

Mid-Infrared Milk Testing: Herd Management Tools

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Outline

- **What do dairy farmers need for farm management?**
- **Review of herd level milk fatty acid analysis and interpretation.**
- **New data (herd level and individual cow level)**
 - **milk fatty acids: relation to seasonality of fat and protein**
 - **data on fatty acids and stage of lactation**
 - **data from 167 farms from all over the US – bulk tank**
- **Future Directions**

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?

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**”

Outline

- **Where are we at on the “cow of interest”?**
 - **Bulk Tank:** completed study of about 170 farms from all over the US
 - **Instruments testing bulk tank milk for de novo, mixed performed, chain length, and unsaturation**
 - **St Albans Cooperative, AgriMark Cooperative, and Cayuga Marketing Cooperative (1 instrument each)**
 - **Sterns County and Zumbrota DHIA Labs, Minnesota (4 instruments)**
 - **Cornell University, Miner Institute, and Texas Federal Milk Market Laboratory**

Outline

- **Where are we at on the “cow of interest”?**
 - **Individual Cows:**
 - **Instruments testing bulk tank milk for de novo, mixed performed, chain length, and unsaturation.**
 - **Sterns County and Zumbrota DHIA Labs, Minnesota (4 instruments)**
 - **Cornell University and Miner Institute (continued research for further development of more herd management metrics and to develop a hardware approach that would integrate into a milking system for analysis of milk from every cow.)**

Status Cow of Interest?

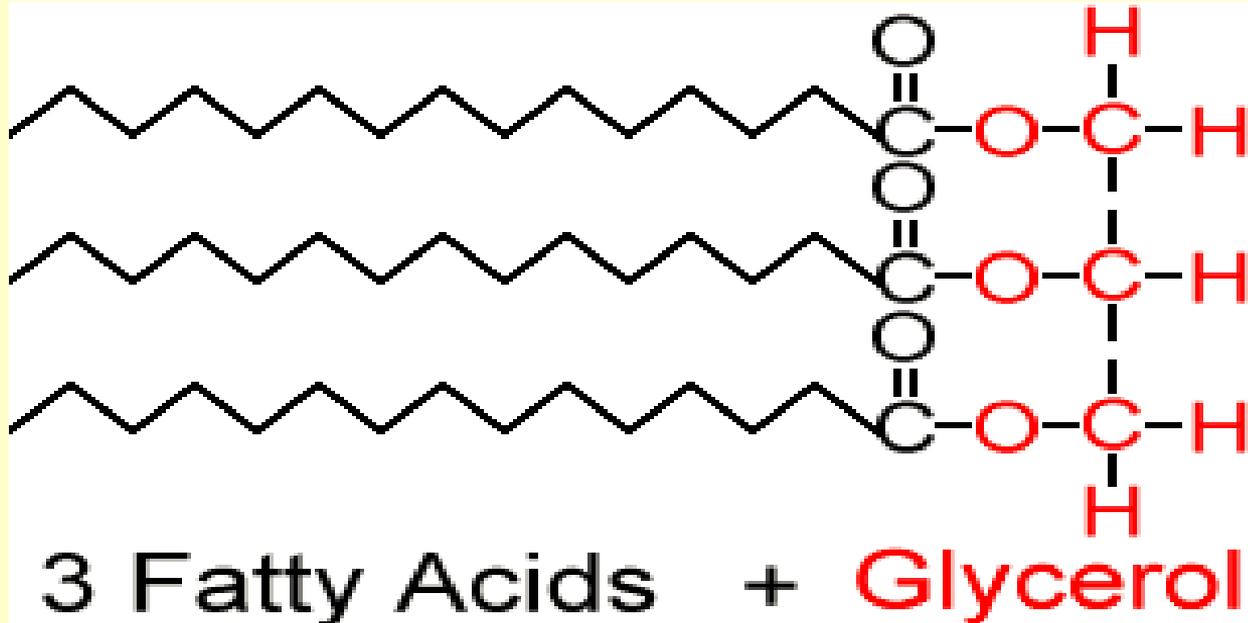
- 1) We are getting a much better understanding of how to use fatty acid data for whole herd or milking group diagnostics.**
- 2) We need to develop hardware and software to integrate this approach into the milk system for analysis of milk from each cow.**

