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Calf Note #115 – Abomasal pH and milk feeding

Introduction

Digestion of liquid feeds is a critical component of nutrition and health of young calves. "Mother Nature" designed calves to digest cow's milk. The calf has the requisite digestive apparatus and enzyme systems to digest and absorb cow's milk efficiently and utilize nutrients for growth.

But what about milk replacers? Calf milk replacers are generally based on milk ingredients – whey, whey protein concentrate and (in some countries) skim milk. Other milk replacers may contain alternative ingredients such as soy or wheat protein, vegetable fats, etc. How are these products digested by the calf? Are they as efficient? Do the differences in ingredients, processing and digestion predispose the calf to digestive upset?

At least some of these questions were addressed in a paper published in a 2005 issue of the Journal of Veterinary Internal Medicine (Constable et al., 2005). In this paper, the authors studied the effects of different types of liquids (milk vs. two types of milk replacers) on the pH in the abomasum for a 24 hour period.

Why is this important?

The data from this study are important for a number of reasons. First, if we understand the effects of the kinds of liquid we feed to calves on how it might influence the digestive system, we can understand if one type of feed might predispose a calf to enteric disease such as abomasal bloat. Secondly, the way that liquids are digested can have a big effect on the growth and health of the calves.

The study

In this small study, six male calves were abomasally cannulated at 3 days of age. From 17 days of age, calves were used to determine the changes in pH that occurred when they were fed one of three liquid feeds – cow's milk, an all-milk protein milk replacer or a replacer containing milk ingredients plus soy protein. A pH electrode was inserted in the abomasal cannula and pH was measured once every second for 24 hours. The researchers then followed changes associated with pH for a total of 24 hours.

Changes in pH

As can be seen in Figure 1, there was an immediate change in abomasal pH when calves were fed. The pH increased from about 1.5 to approximately 6.0 within 15 minutes of feeding. This naturally occurs when calves are fed twice daily, since they tend to consume all of their feed in large meals. The reason this observation is interesting is that when abomasal pH is too high, it can allow pathogens such as Salmonella or E. coli to pass through the abomasum intact. Normally, low stomach (abomasal) pH is a key defensive mechanism for the animal (in fact for many different

animals). By feeding twice per day, we tend to inhibit the abomasum from providing optimal defense against potential pathogens.

Another consideration is the risk of abomasal ulcers, which can occur when the abomasal pH remains too low for an extended period of time. This was a primary consideration of the researchers in this study.

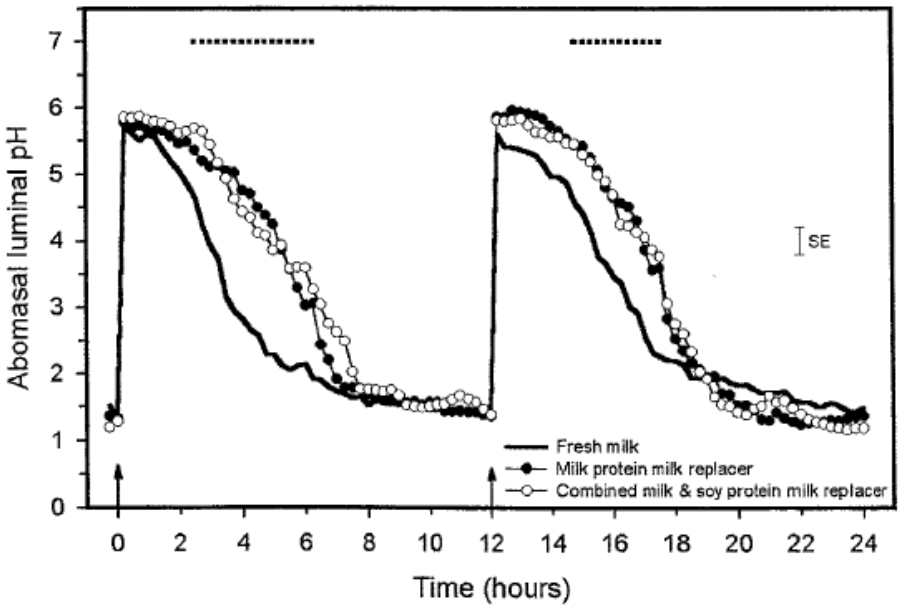

Figure 1. Change in abomasal pH in calves fed cow's milk or two different milk replacer formulations. From Constable et al., 2005.

