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Calf Note #27 – How Calf Starter Intake Drives Rumen Development

Introduction. Development of the rumen generally occurs during the first 4 to 8 weeks of a calf's life. The process of rumen development is driven primarily by consumption of dry feed. If calves have feed - particularly calf starter - available from an early age, then the development of the rumen will begin within a couple weeks of birth.

There are 5 requirements (or "ingredients") for rumen development. These include the presence of bacteria, availability of liquid in the rumen, rumen motility, absorptive ability of the rumen epithelium and availability of calf starter. Bacteria, liquid, rumen motility, and absorptive ability are established prior to rumen development, or develop rapidly when the calf begins to consume dry feed.

There are five requirements for ruminal development. They are:

- Establishment of bacteria in the rumen
- Liquid in the rumen
- Outflow of material from the rumen (muscular action)
- Absorptive ability of the tissue
- Substrate

A number of other metabolic changes occur during ruminal development in the rumen and other tissues, but we will consider the above requirements for the rumen to begin to function.

Bacteria. When the calf is first born, the rumen is sterile - there are no bacteria present. However, by one day of age, a large concentration of bacteria can be found which are mostly aerobic (or oxygen-using) bacteria. Thereafter, the numbers and types of bacteria change as dry feed intake occurs and the substrate available for fermentation changes. The change in bacterial numbers and types is almost always a function of intake of substrate. Prior to consumption of dry feeds, bacteria in the rumen exist by fermenting ingested hair, bedding, and milk that flows from the abomasum into the rumen. The substrate ingested will also affect the types of ruminal bacteria that flourish in the young rumen. For example, calves fed mostly hay develop a different flora from those fed mostly grain.

Liquid in the Rumen. To ferment substrate (grain and hay), rumen bacteria must live in a water environment. Without sufficient water, bacteria cannot grow and ruminal development is slowed. Most of the water that enters the rumen comes from free water intake. If water is offered to calves from an early age, this is not usually a problem; unfortunately, many producers in the U.S. do not provide free water to their calves until calves reach 4 or more weeks of age. Offering water in the winter can be a significant challenge in Canada and the northern U.S. However, calves still need water, even when it is cold. Sometimes, it may be necessary to bring warm water at an additional

feeding to ensure that calves have enough liquid water available. Free water has been shown to increase rate of body weight gain and reduce scours.

Milk or milk replacer does not constitute "free water". Milk or milk replacer will by-pass the rumen by closure of the esophageal (reticular) groove. Closure of the groove is a neural response to feeding. Free water does not stimulate closure of the groove, so water enters the rumen. Feeding water can increase body weight gain, starter intake, and reduce scours score.

Outflow of Material from the Rumen. Proper ruminal development requires that material entering the rumen must be able to leave it. Measures of ruminal activity include rumen contractions, rumen pressure, and regurgitation (cud chewing). At birth, the rumen has little muscular activity, and few rumen contractions can be measured. Similarly, no regurgitation occurs in the first week or so of life. With increasing intake of dry feed, rumen contractions begin. When calves are fed milk, hay, and grain from shortly after birth, rumen contractions can be measured as early as 3 weeks of age. However, when calves are fed only milk, rumen contractions may not be measurable for extended periods. Cud chewing has been observed as early as 7 days of age, and may not be related to ruminal development per se. However, calves will ruminate for increasing periods when dry feed (particularly hay) is fed.

Absorptive Ability of the Rumen Tissue. The absorption of end-products of fermentation is an important criterion of ruminal development. The end-products of fermentation, particularly the volatile fatty acids (VFA; acetate, propionate, and butyrate) are absorbed into the rumen epithelium, where propionate and butyrate are metabolized in mature ruminants. Then, the VFA or end-products of metabolism (lactate and ß-hydroxybutyrate) are transported to the blood for use as energy substrates. However, there is little or no absorption or metabolism of VFA in neonatal calves. Therefore, the rumen must develop this ability prior to weaning.

The rumen wall consists of epithelial and muscular layers. Each layer has its own function and develops as a result of different stimuli. The muscle layer provides support for the interior (epithelial layer) and moves ruminal contents in the rumen. The epithelial layer is the absorptive layer of tissue inside the rumen which is in contact with rumen contents. This tissue contains many small finger-like projections called papillae. These papillae provide the absorptive surface for the rumen. At birth, the papillae are small and non-functional. They absorb little and do not metabolize significant VFA. Many researchers have evaluated the effect of various compounds on the development of the epithelial tissue in relation to size and number of papillae and their ability to absorb and metabolize VFA. Results of these studies indicate that the primary stimulus to development of the epithelium are t**he VFA - particularly propionate and butyrate**. **Milk, hay, and grain added to the rumen are all fermented by the resident bacteria to these acids; therefore, they contribute VFA for epithelial development.** Plastic sponges and inert particles - both added to the rumen to provide "scratch" - did not promote development of the epithelium. These objects could not be fermented to VFA, and thus did not contribute any VFA to the rumen environment. Therefore, rumen development (defined as the development of the epithelium) is primarily controlled by chemical, not physical means. This is further support for the hypothesis that ruminal development is primarily driven by the availability of dry feed, but particularly starter, in the rumen.

Availability of Substrate. Bacteria, liquid, rumen motility, and absorptive ability are established prior to rumen development, or develop rapidly when the calf begins to consume dry feed. **Thus, the primary factor determining ruminal development is dry feed intake**. To promote early

rumen development and allow early weaning, the key factor is early consumption of a diet to promote growth of the ruminal epithelium and ruminal motility. Because grains provide fermentable carbohydrates that are fermented to propionate and butyrate, they are a good choice to ensure early rumen development. On the other hand, the structural carbohydrate of forages tend to be fermented to a greater extent to acetate, which is less stimulatory to ruminal development.

In conclusion, the primary factor determining ruminal development is dry feed intake. To promote early rumen development and allow early weaning, the key factor is early consumption of a diet to promote growth of the ruminal epithelium and ruminal motility. Because grains provide non-structural carbohydrates that are fermented to propionate and butyrate, they are a good choice to ensure early rumen development. On the other hand, the structural carbohydrates in forages tend to be fermented to a greater extent to acetate, which is less stimulatory to ruminal development.