Maximizing Milk Fat Yield

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Thoughts on adapting in ”Historic” times

- **High feed and other input prices**
  - Feed efficiency becomes more important for profitability
  - Profitability depends on your cost to make each milk component
    - Think about “marginal” cost and profit
      - Different return for each ingredient
  - You can’t lose milk yield when chasing increased fat concentration!
- **Long vs. short term decisions**
  - Short-term adjustments to match the current market
  - Long-term planning for the future based on your vision of future markets and opportunities

How to feed for more milk fat?

We need to think about what the cow needs to make milk fat?

~45% made from scratch by "de novo" synthesis
Acetate, glucose, and a little bit of butyrate
- High quality forages and good rumen fermentation

~55% taken up from the blood as preformed fatty acids
85% of this directly from absorption of dietary fat

…so think about good rumen fermentation and dietary fat

What should you be thinking about to maximize milk fat concentration and yield

1. Set your goal
   - Seasonal pattern
   - Genetics

2. Balance the diet
   - Unsaturated fat
   - Fermentability
   - Fiber digestibility
   - Fat supply
   - Additives

3. Manage the feeding system
   - Feed mixing and delivery
   - Reduce slug feeding

4. Monitor and adjust
   - Milk fat concentration
   - De novo and *trans*-10 C18:1
   - Responses in 7 to 10 d

Also- overall good management to maintain optimal milk yield (cow comfort, reproduction etc)

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Milk fat is affected by many nutritional and non-nutritional factors!

Nutritional Factors

Decreased by “biohydrogenation-induced” milk fat depression
- Unsaturated fat
- Fermentability
- Acidosis
- Feeding strategies
  - slug feeding/eating
  - sorting

Increase by additional substrate
- Acetate from forages
- Fat supplement
  - Palmitic acid

Milk Fat

Non-nutritional Factors

Genetics

Season

Time of day

Stage of lactation

Parity

Milk yield
(impacts yield potential!)

You can think of the mammary gland as a milk synthesis "factory" with three assembly lines:

Fat, Protein, and Lactose

- **There is coordinated regulation of these three assembly lines**

  …….. and also some differential regulation

- We need to turn on the assembly line and make sure enough substrate is available to keep it running!

Do not forget about “milk flow”: You can’t give up much yield when seeking to increase milk fat or protein (especially if paid for protein!)

Fat Yield = Milk Yield * Fat %

Fat Yield, kg

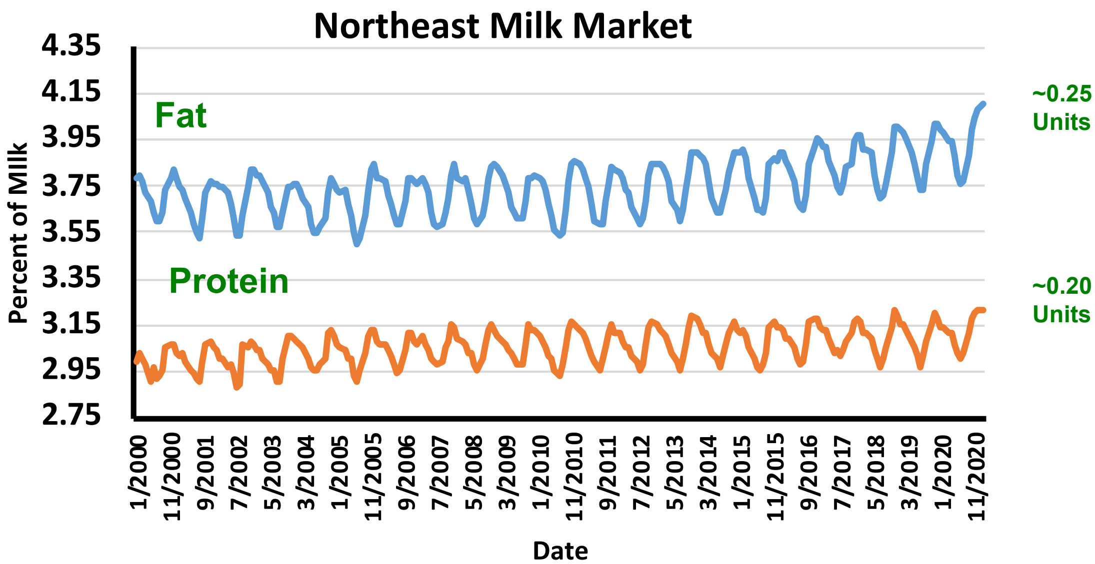
	Milk Fat, %	
Milk, kg	**4.0**	**4.1**
36.0	1.44	1.48
36.9	1.48	1.51

Protein+Fat Yield, kg

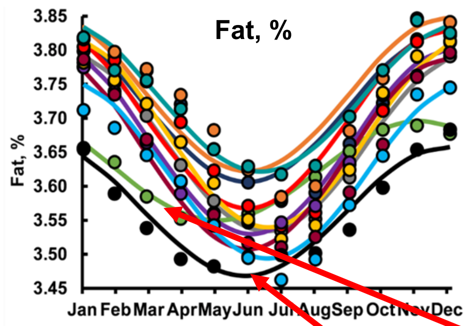
	Fat+Protein, %	
Milk, kg	**7.0**	**7.1**
36.0	2.52	2.56
36.5	2.56	2.59