There were important differences between cow's milk and the milk replacers. All feeds tended to peak at approximately pH = 6 at the first feeding, but the pH in the abomasum of calves fed cow's milk tended to decline faster than that of calves fed either milk replacer. In fact, by the second feeding, the pH in the abomasum of calves fed cow's milk remained lower.

The researchers also looked at the average pH over the total 24 hour period. The average pH was also consistently lower when calves were fed cow's milk and did not differ when calves were fed either milk replacer (See Table 1).

What's going on in the abomasum

Once the calf drinks a meal of milk or milk replacer and the pH increases (as you can see in Figure 1), the abomasum is going to respond to that meal by beginning to secrete acid and digestive enzymes to begin the process of digestion.

Calves secrete the enzyme chymosin (rennet), which causes casein to clot in the abomasum. In this study, both milk replacers contained no casein (note that most calf milk replacers sold in the U.S. do not contain casein. Milk replacers sold in other countries with skim milk may contain variable amounts of casein). In the present study, when calves were fed cow's milk, secretion of chymosin by the calf would cause the casein in milk to clot. This clot, which would contain amounts of casein (protein) as well as fat, would be released more slowly from the abomasum than the whey proteins or soy proteins in the two milk replacers used in the study. The part of cow's milk that's left after clotting is mostly whey and minerals. This material can have quite a low pH, which can be positive (reduce risk of transfer of pathogens) or negative (induce abomasal ulcers).

Because of the differences in feeds used in this study, there are some big differences in the characteristics of the abomasum outlined in Table 1. For example, the percent of time (in 24 hours) that the abomasum had a pH greater than 3 or 4 was consistently higher when calves were fed milk replacer compared to cow's milk. The time (number of minutes) it took for the abomasum to get back to pH = 1 was much longer when calves were fed milk replacers compared to cow's milk.

Generally, there were very few differences between the two milk replacers, which suggests that the type of protein used in milk replacers didn't have a big effect on pH in this study.

Table 1. Characteristics of abomasum of calves fed cow's milk or milk replacers based on all-milk or soy protein.

Item	Cow's milk	Milk CMR	Soy CMR	SE
Abomasal pH	2.77[a]	3.22[b]	3.27[b]	0.08
% of 24 h > 3	37.7[a]	49.5[b]	51.6[b]	4.7
% of 24 h > 4	26.8[a]	41.8[b]	38.9[b]	4.7
Time to pH = 1	320[a]	383[b]	399[b]	25

From: Constable et al., 2005.

[a,b]Means in rows with different superscripts are different ($P < 0.05$).

What's all this mean?

The dramatic differences in pH caused by feeding two meals per day are clear in this study. It is also clear that the kind of feed that is fed to calves will affect how quickly the abomasum returns to very low pH. The authors of this study hypothesized that when calves (especially beef calves) are left to nurse the dam and there is some disturbance in the pattern of nursing (e.g., bad weather when calves are out on the range) the low pH caused by suckling cow's milk may lead to an increased incidence of abomasal ulcers, which is a significant concern to many cattle producers.

However, an evaluation of the pH data would suggest that lower pH in the abomasum of calves fed cow's milk isn't necessarily a bad thing – certainly, low pH is used by the body as a defensive mechanism. The longer that the abomasal pH is above 4, the greater the risk that pathogenic organisms might be able to survive the abomasum and cause disease in the intestine of the calf.

Reference

Constable, P. D., A. F. Ahmed, and N. A. Misk. 2005. Effects of suckling cow's milk or milk replacer on abomasal luminal pH in dairy calves. J. Vet. Intern. Med. 19:97-102

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