PennState
College of Agricultural Sciences

# *In a tier pricing system: Managing for both milk fat and protein*

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## Thoughts on adapting in ”Historic” times

- **Most quotas/limits and trucking are based on pounds of milk**
  - **There is extra value to watching fat and protein percent**
- **High feed costs**
  - **Feed efficiency is important**
- **Dynamic milk fat and protein prices**
  - **Profitability depends on your cost to make each component**
  - **Think about “marginal” cost and profit**
- **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**

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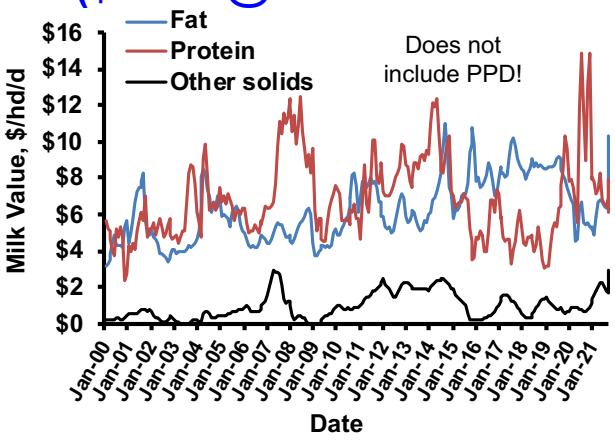
## Milk fat and protein yield are the main drivers of cash flow on dairy farms ($/hd/d @85 lb of 3.9 fat & 3.1 protein)




**5 year average:**
**Fat = $2.25/lb**
**Prot = $2.48/lb**
**Other Solids = $0.22/lb**

Harvatine unpublished based on USDA NASS milk price

- **Goal is maximal Fat + Protein yield**

**(and beat average milk fat and protein concentration!)**

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## What is a 0.1 unit increase in milk fat or protein worth? Depends on production level and price!

| @ $2.40/lb | Milk | | |
|---|---|---|---|
| | 65 lb/d | 80 lb/d | 95 lb/d |
| per d | $0.16 | $0.20 | $0.24 |
| per hd/year | $59 | $72 | $86 |

**Value in 80 lb cow at different fat/protein values**

| $/lb | $/d for 80 lb cow |
|---|---|
| $2.00 | $0.16 |
| $3.00 | $0.24 |
| $4.00 | $0.32 |
| $5.00 | $0.40 |

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## The mammary gland is 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

- You are paid for pounds of each component, but a change in percent can give you an idea if the mechanism is specific for protein or fat regulation, or a general stimulation of lactation

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## Some things drive synthesis of all three pathways and that is OK

- "A rising tide lifts all boats"
- Regulation of lactose and protein are tightly connected
- Milk fat has more differential regulation from lactose
- Long term- hopefully we can disconnect lactose synthesis from fat and protein synthesis
  - Jersey breeders started doing this long ago!

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## How are the "Assembly Lines" regulated?

- We have to make the "machines" (Enzymes) for the assembly line
  - Turn-up expression of the genes
  - Translate the mRNA into protein
- We have to turn all the "machines" on high
- Make sure the "machines" have enough substrate to keep them going

The "factory" needs nutrients to make milk components, but the number and activity of the enzymes in the factory is highly regulated by hormones

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## What does this mean to the nutritionist and dairyman?

Optimizing milk fat and protein yield is not just about supplying the perfect amount of nutrients!

- We can limit the factory through poor nutrition

- Some nutrients are also regulators, but it is harder to "push" the system

- We need to think broadly about the many other factors impacting our "factory"

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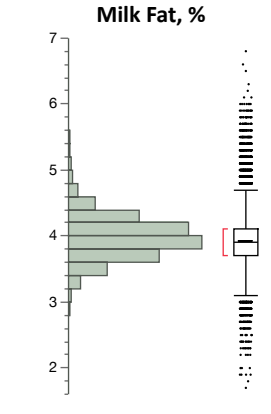
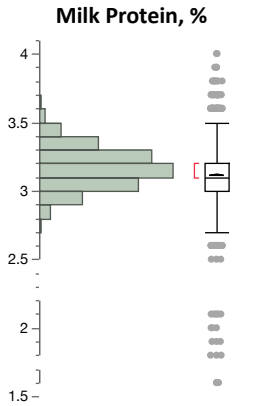
## There is large variation between herds in both milk components, but more in fat than protein




