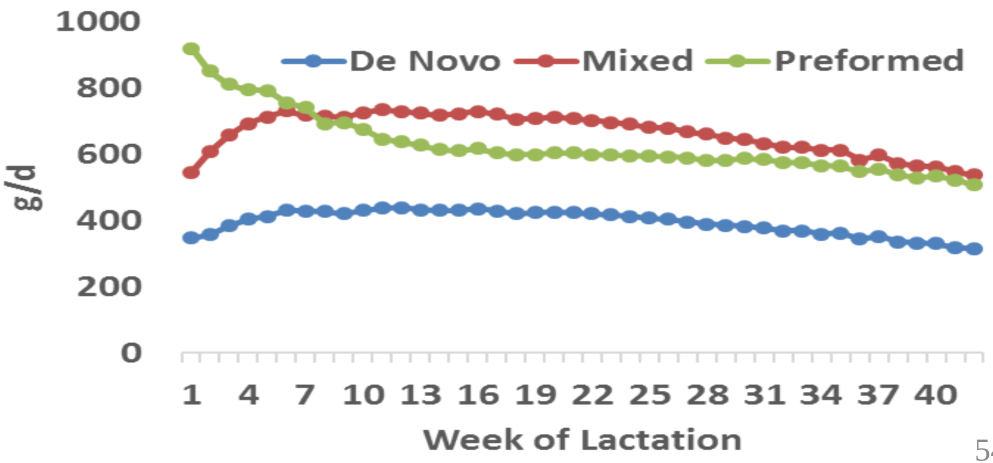
“Days In Milk” Changes in Milk Composition





“Days in Milk” Changes in Component Yields

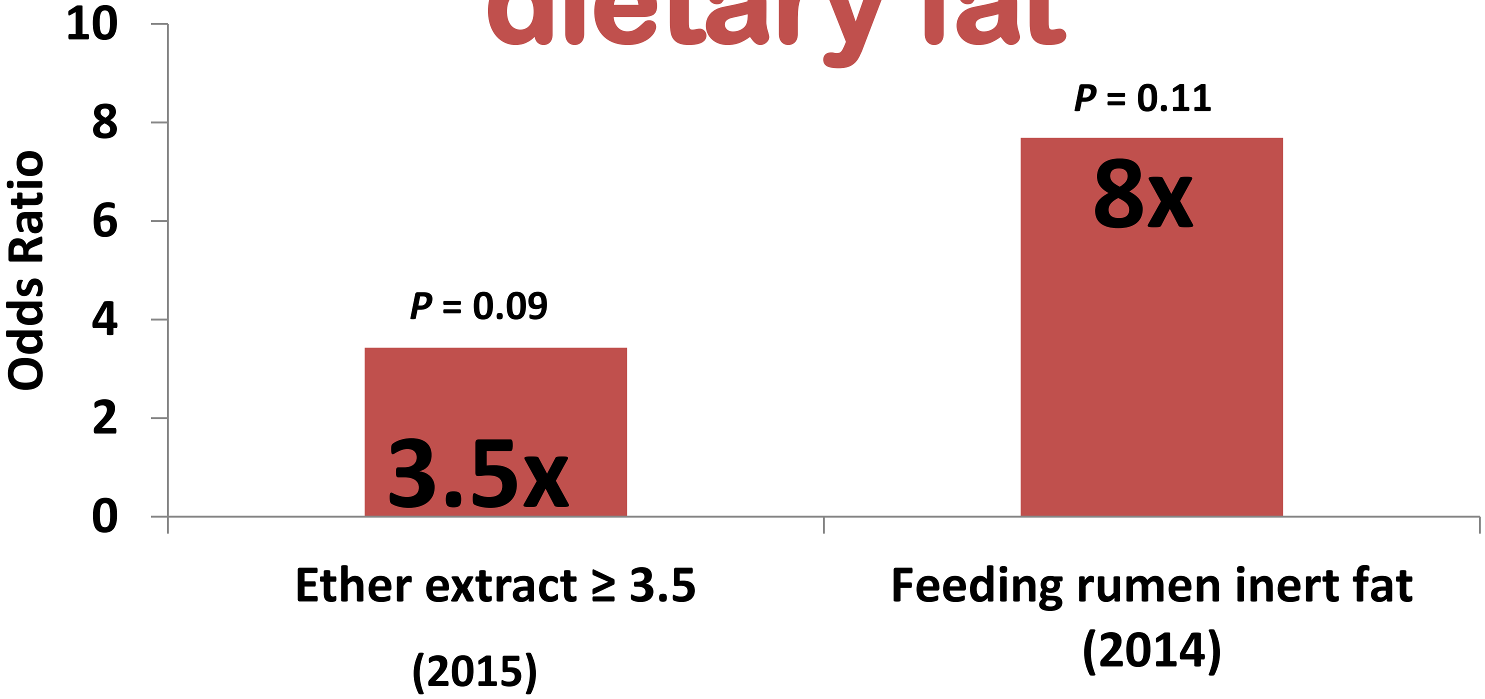




What factors are most related to de novo fatty acid content?

