Talking Points Milk Components Discussion for Federal Order Reform 2023

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Primary factors affecting milk components

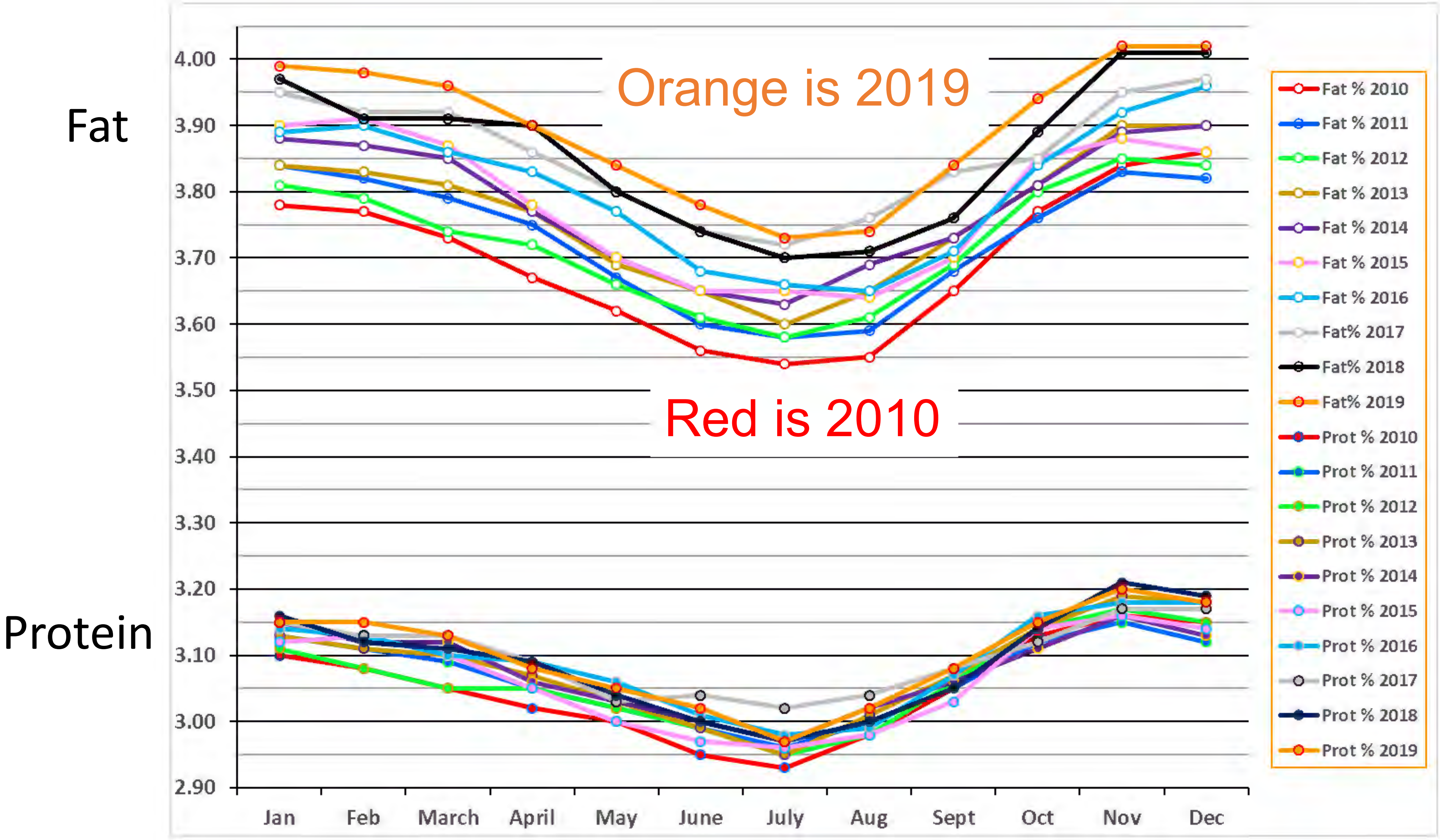
- Genetics
- Nutrition
- Environment and management