Whole herd bulk tank data

Bulk Tank Milk Testing

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

Milk Fat Structure



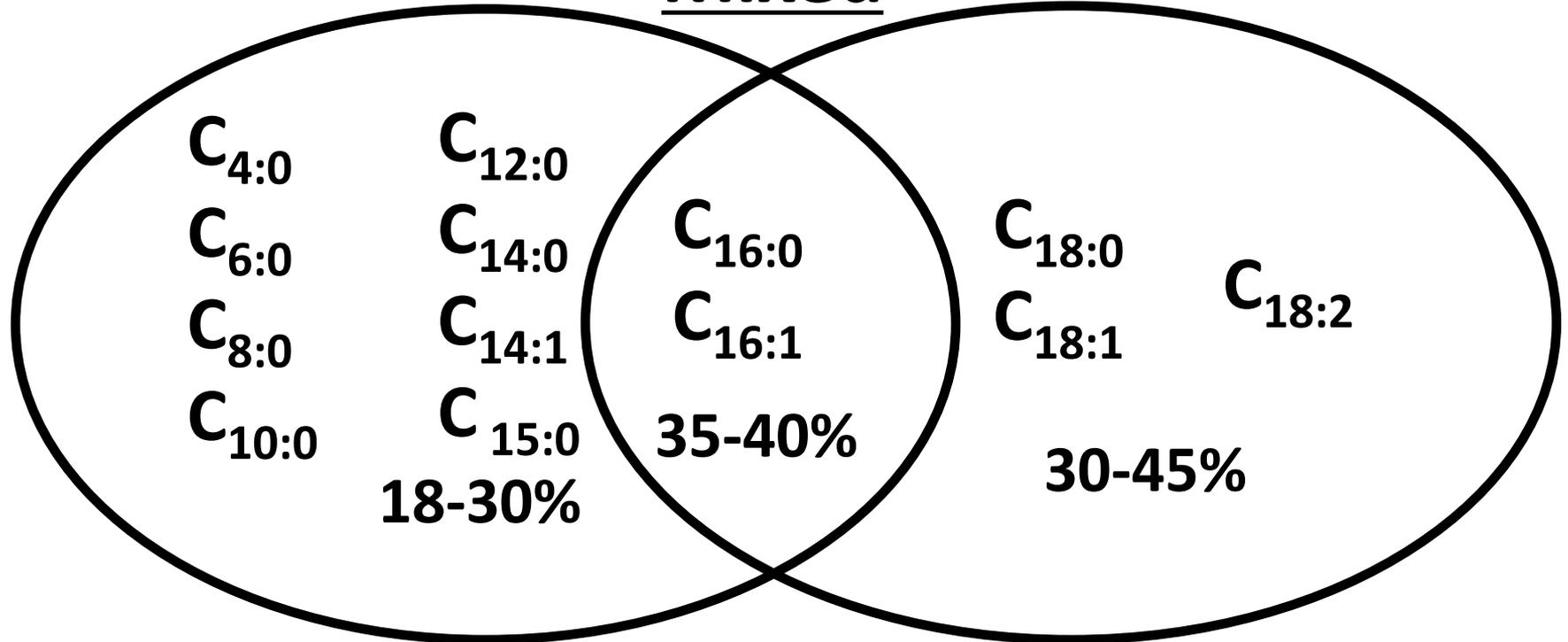
3 fatty acids per triglyceride

Milk Fatty Acid Origin

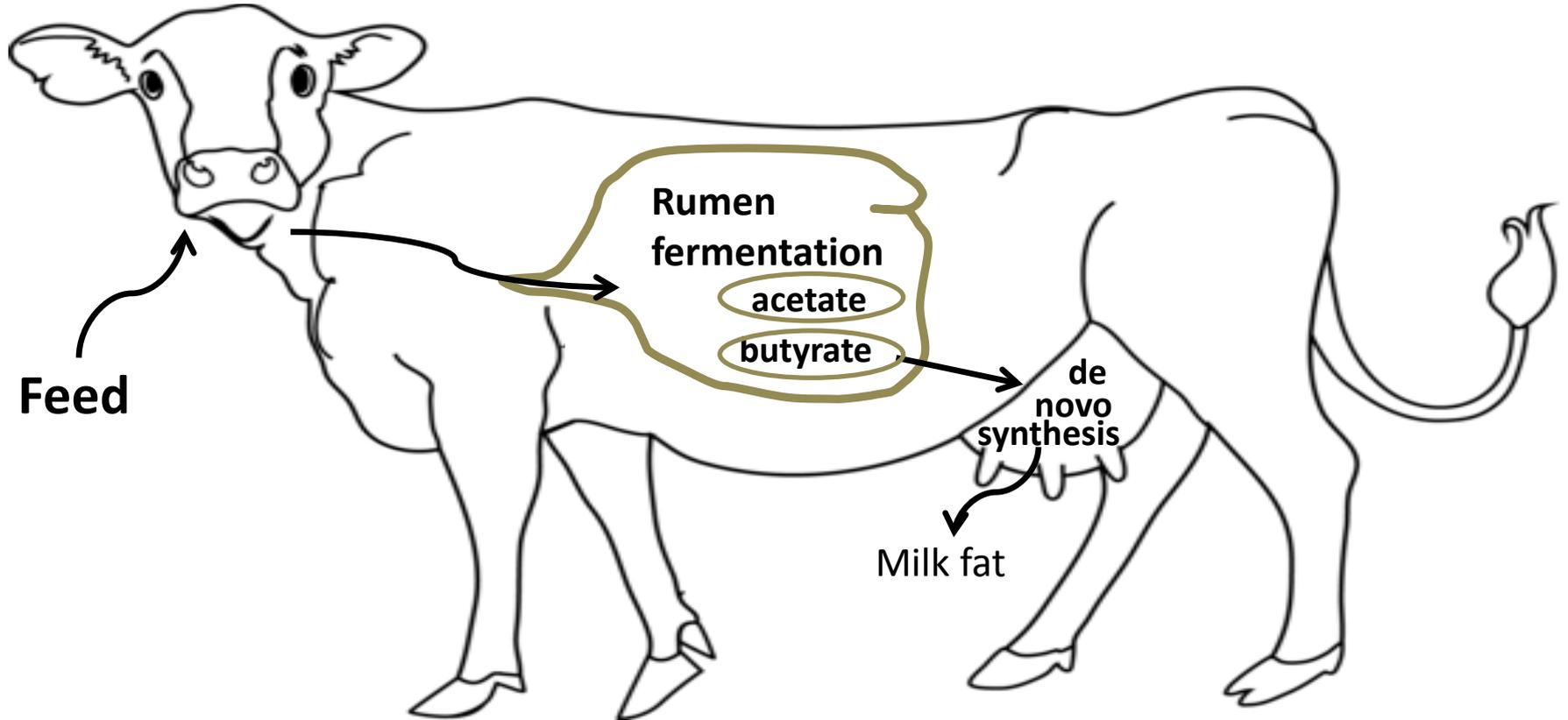
De novo

Mixed

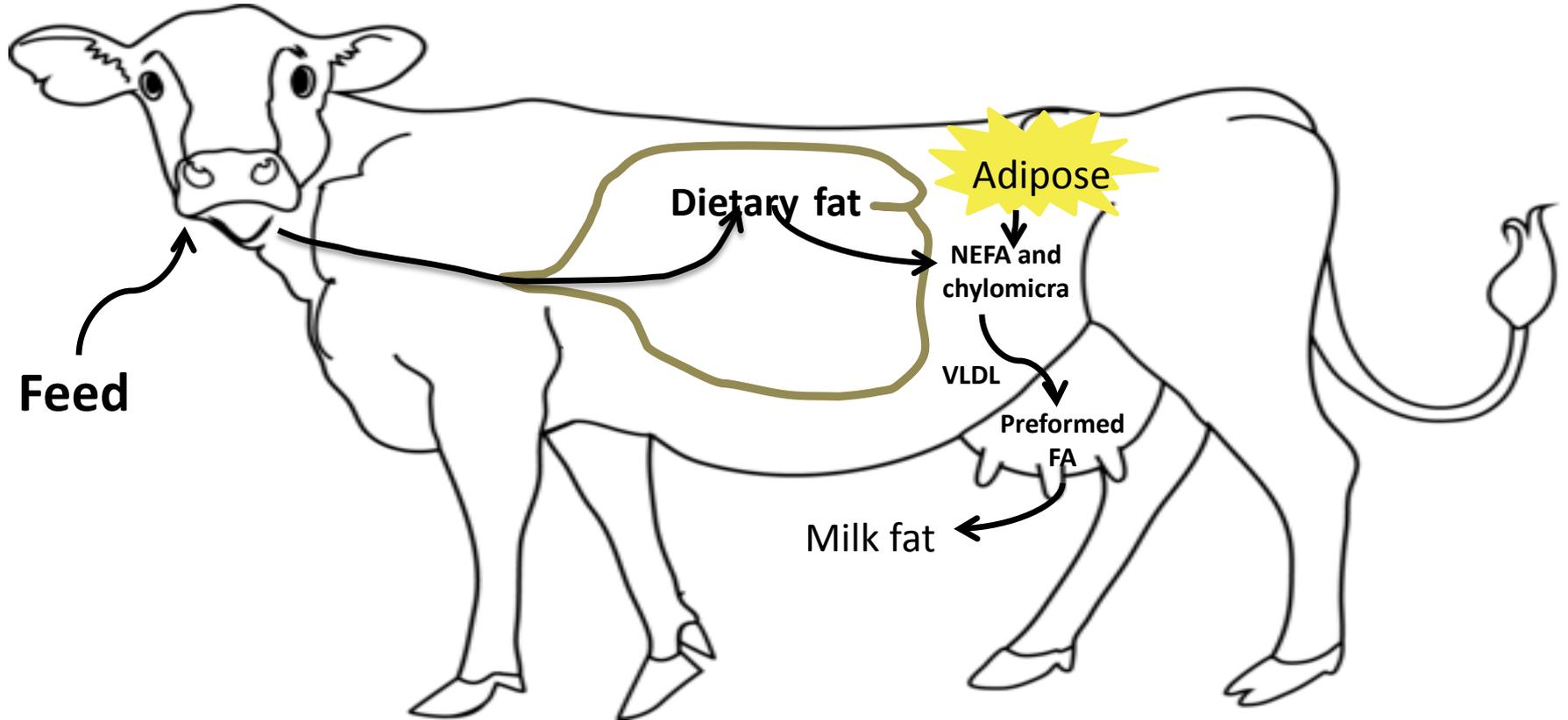
Preformed



De novo Fatty Acid Synthesis



Preformed Fatty Acids



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.

Outline

- Where are we at on the “cow of interest”?
- **Review of herd level milk fatty acid analysis and interpretation.**

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

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

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.

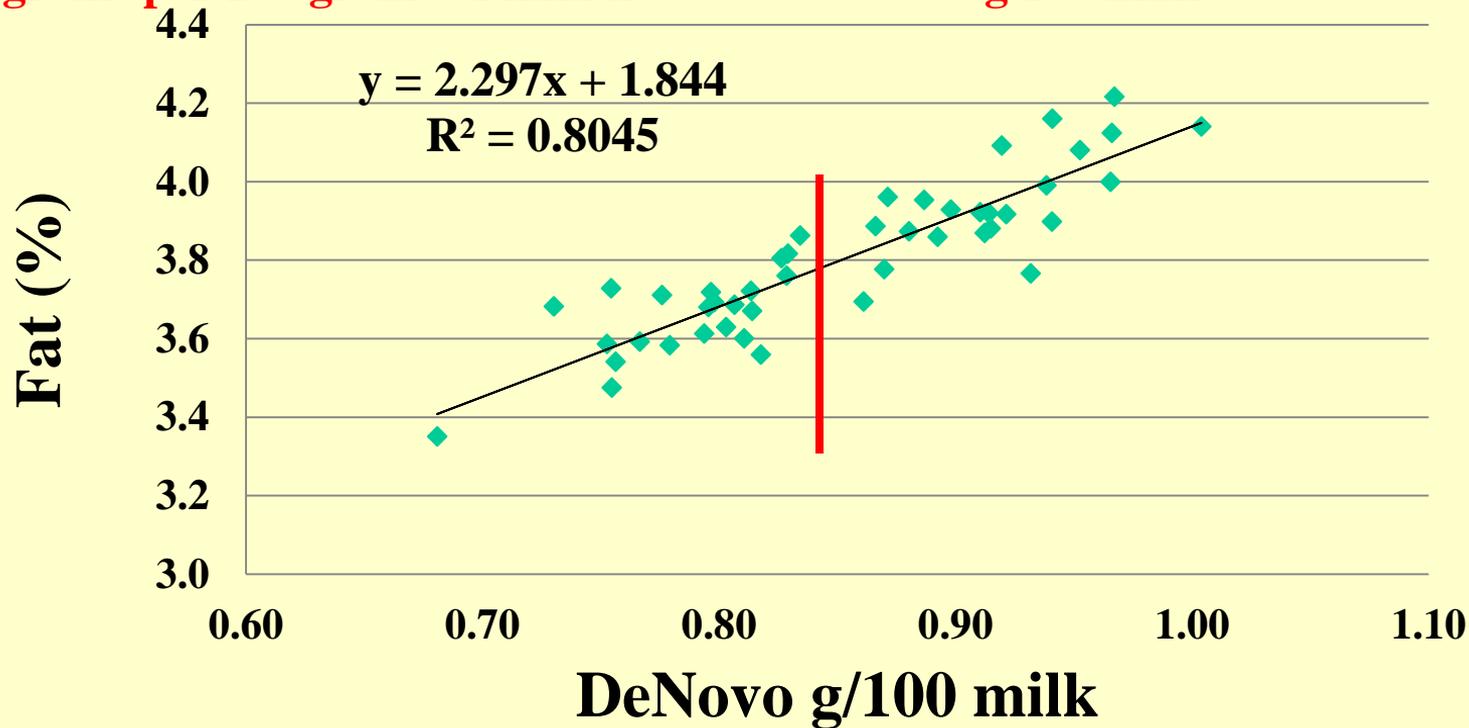
Higher average ether extract in the ration for lower de novo fatty acid farms.

