Rumin8®: Feeding the Microbes That Feed the Cow

A SPECIAL RESEARCH REPORT

What Soluble Sugars and Organic Acids Can Do For the Rumen

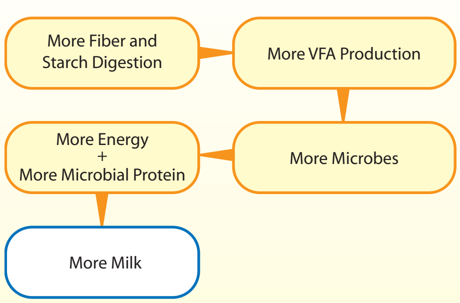
MS Specialty Nutrition

Milk yield per cow has continued to increase over the last two decades. The increase can be attributed to improved management and genetics, but a major component is a better understanding of both the cow's nutrient requirements and the nutrient composition of the feedstuffs.

One area of nutrition that has been receiving a lot of interest is the supplementation of dairy rations with blends of soluble sugars. Recent field studies have reported substantial increases (4–6 lbs) in daily milk yield from cows supplemented with specific blends of soluble sugars.

It is a challenge to feed the high producing dairy cow because total nutrient utilization is a combination of those nutrients digested as feed and the digestion by ruminal microorganisms. The optimum ration provides the timely availability of the proper nutrients to increase the growth of ruminal microorganisms. Greater rumen microbial populations then increase the cow's total nutrient utilization, enhance fibrous feed digestion, and provide a more stable rumen environment. Ruminal microbes utilize ammonia, amino acids and peptides as nitrogenous nutrients, but require an energy source. The energy for the microbes is supplied by fermentative digestion of carbohydrates and glycerol from dietary fats. The end products are volatile fatty acids (VFA) as the primary energy source needed for growth and production. Dietary protein and ruminal microorganisms then in combination provide the total amino acids utilized by ruminant tissue (Figure 1).

Figure 1. Maximizing Rumen Efficiency



Milk production by the lactating dairy cow can frequently be limited during lactation by energy intake and protein supply to the small intestine. Maximizing rumen microbial protein synthesis is a very economical way to increase the protein supply to the small intestine. Non-structural carbohydrates (NSC), which are readily fermentable in the rumen can be added to the diet to increase the utilization of ruminal ammonia nitrogen for additional microbial protein synthesis. Excellent sources of fermentable carbohydrates are specific soluble sugars.

Increased Nitrogen Flow

Several research trials have reported the beneficial effects of supplementing the ruminal diet with specific sugar(s) (Poncet and Rayssiguier, 1980; Schingoethe et al, 1979; Schingoethe & Skyberg, 1980; Windschitl and Schingoethe, 1984). The inclusion of these soluble sugars into the ruminant diet results in an improvement in non-protein nitrogen utilization by the rumen microbes increasing microbial protein synthesis.

Furthermore, researchers report significantly greater uptake of ammonia from the rumen resulting in additional microbial protein synthesis. Poncet and Rayssiguier (1980) evaluated nitrogen digestion of sheep fed lucerne hay (31–35% soluble protein) with and without specific supplemental sugar. Nitrogen (N) intakes were similar, however the amount of N and non-ammonia nitrogen (NAN) reaching the duodenum was increased by 8 g/day for the sheep receiving the supplemental sugar (Table 1). The amount of N flow to the abomasum was increased by 47% and the amount of NAN apparently digested in the small intestine was increased as much as 83%.

Table 1. Effect of Soluble Sugar on Nitrogen Digestion of a Lucerne Hay Diet in Adult Sheep

	Diet	
	Hay	Hay + Soluble Sugar
N intake, g/day	17.07	16.82
NAN at duodenum, g/day	15.56	23.78
NAN apparently digested in small intestine (SI), g/day	8.12	14.88
Percentage entering SI	52.20	62.40
Blood urea, mg N/100 ml	20.50	8.70
Rumen ammonia, mg N/100 ml	20.60	2.30

Poncet & Rayssiguier, 1980

In addition, the percentage of NAN entering the small intestine was enhanced in the sugar supplemented sheep. These results suggest that a greater uptake of ammonia from the rumen is occurring, and thus there is more efficient protein synthesis.

The improvement in ammonia uptake and utilization was supported by lower blood urea nitrogen (BUN) and rumen ammonia concentrations in the sugar supplemented diets. Rumen ammonia dropped from 20.6 to 2.3 mgN/100 ml, and BUN levels decreased from 20.5 to 8.7 mgN/100 ml when sugar was fed (Table 1). The reduction in rumen ammonia in animals fed sugar(s) is supported by work reported by Windschitl and Schingoethe (1984) in rumen-fistulated cows.