Genetics

- Genetic selection is greatly accelerated with the advent of genomic selection
- In addition, reproductive technologies have reduced the lag time when genetic materials can be secured from animals greatly reducing the generation interval and speeding up rate of change
- Selection pressure on milk fat is several times greater than for milk protein, primarily because of marker assisted selection and the identification of a specific gene DGAT-1 which is strongly associated with milk fat synthesis

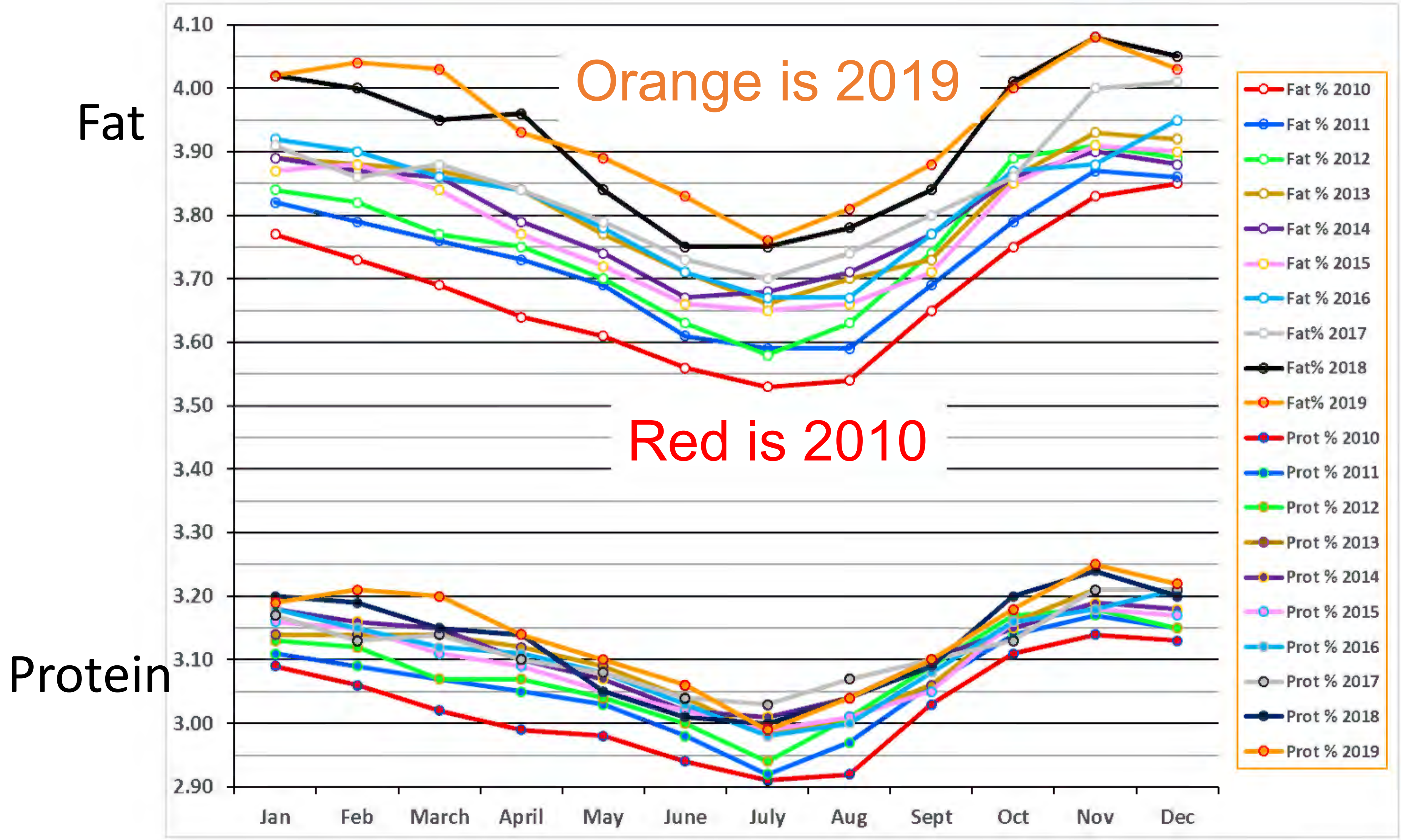
- Milk protein is more complex and tightly tied to lactose synthesis and energy sensing by the cow (liver and mammary gland) so more difficult to move

