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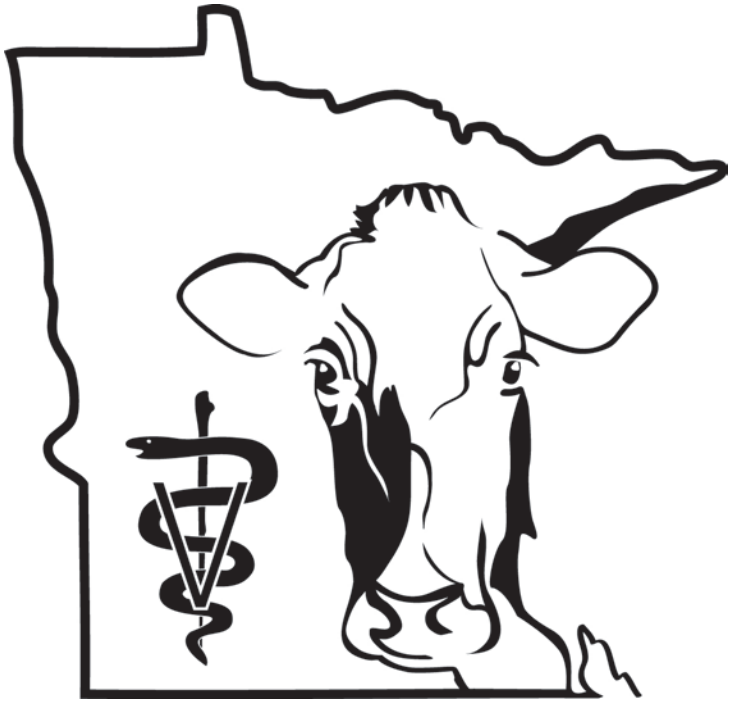

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Carbohydrate Nutrition and Manure Scoring
Part II: Tools for Monitoring Rumen Function in Dairy Cattle

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Proper rumen function is essential to support the profitable performance we strive to sustain with dairy cattle. Excellent cow performance includes high yields of milk and milk components, but encompasses more elements: efficient conversion of consumed nutrients to milk, appropriate maintenance and repletion of body reserves, ease of rebreeding, good health and longevity, among them. Impairment of rumen function as noted with ruminal acidosis can undermine the cow's ability to perform up to her genetic potential, and may lead to her premature exit from the herd as an involuntary cull. It is in the best interests of farm and cow to maintain good rumen function that supports good performance.

A challenge we face as herd managers and advisors is how to determine the state of rumen function in herds before problems become advanced. Our decisions on diet or management changes should take into account the need to maintain or enhance it. So, what direct or indirect indices can we evaluate to determine the adequacy of rumen function?

Indices of Rumen Function

When we think of good rumen function, some of the items that come to mind include:

- Selective retention of feed particles in the rumen for rumination and microbial digestion.
- Stimulation of adequate rumination / rumen motility.
- Extensive ruminal digestion of fiber and other carbohydrates.
- Maintenance of ruminal pH above a certain level.

These conditions should ensure that the majority of fermentation and digestion of carbohydrates occurs in the rumen. It is when the selective retention of feeds is compromised, or rumination is inadequate, or ruminal fermentation of potentially digestible carbohydrate is reduced that we see signs indicative of impaired rumen function. Poor rumen function seems related to a syndrome of overall gut dysfunction. On the farm, several factors that can be evaluated as indicators of rumen function are:

Rumination: Rumination is essential for feed particle breakdown, mixing of digesta, and incorporation of salivary buffers into ruminal digesta. With an upper limit of 10 to 11 hours of rumination per day, at least 40 to 50% of all cows not sleeping, eating, or drinking should be ruminating. Time spent ruminating speaks to the adequacy of the physically effective form of the diet to stimulate rumination. The main determinant of physically effective form of the diet is fiber, however, fiber as a proportion of intake alone is not adequate to determine how well a diet will maintain rumen function. The efficacy of fiber in a diet to stimulate rumination is affected by particle size, rate of digestion (if it ferments and breaks down rapidly, it will not remain in the rumen to be ruminated), density (may affect passage), etc.

Often, the proportion of fiber from forage has been used to estimate the adequacy of physical form of the diet. However, with the number of factors that affect physical effectiveness of the fiber, and impact of other dietary components (starch, concentrates) on amount of fiber needed, the truth is that the cow is the only accurate indicator of how much physically effective fiber is present in the diet. Adequacy of physically effective form of the diet is a function of the interaction of the cow and her diet. Aside from formulation or forage quality issues, sorting of a ration by the cows for increased consumption of concentrate and a decrease in forage intake is a common reason that fiber needs are not met. Providing palatable sources of forage, and processing them (chopped to ~ 2 to 5 cm lengths) so they can be blended into a moist total mixed ration can help to reduce sorting.