The increase in N flow to the small intestine is related to an increase in bacterial N synthesis and lower protozoal N

Table 2. Effect of Control and Soluble Sugar Diets on Bacterial and Protozoal Protein Synthesis

	Diet	
	Hay	Sugar
Bacterial N as a percent of rumen N	17.07	16.82
Protozoal N as a percent of rumen N	15.56	23.78

Windschitl & Shingoethe, 1984

Table 3. Effect of Soluble Sugar on Ruminal Fluid Volumes and Dilution Rates in Holstein Cows

	Rumen Parameters	
	Volume	Dilution Rate % / hr
Control	33.8	10.2
Soluble Sugar	39.2	12.8

Windschitl & Shingoethe, 1984

synthesis (Windschitl & Schingoethe, 1984; Table 2).

Bacteria synthesize protein more efficiently than protozoa. Furthermore, several sugar sources contain relatively high levels of mineral salts, which enhance the ruminal fluid volume and the dilution rate (Table 3). This increased dilution and turnover rate favors the bacteria more than protozoa.

It is important to note that the rumen microorganisms are themselves protein and flow out of the rumen in the fluid phase. Thus, the improvement in dilution rate will increase the outflow of nutrients to the small intestine.

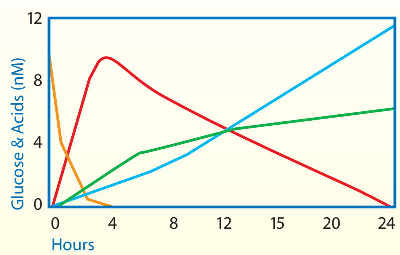
Increased Volatile Fatty Acid Production

The addition of soluble carbohydrates to the ration increases the total VFA concentrations in the rumen. This is attributed to an increase in butyrate concentrations while propionate and acetate levels appear unchanged to slightly lower. Several trials report an improvement in organic matter disappearance within the rumen and small intestine. In addition, both energy and dry matter digestibilities were improved.

Soluble sugars are completely fermented in the rumen, resulting in a lower rumen pH and a higher lactate concentrate (Fig. 2). Selenomonas ruminantium is a gram-negative anaerobe and has a high affinity for glucose, sucrose, maltose and xylose.

As the growth rate increases the predominant fermentation product from these sugars is lactate, while acetate and propionate are decreased. Lactate production and accumulation contributes to the acidity of the rumen fluid. A similar response occurs in ruminants fed high grain diets. After the hexoses are depleted the bacteria then utilize the lactate as an energy source (Scheifinger et al, 1975). The secondary fermentation products are acetate and propionate (rumen energy sources, Figure 2).

Figure 2. Product Accumulation by *Selenomonas ruminantium* HD4

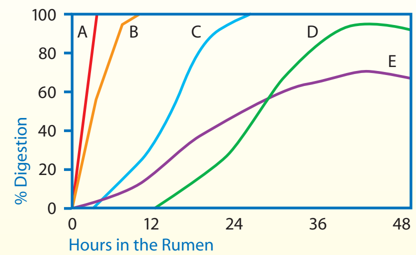


Scheifinger et al., 1975

Substrate Availability

The rate of digestion of nutrients in the rumen and the rate of passage out of the rumen are keys to increased performance. Proteins and carbohydrates are the key nutrients promoting microbial growth. All carbohydrate and N sources are not digested at the same rate. The efficiency of rumen digestion is enhanced by supplying the rumen microbes substrate, both N and carbon, that are digested at similar rates. In addition, it is important that there are nutrients available throughout the day.

Figure 3. Effect of Different Rates of Carbohydrate Digestion Based Upon Cumulative Extent and Time



A Soluble Sugar
B Pectins, Vegetable Celluloses, Branched Starches
C Crystalline Starch
D Crystalline Cellulose
E Alfalfa Cell Wall

Sniffen & Robinson, 1987

Figure 3 illustrates the effect of different rates of carbohydrate digestion upon cumulative extent and time (Sniffen and Robinson, 1987). The amount of digestion and the rate varies considerably depending on the carbohydrate fraction. Notice the difference in digestion rate between sugar and starch. Both are rapidly fermentable carbohydrates, but sugars are completely digested within 30–60 minutes after entering the rumen, compared with 2–6 hours for starch.