Northeast U.S. FMMO 1 Milk Fat and Protein % -- 2010 to 2019



Slide courtesy of Clay Zimmerman

Upper Midwest U.S. FMMO 30 Milk Fat and Protein % -- 2010 to 2019



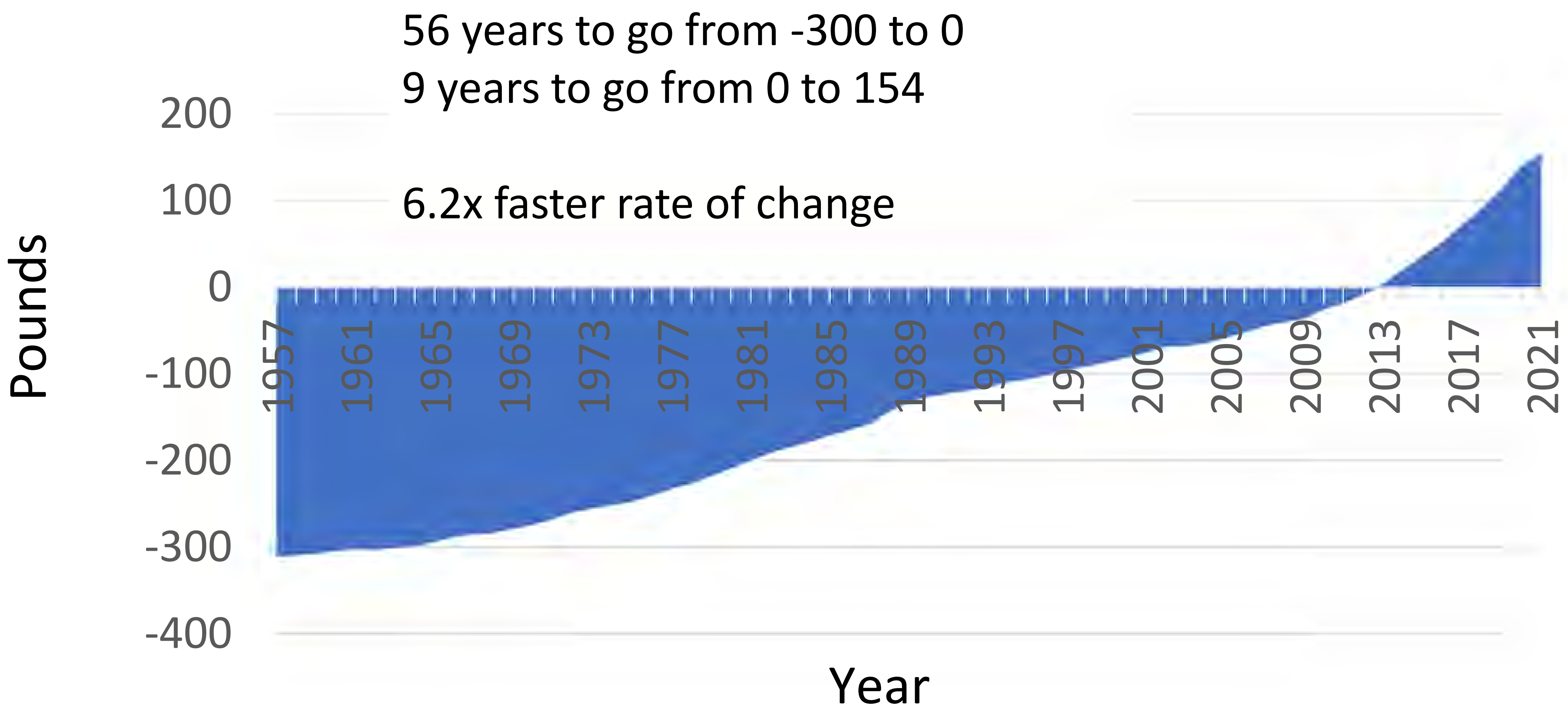
Source: Zimmerman, Balchem Corporation - 2020