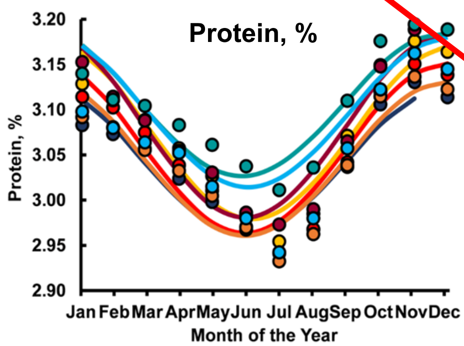
Harvatine Unpublished

Seasonal Pattern of Milk Fat & Protein: Northeast US Milk Market



Harvatine unpublished from USDA NASS





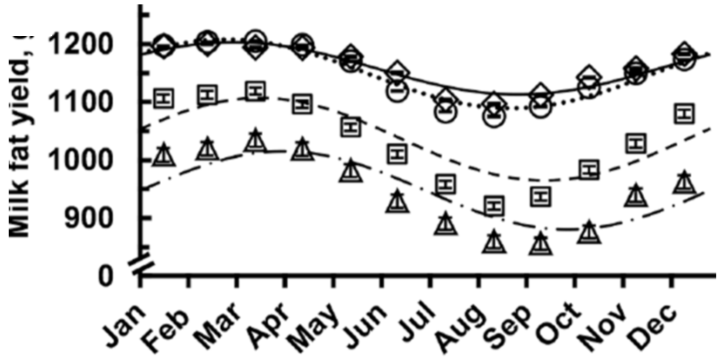
The annual rhythms of milk fat was different by region in the USA

- Northeast
- Florida
- Southeast
- Central
- Arizona-Las Vegas
- Western
- Appalachian
- Mideast
- Upper MW
- Southwest
- Pacific NW

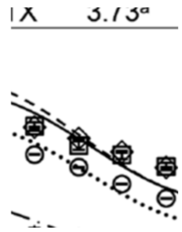
Item	Region	Amp	Acro	*P*-value
Fat, %	Northeast	0.11[b]	Dec 31[a]	< 0.001
	Appalachian	0.13[a]	Jan 17[bc]	< 0.001
	Florida	0.07[d]	Dec 4[d]	< 0.001
	Southeast	0.14[a]	Jan 3[a]	< 0.001
	Upper MW	0.11[b]	Dec 31[a]	< 0.001
	Central	0.14[a]	Jan 19[c]	< 0.001
	Mideast	0.13[a]	Dec 31[a]	< 0.001
	Pacific NW	0.11[b]	Jan 12[b]	< 0.001
	Southwest	0.14[a]	Dec 31[a]	< 0.001
	AZ-LV	0.09[c]	Dec 29[a]	< 0.001
	Western	0.13[a]	Jan 18[bc]	< 0.001
Protein, %	Northeast	0.08[c]	Dec 31	< 0.001
	Upper MW	0.09[bc]	Dec 30	< 0.001
	Central	0.10[ab]	Jan 6	< 0.001
	Mideast	0.09[ab]	Dec 30	< 0.001
	Pacific NW	0.08[c]	Dec 27	< 0.001
	Southwest	0.10[a]	Dec 30	< 0.001
	Western	0.08[abc]	Jan 2	< 0.001

Salfer et al. JDS 2019

There is also an annual rhythm to milk yield: Data from PA, MN, FL, and TX



State	Mean	Amp	Acro	*P*-valu
FL	948^{d}	67^{a}	Mar 31^{a}	< 0.000
MN	1158^{a}	45^{c}	Feb 27^{b}	< 0.000
PA	1149^{b}	59^{b}	Feb 23^{b}	< 0.000
TX	1035^{c}	71^{a}	Mar 13^{a}	< 0.000

