Exhibit-NMPF - 3

Mike Van Amburgh, Ph.D.

Professor

Written testimony for Federal Order hearing concerning skim milk value via milk components

There are three over-arching factors impacting milk and milk component yield in dairy cattle and those are genetics, nutrition, and the combined effects of environment and management NMPF-3-A and NMPF-3-B.

I will spend some time describing each of those factors and how they independently and synergistically impact milk component yield sometimes independent of milk yield itself.

Historically, we used quantitative genetic tools to identify animals within the population that were producing milk or milk components in a manner that characterized them as outliers. This phenotypic observation was combined with parent information and data from contemporaries to make assessments concerning the genetic ability of cattle and possibly, their ability to translate. With this process, cows were identified, selected, bred to a highly selected and proven bull to make an offspring. If the offspring was a bull, then the offspring bull would have to grow up, and come of age for semen collection and then wait for daughters to calve in and produce milk. A group of daughters would require productivity measurements to determine if the offspring from the planned mating carried the genetic capacity for increased productivity. This led to generation intervals of at least four to five years, so selection pressure was greatly reduced because of that timing.

Today, we have genomic selection, in vitro fertilization and embryo transfer that can reduce that interval to less than 4 years for phenotypic measurements and 2 years for genomic testing of newborn calves. Thus, the rate of genetic change due to these technologies is accelerating the capabilities of dairy animals for increased productivity including milk component yield. And genomic selection provides rapid information on the calf's genetic capacity immediately after birth so the selection process can start very quickly once the calf has been identified. And, certain genes have been identified, like DGAT-1 (diglyceride acyltransferase – involved in the formation of triglycerides from glycerol and fatty acids) that allow for increased selection pressure on a particular gene (NMPF-3-C).

In attachments NMPF-3-D and NMPF-3-E, the milk fat and protein percents for Federal Milk Market Order 1 and 30 are plotted. In those graphs we can see that over 10 years, the milk fat percentage increased approximately 0.2 units or about 5.3%. This is true in both FMMOs. The seasonal effect on fat and protein percentage is apparent in both graphs. What is also apparent is the difference between changes in the milk fat and milk protein over the same time. Both fat and protein have been highly selected in the last 10 to 13 years, however, it is easier to observe and feed for increased milk fat percentage and yield in dairy cattle than it is for protein which is why the percentage of protein has not moved nearly as fast as fat in the FMMO 1 and 30 data comparison.

The data on attachment NMPF-3-F are from Dr. Paul VanRaden at USDA- Beltsville, MD. Above the diagonal are the genetic correlations between milk components and milk and below the diagonal are the phenotypic correlations. You can see that genetically, fat is correlated with milk 0.4 whereas phenotypically it is 0.62, suggesting that nutrition and environment can play a significant role in milk fat and the same holds true for protein, although the correlations are high for both genetic and phenotypic expression.

The graph in attachment NMPF-3-G describes the change in sire breeding value from 1957 to 2021 and the sire breeding value represents the relative change per year in milk fat yield. You can see from the data that using this range in time, it took 57 years to increase milk fat yield by 300 pounds using non-genomic selection, whereas, since 2013 with genomic selection, the change has been 154 pounds in 9 years and at the current rate of change, a 300 pounds change will be achieved in 15-18 years which is 6.2 faster than non-genomic selection.

On attachment NMPF-3-H a similar observation can be made for the sire breeding value of protein and again, the rate of change is almost five times more rapid using genomic selection, which means a near exponential rate of change with genomic selection and shorter generation intervals for most sires in the industry. This data clearly points out that overall, with more modern genetic selection tools like genomics, IVF and ET, the rate of change is going to be highly positive and the capacity for milk component yield by Holstein and Jersey cattle will be quite high.

There is no reason to believe that Holstein cattle cannot routinely be at 5% butterfat and 3.5% protein in the near future and that most Holstein cattle now can easily achieve butterfat percentages of 4.2% to 4.6% with protein between 3.1% and 3.4%. Jersey cattle have similar capacity for change however, the component yield will lag the Holsteins simply due to milk volume.

The graph on attachment NMPF-3-I shows a nearly 100-year description of butterfat levels in U.S. and the rate of change since genomic selection took over in the industry. This slide is important as it represents all breeds. As milk yield increased, the percentage dropped especially from 1950 to 1970. After 1970, milk fat was stable but lower through to 2012-2013. Then from 2015 on, there has been a 0.25 unit increase in butterfat. The drop from approximately 4% in 1950 took about 20 years, however the increase back to those pre-1950 levels took only 5 years, demonstrating the power of genomic selection and some changes in how we feed cows. The role of nutrition in milk fat is important and something that was overlooked for many years until the role of particular fatty acids in milk fat synthesis and depression were identified. This is still an emerging area of work, but we now have a good idea of which fatty acids (fat) to avoid feeding to not cause what we call milk fat depression. For many years we overfed unsaturated fatty acids, fatty acids with one or two double bonds, and those fats are toxic to rumen bacteria, so there are bacteria in the rumen which will saturate or hydrogenate those fats. Some of the intermediate fats will negatively impact the production of de novo fats which reduces milk fat in a condition we call milk fat depression. Once this phenomenon was fully understood by practicing nutritionists, they began to reduce the feeding of these unsaturated fatty acids, which then allowed for an increase in milk fat synthesis by the cow and an increase in butterfat levels. Some of the data on attachment NMPF-3-I reflects this situation from 1970 to about 2010 when there is a noticeable increase in butterfat due to the shift in diets, then in 2016, you can see the combined effect of diet and genomic selection for milk fat in the increase in milk fat percentage.