- **Nutrition**
  - **Diet fat - RUFAL**
  - **Diet peNDF**
  - **Fermentability**
- **Management**
  - **Stocking density**
    - **Feed bunk and stalls**
  - **Feeding frequency**
  - **Feed push-up**
- **Interaction of Nutrition x Environment**

LDN diets contained more dietary fat



	HDN	LDN
Mean	3.7	4.0

	HDN	LDN
% of farms	6.7	33.3

Impact of dietary fat on de novo fatty acids

- **Armentano: 36 studies found that added dietary fat containing unsaturated FA reduced short-chain FA yield (C<16) when added at any amount.**

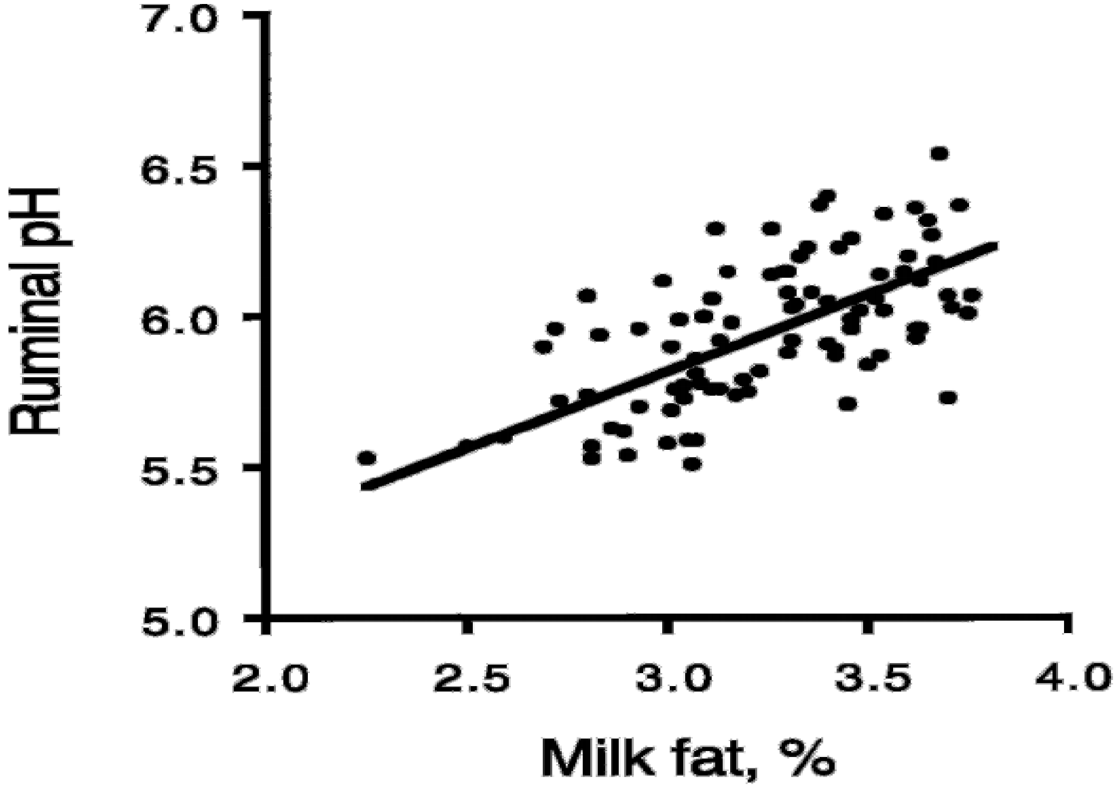
RUFAL

(Jenkins, 2013)

- C18:1 + C18:2 + C18:3

- <3.5% of diet DM
- <500 g/d
  - Includes protected and unprotected fat sources
  - Doesn't consider availability of the fatty acids
- <u>Only a guideline</u>!

Milk Fat and Rumen pH



(Allen, 1997)

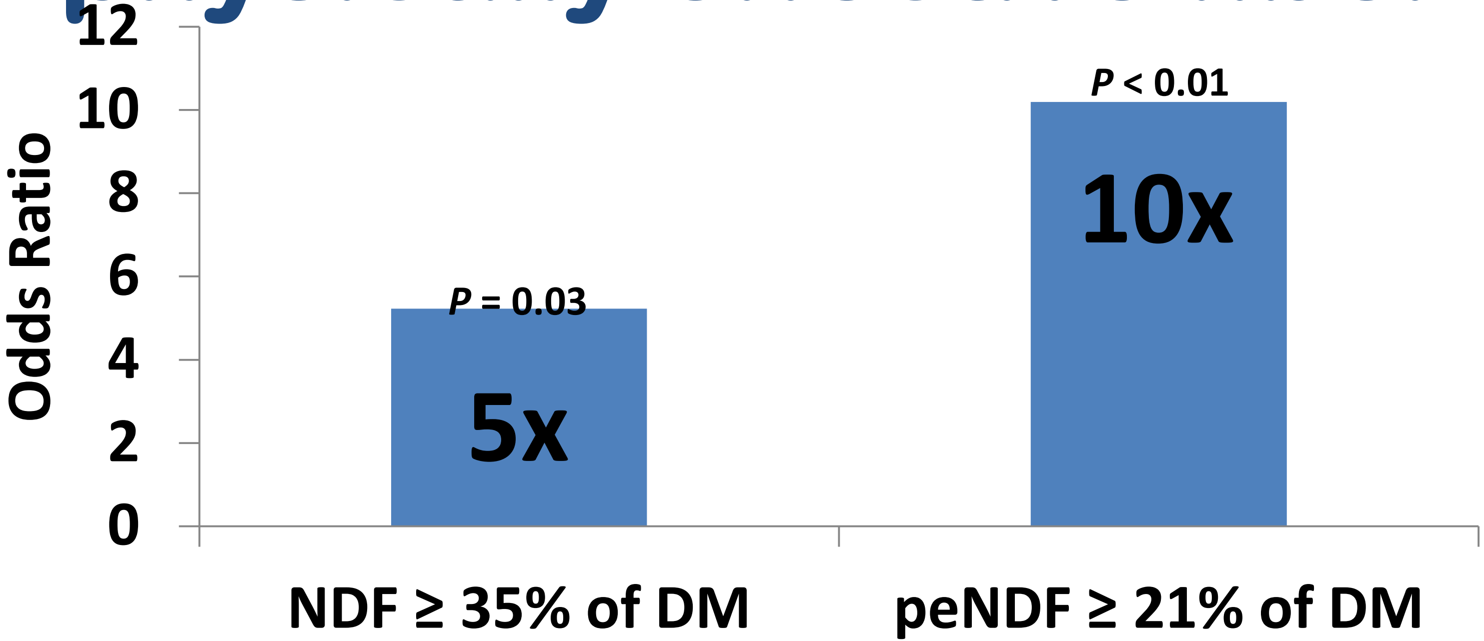
Example of How Milk FA Change: Soybeans, RUFAL, and Low Milk Fat