Stdev = 0.34 $10^{th}$ = 3.5 $90^{th}$ = 4.3




Stdev = 0.15 $10^{th}$ = 2.9 $90^{th}$ = 3.3

(64,895 test days from 5926 herds)

Harvatine unpublished from DRMS Dataset

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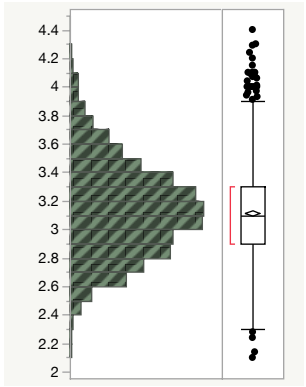
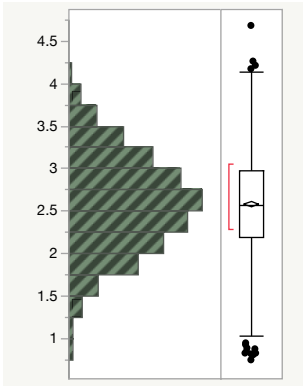
## There is larger variation between cows within a herd: Milk Protein




$90^{th}$ = 3.54%
$10^{th}$ = 2.70%




$90^{th}$ = 3.34 lb
$10^{th}$ = 1.85 lb

- Differences between cows likely influenced by DIM, feeding behavior etc

1720 cows from 5 herds

Harvatine Unpublished

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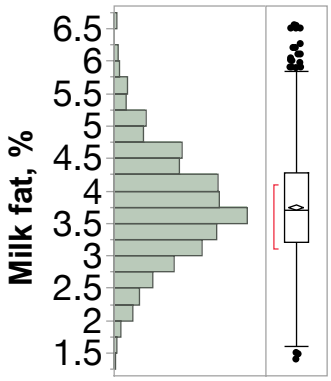
## There is even larger variation in milk fat between cows within a herd




$90^{th}$ = 4.8%
$10^{th}$ = 2.7%

**1720 cows from 5 herds**

**- Differences between cows likely influenced by DIM, feeding behavior etc**

Harvatine Unpublished

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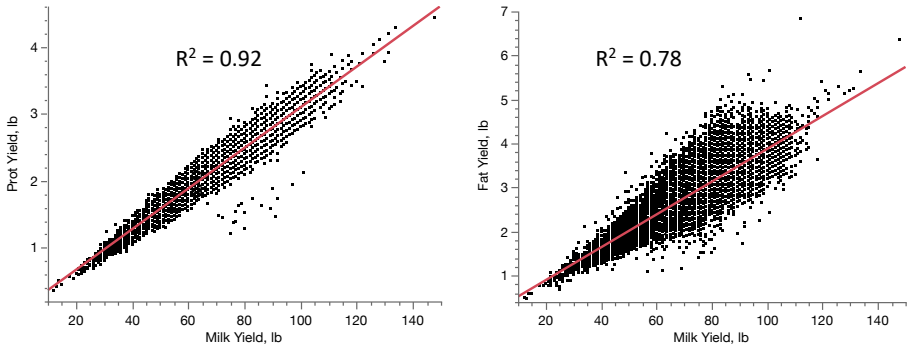
## Milk yield is the main driver of milk protein and fat yield