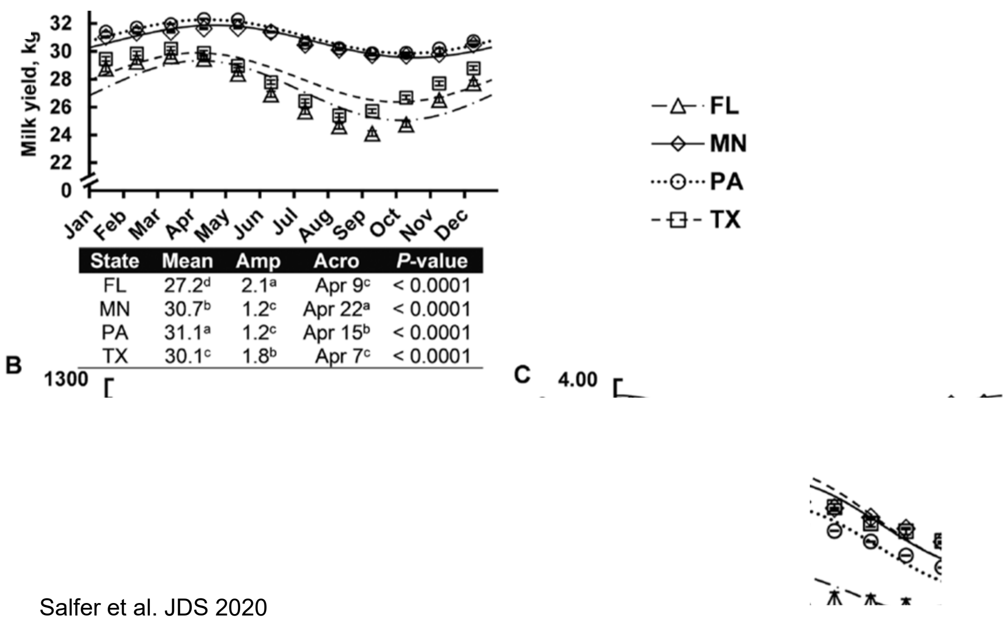


DHIA data from 2003 to 2016

764,196 records from 9,757 Holstein herds

Salfer et al. JDS 2020

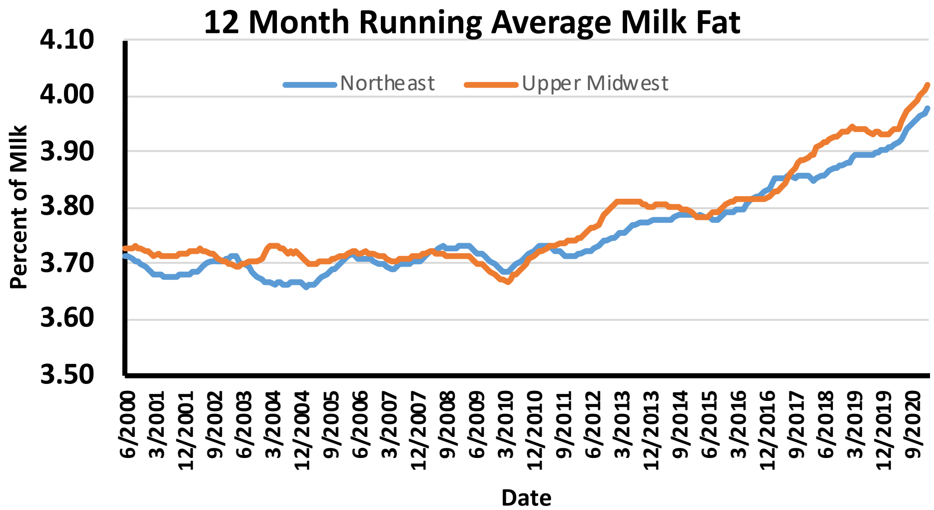
Milk fat percent peaks at end of year, but milk fat yield peaks in March and differ by region



State	Mean	Amp	Acro	*P*-value
FL	27.2[d]	2.1[a]	Apr 9[c]	< 0.0001
MN	30.7[b]	1.2[c]	Apr 22[a]	< 0.0001
PA	31.1[a]	1.2[c]	Apr 15[b]	< 0.0001
TX	30.1[c]	1.8[b]	Apr 7[c]	< 0.0001

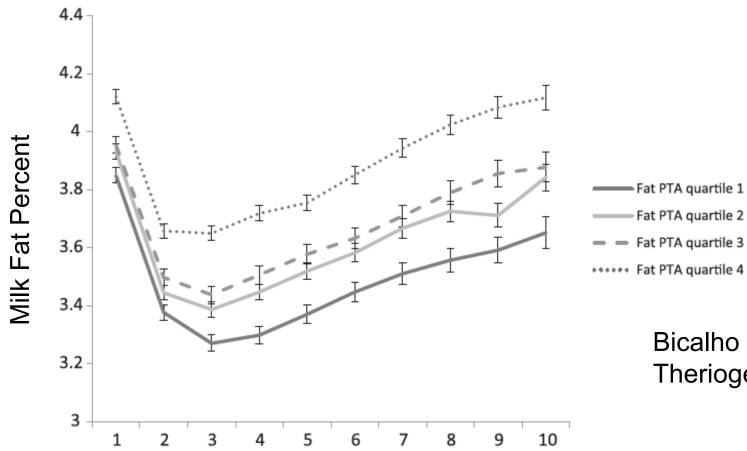
Salfer et al. JDS 2020

Overall milk fat concentration has been on a linear increase in the USA so need to have change your target!



Harvatine unpublished from USDA NASS

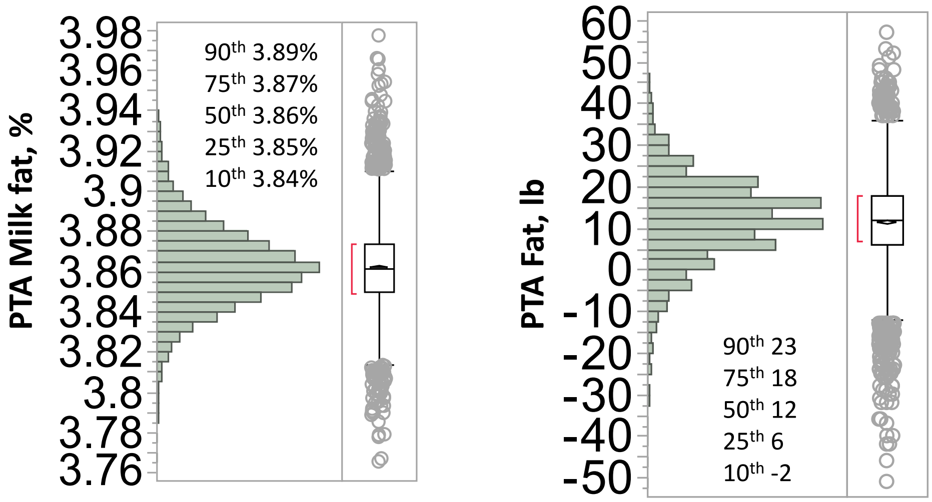
Milk fat is the most heritable production trait and PTA Fat gives an indication of genetic potential