Higher peNDF as a % of DM for the high de novo fatty acid farms (26.8 vs 21.4%) ($P < 0.01$)

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

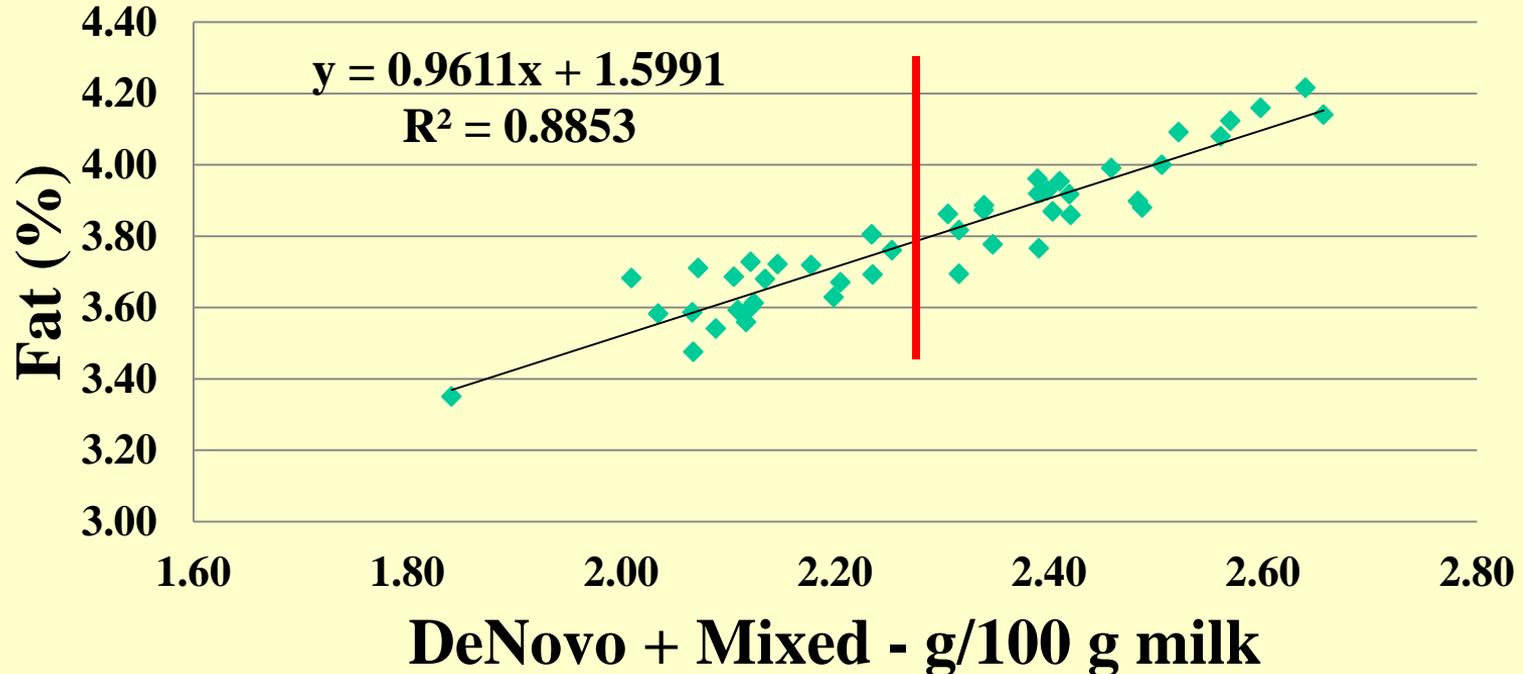


40 Farms Holstein Farms 2015

St Albans - Fat

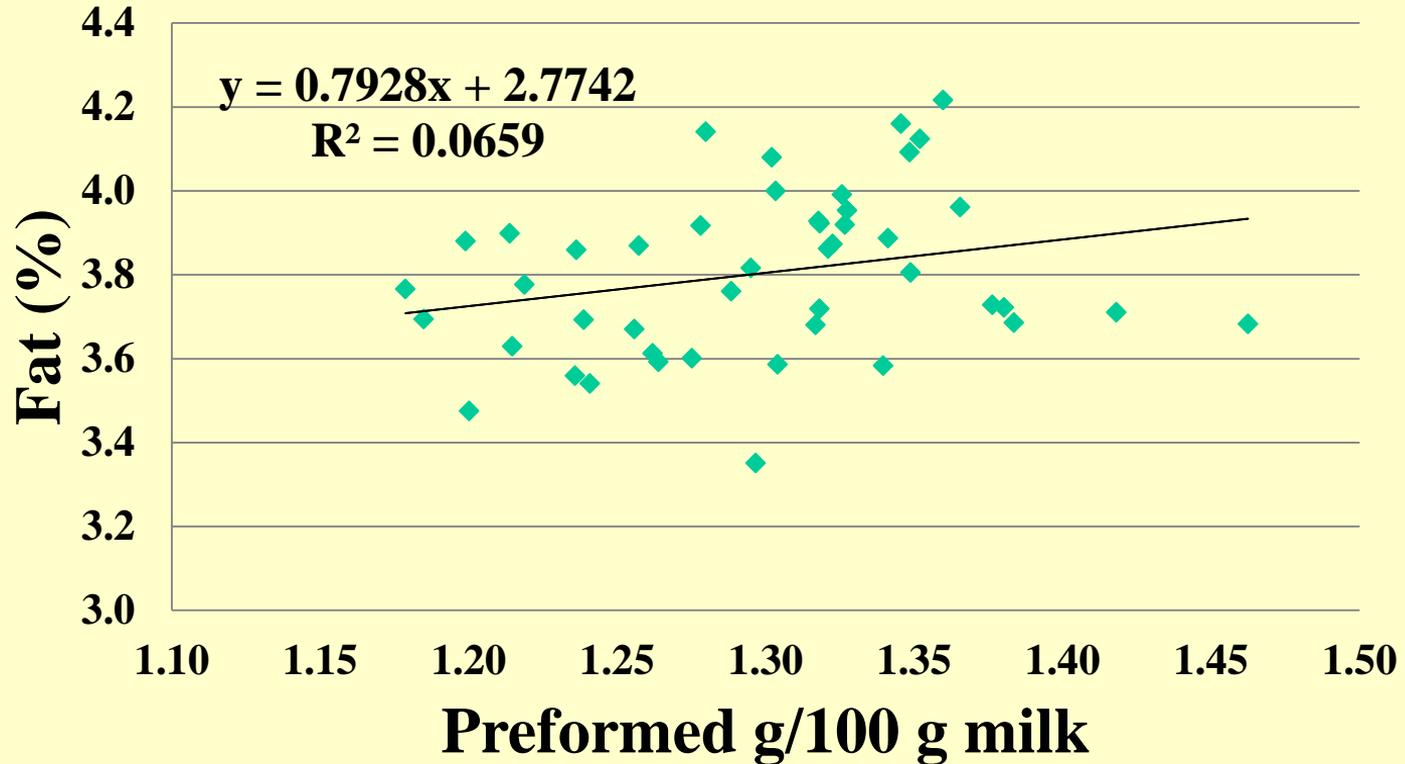
If you want a fat test > 3.75% fat in bulk tank with Holsteins, then the denovo + mixed fatty acids in grams per 100 grams of milk needs to be > 2.25 g/100 milk

