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Calf Note #63 – What is Rumen Abrasive Value?

Introduction

Development of ruminal function in newborn calves is critical to proper health and growth. Over the past 50 years, researchers have debated the optimal ways to feed and manage calves for optimal rumen development. The general consensus among researchers is that the end-products of fermentation of carbohydrate – namely, the volatile fatty acids – are responsible for development of the physical and metabolic capabilities of the rumen.

However, researchers such as McGavin and Morrill (1976) reported that a lack of forage in the diet of calves at 6 weeks of age resulted in development of abnormally shaped rumen papillae that were indicative of *ruminal parakeratosis*. This condition is characterized by the development of hard, keratin layers on the surface of the rumen papillae. The papillae, which are responsible for absorbing volatile fatty acids into the bloodstream, can also clump together, causing a reduction in the absorptive surface in the rumen.

Parakeratosis

Parakeratosis is the build up of excessive amounts of keratin on the surface of the papillae. This buildup effectively covers the absorptive sites on the papillae and reduces the ability of the cells to absorb VFA and other compounds into the blood. Excess keratin build up has been attributed to a lack of fiber in the diet, excess grain and production of butyric acid (the acid primarily responsible for growth of the papillae), and other factors. A lack of forage in the diet can reduce the amount of physical abrasion of the feed particles on the papillae. This physical abrasion has often been referred to as "scratch factor" or "rumen abrasion value" (**RAV**). In severe cases of parakeratosis, the rumen papillae can clump together, which further reduces the amount of absorptive surface available. In response to the buildup of keratin, papillae may for branches, to try to increase its surface area.

Parakeratosis is a metabolic condition, but it has not always been associated with reduced animal performance (i.e., growth). In fact, many calves fed diets containing little forage may develop parakeratosis, but grow very well. Researchers have reported increased incidence of parakeratosis in the rumens of calves fed "all-in-one" type of rations. These are commonly fed in the U.S. by several feed companies and include a source of "roughage" such as cottonseed hulls or soybean hulls. However, these roughage sources are finely ground to allow them to be included in a pelleted form. Thus, the ability of these "roughage" sources to actually provide any RAV is probably quite limited.

Estimation of the ability of the diet to provide sufficient abrasion has not been widely utilized. In the mid 1970's some researchers began to use the bulk density of the diet as an indication of the abrasive ability of the diet. Generally, forages will contain a lower bulk density (and higher abrasive value) than concentrates.

A new method

Researchers at Kansas State University (Greenwood et al., 1997) reported a method to estimate the RAV of various diets. The method described in the research article is summarized below.

Equipment: a Hobart mixer (model A 200 was used in the research) fitted with a mixer bowl (model A 200-20) and a mixer hook (model ! 200-ED) an oven and paraffin wax.

Procedure: heat the paraffin (about 1,800 g) in an oven at 55 C overnight to melt. Place the mixer hook in the refrigerator (4 C) for about 10 minutes. Weigh the hook and then dip the hook several times into the melted paraffin. After each application, the hook was held vertically upside down to allow drips of wax to collect at the base. This procedure gave an even coating to the base of the hook (which would come into contact with the feed. Allow the paraffin about a half-minute to solidify on the hook between applications. Repeat the process until about 60 grams of paraffin was added to the hook. Remove any solid paraffin that does not have a good seal with the hook (by trimming with a knife) and then give the hook one final sealing coat of paraffin. Allow the hook to cool to room temperature and then weigh.

TABLE 1. Characteristics of calves fed diets of different particle size.

	Diet[1]		
Item	Fine	Medium	Coarse
Sieve screen[3]	20-40	8-20	6-8
RAV	5[a]	20[b]	26[c]
Rumen VFA, mM	81.7	86.7	76.1
Acetate, %	51.0	50.7	51.3
Propionate, %	32.1	31.5	32.6
Butyrate, %	11.9	11.1	10.7
Rumen pH	5.83	5.39	5.68
Plasma urea, mM	3.3	4.0	3.6
Plasma glucose, mM	4.7	4.8	4.6
Blood BHBA, mM	0.19	0.21	0.15
Empty stomach weight, g	1.72	1.55	1.54
Reticulorumen, %	57.9	58.3	60.5
Omasum, %	19.7	14.5	13.7
Abomasum, %	22.5	27.2	25.7
Ruminal keratin, %	31[a]	14[b]	8[b]
Papillae length, mm	2.22[a]	1.62[b]	1.10[c]

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

[1]Diet: Fine = ground concentrates and ground hay; coarse = textured concentrate and chopped hay; medium = 50% fine and 50% coarse diets.

[2]Probability of a significant treatment difference; NS = $P > 0.10$.

[3]Tyler sieve screen size upon which > 50% of the feed particles remained. The higher the number, the more coarse the material.

Reference: Greenwood, et al. (1997).

Connect the coated hook to the mixer (being careful not to damage the paraffin coating). To the mixer bowl, add 5,800 mL of water and 500 g of feed sample. Mix the water/feed sample for 1.5 hours at a mixing speed of 1 on the mixer. Carefully remove the hook, rinse with deionized water and allow to dry. Weigh the hook to determine the amount of paraffin removed. The RAV was the amount of paraffin removed during mixing.

In the study, Holstein bull calves (n = 12) were limit-fed each of three diets (fine, coarse and intermediate) for 6 weeks, then sacrificed to measure indices of stomach development and rumen morphology. Blood samples were also measured at 3 and 6 weeks of age.

Results of the method are shown in the table. There were few differences among diets in indices of rumen development such as rumen VFA (total concentration or molar percent), pH or blood parameters such as urea N, glucose or β-hydroxybutyrate (BHBA). Empty stomach weight and proportion of each compartment were not markedly different due to diets, although empty omasal weights declined as diet particle size increased.

The amount of keratin on ruminal epithelium and the length of ruminal papillae declined as the particle size increased. The amount of branching in papillae (thought to be a sign of loss of absorptive ability) did not vary according to treatment.

The authors concluded that the degree of keratinization within the rumen is related to the abrasiveness of the diet, which can be estimated by the RAV.

Conclusions

The importance of forage in supporting good ruminal health is well established. However, the minimum particle size (and RAV) of diets is not as well established. It is not clear, currently, if particle size of diets typically used in the industry (e.g., textured calf starters) provide sufficient particle size to minimize the development of parakeratosis in calves.

References

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2. McGavin, M. D. and J. L. Morrill. 1976. Scanning electron microscopy and ruminal papillae in calves fed various amounts and forms of roughage. Am. J. Vet. Res. 37:497-508.