Genetic and phenotypic correlations

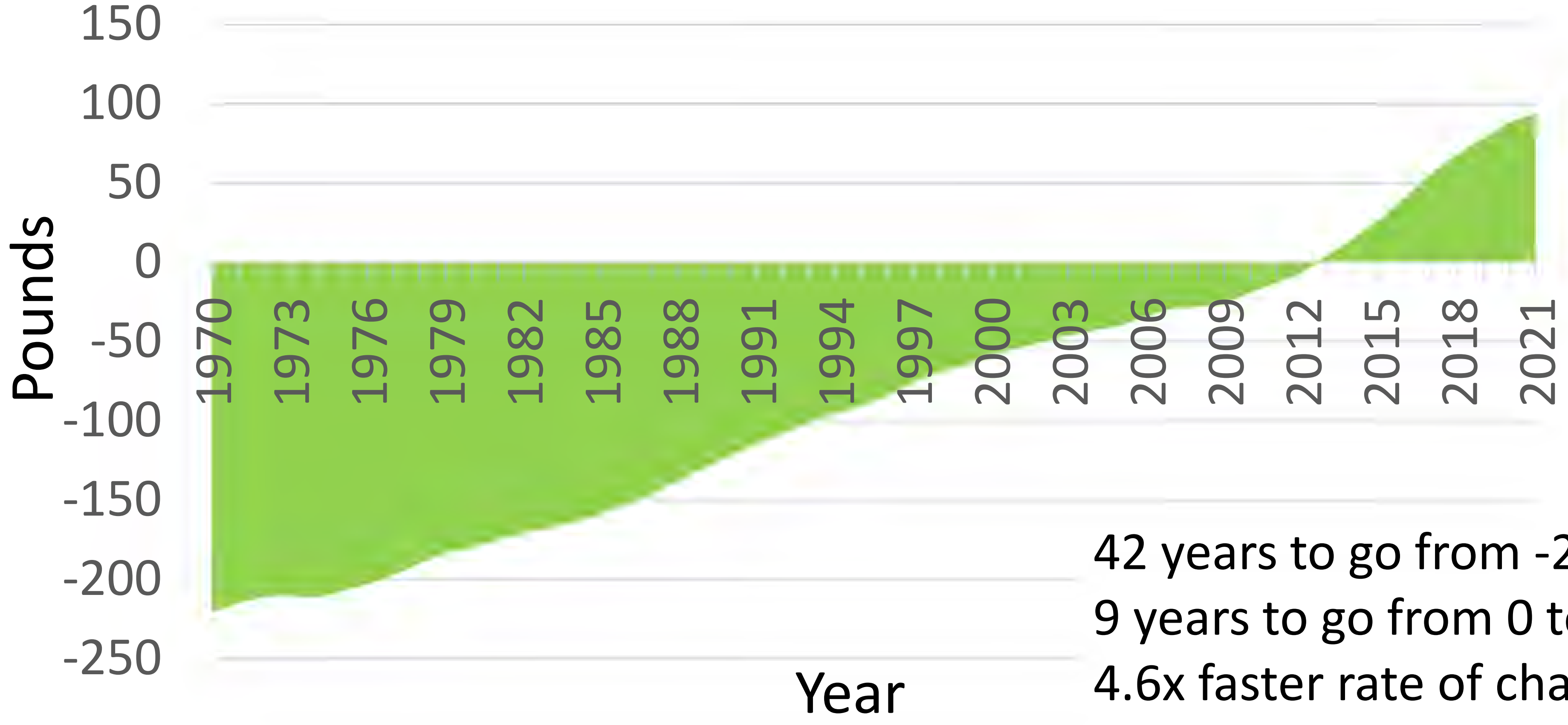
- Genetic correlations above and phenotypic below diag.
- Correlations are for 305-day lactation totals
- Component testing adds more info for fat than protein due to lower correlation with milk, adds even more info for SCS
- Multi-trait model since 2014, previously approximate MT

Correl-ations	Milk	Fat	Protein	SCS
Milk	**1**	0.40	0.84	0.18
Fat	0.62	**1**	0.59	0.12
Protein	0.90	0.72	**1**	0.17
SCS	-0.16	-0.17	-0.15	**1**