Fat % vs DN + Mixed g/100 g Milk



40 Holstein Farms 2015

St Albans - Fat

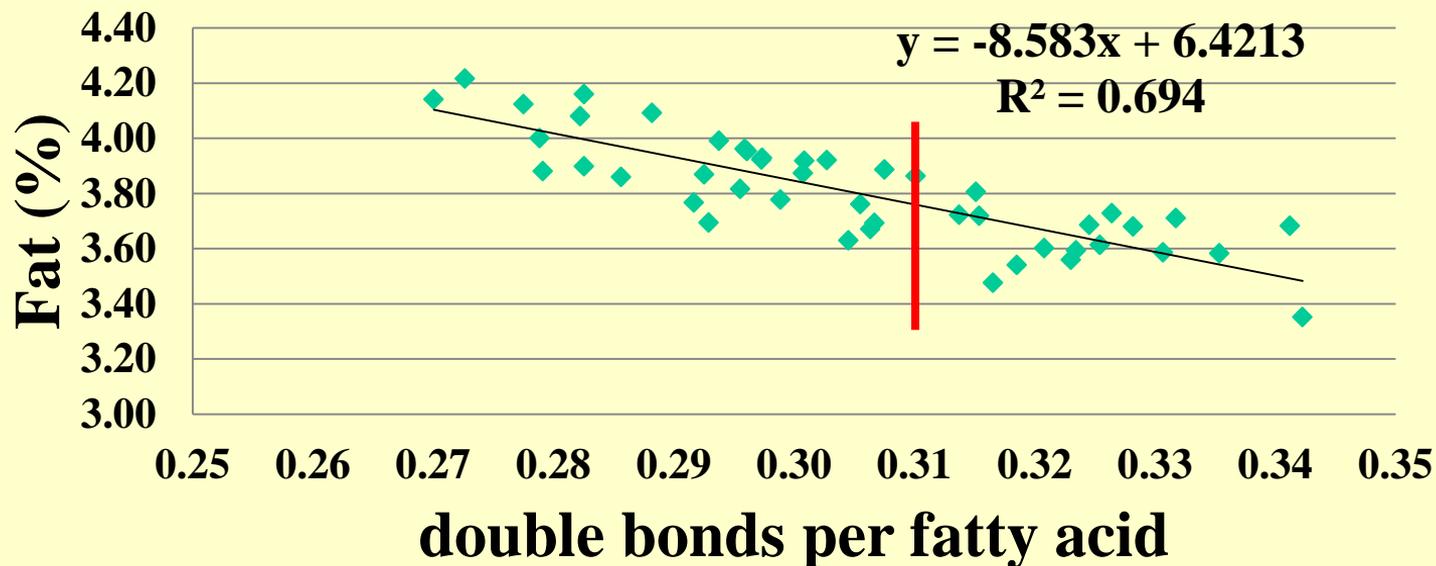


40 Holstein Farms 2015

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.

Fat % vs double bonds per fatty acid

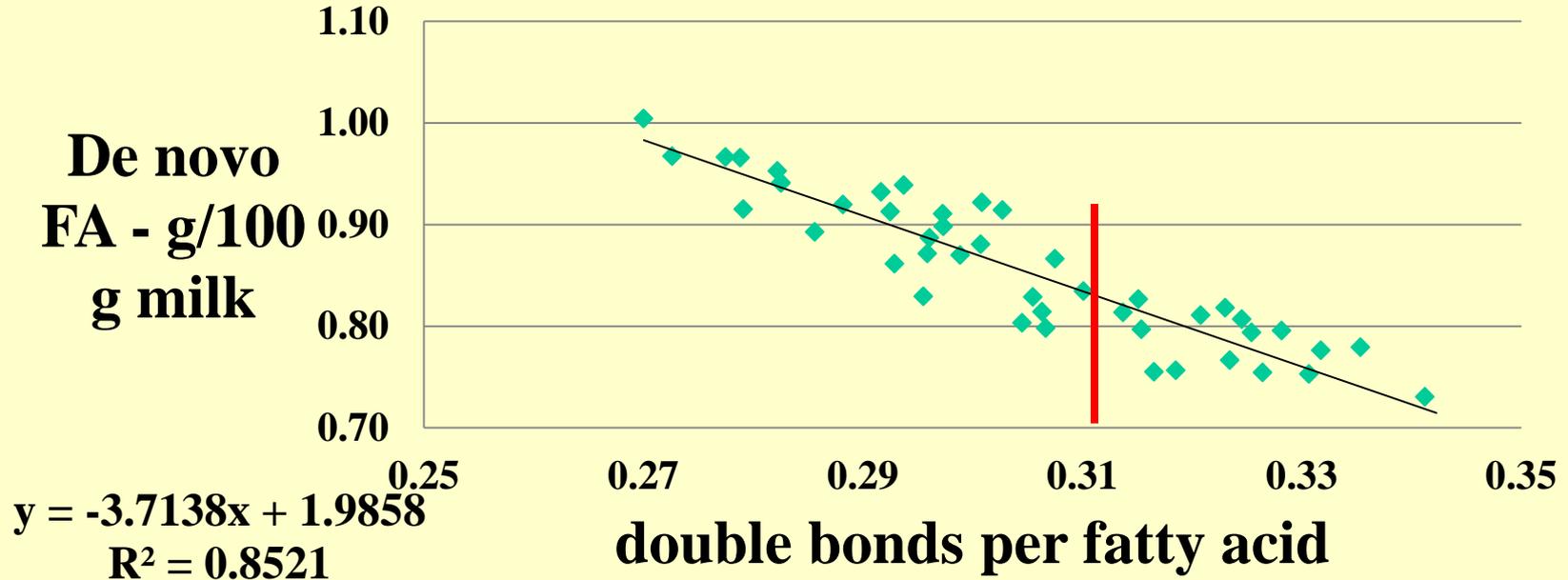


40 Holstein Farms 2015

St Albans – Milk Fat Depression

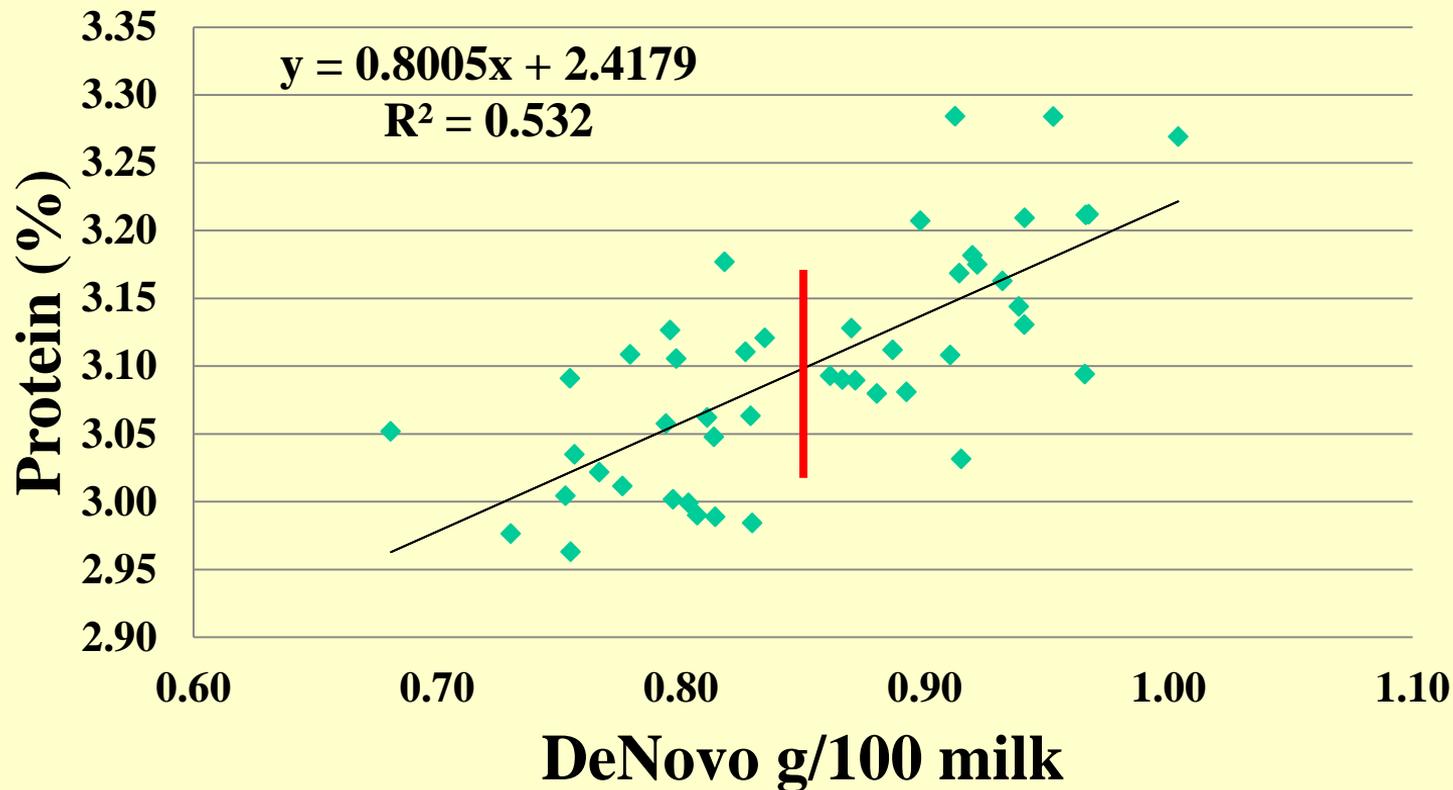
As double bonds per fatty acid increases in milk fat, the output of de novo fatty acids decreases. This metric seems to indicate the overall level of milk fat depression