**Not independent X-Y axis, but shown to compare between protein and fat.**




**(64,895 test days from 5926 herds)**

Harvatine unpublished from DRMS Dataset

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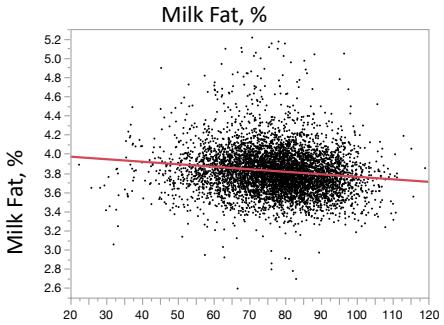
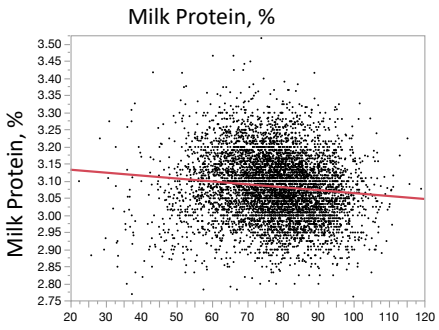
## But, milk yield has little effect on protein and fat concentration at the herd level




Fat % = 4.0214377 - 0.0026 * Milk

**$R^2$ = 0.02**

Prot % = 3.15 - 0.00085 * Milk

**$R^2$ = 0.01**

**(5926 herds with RHA)**

Harvatine unpublished from DRMS Dataset

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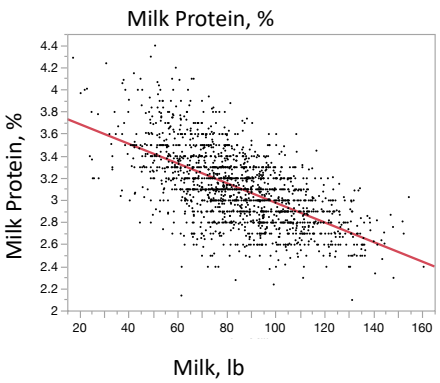
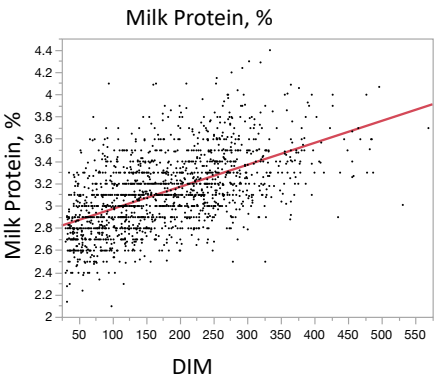
## Milk yield and DIM does have better relationship to components at the cow level




Prot % = 3.863 - 0.0089 * Milk

**$R^2$ = 0.36**

Prot % = 2.769826 + 0.00198 * DIM

**$R^2$ = 0.31**

**(~1700 cows)**

Harvatine unpublished

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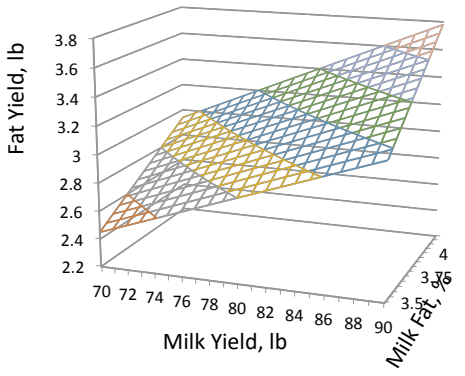
## Take home: "Do not forget about milk flow" You can't give up much yield when seeking to increase milk fat or protein




Harvatine Unpublished

**Protein+Fat Yield**

| | Fat+Protein, % | |
|---|---|---|
| Milk, lb | 7.0 | 7.1 |
| 80 | 5.6 | 5.68 |
| 81.1 | 5.68 | 5.76 |

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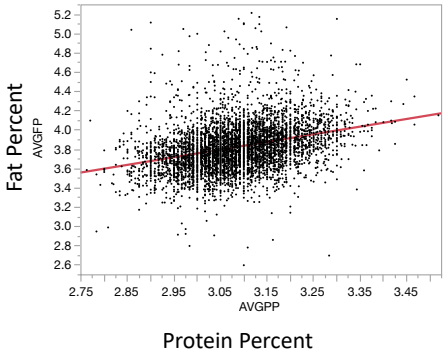
## We can have both fat and protein percent and yield!