Sire Breeding Value for Fat 1957-2021



Sire Protein Breeding Values over 51 years

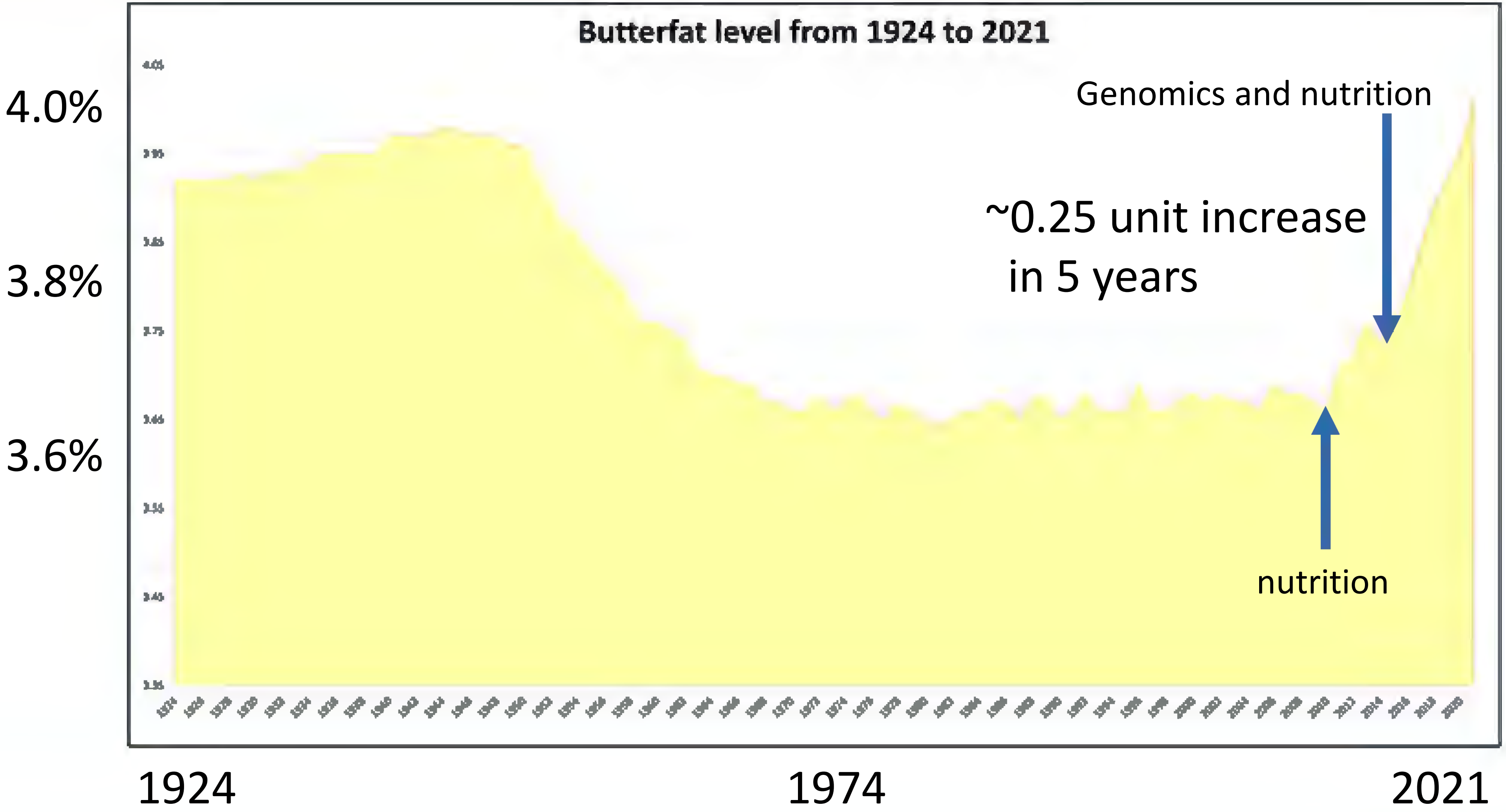


42 years to go from -221 to 0
9 years to go from 0 to 94
4.6x faster rate of change