de novo fatty acids vs double bonds per fatty acid



40 Holstein Farms 2015

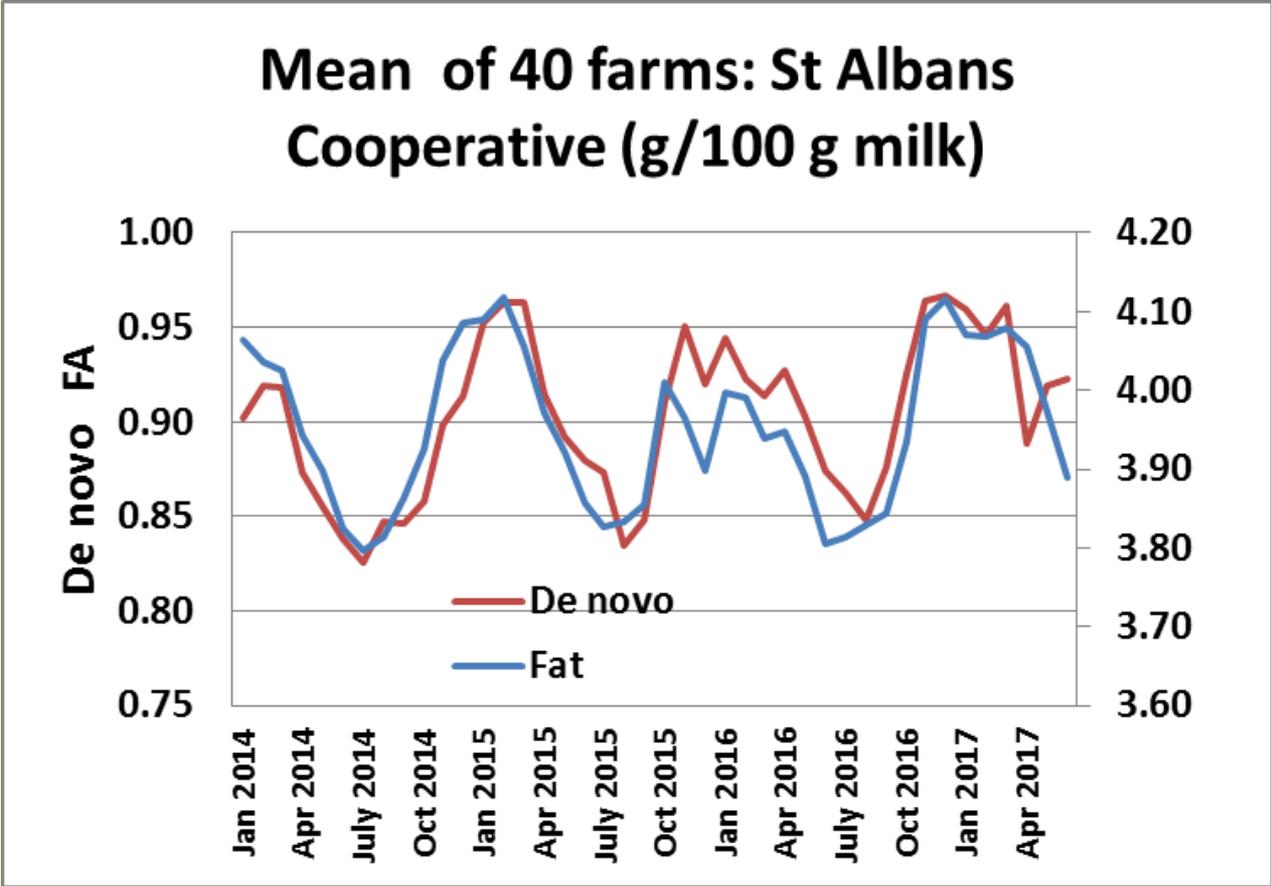
St Albans - Protein



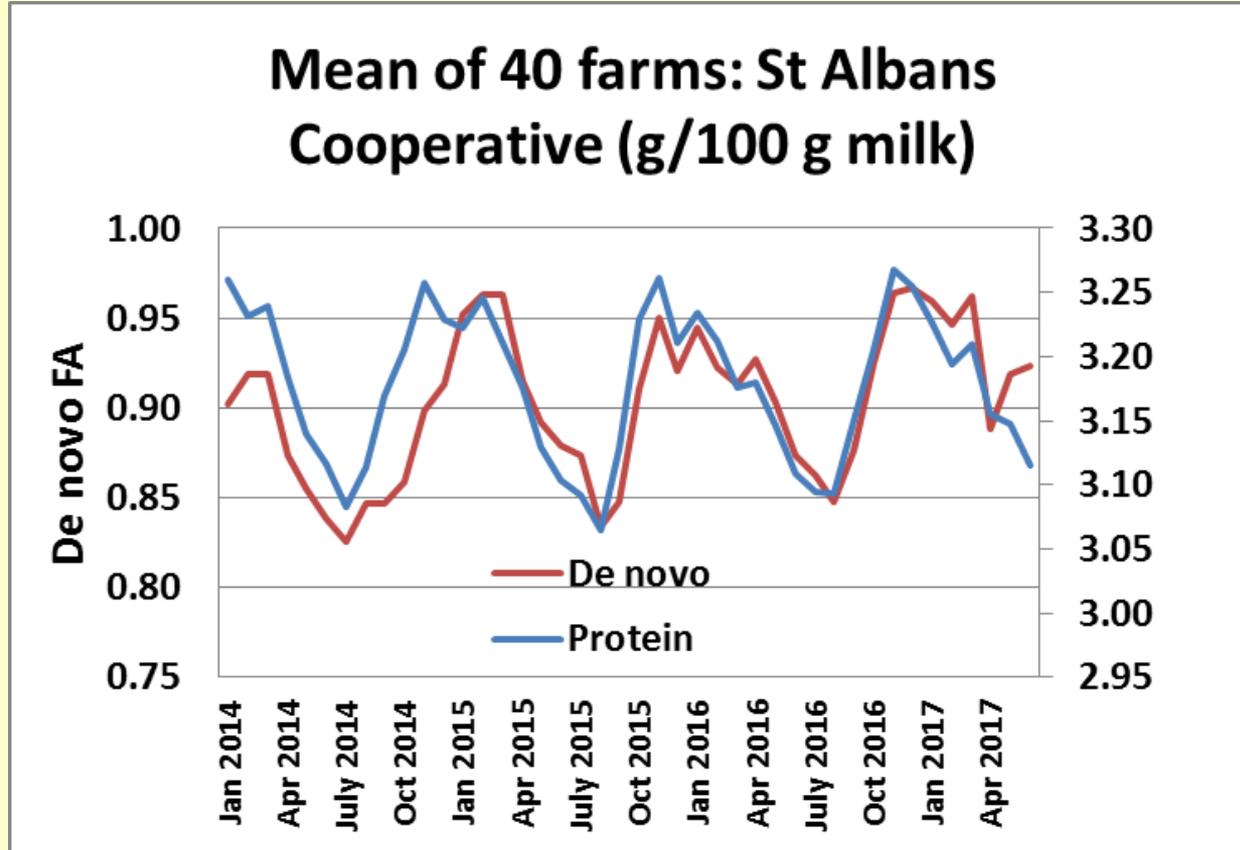
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Seasonality of Bulk Tank Milk - Fat



Seasonality of Bulk Tank Milk – Protein

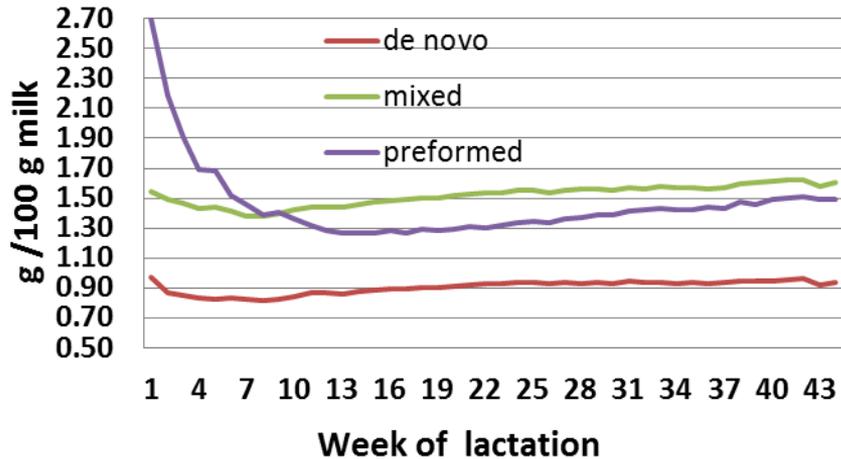


Outline

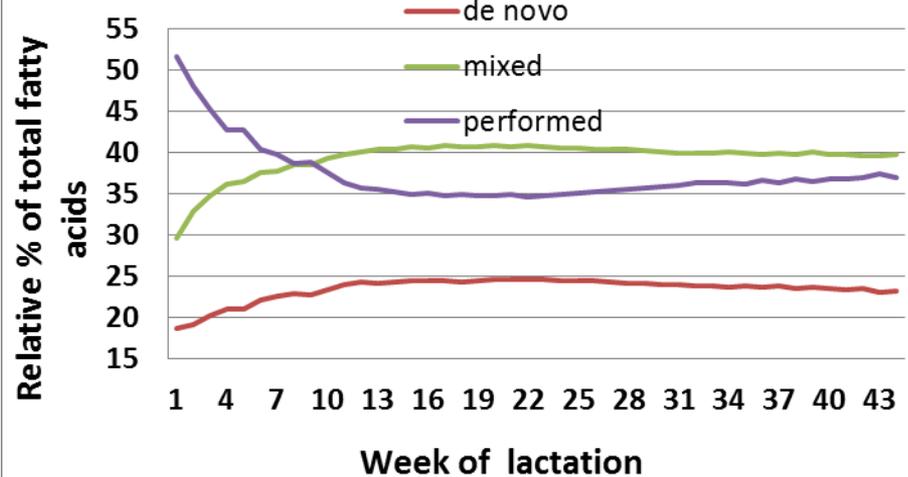
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Stage of Lactation – Holstein