**Fat and protein percent**

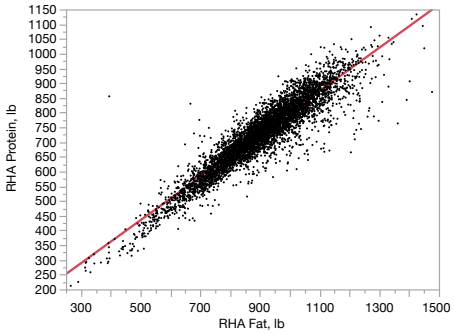



Protein Percent

Fat Per = 1.37 + 0.793 * Prot Per

$R^2 = 0.10$

**Fat and protein yield**




RHA Protein = 69.3 + 0.731 * RHA Fat, lb

$R^2 = 0.86$

**(5926 herds)**

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## What can we do to increase milk yield and fat and protein yield? All the things good farms do right!

- Cow Comfort/barn design
- Optimal calving intervals (herd DIM)
- Genetics
- Herd health
- Transition cow program
- Photoperiod management
- Forage quality and energy intake
- Good silage management
- Good feed management
- Etc

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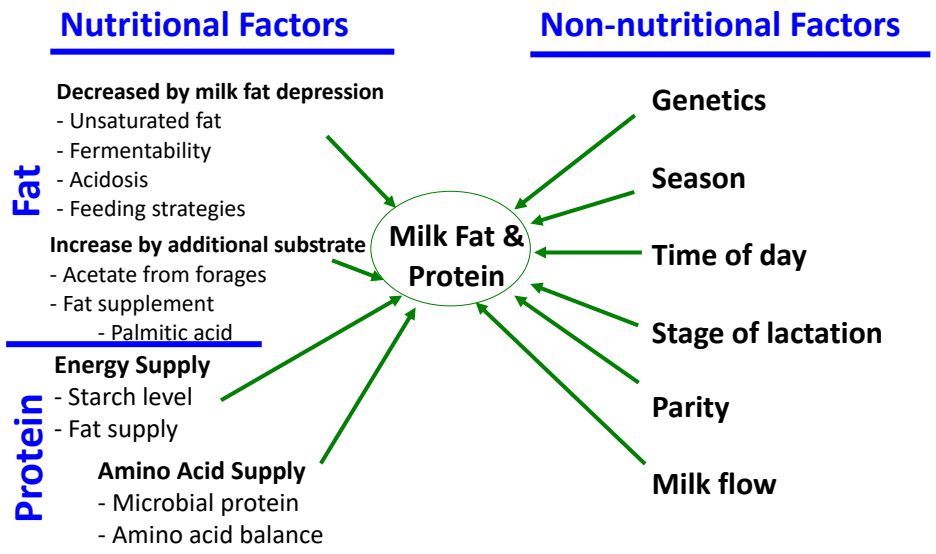
## Milk fat and protein differentially regulated by many factors!

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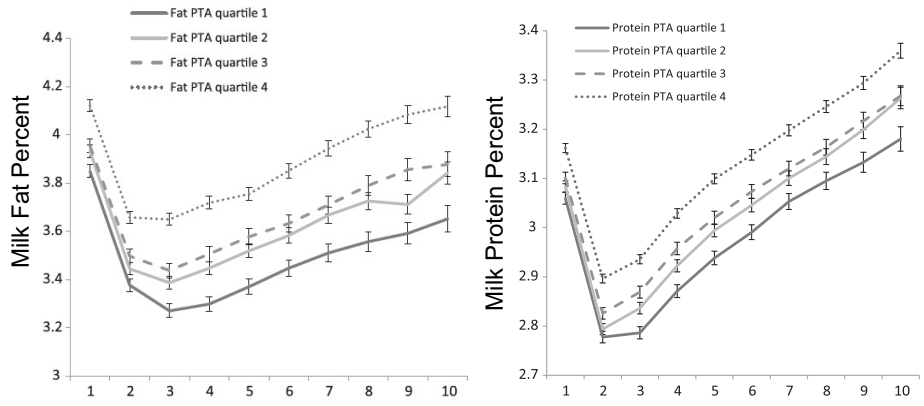
## Milk fat and protein are highly heritable production traits