Dechow, 2023; https://webconnect.uscdcb.com/#/summary-stats/genetic-trend

U.S. butterfat percentage has increased since 2015

Exhibit- NMPF-3-I



Data: USDA

Graphic: Hoard's Dairyman

Dr. Paul VanRaden USDA

Nutrition: Milk fat

- Milk fat is a combination of de novo fatty acids (C4 to C14), mixed fatty acids (C16+C16:1) and preformed fatty acids (C18 to C22)
- Milk fat is synthesized by the mammary gland from acetate and butyrate for de novo fatty acid synthesis (C4 to C14 carbon length FA)
- De novo milk fat synthesis is dependent on acetate availability, amino acid availability and energy from glucose for ATP and reducing equivalents – we are learning how to best modify nutrient supply to enhance de novo fatty acids
- The gland can elongate C14 to C16 to make mixed and needs to for fluidity (melting point) so the fat melts at body temperature and the same requirements for de novo are needed for mixed fatty acids
- Mixed and preformed can come from the diet, or from mobilized tissue (adipose tissue mobilized when cows are in early lactation).
- Milk fat can be depressed or decreased by feeding too many unsaturated fatty acids, which then are modified by bacteria and create reductions in milk fat production which lowers milk fat content. The milk fat levels from 1970-2012 are partially due to diet induced milk fat depression, along with genetics.

Fat supplementation on milk fat yield

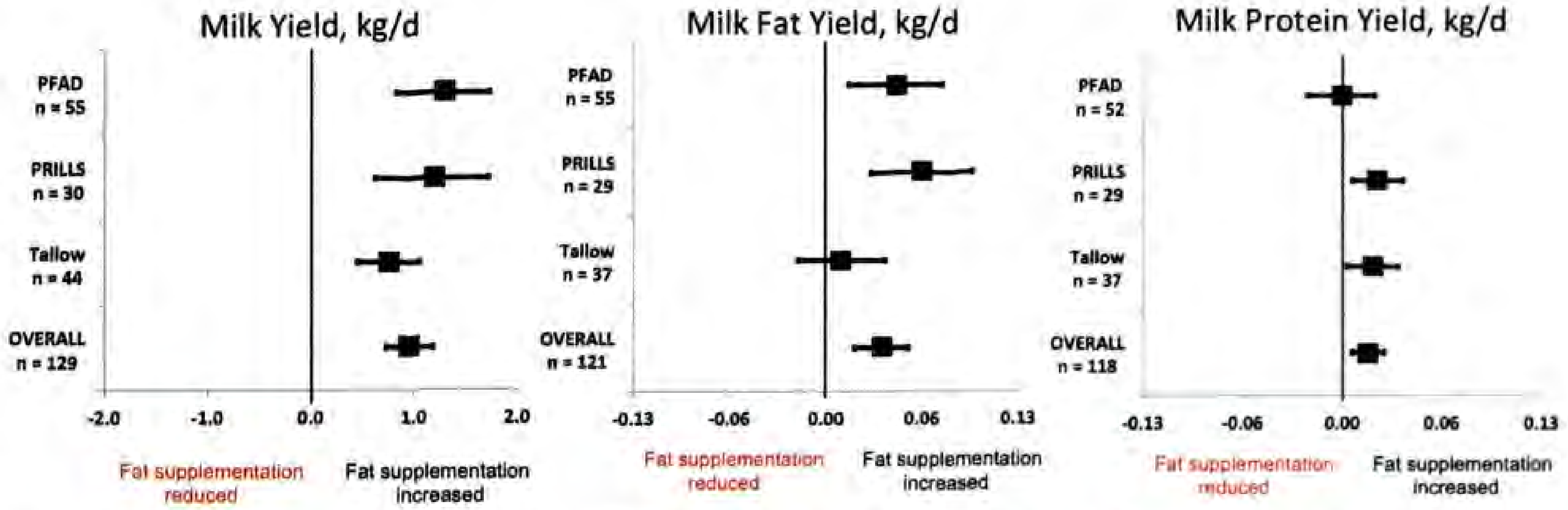


Figure 1. Effect of commercially available FA supplements on yield of milk, milk fat, and milk protein (Boerman JP, Lock AL. Feed intake and production responses of lactating dairy cows when commercially available fat supplements are included in diets: a meta-analysis. *J Dairy Sci* 2014; 97 (E-Suppl. 1):319). All data reported in peer-reviewed journals in which FA supplements were included at ≤ 3% diet DM compared to control with no added FA supplement. All studies had to have measurements of variance reported. **PFAD** – calcium salts of palm FA distillate (~ 50% 16:0, ~ 50% unsaturated 18-carbon FA); **PRILLS** – saturated FA prills (> 80% saturated FA [16:0 and/or 18:0]); **Tallow** – animal fat labeled as tallow (~ 50% 16:0 and 18:0, ~ 45% 18:1). Data analyzed using Comprehensive Meta-Analysis (CMA) version 2.0 (Biostat, Englewood, NJ), calculating difference between FA supplemented and control diets using a random effects model.