Bicalho et al. 2014.
Theriogenology. 81:257-265

Fig. 2. The effect of sire predicted transmitting ability (PTA) for milk fat percentage quartile on milk fat percentage for the first 10 months of lactation. Data were analyzed using repeated measures ANOVA and the effect of animal nested within farm was controlled in the model as a random effect. Parity was also kept in the model as a fixed effect. Error bars represent 95% confidence interval of the mean.

There is very little difference between herds for genetic potential for milk fat

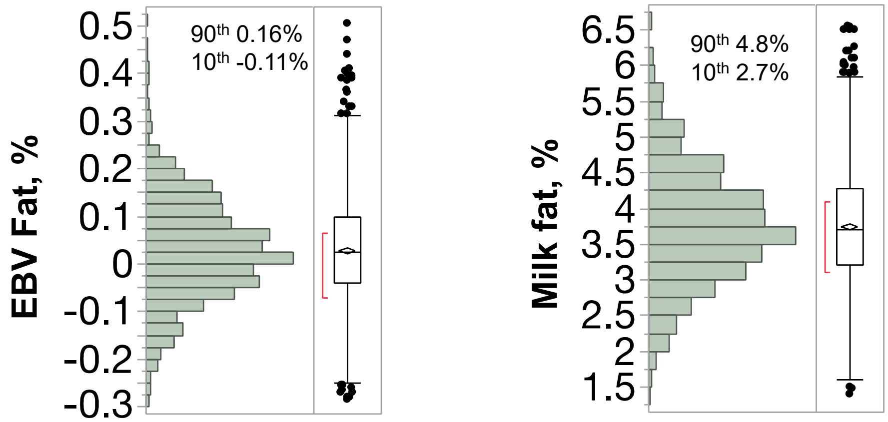


PTA Milk fat % = [(PTAF + 1006) / (PTAM + 26995)] * 100

(5926 DRMS Herds)

Harvatine Unpublished

But, there is larger variation in EBV and milk fat between cows within a herd

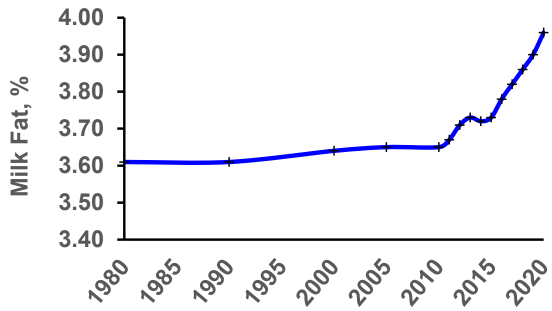


1720 cows from 5 herds

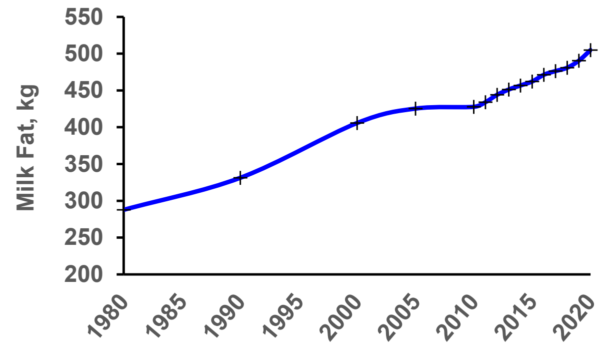
- Differences between cows also influenced by DIM, feeding behavior, sorting, and susceptibility to BH-induced milk fat depression

Harvatine Unpublished

Milk fat genetic potential of Holsteins has increased ~0.3 units and 71 kg in 10 years



From Center for Dairy
Cattle Breeding



Lets talk about nutrition:
Milk fat can be decreased by diet-Induced Milk Fat Depression (MFD)

Diet and management risk factors result in a change in the rumen microbes that produces bioactive "*trans*-10" FA intermediates

- **Up to a 50% reduction in milk fat**
- **Greater decrease in fatty acids made by the mammary gland (de novo)**

This is a very common cause of large decreases in milk fat yield, but is not meant to explain every change in milk fat!!!