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

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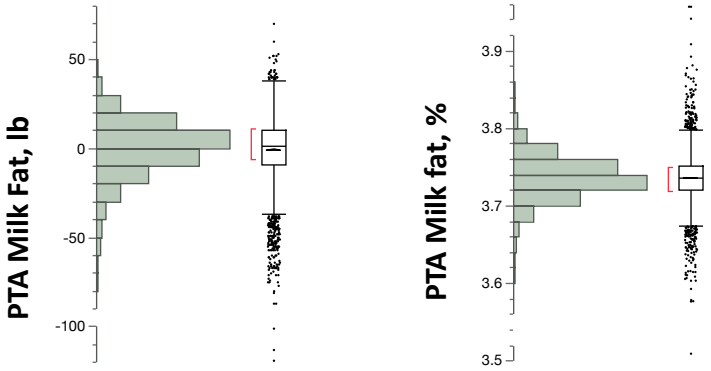
## There is little difference in genetic potential for milk fat between herds




90th 17 lb
75th 10
25th -9
10th -20

**Actual 10th to 90th production is 440 lb!**

90th 3.769%
75th 3.752%
25th 3.721%
10th 3.705%

(6521 DRMS Holstein Herds >30 cows)

**= [(PTAF + 1017) / (PTAM + 27251) ] * 100**

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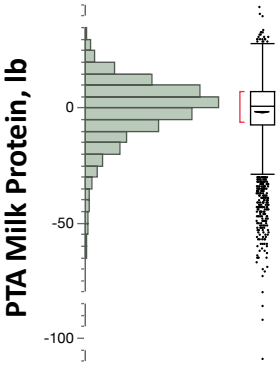
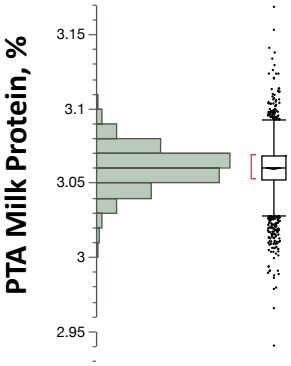
## There is also little difference in genetic potential for milk protein between herds




**90th = 12 lb**
75th = 7 lb
25th = -8 lb
**10th = -18 lb**




**90th = 3.077%**
75th = 3.069%
25th = 3.052%
**10th = 3.044%**

**= [(PTAF + 834) / (PTAM + 27251) ] * 100**

(6646 DRMS Holstein Herds in 2021)

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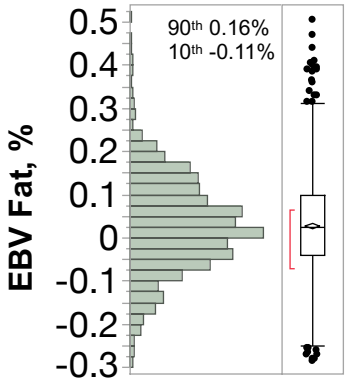
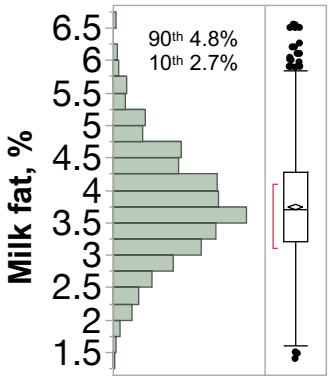
## But, there is larger variation between cows (Milk fat example)




**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

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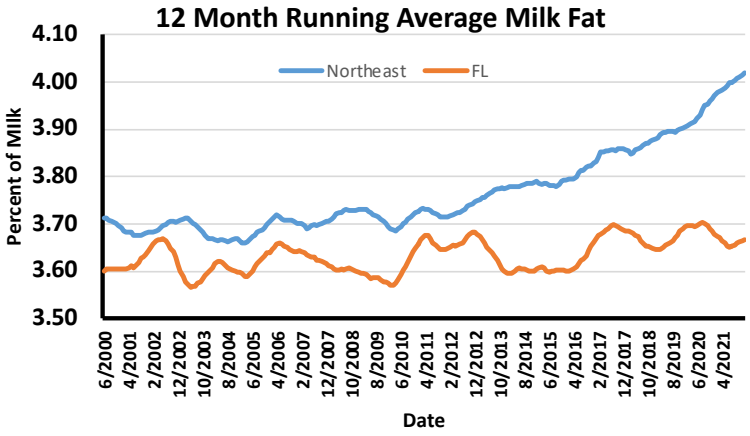
## Milk fat concentration linearly increasing in all milk markets but FL