Lock and de Souza, Proc. Cornell Nutr. Conf. 2015

Nutrition

- Milk Yield and Milk Protein Synthesis
- Are **energy** driven events
  - Relies on an adequate supply of amino acids from both rumen function and dietary sources
  - Driven by propionate production in the rumen
    - Propionate is converted to glucose in the liver – which in turn stimulates insulin secretion
  - Insulin secretion stimulates protein synthesis in the mammary gland
  - Energy intake and amino acids stimulate insulin like growth factor – I (IGF-I) secretion from the liver
  - Protein supply per se is not an activator of milk protein output but can modulate some of the signaling – IGF-I, mTOR, elongation factors (methionine, leucine and others)

Effects of insulin on milk protein

- Hyperinsulinemic-Euglycemic clamps (lots of glucose and then insulin to match to keep them at normal physiological levels of glucose)

  - Insulin and glucose alone
    - **15% increase in milk protein yield** (Mackle et al., 1999)
  - Insulin and glucose w/ abomasal infusion of casein
    - **28% increase** in milk protein yield (Griinari et al., 1997)
  - Insulin and glucose w/ abomasal infusion of BCAA & casein
    - **25% increase** in milk protein yield (Mackle et al., 1999)

Modification of milk composition due to diet formulation

With the increase in genetic capability for milk component dietary requirements for nutrients are slowly increasing

Nutritionally, we are learning how to better meet the nutrient requirements of lactating dairy cattle to allow them to produce milk fat and protein consistent with their genetic capability

When we refine the diets to better meet the requirements for amino acids, fatty acids and various carbohydrates, we observe increases in milk fat and protein yield – in some cases allowing Holstein cattle to produce components consistent with Jersey cattle

Average Milk Composition of Holstein and Jersey Cattle – published 1998

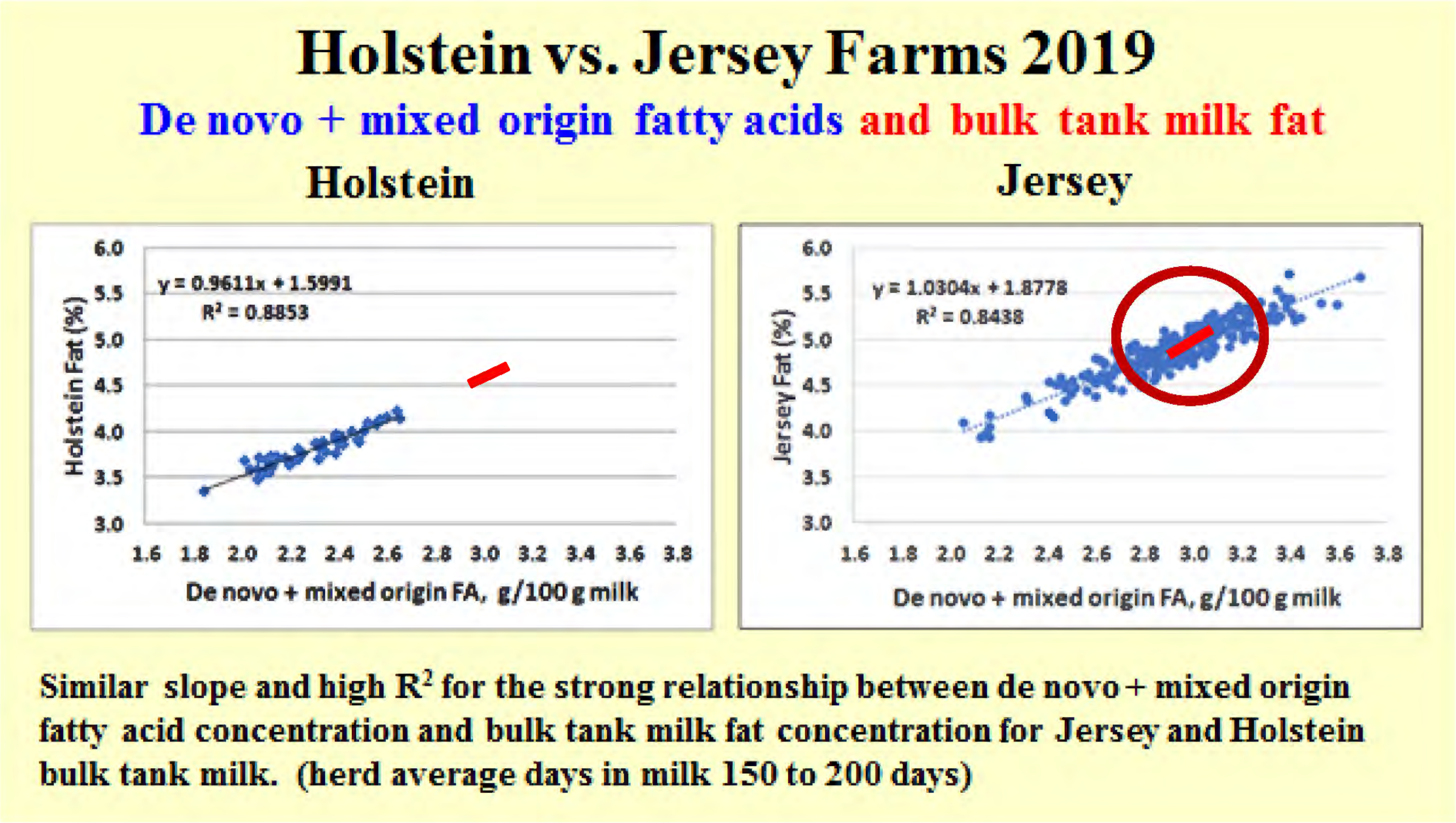
Milk component	Holstein	Jersey
Fat, %	3.7	5.1
Protein, %	3.1	3.7
Lactose, %	4.9	5.0

