Tech Seminars

Tech Seminar #02 – New Recommendations on Passive Immunity

Good morning and I appreciate the opportunity to speak with you today about the new NASEM requirements for dairy calves. I want to thank DCHA for asking me to talk with you today and to my employer, Cargill, for sponsoring this meeting. Today, I will discuss the new nutrient requirements published by the National Academies of Sciences, Engineering, and Medicine or NASEM. The same organization, previously named the National Research Council, published the last set of requirements, which was published in 2001.

Obviously, nutrient requirements are used to help us know how to feed calves. Back in the day, our approach to formulation and feeding calves was a little different. This is a list of rules, published back in 1847 by the US government, about how to raise calves. Rules 6 through 8 referred to how calves should be fed. They are: The first four weeks of its life the calf must receive the whole of its mother's milk, because in this period the nutrition contained in the milk in so small volume can be replaced by no other equally nutritious and as easily digestible means of food. After four weeks the milk may be replaced by that means of fodder which nutritious substance next to it in equal weight of dry volume, in the greatest possible amount. The withdrawal of milk is to be advised on gradually – one-eighth or one-fourth of the quantity daily.

Today, our nutrient requirements are more sophisticated. The NASEM book, published at the end of 2021, represents the latest knowledge regarding nutrients for lactating and dry cows, growing heifers and young calves. The authors developed a mathematical model to estimate nutrient requirements and also nutrient supply based on the types of feeds that are typically fed to young calves. This model is used to establish the goals – or requirements – that we need to achieve to reach our goals for growth in our calves.

Just to set the stage, let's start with a little trivia question… the new NASEM defined tht term calves to differentiate them from heifers. You should choose 1 of the 3 potential answers – calves are defined as <18% of mature body weight, they are not weaned and less than 12 weeks of age, or are animals that have not reached puberty. Go to >>> and select your answer.

Before we dive into how to use the new requirements, I want to take a moment to set the stage..

In Part 1, I'll introduce you to the document and highlight two key concepts to the new nutrient requirement model – predicting dry feed intake, and how the model calculates requirements for energy and protein. In Part 2 I'll discuss energy and in Part 3, protein. Finally, we'll discuss a bit about implementation of the new NASEM. Note that we are not going to discuss the "nuts and bolts" of how these requirements were determined, the modeling involved, et cetera. Rather, I want to focus on how we as producers and advisors can use these requirements to feed our calves. I will be focusing on calves – as the NASEM has defined them.

The young animal requirements are divided into chapters 10 for calves and 11 for heifers. And, to answer my previous question, calves are defined as animal that are less than or equal to 18% of mature body weight. For Holstein calves, that's about 125 kg or 275 pounds. Chapter 10 covers many topics that we won't have time to cover today, including dry matter intake, energy, protein, minerals and vitamins, and considerations around feeding, including things like colostrum feeding, additives, and other topics.

The new NASEM includes an equation to predict dry feed intake in calves. This is a major improvement from the 2001 edition, which didn't provide any prediction of dry feed. Of course, calves don't eat dry feed when they're very young but will begin eating increasing amounts as they get older and have a need to begin transitioning from liquid to dry feed. So, what causes a calf to begin eating dry feed – that is, either starter, forage, or both? The variables that NASEM considered important in their model were body weight of the calf, the intake of energy (as metabolizable energy) from the liquid diet, and when the calf was first offered starter. They also considered temperature in their model, and eventually developed two equations – one for more temperate climates and a second for hotter, semi-tropical climates, where intakes are consistently lower. Coincidentally, our calf research team at Cargill also published a similar equation to predict dry feed intake in calves to 4 months of age. The variables in our equation were actually quite similar to those of NASEM. We used age, which could be a proxy for the body weight variable in the NASEM equation. We included temperature, as did NASEM. And finally, we considered the energy intake from liquid feed. In our case, we calculated the difference between the energy requirements of the calf minus the energy intake from liquid. This is a bit of a mixture of the body weight variable and the liquid intake variable in the NASEM model. Overall, however, the variables chosen were quite similar. OK, let's have a look at what this means if we feed a calf. Here, I have a graph of predicted intakes using the temperate NASEM equation and the Cargill model. In the first graph, we will feed a calf milk replacer up to about 1.8 pounds or 800 grams per day to weaning. The NASEM temperate equation and the Cargill equation are very similar until about 70 days, when the NASEM equation increases more rapidly than the Cargill equation. This is probably because calves at this age are fed increasing amounts of forage which will begin to limit the increase in DM intake, but there isn't a method to control intake in the NASEM model. Until about 2 months, the differences are very small. Calves reach 1 kilo of intake about 40 days of age and 2 kilos at about 68 days. When we offer calves much more milk, both equations predict that calves will begin eating dry feed more slowly and it will take longer to reach target intakes of 1 and 2 kilos. This is a clear example

that when we offer calves more milk, we see delays in the age at which calves begin eating dry feed and the rate of increase. This has important implications, particularly when we think about preparing the calf for weaning.