- **Have you changed your target/goal?**

Harvatine unpublished from USDA NASS

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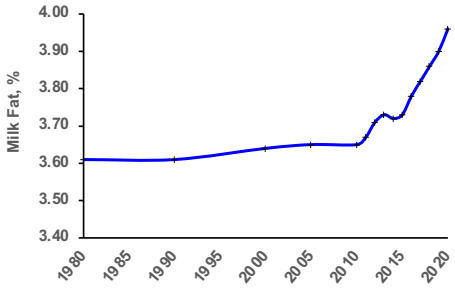
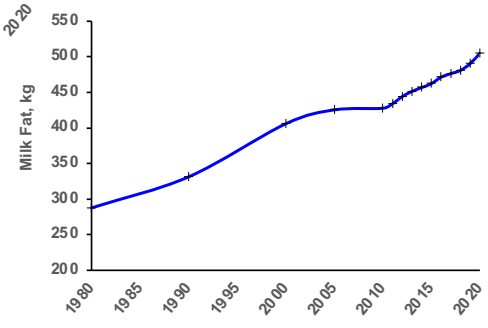
## Milk fat genetic potential of Holsteins has increased ~0.3 units and 156 lb in 10 years!




From Center for Dairy Cattle Breeding




- **Genetic potential of Jerseys has also increased**

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## I have been told "*diet-induced MFD is not a problem anymore*"! Is this true?

- Risk factors have decreased?
- Maybe we all listened to Dr. Jenkins and it is solved?
- We have selected for cows more resistant to MFD?
- We are missing diet-induced MFD because we have not adequately adjusted to the new genetic potential?

**I don't know, but don't stop increasing your expectations**

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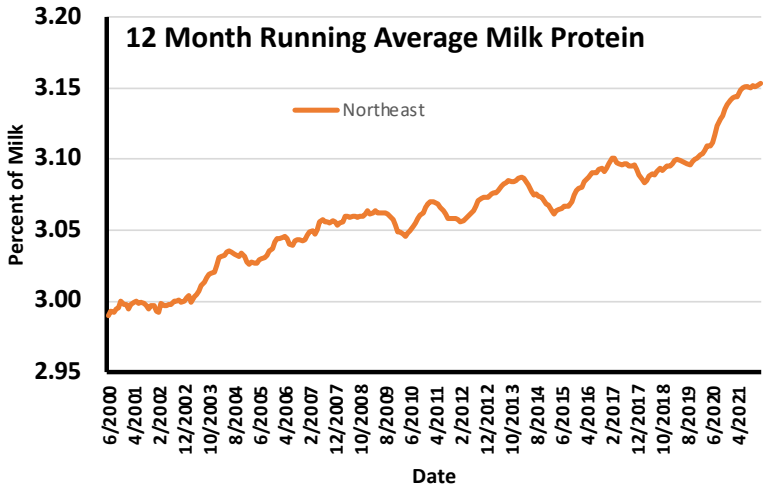
## Milk protein has also been increasing




**Why?**

- **Probably lots of reasons!**

Harvatine unpublished from USDA NASS

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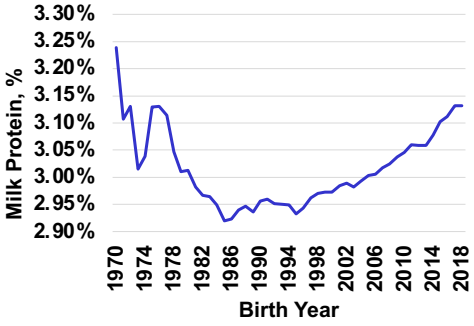
## Genetic potential for milk protein % and yield has also been increasing in Holsteins