De novo, mixed and preformed FA



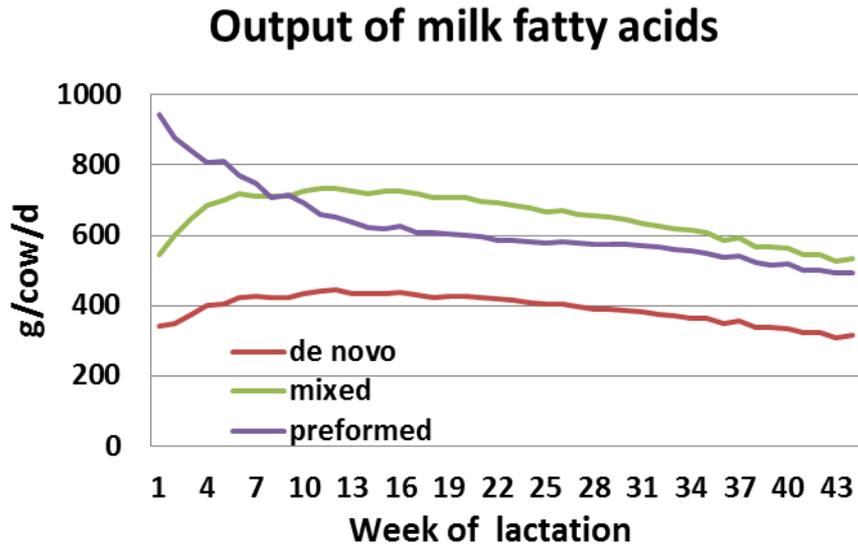
De novo, mixed, preformed FA



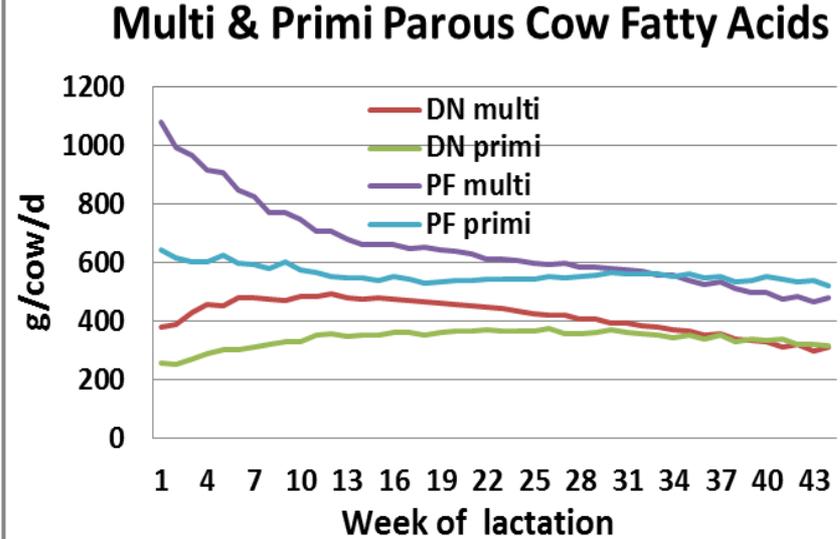
Herd producing an average of about 92 lb (41.77 kg) per cow per day on TMR feeding system.

Stage of Lactation – Holstein

All Cows



DN & PF by Parity

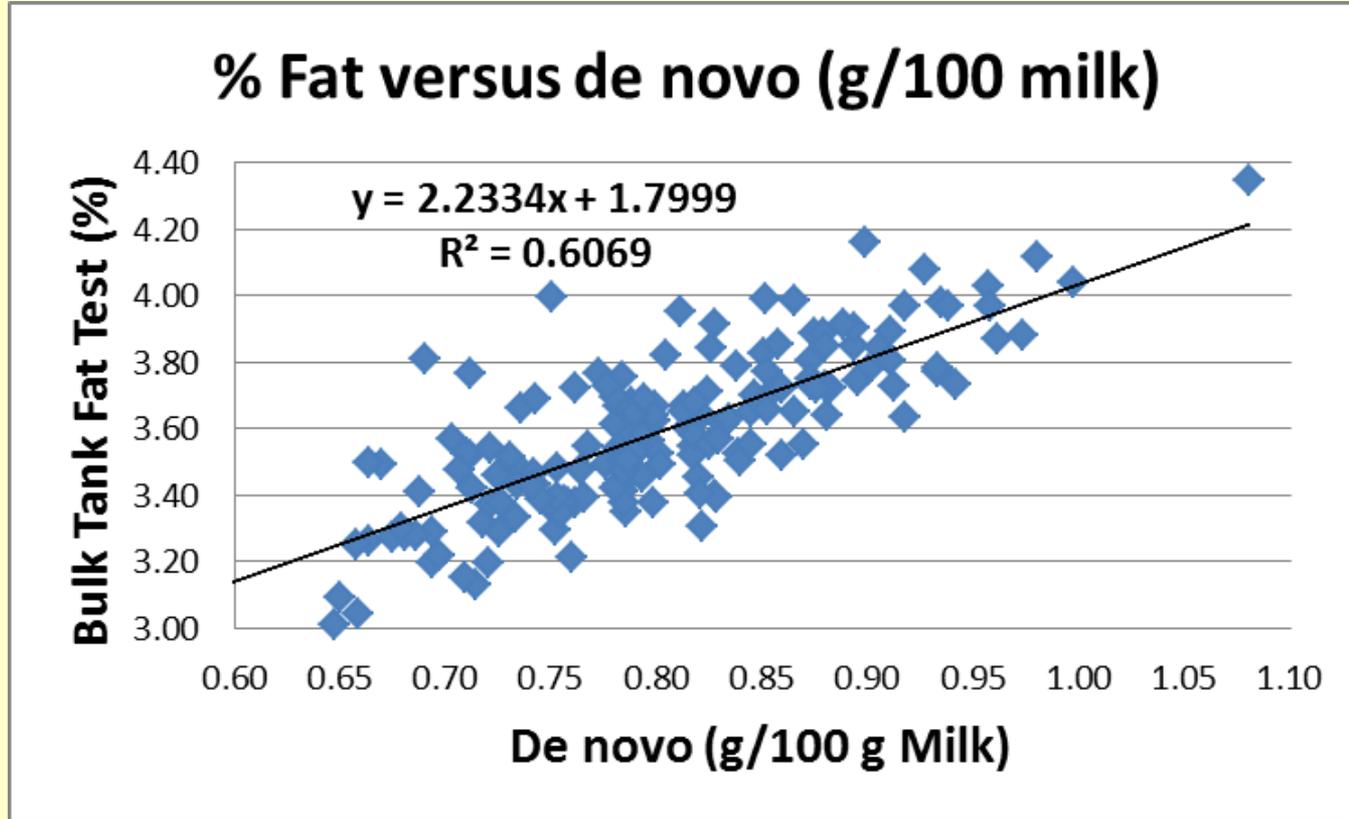


Herd producing an average of about 92 lb (41.77 kg) per cow per day on TMR feeding system.