- **Snapshot: ~3.4 to 3.5% fat**
  - 0.77 g de novo FA/100 g milk
  - 0.35 double bonds/FA
- **Problem: Diet too high in RUFAL**
  - Use of home grown roasted soybean
  - Ground extremely fine with hammer mill
- **Solution: ↑ grind size**

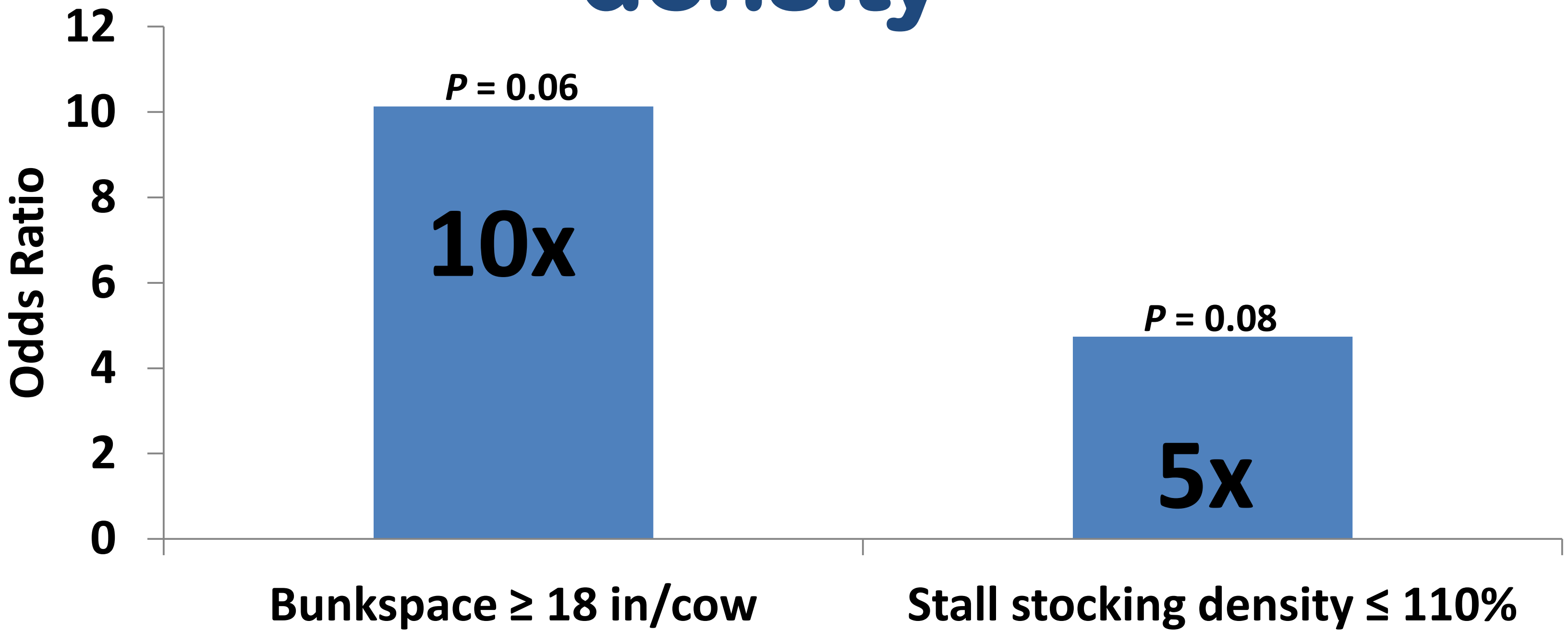
- **Outcome: ≥ 3.7% fat**
  - 0.94 g de novo FA/100 g milk
  - 0.31 double bonds/FA

➢ Example courtesy of M. Carabeau

HDN herds feed more physically effective fiber



HDN herds have lower stocking density



	HDN	LDN
Mean	19.7 in	15.7 in

	HDN	LDN
Mean	111%	116%

Overstocking changes feeding behavior

↑ feeding rate (slug feeding)

