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Calf Note 209 – How much energy is in my starter?

Introduction

The first dry feed we offer to a young calf is critically important to getting the animal off to the best possible start. We generally refer to this feed as "calf starter", though in some parts of the world, it might be called a "prestarter". Calf starter comes in many forms – meal, pelleted, texturized (muesli) and others. Examples of the most common commercial forms, textured and pelleted starters, are in Figures 1 and 2, respectively.

Figure 1. Texturized calf starter containing steam flaked corn, pellets, rolled oats and molasses.

Starters must be formulated with a specific purpose in mind – to supply the nutrients calves need to maintain their body weight (maintenance) and grow at an acceptable rate (growth). Prior to weaning, a starter will provide only a small fraction of the total nutrients consumed by the calf. As the calf ages and the amount of liquid (milk or milk replacer) is reduced, the contribution of starter to total nutrient supply increases. Then, at weaning, starter becomes the sole source of nutrients (assuming no forage is offered). Thus, the nutrient content of the starter and the willingness / ability of the calf to consume sufficient amounts of starter become critically important. This ability to consume starter is especially important when calves are fed high milk allowances (>800 g of solids per day). Increased milk allowance will delay the age at which calves begin consuming starter and amount of starter consumed at a given age.

What makes a good starter?

There are several critical components to a quality calf starter. I've discussed calf starter quality and composition in previous Calf Notes (#10, #47, #107, #109, #197, #202), but a short summary here is worthwhile.

Figure 2. Example of a complete pelleted calf starter.

A good starter must be *palatable*. If a calf doesn't like the form and formula, the rest of our discussion is moot. The only way a starter does a calf any good is if the animal is willing to eat it. Therefore, ingredients that reduce palatability (e.g., animal proteins, certain minerals, oxidized fats) must be avoided. Some research suggests that flavors and sweeteners can improve palatability, but the research is not always positive. Generally, it's my experience that many commercial starters will have a palatability agent added. I've outlined some issues related to starter palatability in Calf Note #47.

Physical form also affects palatability. Generally, calves don't like meal feeds or pelleted feeds that contain significant amount of fines (>5-10%). Some anecdotal reports suggest that mini pellets (3 mm diameter) are preferred to larger pellets, though others contend that 5 mm pellets are preferred.

Management of the starter is critical to promoting early and aggressive intake. Feed should be changed *daily* and the amount offered should be carefully monitored to ensure ad libitum consumption but not so much as to cause wastage. Early in life, calves will consume little starter, but it should still be available so the calf learns that the starter is a food source.

Nutrients in starter

Of course, the nutrient content of the starter has a profound effect on its ability to support maintenance and growth. A starter should be nutritionally complete, including protein, energy, vitamins and minerals. Many starters include B-vitamins in their formulas, as the immature rumen may produce insufficient amounts of these important vitamins prior to weaning and sufficient rumen development.

While it is possible to analyze nutrients such as crude protein or vitamin A in a calf starter, determining the amount of usable energy is a different challenge. We can determine the amount of *gross energy* in a feed by burning it (in a device called a *bomb calorimeter*) and calculating the amount of energy (calories or joules) released. However, gross energy does not tell us how much energy is available to the animal. In calf nutrition, we generally calculate *metabolizable energy* (ME) as the amount of energy that is available for metabolism by determining the amount of energy that is digested (digestible energy) and metabolized (metabolizable energy). Accurate measurement of ME is conducted experimentally in a research laboratory wherein feces and urine can be collected from test animals.

Most nutritionists calculate ME in calf starters with a set of equations that predict the digestibility and metabolizability of several nutrient fractions within the feed. A popular approach is one taken by the National Research Council in the 2001 publication "Nutrient Requirements of Dairy Cattle" (you can download a free PDF version of this publication here). The NRC uses a series of calculations based on digestibility of lactating dairy cows and then corrects these calculations to determine the ME. Most reported values for ME in calf starters in the scientific literature are based on these calculations.