The information on attachment NMPF-3-Jis background information is about how milk fat is formed. I am available for a more in-depth discussion of the basic biochemical mechanisms involved.

On attachment NMPF-3-Kis a graph again depicting the effects of feeding particular fatty acids on milk yield, milk fat yield and milk protein yield. It is important to recognize that we have learned how to use particular fatty acids to improve all three outcomes and generally it is cost effective to do so on a daily basis. You can see in the figure that in the case of fat supplementation, milk yield increases and for the most part, milk fat yield increases when feeding most of these fats. Of interest is the last plot where milk protein yield is shown to marginally improve when feeding these dietary fats. At first this seems counterintuitive; however, the fats will stimulate insulin increases in cows, and the insulin will in turn signal the mammary gland to increase protein synthesis and one of the outcomes of this will be more milk protein yield.

An overview of this process is found on attachment NMPF-3-Lwhere one of the primary promoters of milk protein synthesis is energy and the energy stimulates insulin secretion which in turn promotes milk protein synthesis. The details can be discussed if anyone is interested but recognize that energy and insulin are important drivers of milk protein and on attachment NMPF-3-M, there are studies showing that an infusion of glucose and insulin in dairy cattle can increase milk protein up to 15% without any additional amino acids being supplied and with amino acids, up to a 28% increase can be observed.

The data on attachment NMPF-3-N discusses factors related to diet formulation and milk component yield. In addition to understanding the mechanisms involved in milk fat and protein production, with the increases in genetic capacity, the nutrient requirements for amino acids, fatty acids and particular carbohydrates are slowly changing and as an industry, we are likely not meeting them due to a lack of knowledge or cost of ingredients. When we do a better job of formulating and feeding a diet that meets those requirements, we can observe significant increases in milk fat and protein percentage and yield. In many cases, these increases in milk fat and protein in Holstein cattle allows them to yield components similar to historical Jersey cow milk composition, which is higher.

The table and information on NMPF-3-O shows some historical data on the differences in composition between Holstein and Jersey cattle (published in 1998 for reference). It is apparent there is a significant difference between the breeds of cattle in fat and protein percent. As described earlier, to improve milk fat we want the cow to make more “de novo and mixed fatty acids” (4 to 16 carbons). In some research studies, we have been able to increase milk fat by up to 10% (4.2% to 4.7%) and milk protein by 8% (3.1 to 3.35%) while maintaining milk yield. Thus, there is significant capability to use nutrition to improve milk component yield and we are not yet making best use of that in the industry due to a lack of information and the perceived cost of the dietary ingredients versus the benefits.

The graphs on NMPF-3-P from Dr. David Barbano (Cornell University) show where Holstein cattle de novo and mixed fatty acids were in 2019 versus what we observed in our study (left side, red line vs the regression line). For comparison the data from Jersey cattle is on the right graph and you can see that the Holsteins in our study were performing in the top 50% of the Jersey cattle. This data clearly shows the potential for nutrition to impact milk components and the current industry hold up is being able to demonstrate to dairy producers and nutritionists that diet composition, especially amino acid balancing can have a profound impact on milk component yield.

To demonstrate this is only possible in research data, data from two herds in Southern Pennsylvania are on attachment NMPF-3-O. Again, the important aspects of this are that with updated formulation guidelines, the nutritionists were able to maintain milk yield and increase the milk fat by 0.4 to 0.5 units, which is a 9.5 to 12% increase, and increase milk protein by 0.3 to 0.4 units. Again, reinforcing the capability of our current dairy cows to produce more components without increasing dry matter intake but simply doing a better job of meeting their nutritional needs with more refined requirement information and better knowledge about how some ingredients can be used to enhance components.

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Finally, the environmental effect is important to consider. As a consequence of selection for milk yield, cows continue to get larger which means over time facilities need to be updated to accommodate these cows. The data on attachment NMPF-3-R and S shows the change in mature size of cows at the Cornell University Research Facility from 1993 to 2016. You can see that mature body weight increased 300 pounds, which is a sizeable amount weight. Where dairy barns have been updated and cow comfort increased to accommodate the cows along with a myriad of other factors, like bunk space, water space, and cooling, greater productivity responses can be observed. Thus, cow comfort, lying time and related factors can be a limiting factor for productivity and although not a driver of milk components like genetics and nutrition, can be a limiting factor for herds that don't have the capacity to update.

In 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 and Jersey cattle have parallel capacity, I just don't have data for them. 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. Finally, housing, cow comfort, lying time and other time budget related functions will only enhance the expression of their potential.