Reviewed by Harvatine et al. 2009

We must manage the risk factors that cause “Biohydrogenation-Induced MFD”

- Dietary fatty acids
  - Level and profile
  - Rate of availability
- Diet fermentability
  - Carbohydrate profile
  - Rate and extent of fermentation
  - Effective fiber
- Adequate RDP/ Ruminal N balance
- Feeding strategies/management
- Ruminal acidosis
- Rumen modifiers- ionophore
- Silage fermentation/quality
- Forage types
- Individual cow effect (level of intake etc)

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

High producing cows normally most susceptible

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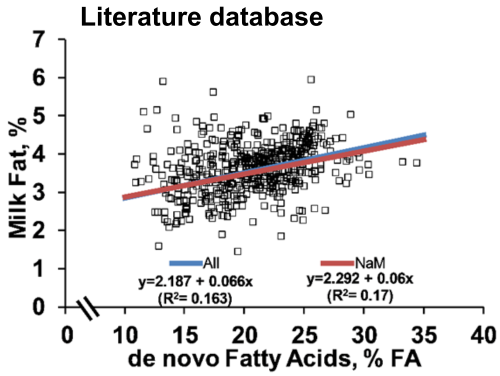
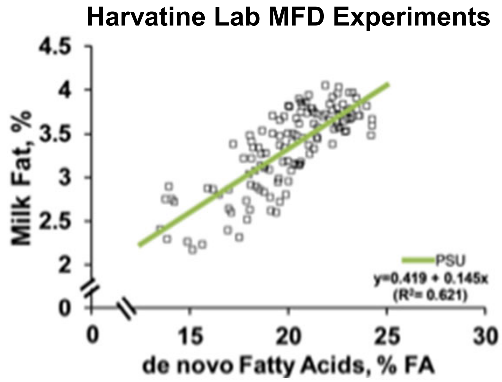
There is also a relationship between milk fat and de novo FA (<16 C), but it is not specific for MFD

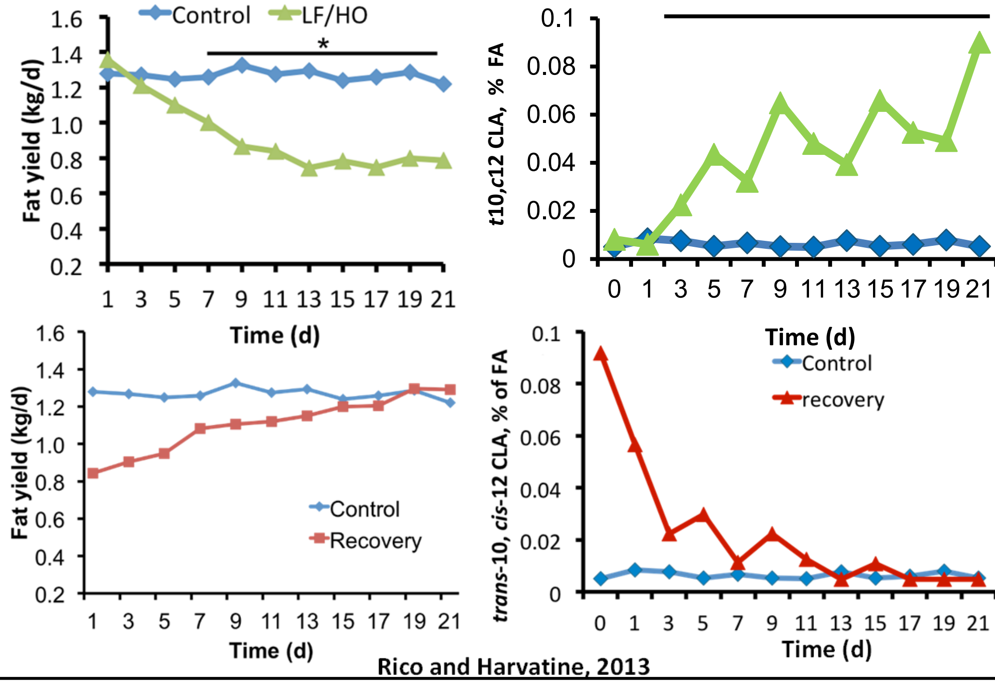




- <16 C FA can be predicted by MIR at some DHIA and payment labs
- Helpful data, but don't over-interpret!
- Best used to compare within herd over time or between herds with similar diets

Matamoros et al. JDS 2020

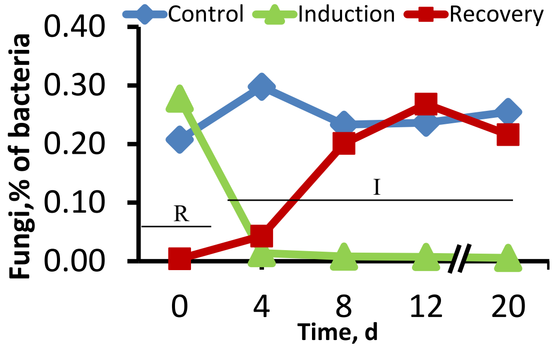
Diet-induced MFD occurs and can be fixed in 10 to 14 d



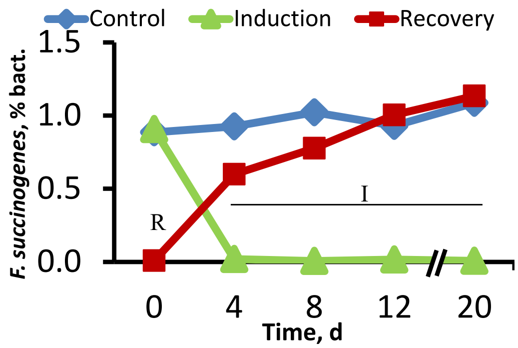
Rumen microbes change rapidly during diet-induced MFD