It is an interesting question to ask "are estimates of ME, calculated with equations derived for mature dairy cows, accurate for young calves?". The answer to this question is the topic of this Calf Note.

The Research

During the past several years, the research group at Provimi North America has conducted several research trials wherein we have measured nutrient digestibility in calves fed different milk and starter programs. The objective of these trials was to better understand the nutrient availability (and, therefore, growth) of calves fed moderate and high levels of milk replacer as well as the composition of starch and fiber in the starter. Results of these studies have helped improve our understanding of nutrition during weaning and better formulate starters for optimal growth. Digestibility is also important to the calculation of ME. So, although our original intent was not to calculate the ME in calf starter, we realized we had most of the information we needed to evaluate the ME content of calf starters, and determine whether that value changed over time. So, we developed a series of models of digestion (Quigley et al., 2019a) to determine how best to estimate the actual ME in calf starter. We used three published experiments and a total of 207 individual digestibility measurements in calves from 3 to 16 weeks of age to develop our models. We used a series of mathematical techniques and calculated the ME in calf starters in each calf at each time period. We called this value the **MEcs**. The MEcs was not a fixed value, but varied by animal and age. As a basis for comparison, the ME was also estimated using the NRC calculations. We called this value the **MEnrc**. Finally, we calculated the ratio of MEcs / MEnrc. We thought that if the ratio was about 1, then the amount of ME the calves extracted from the starter (the MEcs) was equal to that predicted by the NRC (MEnrc). This might suggest the point at which the gastrointestinal tract was sufficiently "mature".

Finally, we looked at the various factors that might influence the change in MEcs. We evaluated factors like age, intake of milk replacer and intake of different nutrients from the starter (DM, protein, NDF and non-fiber carbohydrate, or NFC).

The Results

When MEcs was calculated using the actual calf starter digestibility measurements, the ME values looked a lot different than those predicted by the NRC. We made several interesting observations that are outlined below.

Digestion of starter is low early in life. We found that, early in life, calves didn't digest the nutrients in calf starter very well. That's not a huge surprise, since the rumen isn't functioning (much) prior to weaning and many intestinal digestive systems (e.g., pancreatic amylase production) are also immature early in life.

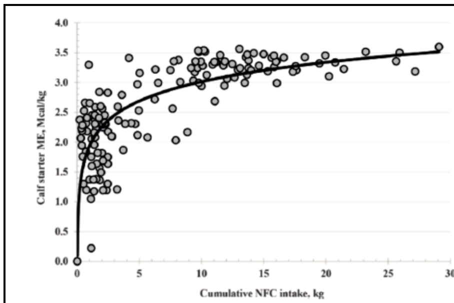

Figure 3. Estimated calf starter ME (Mcal/kg of DM) in calves consuming milk replacer and calf starter. From: Quigley et al., 2019b.

Digestion of nutrients changed at different rates. Our calculation of protein and fat digestion in calf starter (excluding contribution of milk replacer) indicated that digestion of these nutrients in starter was also low early in life, but increased rapidly. On the other hand, digestion of NDF increased more slowly and depended on the type of feed offered. Thus, it appears that understanding the changing digestion of each component of equations for calculating ME will be important.

ME increased with increasing intake. As you can see in Figure 3, our calculated MEcs increased with increasing NFC (non-fiber carbohydrate) intake. The increase was curvilinear and appeared to reach a peak at approximately 3.2 to 3.5 Mcal of ME/kg of DM. That's very interesting, because this value is very similar to the estimates made by the NRC.

Increasing digestion (and calculated ME) with increasing intake and rumen development is consistent with our theories of what drives rumen development. These data support our idea that intake of dry feed (and, especially, NFC) is very important to prepare the calf for weaning.