MBH Observation: Effectiveness of fiber is not only related to particle size, but to a variety of factors that affect rate of digestion. For example, grass NDF tends to ferment more slowly than does that in legume forages. Additionally, the particles from grass tend to be more needle-shaped, and those from legumes to be more cuboidal. In my experience, grass has tended to be a more effective physically effective fiber source than legume forages possibly because the fiber is retained in the rumen for a longer period of time. Long pieces (1 to 7.5 cm) of very tender or pliable grasses can sometimes be found in the feces - they seem to be able to bend and escape the rumen. The physically effective fiber has to be in the rumen to be effective. A greater amount of NDF from a more rapidly fermented physically effective fiber source would have to be fed to provide the same amount of physically effective fiber as from a more slowly fermenting source. Take as an example that a small amount of chopped straw included in a ration can quickly resolve problems due to physically effective fiber inadequacy of the ration. Alfalfa can be an excellent feed, but it can be a poor choice as a major source of effective fiber. The need to provide adequate physically effective fiber to allow for proper rumen function and ration digestion is a balancing act with providing adequate nutrients. Best done with appropriate quality forages and feeds in adequate quantities.

Fecal Consistency / Mucin or Fibrin Casts: If the rumen fails to selectively retain particles, ruminal digestion of feeds is reduced, the site of digestion may change as the passage of potentially digestible feed to the small and large intestines is increased. Fermentation products in the hindgut are essentially the same as those produced in the rumen and are likely the basis for changes in fecal consistency (Figure 1). Gas produced from hindgut fermentation can appear as bubbles in the manure, sometimes to the point that the feces have a low density, foamy texture. The organic acids can be absorbed by the gut. However, a major difference between the hindgut and the rumen is the potential for the fermentation to be buffered. Where rumination and mixing with saliva provide buffers to reduce the extent of pH decline in the rumen, a system of that magnitude does not exist for the hindgut. If a great deal of fermentable carbohydrate reaches the hindgut, its fermentation to organic acids may result in injury to the gut, with the increased acidity causing damage to and sloughing of the surface cells (epithelium) in the large intestine. When the damage is sufficiently severe, the intestine secretes/leaks mucous or fibrin to which covers the injury (Argenzio, et al., 1988; Argenzio and Meuten, 1991). Depending upon the severity of the damage, the gut may repair itself in a few hours to a day (R. A. Argenzio, personal communication). Is extreme

damage permanent? The mucin casts found in the feces often have the tubular form of the gut; they are evidence that intestinal damage has occurred.

A more "loose" fecal consistency has been associated with feeding of magnesium oxide, higher levels of digestible protein, or animals consuming lush pasture. Very firm or dry manure

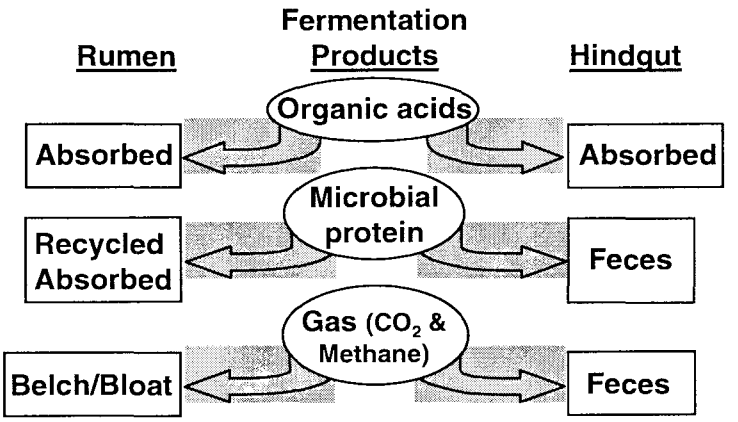

Figure 1. Fates of fermentation products from rumen and hindgut (cecum and large intestine) fermentations.

has been associated with less hindgut fermentation, and lower dietary concentrations of protein. In contrast to more "loose" manure, diarrhea is almost purely liquid in appearance. Diet related increases in hindgut fermentation or feeding of spoiled or moldy feed has been associated with an increased incidence of diarrhea.

Fecal consistency should be similar among cows receiving the same diet, with the exception of the ~5% of cows that normally have different looking manure. If the manure is not relatively uniform in a group, the cows are not all receiving the same diet, often due to sorting of feed.