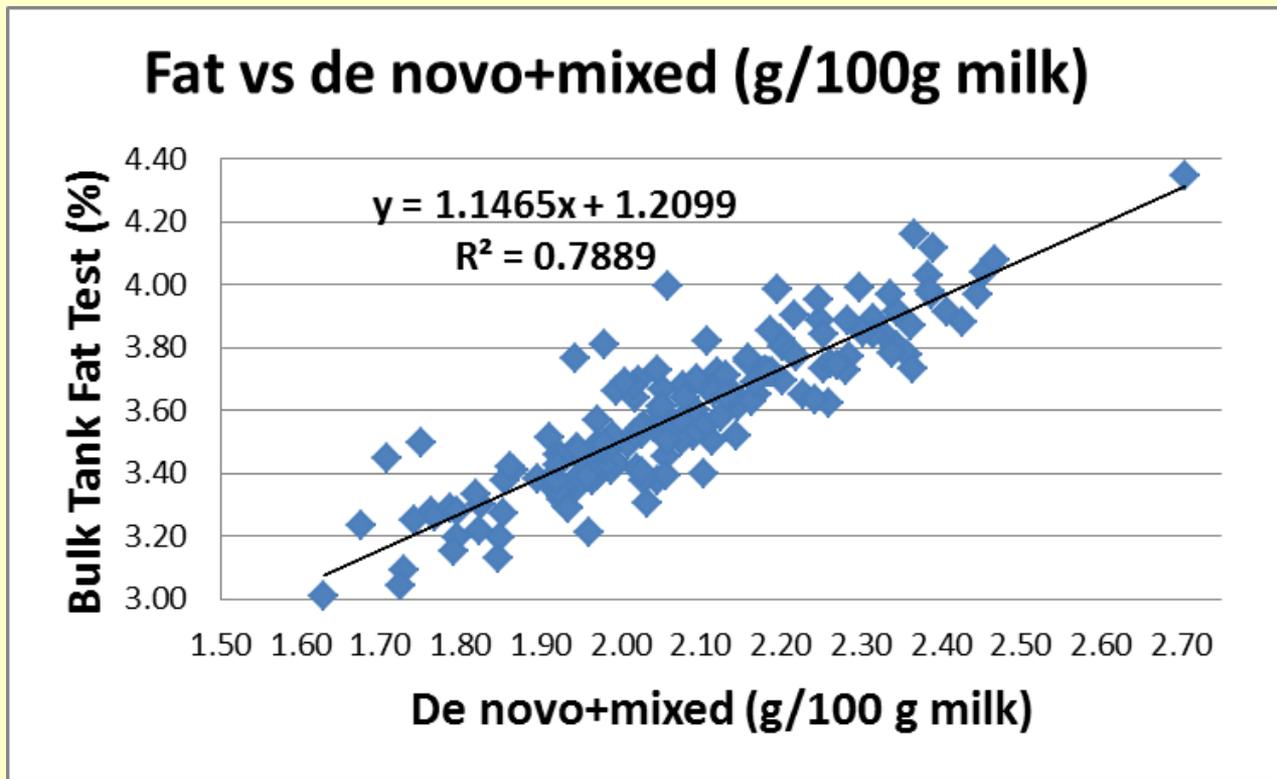
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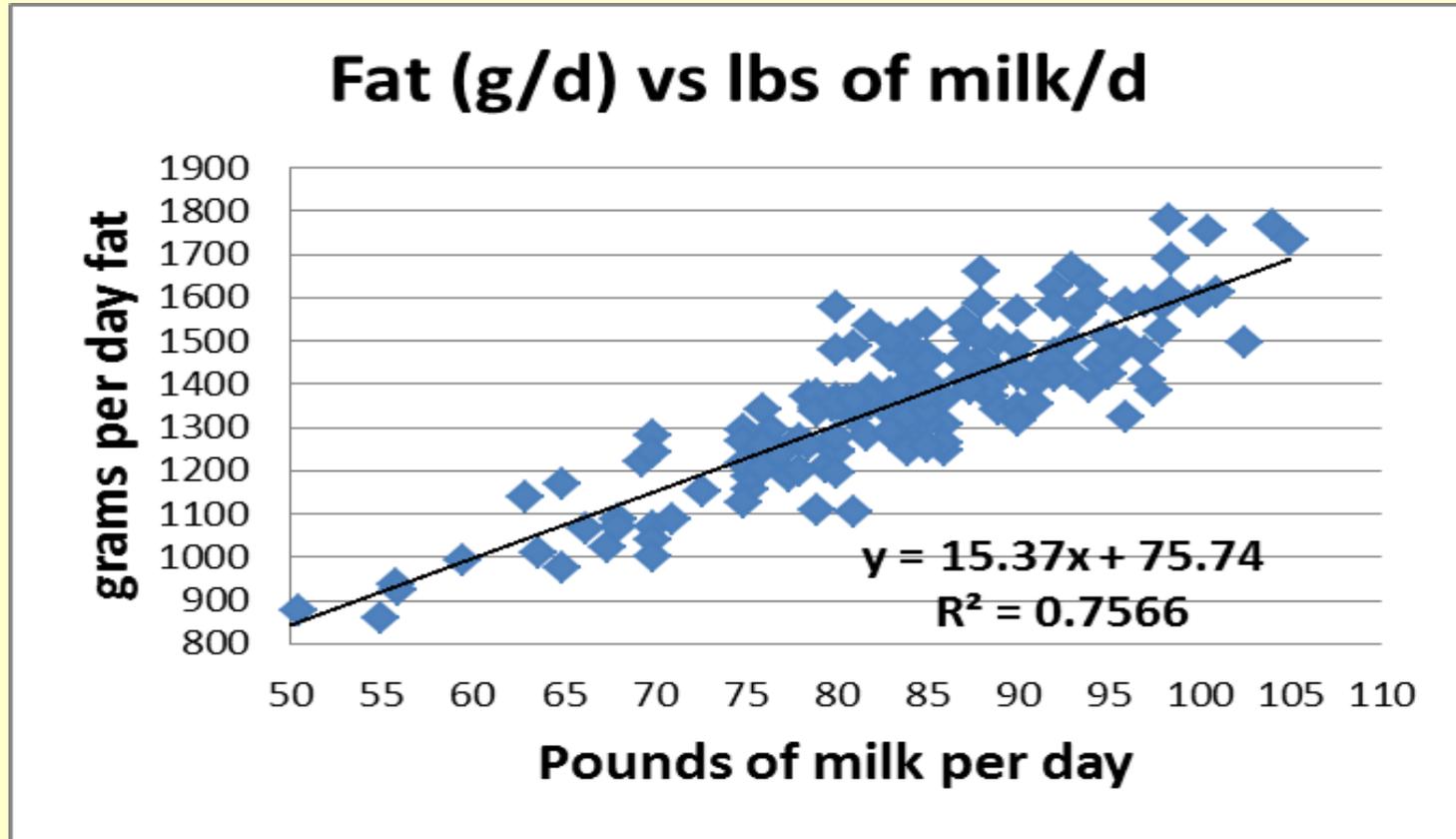
Bulk Tank Milk – 167 Farms - Fat