↑ aggressive behaviors

↓ rumination

↑ risk for low rumen pH

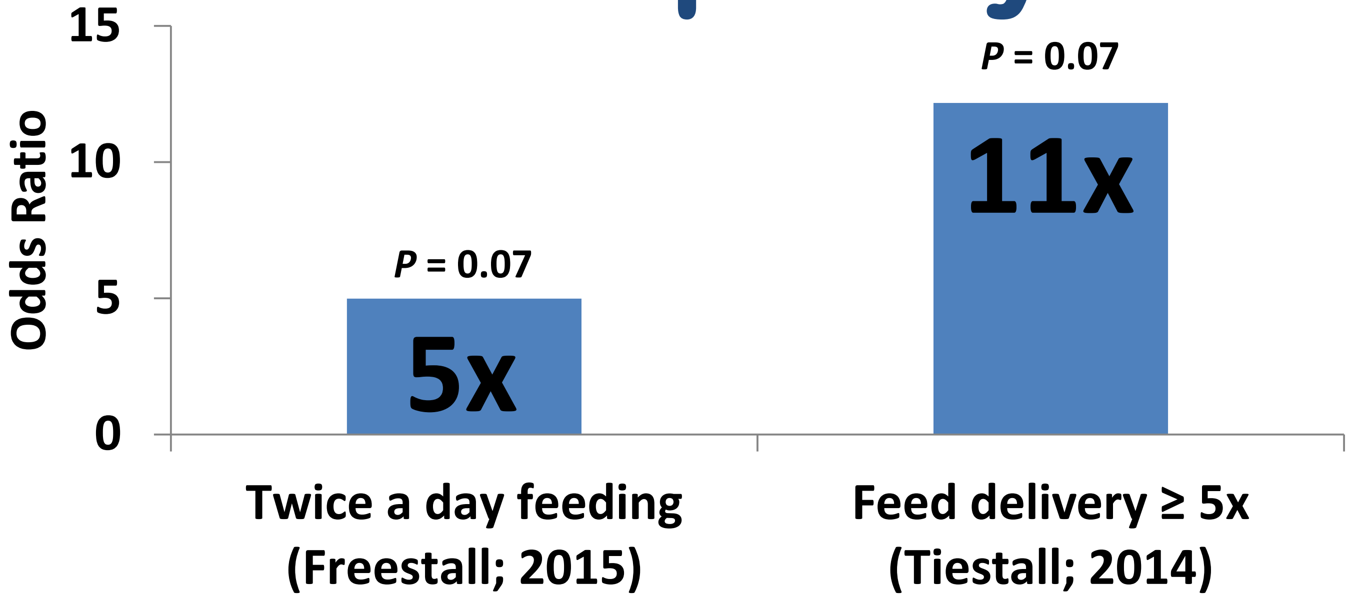
French and Kennelly, 1990; Batchelder, 2000; Huzzey et al., 2006; USDA, 2010; Collings et al., 2011

Bunk Space and Milk Components

- **Higher de novo milk fatty acid synthesis** (Woolpert, 2016)
  - 65% of variation explained by bunk space
  - De novo, relative % = 20.12 + 0.09 x bunk space, cm; $P < 0.002$

- **Greater bunk space** (Sova et al., 2013)
  - Increased milk yield and fat%
    - +0.06% greater milk fat per 4-in increase in bunk space

HDN herds feed more frequently



	HDN	LDN
Mean	1.7	1.4

	HDN	LDN
Mean	4.6	2.9

Fresh feed delivery motivates cows to eat

- 2x versus 1x TMR feeding
  - ↓ sorting against long particles
  - ↑ feed intake and milk yield
  - ↑ eating time
  - ↑rumination

= healthier rumens

Sova et al., 2013; www.hoards.com

When do you intervene? When has something changed?

Factors Affecting Variation

Within & Between Herds

- **Management related to feeding, housing, and milking of cows**
- **Diet and feed quality**
- **Consistency in day to day routine**
  - **Affects time budget of cow**
- **Days off and vacations**
- **Weather changes**
- **Filling sequence of multiple tanks**