The NASEM system to estimate calf growth is based on two systems – the amount of energy (or metabolizable energy) the calf needs to grow and the amount of protein (as metabolizable protein) the calf needs. Other requirements, such as vitamin and mineral requirements are not included in the model that predicts calf growth. When we formulate a diet for calves, the amount of energy and protein must be in balance to ensure calves don't grow fat due to excess energy or too slow due to too little energy. Protein must be provided in the right ratio to energy to make sure calves grow without becoming too fat. The ratio of metabolizable protein, or MP, to metabolizable energy, or ME, is shown in the blue lines in the two graphs. The ratio of crude protein to ME is the orange lines. You can see that we generally need to provide from about 50 grams of MP per megacalorie of ME in the diet. This value decreases to about 40 as the calf reaches about 56 days of age and then increases again to the end of the 4 month period. An important consideration that I'll discuss later is the idea is that energy drives body weight gain and we feed protein to meet the growth available from energy.

OK, let me summarize a few of the important changes in the new NASEM. First, the new publication incorporates much of the research published since the 2001 version. Our ability to predict dry feed intake is an important next step to allow us to better model nutrient requirements and nutrient supply. And finally, the idea that the model evaluates the potential growth allowed by the intake of energy and protein, and the balance of protein and energy is an important consideration in the new model.

OK, let's see what we have learned. Can you tell me what is the primary driver of growth in the new NASEM model? Is it dry matter intake, protein intake, or ME intake? We'll review the answer in a moment.

We've talked about the importance of energy in the new NASEM model, so let's take a little deeper dive into how we can use energy to develop feeding programs.

In part 2, we'll cover some energy aspects of the new model. We'll discuss ME requirements, setting the target average daily gain and how we meet the ME requirements with the feeds that we offer to the calf.

Energy requirements are based on requirements for maintenance plus gain. The energy for maintenance is the amount of energy that the calf uses to maintain body weight, perform body functions, and maintain body temperature by heating or cooling. In this regard, the new NASEM requirements included adjustments for both cold and warm, which is a great improvement over the 2001 model. Other factors that affect how ME is calculated, including the extent of rumen development and diet.

The process begins by estimating the net energy for each function. Maintenance ME is based on the calf's body weight and adjustments for environment, rate of maturity, and diet. For growth, the net energy requirement is the caloric value of the tissues deposited. Once we have estimated the net energy requirements for maintenance and growth, we can calculate the metabolizable energy values based on the efficiency of ME use for net energy. This is a table adapted from the NASEM publication for calves fed milk and starter ranging from 50 to 80 kg body weight with target daily gains from 400 grams per day to 1 kilo per day. We see that the ME maintenance is always the same within each body weight group. For example, a 50-kg calf needs 2.03 megacalories per day to maintain its bodyweight at thermoneutral conditions. The ME requirement for gain depends on several factors, including the target gain and diet. For example, a 60-kilo calf with a target gain of 0.6 kilos per day needs 2.23 megacalories of ME to achieve the growth of 600 grams per day when it's consuming a diet of 80% liquid, while a similar calf eating a diet mostly of starter needs 2.46 megacalories.

Let's take a slightly "deeper dive" into the energy requirements. Here we have a subset of the table we saw in the previous slide. We see only the calves weighing 60 kilos. Let's look a little deeper into how we determine the requirements and how diets can be used to meet them. We see in the table below that total DMI is 1.5 kilos and 40% of that, or 0.6 kilos is from CMR and the rest is from starter. We multiply those intakes by the ME value of each feed to get the total ME intake. In this case, the total diet ME is 5.64 megacalories per day, which is not far off from the requirement of 5.70 megacalories per day.