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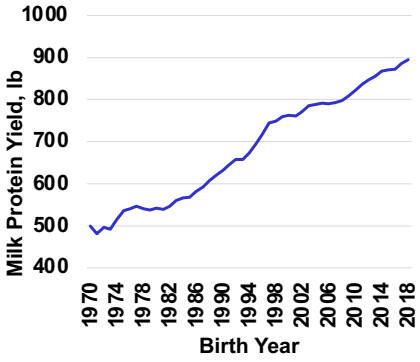


**Genetic potential of Jerseys has also increased**

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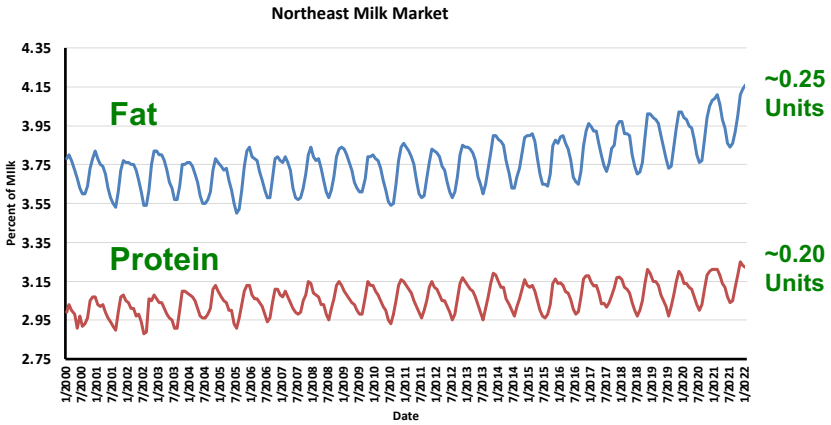
## Also remember the seasonal pattern:
## Northeast US Milk Market




Harvatine unpublished from USDA NASS

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## How do we feed for more milk protein?

1. **Make sure adequate AA are being absorbed (essential AA!!)**
   - **Healthy rumen**
   - **Amino acid balancing**

2. **Turn on milk protein synthesis in the mammary gland**
   - **"Energy signals"**
     - **Hormones…….Insulin/IGF1 mechanism**
     - **Number of potential mechanisms (mTOR)**
   - **Individual AA provide some regulation through mTOR**

**Need Both!**

**Hard to simply "Push" metabolism by adding more protein**

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## 2021 NASEM Milk Protein Equation

**Milk protein yield predicted from**

- **Supply of individual essential AA**
- **Digestible energy intake – energy in MP**
- **Diet digestible NDF**
- **Body weight**

**** Predicting milk protein over a very broad range (400 to 1600 g/d) and large part of this is predicting milk yield**

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## Maximizing rumen microbial protein yield should always be the first goal!

**We get:**

- **Optimal amino acid supply**
- **Normal biohydrogenation (no milk fat depression)**
- **Optimal acetate yield for milk fat synthesis**
- **Optimal energy intake**
  - **Drives milk flow**
  - **Drives milk protein synthesis**
    - **Probably through insulin and IGF-1**
  - **Gets cows rebred**

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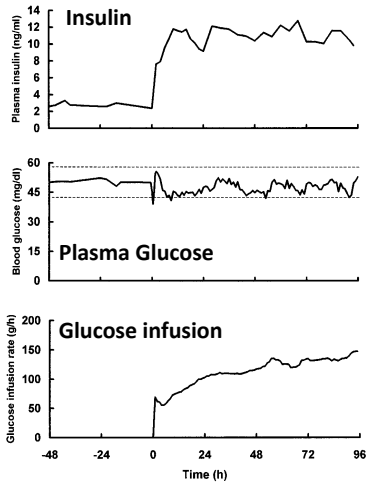
## The Hyperinsulinemic-euglycemic clamp studies clearly demonstrated hormonal regulation of milk protein

- Infuse insulin to increase insulin and glucose to maintain blood glucose concentration