Bulk Tank Changes Associated with Milk Fat Depression

A gradual change in fat % under most situations

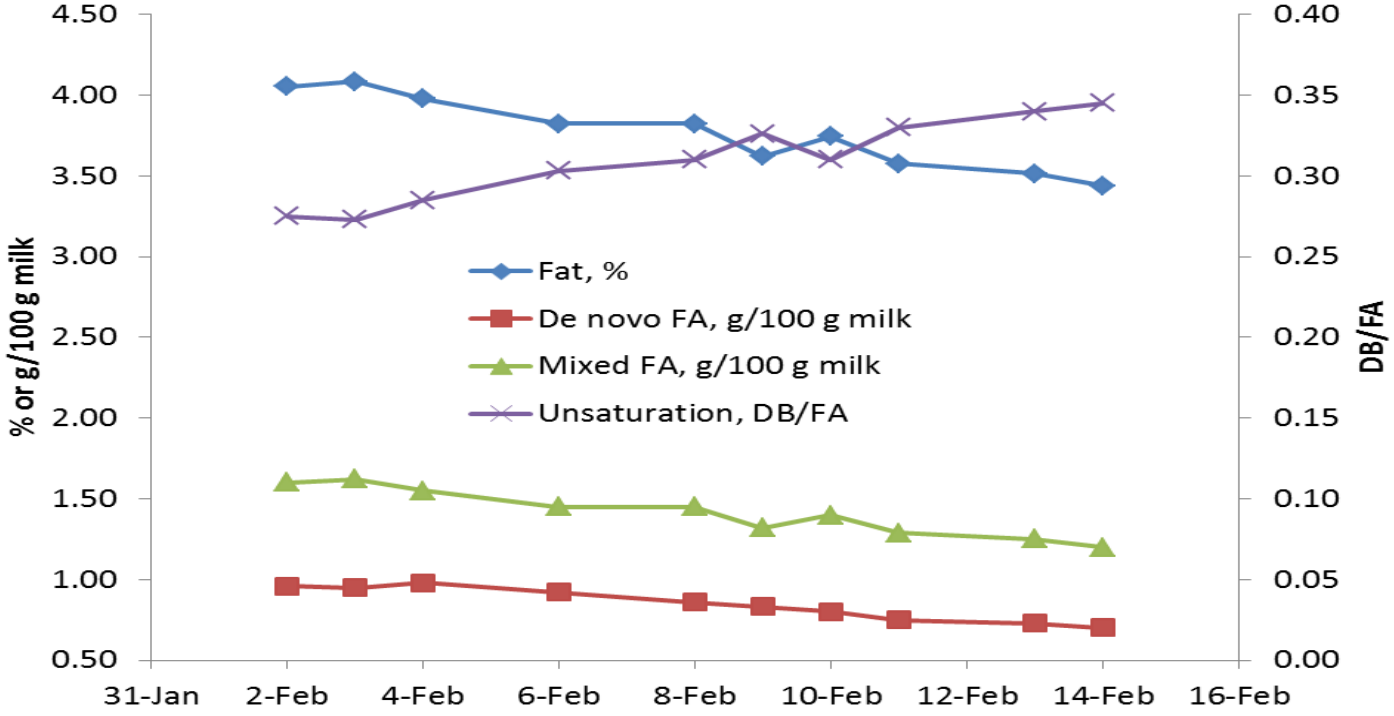
1. **↑ in unsaturation index (>0.31 DB/FA)**

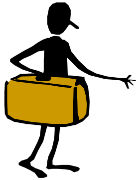
2. **↓ in mixed FA (g/100 g milk)**

3. **Continued ↓ in mixed FA and ↓ de novo FA (g/100 g milk)**

4. **↓ in true protein (%)**

Herd with Decreasing Milk Fat





Take Home Messages

- **Bulk tank milk fatty acid metrics are available**
  - **Make nutrition and management decisions**
- **Herd “snapshot” and troubleshooting**
  - **Milk fat depression**
- **Evaluating changes over time**
  - **Planned and unexpected**

Outline

- What Do Farmers Want?
- What Do Processors Want?
- **An example of connecting analytical measures to dairy farmer needs.**
    - **Milk fatty acid composition – individual cow**
    - **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.

Comparison of blood and milk NEFA results

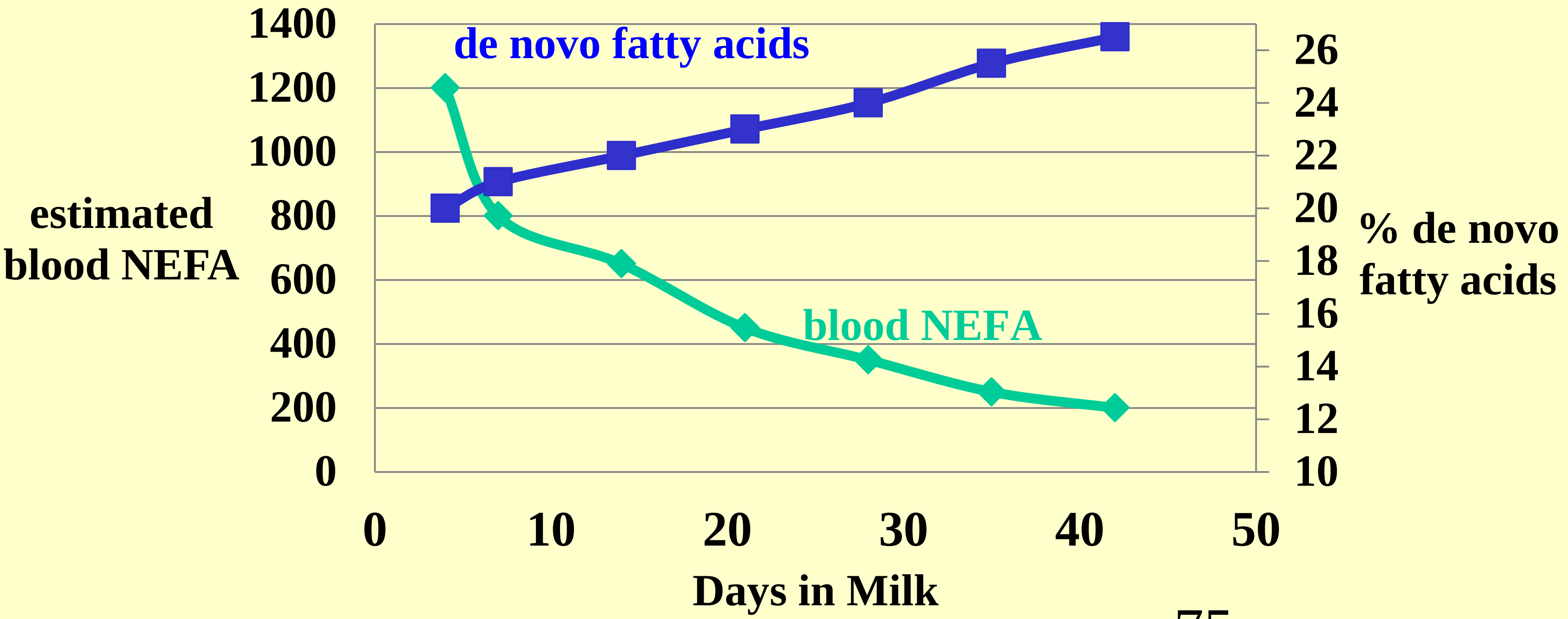
The NEFA concentration measured in blood represents the concentration at an instant in time. The level can vary with time and with the level of stress of the individual cow at the time of blood sampling.