Total Fungi

	P value
Trt	<0.001
Trt x time	<0.001
SEM	1.18



I, R = *P* < 0.05



Fibrobacter succinogenes (Fiber digester)

	P value
Trt	<0.001
Trt x time	<0.001
SEM	0.13

Rico et al. Bri. J. Nutr. 2015

Unsaturated fatty acids are a big risk factor

1. Amount of unsaturated fatty acids

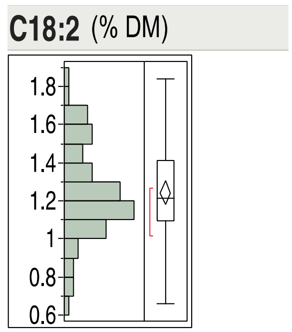
- Fatty acid concentration and profile
  - 18:2 more important than 18:1 and 18:3
    - 18:2 is higher in corn and soy
    - 18:1 higher in canola
    - 18:3 in forages and flax

2. Rate of availability of the fatty acids is very important

  - Cottonseed vs DDGS

- Hard to predict how much is too much!

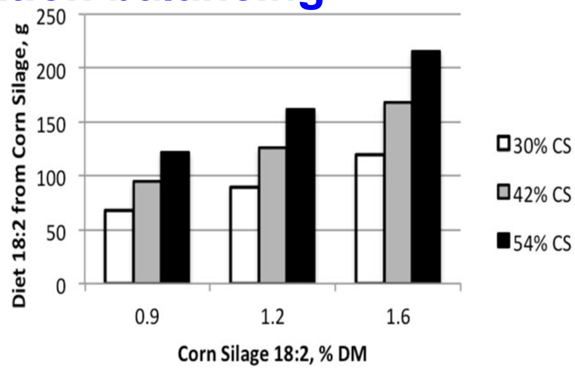
Corn silages differ in C18:2 and should be considered in ration balancing



Quantiles

90.0%		1.60384
75.0%	quartile	1.4094
50.0%	median	1.2167
25.0%	quartile	1.0954
10.0%		0.93576