The same is true for different nitrogen sources. Figure 4 represents the rate of protein fraction disappearance from a dacron bag (adapted from Satter 1986). Non-ammonia nitrogen is completely digested within 30–60 minutes while rapid and moderate degradable protein require 3–12 hours. To increase the growth of ruminal microorganisms we must feed a ration that provides the timely availability of proper nutrients to the microbes. Obtaining the appropriate balance of

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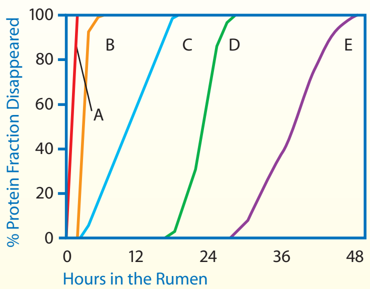
Figure 4. Rate of Protein Fraction Disappearance From Dacron Bag



A Nonprotein N
B Rapid Degredation
C Moderate Degredation
D Intermediate Degredation
E Slow Degredation

Sniffen & Robinson, 1987

energy and protein fractions and achieving a balanced nutrient flow over time is critical to maximizing milk production.

It should be noted that not all sugar sources elicit a response. Sugar sources as starch are digested at different rates, so it is very important to provide proper blends and concentrations of specific sugars to enhance rumen digestion.

Nombekela and Murphy (1995) reported a sucrose-sweetened diet did not enhance mean DMI over the first 12 weeks post partum compared to the control diet. In addition, supplementing the diet with sucrose failed to elicit an improvement in milk yields, 3.5% FCM yield and the percentages of milk fat and milk protein.

Several studies have been conducted evaluating the effect of molasses supplementation to ruminant diets. Results have been extremely variable. Morales et al (1989) reported results that clearly showed the molasses effect depended on the percentage of molasses and the type and amount of roughage in the diet. Cows fed cottonseed hull (30% of DM) and molasses diets recorded relatively small increases in DMI and milk yield (1.8–2.2 lbs). Diets with alfalfa haylage (35% of DM) and 8% molasses depressed milk yield, DMI, milk protein and milk fat percentages. No effect was recorded at higher levels of alfalfa haylage. It is important to note that cane molasses is only 42–50% soluble degradable carbohydrate (sugar).

Table 4. Response to Rumin8 in 34 Field Trials[1]

Feed Rate, lbs/hd/d	# Cows	Weighted Response, lbs/hd/d
0.33	1480	+3.12
.5	1949	+3.7
All	3429	+3.47

1 Data includes one herd that showed no response to Rumin8®, but when Rumin8® was taken out of the diet, milk yield decreased by 4 lbs/hd/d.

Improved Lactic Acid Uptake

As previously discussed, rumen bacteria digest hexoses and produce lactic acid as an intermediary end product (Figure 2). Once the hexoses are depleted, certain bacteria can utilize the lactic acid and synthesize propionic acid. S. ruminantium and Megasphaera elsdenii are the two predominant ruminal microorganisms that have the capability to convert lactate to propionate through a randomizing pathway.

However, when the level of lactic acid production exceeds the bacteria's ability to convert it to beneficial VFA, lactic acid accumulation occurs. The extra production and accumulation of lactate contributes to the acidity of the rumen fluid, lowering rumen pH which may lead to rumen dysfunction.

Enhancing the uptake and utilization of the lactic acid by bacteria may help maintain the rumen pH by preventing an acidotic state due to lactate accumulation. Nisbet and Martin (1991, 1993 and 1994) reported an increase in the uptake and utilization of lactate by S. ruminantium when the dicarboxylic acids, malic and fumaric, were added to the culture medium. Similarly, Rossi et al (1995) observed that extracts from yeast culture preparations enhanced the growth and lactate utilization of a second lactic acid-utilizing ruminal organism: Megasphaera elsdenii. The key component for this stimulatory response was malic acid.

Malic and fumaric acids act as catalyst to the S. ruminantium and stimulate the conversion of lactate to propionate. The inclusion of malic acid in ruminal fluid can elevate the concentration of valuable VFA and help prevent the decline in rumen pH and ruminal dysfunction.

Malic acid also appears to have a similar mode of action as monensin. Both have the capability to capture H+ ions, reducing the amount of methane produced. It has been suggested that the end result is higher propionate levels.

Summary

This is the science used to research and develop the commercial sugar supplement, RuMin8®. RuMin8® is a specific blend of soluble sugars and organic acids developed by MS Specialty Nutrition.

The advantages of supplementing sugars to lactating dairy cows are greater uptake of rumen ammonia, lower blood urea and greater microbial protein synthesis. Having adequate soluble sugar levels will allow for maximum milk production and economical use of microbial protein.

Field Trial Results

Table 4 illustrates the positive response to feeding RuMin 8® from 34 field studies. The improvement in milk production ranged from 1.5 to 7.5 lbs per cow per day, resulting in a 3.47 lb average increase. These increases were achieved by feeding ⅓ to ½ lb of RuMin 8® per cow per day.

Advance® RuMin 8® RUMEN ENHANCER

Rumin8®: Feeding the Microbes That Feed the Cow

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