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.

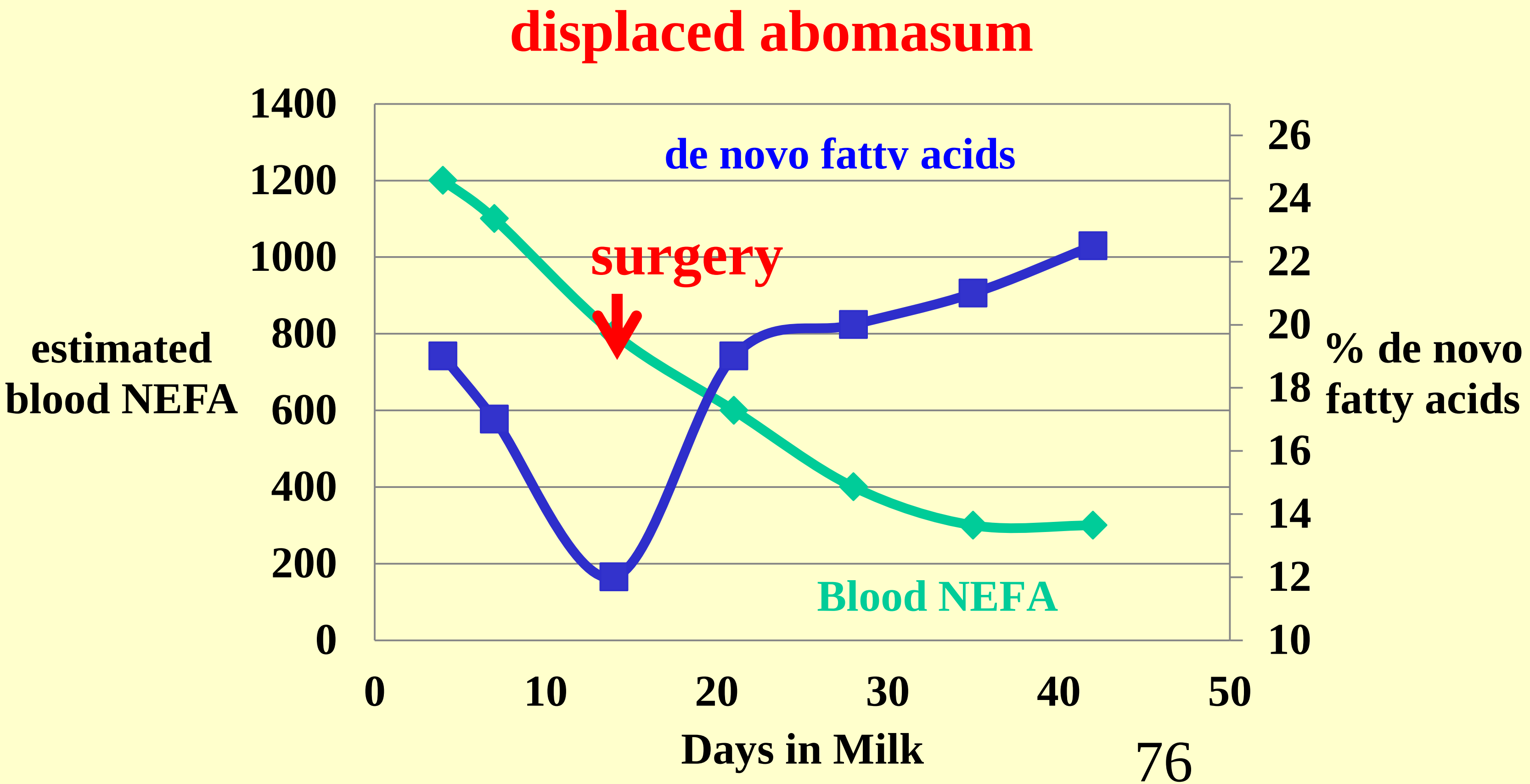
Therefore, the estimate for blood NEFA based on milk analysis may be a more stable and integrated estimate of the status of a cow's blood NEFA level for a period of time than the estimate obtained from a blood sample.