In our previous two examples, we saw how different feeding programs resulted in different growth rates and determined whether or not our calves would grow according to our goals. As we think about how we want our calves to grow and how to feed them appropriately, we should consider some of the following questions – how fast should our calves grow? How fast can our calves grow? In large part, these factors will be dictated by the feeding program – amount of liquid fed, quality of dry feeds and feeding management. Of course, the cost of each feed is critical. Feeding more liquid is generally more expensive, but your mileage may vary. The next critical consideration is management – are there hurdles that may impair growth? Factors like weather, intensity of the colostrum program and disease will all factor into whether calves will reach their targets. All the high quality feed in the world won't help calves that are struggling to stay healthy in highly stressed environments. As you consider specific growth targets, it's valuable to consider that during the first couple of month of life, calves generally will grow more slowly than later. That's because their digestion is immature for about 30 days, and they can't fully utilize all the milk they're fed. Also, the lack of rumen development means that they also can't fully utilize calf starter. In my opinion, growth of 600 to 800 grams per day is quite reasonable for calves to 2 months of age. If we use the average of 700 grams per day, then a 40-kilo calf will weigh about 82 kilos at 60 days, which reaches our goal of doubling birth body weight by 60 days. We'll look at how to achieve 700 grams of growth per day in a moment. Finally, it's important that you dispassionately assess your current situation – how are your calves growing from birth to 2 months? To 4 months? If you are not achieving your goals, what types of changes are

required to help you achieve these goals? And, importantly, what are you willing to pay to achieve your goal?

OK, let's talk a little about energy supply. All the feeds we offer except vitamins and minerals can contribute energy to the animal. The amount of ME ultimately obtained by the calf depends on many, many factors, including the nutrient profile – that is, the amount of protein, fat and carbohydrates and the type of each. For example, NDF has about the same caloric value as starch and sugar, but NDF is less well digested, especially in very young calves. So, these two milk replacers, that vary in protein and fat concentration will have different ME concentrations. Whole milk contains more protein and fat on a dry matter basis than milk replacers, so the ME concentration is higher than CMR. Similarly, the ME of dry feed depends on the ingredients used, their caloric content and digestibility. These pictures show three forms of starter. Even if the same formula was used in each, the ME would vary somewhat because digestibility of nutrients is somewhat lower in meal feeds compared to pellets or textured feeds. And, finally, method of processing of grains can impact ME value. In young calves, the effects of grain processing – other than form of commercial feed – is less well defined, but certainly in calves with functioning rumens, there is a difference in ME value of grains depending on their processing. I won't go into more detail about differences today, due to time limitations, but more information about these differences is available in the resources listed at the end of the presentation.

We'll switch gears for a moment and discuss NASEM requirements for protein.

Again, we'll divide our discussion into requirements, supply and how we do calculations for protein.

The new NASEM made some important changes to the way requirements are calculated. The 2001 NRC utilized a system called "apparent digestible protein" and based the calculations on a concept called "biological value" of proteins. These were dropped in favor of the metabolizable protein system, which is used for calculating for all other classes of dairy animals, as well as many other species. Therefore, this important change makes our requirement calculations consistent with those in the rest of the NASEM publication. As I mentioned previously, the NASEM model from which the requirements are calculated is driven on the basis of ME allowable gain and the protein requirements are calculated for maintenance and the gain allowed by the energy intake. Maintenance is calculated from all nitrogen losses from body including urine, feces, and skin and hair, called scurf. The growth requirement is calculated from the protein in gain, which tends to decline as calves get older. Calves become less efficient in using protein for growth. The graph indicates that a calf weighing about 40 kilograms will deposit about 67% of the MP it consumes into body protein. By the time the calf weighs 200 kilos, that same calf will only deposit about 54% of the MP into body protein. All these biological events are included in the model and used to determine the protein requirement.

A comment about MP supply. This is interesting, if not a little complicated. We know that the rumen of a newborn calf is nonfunctional, so all of the protein the calf absorbs is from the diet – that is milk protein. However, during the rumen development process, when calves are eating increasing amounts of starter and forage, rumen bacteria will ferment carbohydrates in the dry feed and produce volatile fatty acids (or VFA) but also will produce bacterial protein, which will flow the abomasum and become a protein source for the calf. This changes over time. We can see in the graph on the right that the amount of microbial protein is initially very low, as calves eat little starter and mostly milk. As calf starter intake increases, however, the contribution of microbial protein to total protein increases to reach a maximum of about 60% microbial when a calf reaches 1.3 kilos of starter intake. This has a big effect on the calf, as microbial protein is quite different in amino acid composition than the feeds the calf is consuming. The NASEM committee evaluated the change and selected "points in time" in the graph to set protein requirements for calves.