- To increase milk fat percent and yield, the best way is to feed diets to increase those fatty acids called "**de novo**" and "**mixed**" and they represent fatty acids from 4 carbons to 16 carbons

- Through some research studies and our nutritional modeling work, we have been able to increase milk fat by almost **10%** (from 4.2% to 4.7%) and milk protein by **8%** (from 3.1% to 3.35%) while maintaining milk yield

Dr. Stallings, Virginia Tech
https://www.thecattlesite.com/articles/685/nutrition-changes-milk-composition

Milk de novo and mixed fatty acids from this study compared to Jersey milk components



Barbano et al. Proc Cornell Nutr. Conf. 2019

Two herds in Southern PA – both between 100 and 150 cows with diets formulated using similar dietary metrics as the previous study – these values represent the whole herd - these are Holstein cattle. Milk fat in both herds was about 4.2% before dietary interventions. Milk protein was approximately 3.1% prior to diet change.

Herd 1		Herd 2	
Milk yield, lb	90	Milk yield, lb	91
Milk fat, %	4.64	Milk fat, %	4.76
Milk true protein, %	3.48	Milk true protein, %	3.46
Milk fat yield, lb	4.12	Milk fat yield, lb	4.30
Milk protein yield, lb	3.12	Milk protein yield, lb	3.13

Cornell Research Dairy

1993 – mature body weight = 1,471 ± 126 lb

2016 – mature body weight = 1,770 ± 161 lb

Environment

- As we select for more milk, we indirectly select for larger mature size animals
- Thus, stalls, barns and everything around a cow needs to get a little larger, but barns are high-cost investments, so reinvesting is done infrequently.

- Thus, we have some facilities with upgrades to stalls for increased cow comfort but infrastructure that is older
- And, as an industry, we will tend to overcrowd facilities to increase milk output, which does not always favor components – there are no absolutes

- Where infrastructure is modernized, we can see enhancements in productivity
- This also includes factors around cow time budgets, laying time, water availability, feed availability and consistency

Summary

- Cows have tremendous capacity for milk component yields
  - It is likely many Holstein cows in the industry are capable of 5% butterfat and over 3.5% true protein while maintaining milk yield

- The use of genomics and other reproductive technologies is enhancing that capacity faster than nutritionists can learn to meet the updated nutrient requirements – we are not currently feeding the cows to meet their capabilities for components

- Housing, cow comfort, lying time and other time budget related functions will only enhance the expression of their potential