Sample Individual Cow Data

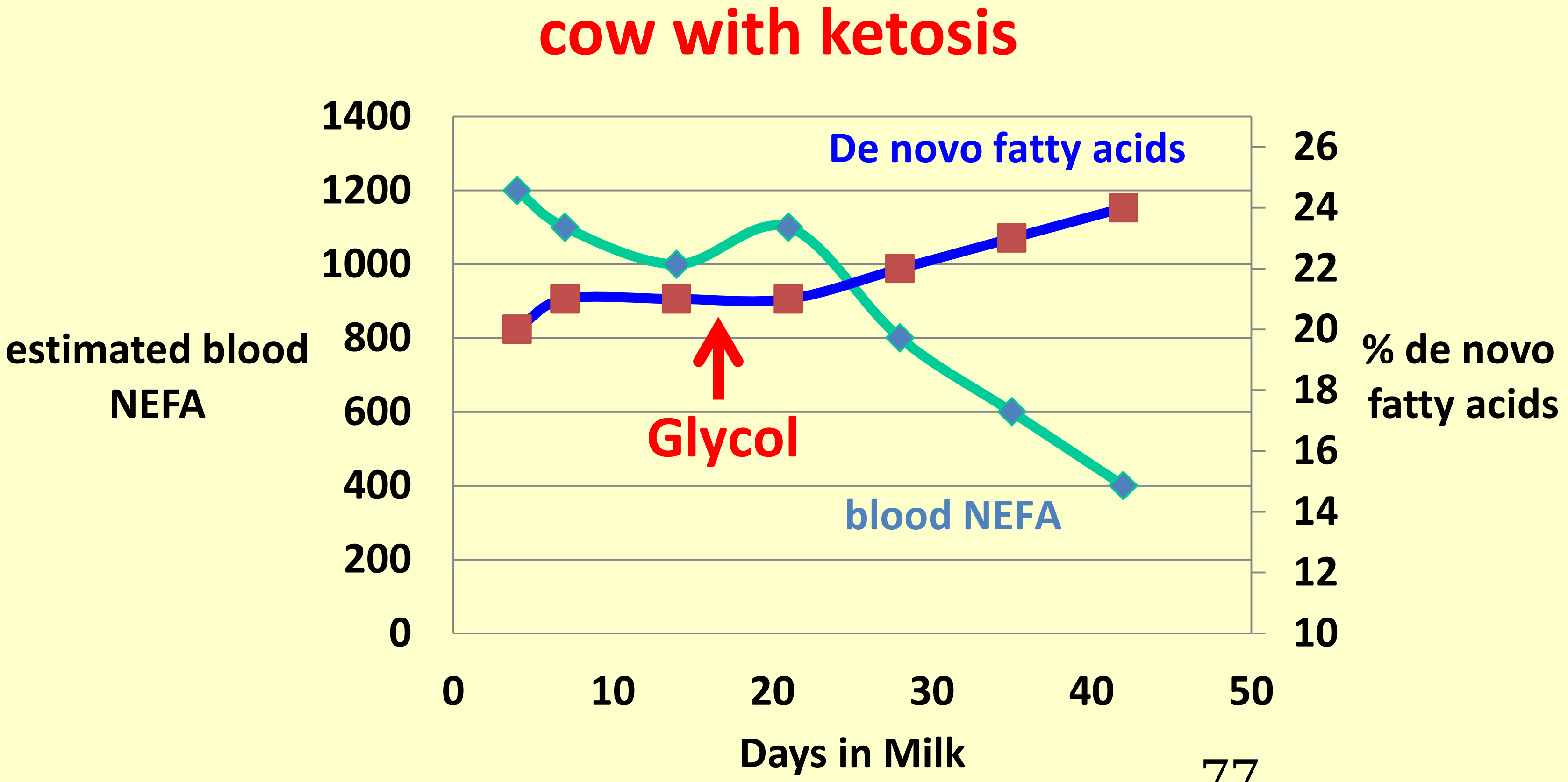
Cow with high body condition at calving with good liver function



Sample Individual Cow Data



Sample Individual Cow Data



Conclusion

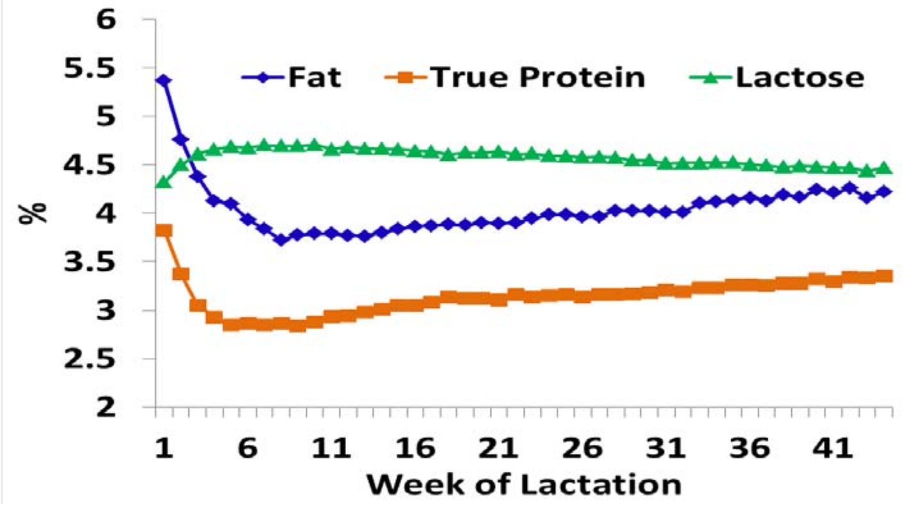
- **The milk estimated blood NEFA and milk fatty acid data correlated well with documented ketosis and displaced abomasum (DA), but more data is needed.**