Here we see a table of the calculations for protein that is set up in a manner similar to the table we saw previously for energy. The MP requirement for maintenance is quite low in comparison to the MP requirement for gain. The MP requirements are summed to give us the total MP requirement. We can then convert this requirement to a crude protein requirement based on the efficiency with which crude protein is used by the calf. This varies by feed – liquids are used with highest efficiency and starters with lower efficiency. Forages are used with the lowest efficiency. This second table compares the new NAS requirements with those from the 2001 NRC. You can see that there are some differences, but they are relatively small, though the new NASEM requirements increase the requirements for protein.

Let's we go back to our original example – a 60 kilo calf with a target average daily gain of 800 grams. We are going to feed this calf the same CMR and starter as before, but now we'll assume the CMR contains 25% crude protein on a dry matter basis and the starter contains 22% protein. If we partition the intake (remember, it's 1.5 kilos per day) into CMR and starter and then multiply the protein concentration in each feed, we see that the total protein intake is 348 grams per day. On a dry matter basis, our ration is about 23% protein. NASEM sets the requirement at 323 grams. So, we are overfeeding protein in this example, by about 25 grams per day. That about 7 % of the total protein intake that is wasted and excreted into the environment. If we do the math, we can calculate that the actual crude protein needed in the starter was about 19% on a dry matter basis. So, this method of calculation tells us a bit about how we can manage feeding to maximize growth, but also to minimize nutrient wastage.

Let's move to the final part of today's presentation – the application of the NASEM model.

Here, we'll discuss the "snapshot" nature of the NASEM model and how this limits the application of the table values to establish feeding programs. We'll also discuss managing growth and finish with some comparisons of feeding plans.

One challenge with the NASEM model is the "point in time" or "snapshot" nature of the model. We predict growth of a calf on a given day and fed a given diet.

Here is an outline of the situation. Let's assume the calf started at 42 kg at birth and previously had an ADG at 800 grams per day, or about 1.76 pounds per day. If the calf gains at this rate, it will be 60 kilograms at 23 days of age. From the NASEM table, we get the ME requirement, and dry matter intake estimate. Assuming the milk replacer we feed contains 4.6 megacalories of ME an the starter has 3.2 megacalories of ME. We partition the dry matter intake into 0.65 kilos of CMR and 0.85 kilos of starter. In this case, we see that the amount of energy provided by the diet is 5.71 megacalories per day, which is just about equal to the requirement of 5.70 megacalories. Success! But wait, we have one slight issue… how likely is this 3-week old calf to eat 850 grams, or about 1.9 pounds of calf starter? Well, it may be possible, but if we use the new dry feed intake prediction equations, we estimate that a 3-week old calf eating 650 grams of milk replacer will eat about 640 grams of starter dry matter – that's about 1.4 lbs per day. This also, of course, assumes the calf is well managed, has plenty of water, isn't sick, not stressed, and not in hot or cold environments. In any event, if we do the math using this predicted dry feed intake, we see that the calf is only likely to gain about 610 grams per day, or about 1.3 pounds per day. Now, if we use this feeding program – 650 grams of milk replacer and ad lib starter – from birth, we can model the calf's growth from birth to 70 days of age, which we see in the graph below. We estimate that this calf will double its birth body weight at about 67 days of age and will weigh about 77 kilos, or 170 pounds at 60 days. So, this feeding program – of starting with 650 grams of CMR per day doesn't get us to our target of 800 grams of growth per day. It's important to note that the tables in the new NASEM book don't actually model different programs – they are only examples of the amount of energy needed to reach the ME requirement. We need to do the modeling on our own to actually determine how the calf may grow.

Let's model another situation. Here, we'll feed the calf 2 lbs of the same CMR. Note that the base information – here in gray – is all the same. On the right, we feed 907 grams of CMR and predict the amount of starter. In this case, we estimate the calf will be 60 kg at 27 days, and will eat 310 grams or 0.7 lbs of starter per day. The total intake is about 5.18 megacalories and comes almost exclusively from CMR. Because CMR is used more efficiently for growth than starter, we predict this calf will gain 0.77 kilos on this diet, which is about 1.7 pounds per day. On this diet of 2 lbs of CMR per day, the calf will average about 850 grams per day to 2 months of age and will double its body weight at 54 days of age. Here we are meeting our goal of at least 800 grams of gain per day.