Intake of NFC was most important. We evaluated effects of intake of several nutrients from calf starter on calculated ME, and found that intake of NFC was most important. This is also quite logical. Non-fiber carbohydrate contains starch, sugars and other non-fibrous carbohydrate fractions (Penn State has an excellent review of carbohydrates in ruminant nutrition). Our current understanding is that fermentation in the rumen, particularly of feed components that product butyrate and propionate, are critical to rumen development. We know that the NFC component of the feed is most rapidly fermented in the young rumen and most likely to produce propionate and butyrate. When this factor was considered in our model, other factors (age, body weight, intake of milk, etc.) were not significant. Also, other nutrients in calf starter (protein, fat, NDF) were not as important as NFC.

Cumulative intake was most important. We evaluated many different factors that influenced changing MEcs, but the single most important factor was *cumulative* intake of NFC. We calculated cumulative intake as the intake of NFC by the calf from the time of birth until the end of each digestion period measurement. We calculated cumulative DM intake, and then multiplied that number by the nutrient content of the feed to calculate cumulative NFC intake, NDF intake, etc. When we compared these values to changing MEcs, we found that cumulative NFC intake was more important that all other factors.

The idea behind this finding is that the rumen develops in response to ALL of the starter a calf consumes, and not just the starter the calf consumes on a given day. Consider – many calf specialists and advisors recommend that calves should be weaned when they consume some specific amount of starter – say, 1 kg/day for 2 or 3 days. Our data suggest that it is not 1 kg of starter *per se*, that is important, but the total amount of NFC the calf has consumed. We think this is also consistent with the biology of rumen development and preparation for weaning.

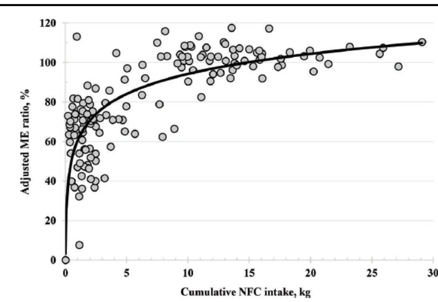

Figure 4. Ratio of MEcs / MEnrc in calves fed varying programs of milk replacer and calf starter. A ratio of 100% indicates calves digested feed similarly to NRC predictions, suggesting mature rumen function. From: Quigley et al., 2019b.

15 kg is key. In Figure 4, we can see the ratio of MEcs / MEnrc for calves consuming up to about 30 kg of cumulative NFC. A close evaluation of the line suggests that, when calves have consumed about 15 kg of cumulative NFC, the ratio of MEcs / MEnrc = 100%. This could be the point at which the gastrointestinal tract (and, especially, the rumen) is sufficiently mature that calves are able to extract the amount of energy from calf starter that we predict for mature animals. This could be an appropriate time to wean a calf.

When are calves ready to wean? In each experiment, we calculated the age at which calves reached cumulative 15 kg of cumulative NFC intake. The age ranged from about 54 to 64 days of age and depended on the amount of milk replacer fed (more milk replacer fed delayed NFC intake) and the composition of the starter (high fiber starters also reduced NFC intake). So, to use these data to make weaning decisions, it's important to know the NFC content of the starter. An approach to estimating 15 kg of NFC intake will be the topic of a future Calf Note.

Meantime, however, it is instructive to know which type of carbohydrates are in calf starters used on the farm. Formulations vary widely depending on cost and form. Generally, lower cost, pelleted feeds will contain greater amounts of NDF and texturized feeds containing whole or processed grains will contain greater amounts of NFC. However, these are generalizations and it's important to discuss with the feed supplier.

It is certainly possible to wean a calf prior to consumption of 15 kg of NFC. However, our data suggest that the animal will be less efficient at obtaining energy from the calf starter and may grow more slowly until rumen development reaches sufficient maturity (possibly, at 15 kg of NFC intake).

Summary

Our research published in the Journal of Dairy Science contributes some new ideas about how calves develop and how we should think about preparation for weaning. One important idea is that calves lack the ability to extract energy from the diet early in life, and this ability develops with advancing NFC intake. We may overestimate the contribution of ME from starters early in life.

Understanding the composition of starters fed to calves (particularly the carbohydrate fraction) and the amount consumed will help us prepare calves more appropriately for weaning and reduce the post-weaning depression in growth that occurs commonly.

References

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