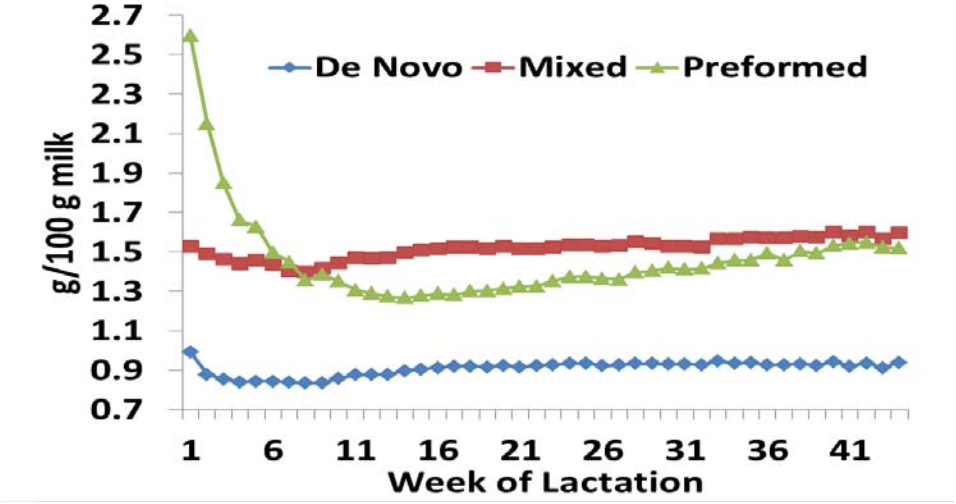
Use of Mid-IR Milk Analysis for Individual Cow Milk Samples

- Understanding how the milk “fingerprint” can be used for individual cows

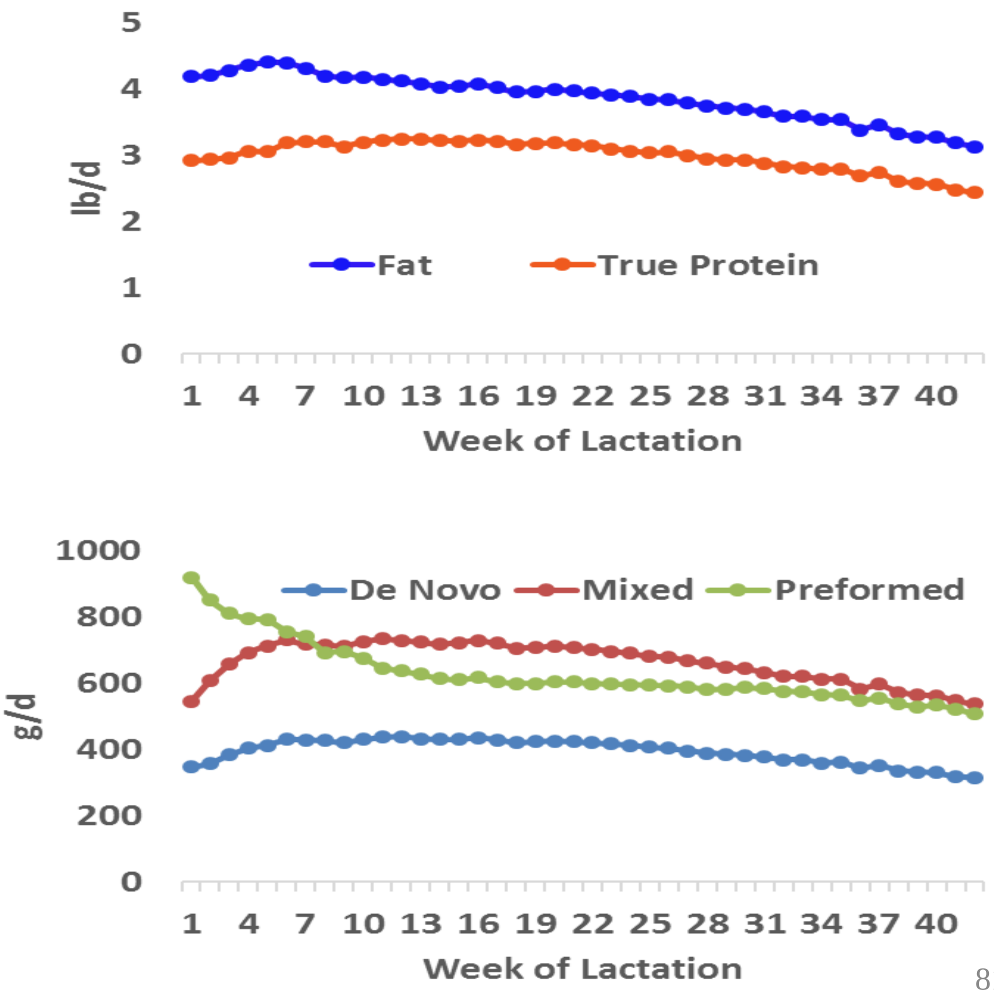
- Milk can tell us more than the traditional fat and protein for individual cows
  - Diet/feeding management
  - Metabolism
  - Health
  - Reproduction

“Days In Milk” Changes in Milk Composition



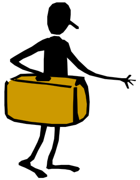


“Days in Milk” Changes in Component Yields



Current Research

- **Use of mid-IR milk analysis…**
  - **To predict blood BHB (ketones)**
  - **To predict displaced abomasum**
  - **To detect estrus**
  - **To determine the likelihood of pregnancy following insemination**
  - **To predict blood acute phase protein (immune markers)**
  - **To predict rumen pH and SARA**



Take Home Messages

- Individual cow testing
  - More frequent sampling and data integration with other systems to better understand
    - Metabolism
    - Health
    - Reproduction

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

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

Caladriel

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

Dandolf the White

Acknowledgments

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.

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Questions??