Mackle et al. 1999

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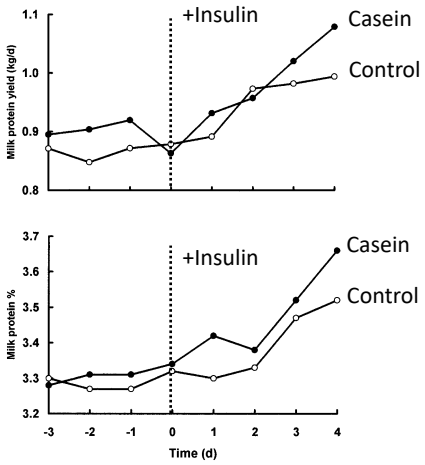
## The interaction of casein and insulin on milk protein was replicated




- True protein increased from 3.14% to 3.33% with insulin and to 3.47% with insulin and casein

Mackle et al. 1999

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## Interaction of protein supply and hormonal signals has been consistent

| | Water | | Casein | | | *P*-values | | |
|---|---|---|---|---|---|---|---|---|
| | Con | +INS | CON | +INS | SEM | Casein | INS | Int. |
| Yield, kg | 0.81 | 0.84 | 0.89 | 1.04 | 0.03 | *** | ** | * |
| Percent | 3.11 | 3.14 | 3.15 | 3.44 | .0.05 | ** | * | * |

Abomasal casein infusion with or without insulin clamp

**This means that not having the energy side right may limit responses to protein and AA balancing**

Griinari et al. 1997

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## Long-acting insulin also increased milk protein in high producing cows

| | | | | | P-Values | | |
|---|---|---|---|---|---|---|---|
| | CON | INS-A | INS-B | | Trt | INS-A | INS-B |
| Prot % | 3.00 | 3.20 | 3.29 | 0.04 | 0.001 | <0.001 | 0.2 |
| Prot yield, kg | 1.46 | 1.40 | 1.54 | 0.08 | 0.08 | 0.06 | 0.22 |

Winkelman et al. 2013

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## What is going to impact the "energy" signals important to milk protein synthesis?

- Cow factors
  - Energy balance
  - Insulin sensitivity and responsiveness
  - GH-IGF1 axis
- Diet factors
  - Fermentability
  - Rumen environment shifting VFA profile
  - Feeding patterns
  - Rumen modifiers?

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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?

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## Maximizing milk fat yield

**1. Minimize milk fat depression**

– Watch the diet

- unsaturated FA, Fermentability etc
- Watch the feeding system and the cows

**- When milk fat is <u>Acceptable</u>**

- Inclusion of MFD risk factors is advantageous to feed cost, production, and efficiency

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## Maximizing milk fat yield Cont.

**2. Good acetate yield**

- Fiber digestibility
- Rumen function

**3. Optimal fat supply**

- Total fat
- Fatty acid profile

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## Maximizing milk protein yield

- Are we meeting AA requirements?
  - Microbial protein
  - AA balancing
- Are we optimizing energy?
  - Careful since can increase risk of milk fat depression

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## Monitor milk yield and milk fat and protein percent over time!!!

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## Let's review

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

- **Focus on fat and protein pounds!**
- **Smaller genetic differences between herds, but larger variation within herds**
- **Maximize microbial protein production, then amino acid balance**
- **Keep in mind effect of energy signaling**
- **Minimize milk fat depression and optimize acetate and dietary fat**

**Constant "Experiment in Progress" and if you figure out the magical recipe let me know!**

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**Lab Members:** **Cesar Matamoros, Beckie Bomberger, Alanna Staffin, Abiel Berhane, Sarah Bennett, Yusuf Adeniji, Muhammad Husnain, Muhammad Arif**

**Previous Lab Members:** **Dr. Ahmed Elzennary. 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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- Harvatine has consulted for Cotton Inc, Micronutrients, Milk Specialties Global,and Nutriquest as a member of their science advisory boards and United Soybean Board, ELANCO, and Novus on special projects.
- Harvatine has also received speaking honorariums from Elanco Animal Health, Cargill, Virtus Nutrition, NDS, Nutreco, Mycogen, Holtz-Nelson Consulting, Renaissance Nutrition, Progerssive Dairy Solutions, Intermountain Farmers Association, Diamond V, Purina, Standard Nutrition, Hubbard, VitaPlus, and Milk Specialties Global in the past four years.

**Thank You**

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