At Cargill, we have developed a growth model applying the new NASEM nutrient requirements and estimates of nutrient supply. This approach begins by calculating ME and MP requirements for a 3 day old calf. We then estimate intake of dry feed based on the input of a milk feeding program, breed, and environment. The model estimates growth and then increments the animal's body weight. This process is repeated until 4 months of age – 122 days. This approach allows us to model growth using various liquid and dry feed

programs. The model calculates efficiency and cost and predicts the effects on future milk production based on estimates of preweaning growth from Penn State. In the picture on the top, we see the predictions of calf performance on an ideal feeding program. The model reports body weight, gain, intake of dry feed, cost, and efficiency. The graph on the bottom of the slide shows the change in body weight in the orange line and intake of liquid, concentrates and forages. The model also reports two statistics of when the calf consumes at least 1.3 kilos of calf starter and when it consumes a total of 15 kilos of NFC. These two statistics indicate when the calf is ready to be weaned. In this example, our calf is ready at 52 and 67 days, so we take the later of the two to indicate an approximate time to wean the calf.

Here's an example of a slightly different, but optimal feeding program. We feed 1.7 lb of milk replacer that is 24, 18 to 7 days of age, then increase to 1.9 pounds to 49 days and then to 0.9 pounds at weaning at 63 days of age. We offer starter containing 20% crude protein to 56 days and then switch to a 16% grower and feed to a maximum of 3 kilos or 6.6 pounds. Grass hay is offered for at lib consumption from 42 days of age. We can see in the graph the change in body weight and intake and the performance report indicates that growth achieves relevant goals. Average daily to 2 and 4 months are 1.54 and 1.95 pounds per day, which are optimal in our opinion.

This table shows performance of calves modeled using our approach under eight different feeding programs. You can see differences in liquid feeds – a 20, 20 CMR, a 24, 18 CMR and whole milk. The feeding program is varied in most scenarios. We offer a couple of different starters and forages. In the body weight columns, the values in blue indicate when the calf gains more than 600 grams per day and the numbers in green indicate more than 800 grams per day. We can see that it's necessary to feed 8 liters of milk per day to 49 days to achieve 800 grams of growth in the first 2 months of age. However, growth to 4 months of age almost always exceeds 800 grams per day as calves increase growth dramatically after weaning. Using the values in the footnotes, we calculated the cost of each program. The milk program is most expensive, assuming a kilo of milk costs 55 cents. That's equivalent to 25 dollars per hundred. Of course, if you're using waste milk, the assigned cost will be much lower than the cost of saleable milk.

So, let's step back for a moment and consider where we've been. We've seen that the NASEM requirements are the latest and greatest and include research conducted in the past 20 years. While the background information has been updated, the actual recommendations for nutrient concentration have not changed dramatically. New capabilities such as models to predict starter intake are significant improvements from the 2001 publication. Consider, though, that the NASEM approach to establishing requirements is a snapshot in time and factors such as previous feeding program isn't included in this snapshot approach. Our modeling approach provides a method to predict growth and establish feeding programs that meet producer goals. It's important to keep in mind that a modeling approach is a simulation. Our model doesn't take into account factors such as poor management, disease, or transportation stress. Future improvements

to the model will help us incorporate other factors and make more applicable to actual farm performance. This limitation doesn't minimize the value of the simulation as a tool to evaluate different feeding scenarios.

To properly use the NASEM model, either at one point in time or in a dynamic fashion, it's important to establish your goals and an evaluation of your existing program. Where are you today and what do you need to do to meet your goal? Then, a feeding program can be established to meet your growth goals. Consider that early growth tends to be lower due to immaturity of digestion. Feeding more liquid can overcome this lower growth, but costs will be greater in these feeding programs. After two months, dry feed intake increases allow calves to gain rapidly and economically. After weaning, quality of starter and grower are more important. We like the modeling approach, which allows you to evaluate various options, not only at one point in time, but over the entire feeding program. Modeling the feeding program can help you determine the program that will meet you goals, cost and what changes in the program are needed.

Well, that will do it for today. Thanks so much for your attention and I look forward to our discussion.