Sometimes, pieces of feces can be found that have a clay-like consistency, unlike the rest of the manure they were excreted with. These clay-like lumps contain little fibrous matter. The veterinarians at the University of Florida (Drs. C. Risco, and A. Donovan) indicated that these are not normal, and are seen when there is some digestive disturbance (may include, not restricted to ruminal problems). It is not certain where these form in the gut.

Fecal Particle Size/Undigested Material in Feces: Fecal particle size relative to the size of particles in the diet is indicative of the extent of feed particle breakdown due to rumination and microbial action in the rumen. Large fiber particles ($\geq$1 cm) or abundant ground grain in the feces suggest that feed is not being retained in the rumen for a sufficient period to be reduced in size through rumination or microbial fermentation. The depression in ruminal digestion may sometimes be related to low ruminal pH (Strobel and Russell, 1986). An inadequate ruminal fiber mat may not effectively retain larger particles in the rumen. Both of these situations can be related to inadequacy of the physically effective form of the diet (combination of particle size, digestibility of fiber, etc.). Generally, when adequate

physically effective fiber is consumed, fecal particle size is smaller and ground grain is less apparent, than when these fiber requirements are not met.

Undigested feed in feces is indicative of an overall reduction in digestibility of the ration. Both fiber and starch can escape digestion. Long pieces of fiber from forage, or even cottonseed with the lint intact can pass undigested through the gastrointestinal tract if they are not retained in the rumen for digestion. Visible particles of ground grain from maize in feces may contain 6 to 18% starch (M. B. Hall, unpublished). Much whole or coarsely ground grain in the manure usually indicates problems with silage harvest methods or inadequate grinding of dry grain. Finer grinding of the dry grain can help to reduce appearance of grain in the manure. Problems with chop length of silage must wait to be addressed in the next harvest. Very digestible feedstuffs such as citrus pulp or beet pulp are rapidly fermented; their presence in feces indicates reduced ruminal retention and increased rate of passage.

Reduced digestion of feed represents a loss of ration nutrients. Consequently, the predicted protein and energy supplies for the ration overestimate what the cow actually receives, and feed efficiency (milk + component yield divided by dry matter intake). High producing cows with high dry matter intakes may also show an increased passage of undigested feed, but not to the extent noted with rumen dysfunction.

Method of Fecal Particle Size Evaluation: Various schemes for on-farm evaluation of fecal particle size have been suggested, from single to multiple mesh screens. On farm, these evaluations have been qualitative, that is, they are not intended to define digestion or rumination, but to give an index of whether large particles and undigested feeds were passing from the rumen at acceptable or unacceptable levels. For this purpose, a simple method may suffice.

For each group of cows, obtain 4 or 5 samples of feces from individual cow pies: select for variation in appearance representative of the group. Make sure the samples are not contaminated with feed. Sample cups (8 oz) with lids are very good sample holders. Use a screen or kitchen strainer (do not return it to the kitchen) with 1/16 inch openings. This is a qualitative, on farm evaluation, so getting very specific about mesh size is not crucial. A strainer that is ~7 nches in diameter and ~4 inches deep works well. Transfer a fecal sample into the strainer, using a steady stream of water to rinse the cup into the strainer. Rinse the sample gently but thoroughly until the water runs clear. The sample can be transferred back to the sample cup so that all of the samples taken can be compared side by side. Does fiber in the sample appear to be coarse (more than 1 cm long, identifiable pieces of forage)? Does cottonseed present still have the lint still on it? Does the feed retain its color (grass that's still green, citrus that's still orange, etc.)? Is there much (relative term) whole grain in the sample? Ground grain? Fecal evaluation is qualitative, so you will need to assess whether there appears to be too much or an acceptable amount of coarser fiber or undigested grain in the feces (see "In Context"). I am not familiar with a common, on-farm way to evaluate the proportion of feces the samples represent, so it would be difficult presently to determine dietary digestibility based on undigested feeds in feces.

pH: Ruminal pH has been evaluated on-farm through the use of rumenocentesis. As a nutritionist, I have preferred to use less invasive routes to determine if rumen function is compromised. A cautionary tale to the use of ruminal pH to determine rumen function is described in Figure 2. In this feeding study, ruminal pH differed significantly by cow. The highest daily ruminal pH was detected pre-feeding, and the lowest at 3 to 6 hours after feeding. The pH maintained by cow 2661 on the alfalfa silage diet at 24% neutral detergent fiber in the diet would typically be deemed as indicative of ruminal acidosis. However, no animals showed signs of health disorders, nor was lactic acid detected in the rumens. Cow 2661 had the numerically greatest milk yield, dry matter intake, protein percentage and ruminal volatile fatty acid concentration, but her milk fat percentage was lowest among the cows. Cow 2661 did have moderately drier (~18% dry matter) rumen contents than the other cows (~13% dry matter) (P.J. Weimer, personal communication). There is ample proof that depressions in ruminal pH can lead to ruminal dysfunction. However, other indices of rumen function may give more certain diagnosis of the problem than ruminal pH alone.