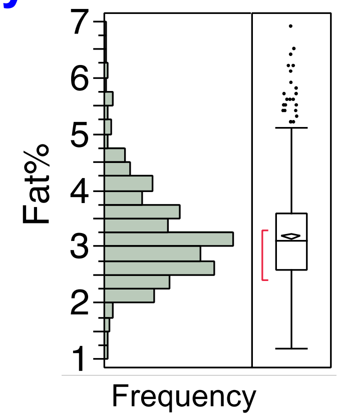
67 Corn Silages from Test Plots

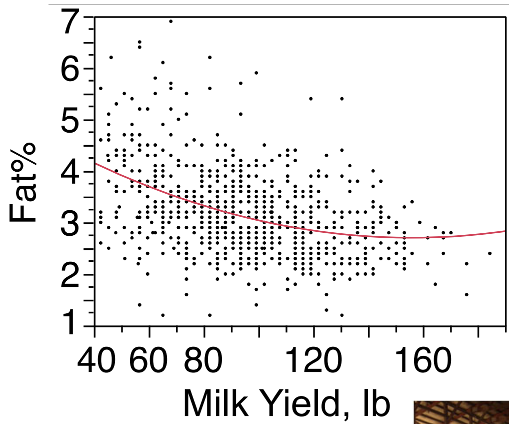


~60 to 90 g/d difference in C18:2 intake just in the corn silage

Baldin et al. JDS 2018

Milk fat depression increases as milk yield increases: 900 cow herd with MFD

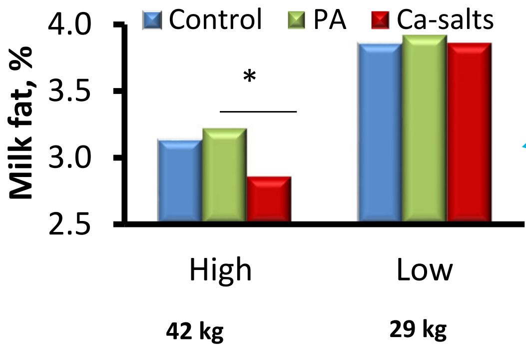




Overall Mean = 3.24%
< 34 kg = 3.8%
34 to 43 kg = 3.2%
>43 kg = 2.9%

Harvatine Slide 2015

Risk of MFD increases with increase milk yield



Milk fat concentration

	P value
Trt	<0.01
Level	<0.01
Trt x level	<0.05
SE	0.23

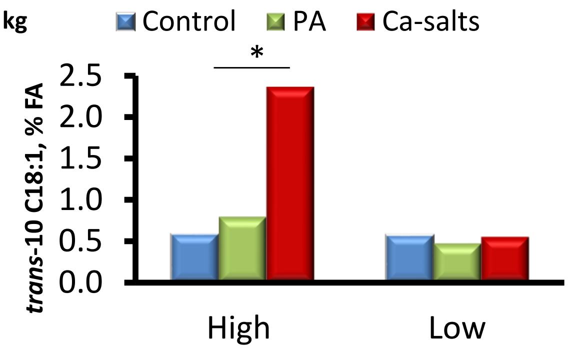
Alternative Pathway

***trans*-10 C18:1**

	P value
Trt	<0.001
Level	<0.001
Trt x level	<0.001
SE	0.18

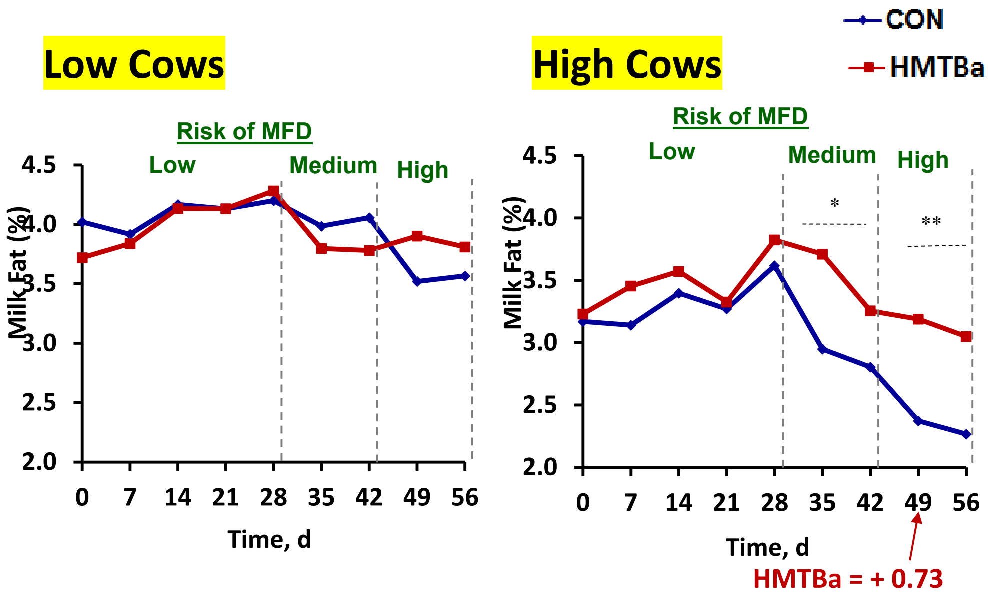
Con vs. PA , 1= P<0.05; 1†=P<0.1

PA vs Cal-salts, 2= P<0.05; 2†=P<0.1



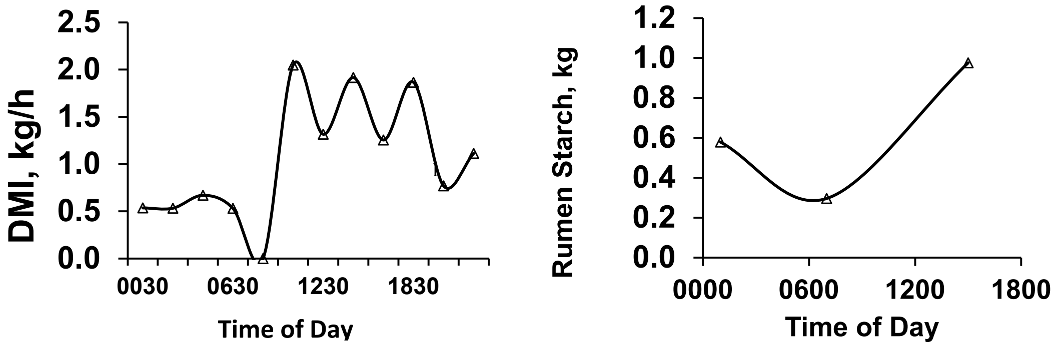
Rico et al. 2014

Rumen available methionine analog HMTBa reduces risk for MFD



Baldin et al., JDS 2018

We need to think about how and when cows are eating as this can disrupt rumen fermentation!



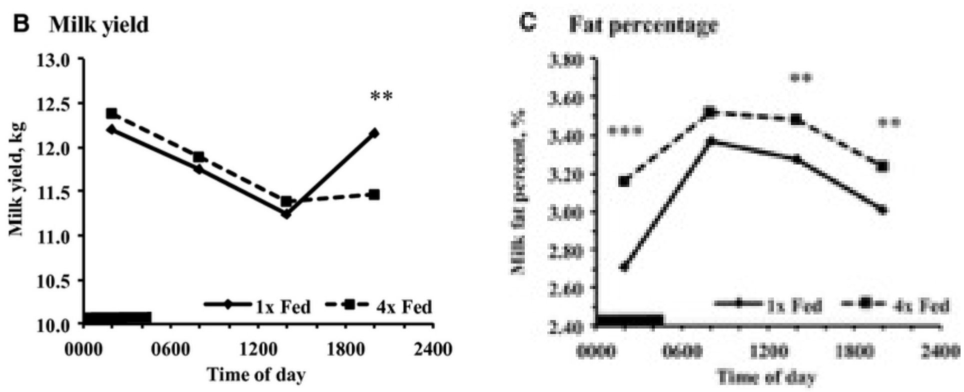
- Timing of feed delivery is our best chance to impact this!