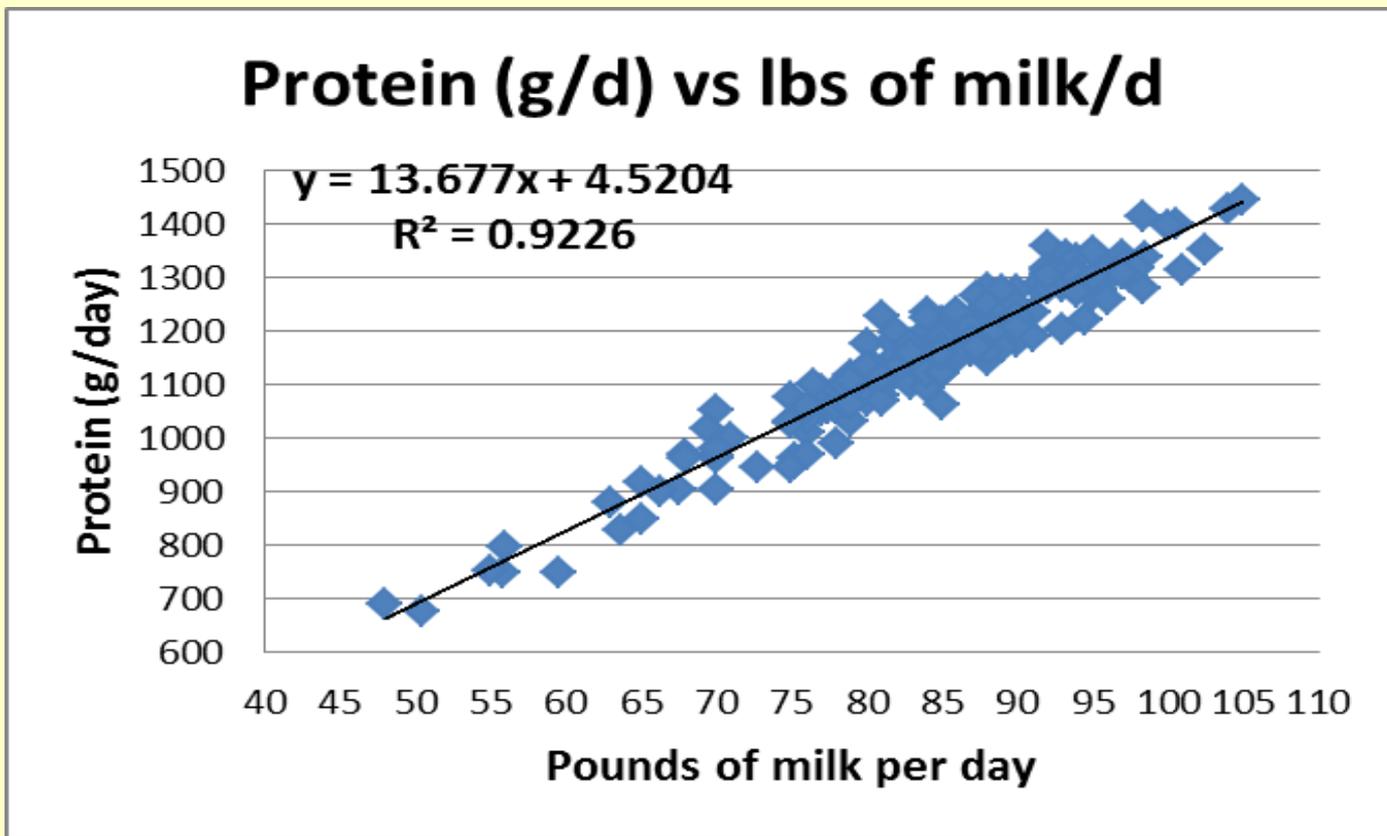
Bulk Tank Milk – 167 Farms - Fat



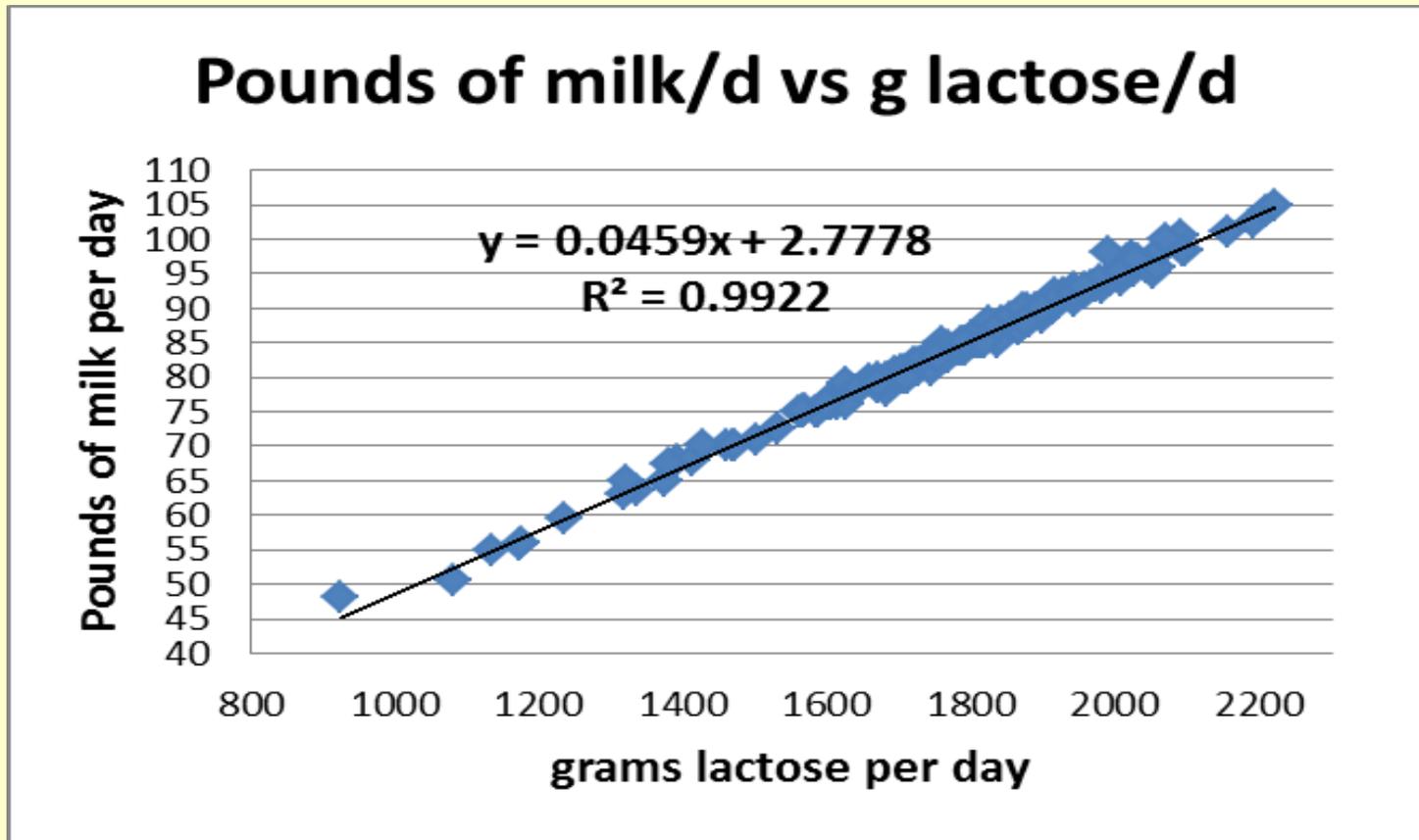
Bulk Tank Milk – 167 Farms - Fat



Bulk Tank Milk – 167 Farms - Protein



Bulk Tank Milk – 167 Farms - Lactose



Bulk Tank Milk – Questions

For milk composition data from an individual farm the following data are useful for the full herd or for groups of cows in combination with information on feed composition and management practices:

Milk per cow per day

Milking frequency (2X or 3X) – milk and component output expected to be 10 to 15% higher on 3X farms

Milk SCC (cells/mL)

Milk MUN (mg/dL or mg/100 g milk)

Milk fat unsaturation (double bonds per fatty acid)

Milk fat (g/100 g milk and g/day production)

Milk protein (g/100 g milk and g/day production)

Milk lactose (g/100 g milk and g/day production)

Milk de novo fatty acids (g/100 g milk and g/day production)

Milk mixed origin fatty acids (g/100 g milk and g/day production)

Milk preformed fatty acids (g/100 g milk and g/day production)

Bulk Tank Milk – Questions

Lactose: grams per cow per day.

When milk production per cow per day is low, synthesis of lactose is low.

If a 3X Holstein multiparous cow is going to produce a lactation average of > 85 lb (38.6 kg) of milk per day, then she is going to need to produce at least an average of 1800 grams of anhydrous lactose per day. This is the foundation upon which to build high fat and protein output per cow per day.

Bulk Tank Milk – Questions

Lactose: grams per cow per day.

To achieve a high output of lactose per cow per day, glucose supply, transport, and metabolism needs to be working very well.

Factors to consider are the production of propionate produced in the rumen and the un-degraded starch that is leaving the rumen and available in the lower gastrointestinal tract.

When milk production per cow per day is low, is there some cow health issue (immune system activation – mastitis, laminitis, leaky gut, etc.) or environmental factors (e.g., thermal stress) in the herd that is putting a demand on the glucose supply and reducing the glucose available for milk lactose synthesis?

Bulk Tank Milk – Questions

Milk urea nitrogen: mg/100 g milk.

What is the concentration and day to day variation in MUN?

If the MUN is >14 to 16, it is likely that rumen ammonia levels are too high.

Another aspect of MUN is to look at the day-to-day variation in MUN within the same farm. MUN decreases rapidly when cows do not have access to feed.

Thus, day-to day-variation in MUN within the same farm is an index of how consistently the farm is keeping feed accessible to cows (i.e., feed bunk management).

Bulk Tank Milk – Questions

De novo and mixed origin fatty acids: g/100 g milk.

There is a strong correlation between changes on de novo FA concentration in milk and bulk tank milk fat and protein tests.

In general, when de novo (> 0.85 g/100 g milk) and mixed origin FA (>1.35 g/100 g milk) are high, it is an indication that rumen fermentation of carbohydrate is working well and the supply of volatile fatty acids from the rumen is good.

This can be the case with either a high or low level of milk (i.e., lactose) production. Increased lactose synthesis is needed to maintain high milk output per cow but with that will come an increase the per day output of fat (from de novo and mixed origin fatty acids) and protein given an adequate supply of amino acid precursors. High de novo fatty acids will probably mean a high rumen microbial biomass and a high availability of essential amino acids produced by the rumen microbes.

Bulk Tank Milk – Questions

FA chain length and double bonds per fatty.

Chain length and double bonds per fatty acid are useful indices of what is happening in the rumen, but they are less of a driver and more of a correlated outcome of changes in de novo fatty acid synthesis.

In general, as double bonds per FA increases milk fat decreases. A rule of thumb based on our observations for Holstein herds is that when the double bonds per FA is > 0.31 , the probability of trans FA induced milk fat depression is greatly increased for Holsteins.

A word of **caution** is that **there is a large stage of lactation impact on double bonds per FA** and cows in the transition period will have a high double bond per FA without having trans FA induced milk fat depression. Thus, be careful with interpretation of milk fat unsaturation on groups of early lactation cows.

Conclusions

- 1. Seasonality in fat and protein content of bulk tank milk is related to seasonality in de novo fatty acid levels in milk.**
- 2. Stage of lactation has a large impact on milk fatty acid composition and when evaluating milk fatty acid data from feeding groups within a herd, mean days in milk needs to be considered when interpreting data.**
- 3. The relationship between variation in milk fatty acid composition and bulk tank milk fat and protein content for Holstein herds in the Northeast US is consistent with data collected from a wide diversity of 167 Holstein farms from across North America.**

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Future Directions – New Metrics

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?

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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Shawn Landersz for “Cow of Interest” video production.

www.landertz.com

Questions??