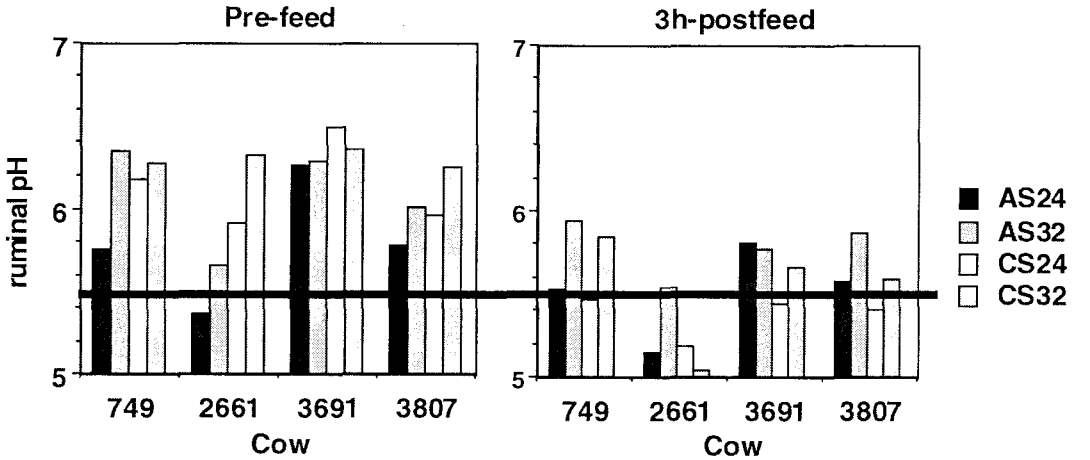

Figure 2. Ruminal pH before and 3 hours postfeeding in four cows fed 24 or 32% neutral detergent fiber diets based on alfalfa silage (AS) or maize silage (CS). The dark line across both graphs represents pH 5.5 (Weimer et al., 1999).

Fecal pH generally declines when there is increased hindgut fermentation, unless diarrhea occurs, in which case fecal pH will be relatively high. In evaluating the fecal pH of cattle on different diets, my impression is that fecal pH is not a very sensitive tool with which to evaluate escape of fermentable feed from the rumen, but that may depend upon how extreme the circumstances are and on the mineral components of the diet.

Other Factors to Observe and Assess

Good or poor rumen function exhibits its effects in a variety of other signs we can observe:

- Body condition: Are animals gaining or losing weight relative to expected response to the diet? Is the average body condition score acceptable for the group? Is there much variation in condition score within a group?
- Lameness: Is lameness due to laminitis, white line disease, etc. present in the herd.

- Eating soil: Deliberate consumption of soil, free-choice bicarbonate, etc. seems to occur most frequently when there is gastrointestinal upset.
- Feed efficiency: Feed efficiency for milk production is defined as fat and protein corrected milk production divided by dry matter intake. It declines in unbalanced rations, in cases of digestive dysfunction, with increased days in milk, with growth, with health disorders, and when maintenance requirements are increased (increased walking, etc.). A minimum of 1.4 is recommended for herds (M. Hutjens, personal communication.
- Feed bunk management: Do cows sort the feed? Do they consume large meals of grain? Is there adequate bunk space for all animals to eat?
- Are the cows receiving and consuming the ration that was formulated? Particle size?
- Do the animals look dull, or bright and healthy?
- Are the cows nervous or calm?
- Are any of the feeds apparently moldy or spoiled?
- Do the feeds appear to contain any undesirable foreign material?
- Are the correct feeds being mixed in the right amounts and order?
- Are the scales used for measuring the feeds accurate?

In Context

To make the information from evaluating factors related to rumen function most useful, they need to be combined with other information and considered in context. Information on cow health (digestive upset, acidosis, laminitis, etc.), cow performance (milk and milkfat yields), cow observations (sorting the ration or not, comfortable or not), ration & feed evaluation, etc. can be joined with rumen function observations into a body of evidence that indicates the elements within the diet or in cow and feeding management do or do not need to be modified. If everything else looks fine, but the observations related to rumen function do not seem quite right, keep observing the cows to make certain that they continue to do well, and further question what you haven't checked. Transient problems like eating patterns changing with weather fronts, a passing problem with silage, etc. can also generate changes -- these demand patience rather than an immediate change.

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