- Limit time without feed and other negative social pressures.

- Goal is to spread intake more across the day. Feeding 2x and earlier is best way to do this.

Ying et al. 2015

Milk yield and composition varies over the day- showing cows fed 1x vs 4x/d



Morning: High volume, low fat and protein%
Evening: Low volume, high fat and protein %

Rottman et al. (2014) *Physiol. Rep.* 2:1-12

Interesting Call From the Field

- One pen of cows on a large farm consistently 0.3 to 0.5 units lower in milk fat than peer pen in another barn fed same diet
- Moved fifteen cows from the pen to another pen and they increased milk fat
- Normal MFD troubleshooting turned up no clues
- Cows being fed later in the day (11:30 AM)
- Switched milking and feeding order so feed delivered earlier and before milking.
- Milk fat increased equal to peer pen

Supply of substrate for milk fat synthesis has a smaller, but important impact

- Absorbed fat
  - Palmitic acid most consistent in increasing milk fat

- Acetate supply for de novo fat synthesis
  - Forage digestibility and rumen function

Palmitic acid is the most consistent to increase milk fat, but others can also increase in some cases

- May depend on concentration of FA in the basal diet, diet type, cow physiology, etc.

Biology of palmitic acid

- Apparent palmitic acid transfer ~15 to 20%
    - (400 g = ~90 g/d increase in milk fat)
- Palmitic decreases de novo synthesized less than other long-chain FA

- **Palmitic acid can change melting properties of milk fat because it is not efficiently made into unsaturated fat like stearic acid (18:0 is made into 18:1)**

High oleic soybeans increased milk fat when fed at higher rates

	Treatment Means[1]					*P*-Values[2]		
	Conv. Soybean		High 18:1 Soybean					Type*
Item	5%	10%	5%	10%	SEM	Type	Level	Level
Milk, kg/d	43.8	43.8	43.4	44.8	1.3	0.69	0.28	0.18
Milk Fat								
%	3.28	3.46	3.42	3.66	0.12	<0.05	0.01	0.69
kg/d	1.29	1.46	1.46	1.57	0.11	0.08	0.01	0.55
Milk Fatty acids, % FA								
>16C[5]	37.4	41.5	37.8	41.5	0.70	0.42	<0.001	0.57
*t*10 C18:1	0.79	0.89	0.62	0.63	0.13	0.01	0.96	0.67

Harvatine, unpublished

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Nutrition and Management is often best practiced as an

“Experiment in Progress”!!

First-

- Accurately and precisely set your goals!

- Account for seasonal effects
- Is the sample a daily average?
- What is the genetic potential of the herd?
- Is the problem across all cows or just the high groups?

- When milk fat is Acceptable

- Inclusion of risk factors is advantageous to feed cost, 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
- When you make the right diet changes milk fat depression will recover rapidly

Fixing Diet-Induced Milk Fat Depression

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
- Decreasing unsaturated fat has the lowest risk to losing milk yield!

2. Diet Fermentability

- Carbohydrate profiles and effective fiber

- Sugars may be beneficial
- 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
- **DCAD**
  - Increasing DCAD decreases MFD (both Na and K)
- **HMTBa**
  - Reduces the risk of MFD
- **Yeast & Direct Fed Microbials**
  - May reduce incidence of MFD in some cases
  - Have not tested their effect on recovery

****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**

Lets review

Rumen environment is critical to milk fat yield and involves interactions of numerous dietary, cow, and environmental factors

1. Set your goal
2. Balance your diet
3. Manage feeding

Constant "Experiment in Progress" to maximize energy intake, milk yield, and milk fat yield

What can we do to increase fat yield?

Management

Increase milk flow & milk fat yield
- Optimal calving intervals (herd DIM)
- Cow Comfort/barn design
- Genetics
- Photoperiod management
- Forage quality and energy intake
- Good silage management
- Good feed management

Increase milk fat concentration
- Genetics
- Seasonal management?

Nutrition

- Minimize milk fat depression
  - Control unsaturated fat
  - Manage fermentability
  - Good feed management
  - Reduce slug feeding/eating
- Adequate supply of acetate
  - Good forage digestibility
  - Stable rumen fermentation
- Optimal dietary fat
  - Corn silage and other basal ingredients
  - Oilseeds and economical fat
  - Dry fat supplements and palmitic acid supply

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Lab Members: **Cesar Matamoros, Beckie Bomberger, Alanna Staffin, Abiel Berhane, Yusuf Adeniji, Sarah Bennett, and Ahmed Elzennary.**

Previous Lab Members: **Reilly Pierce, Dr. Rachel Walker, Dr. Chengmin Li, Elle Andreen, Dr. Isaac Salfer, Dr. Daniel Rico, Dr. Michel Baldin, L. Whitney Rottman, Dr. Mutian Niu, Dr. Natalie Urrutia, Richie Shepardson, Andrew Clark, Dr. Liying Ma, Elaine Brown, and Jackie Ying**

USDA United States Department of Agriculture National Institute of Food and Agriculture

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Thank You!

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