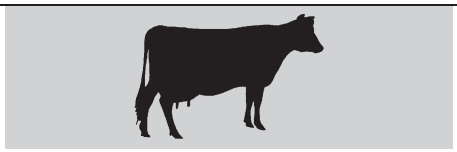
The Professional Animal Scientist 26 (2010):647–654



Effects of Supplementation of Natural Zeolite on Intake, Digestion, Ruminal Fermentation, and Lactational Performance of Dairy Cows[1]

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ABSTRACT

A lactating dairy cow experiment was conducted to determine the influence of a ruminal buffer product containing magnesium-exchanged zeolite on ruminal fermentation and lactational performance. The experimental TMR diet consisted of 38% alfalfa hay, 19% corn silage, 14% corn grain, and 30% concentrate mix on a DM basis, and it was fed ad libitum. Thirty primiparous and multiparous lactating Holstein cows (52 ± 23.0 DIM) were assigned to 1 of 3 dietary treatments with 10 cows in each treatment: control (TMR diet without ruminal buffer), TMR diet with 1.4% sodium bicarbonate (SBD), and TMR diet with 1.4% zeolite product (ZD). The experiment was a completely randomized design performed over 12 wk. Intake of DM was similar (26.5 kg/d) across treatments. Milk yield was similar among the 3 treatments (40.7 kg/d on average), and efficiency (4% FCM/DMI) was not affected by treatments. Milk fat concentration did not differ among treatments, whereas milk protein concentration tended to be higher for the ZD than for the control and the SBD (P = 0.15). Although feeding the ZD resulted in a tendency of increased milk protein concentration, feed nitrogen (N) efficiency for milk N did not differ among the 3 treatments. In addition, milk urea N concentration was not influenced by feeding the ZD. Ruminal pH tended to increase (P = 0.11) when feeding the SBD or the ZD compared with the control. Concentration of ammonia N did not differ among treatments. Feeding the ZD tended to decrease (P = 0.14) total VFA production compared with feeding the control and the SBD, whereas molar proportions of acetate and propionate were not affected by the treatments. The zeolite product used in this study would cost-effectively replace sodium bicarbonate as a ruminal buffer additive in a lactating dairy diet, but its efficacy needs to be further assessed when supplemented in a high-concentrate lactating dairy diet whereby animals may experience subacute ruminal acidosis.

Key words: lactating dairy cow, ruminal fermentation, sodium bicarbonate, zeolite

INTRODUCTION

Sizable inclusion of readily fermentable carbohydrate feedstuffs in dairy rations causes the appearance of digestive disorders such as subacute ruminal acidosis in dairy cattle if appropriate precautions are not taken. Strategic use of dietary ruminal buffers has been suggested as a sound approach to ameliorate the occurrence of ruminal acidosis, especially when lactating diets include large amounts of readily fermentable carbohydrate. Commonly used as an exogenous buffer, sodium bicarbonate ($NaHCO_3$) is involved in the stabilization of ruminal pH in cows that can potentially suffer from ruminal acidosis (Clark et al., 2009). This chemical feed additive is characterized by an acid dissociation constant (pKa = 6.25) that is close to the normal ruminal pH. Therefore, $NaHCO_3$ is generally recognized as an efficient buffer because of its high acid-consuming capacity in

[1] Approved as Journal Paper Number 8224 of the Utah Agricultural Experiment Station, Utah State University, Logan.
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the rumen, and its mode of action is well documented (Erdman, 1988; Russell and Chow, 1993).

Any mineral additive to a diet is costly for the producer, and significant improvements in performance are not always achieved (Rogers et al., 1985; Harrison et al., 1986). Therefore, research is continuing to identify cheaper mineral buffers that exhibit the same mode of action as the established buffers. The natural zeolite clinoptilolite has a high attraction for water and a large number of cations, such as K^+, NH_4^+, Ca^{2+}, and Mg^{2+}, which can be reversibly bound or released, depending on the surrounding conditions (Mumpton, 1999). The high affinity of zeolites for water and osmotically active cations may facilitate ruminal fermentation, and osmotic activity may regulate pH in the rumen by buffering against hydrogen ions of organic acids. In addition, supplementing zeolite in dairy diets may improve nitrogen (N) utilization, because zeolite gradually releases excess ammonia (NH_3) in the rumen and allows rumen microorganisms to capture the NH_3 into microbial protein for assimilation into the animals' digestive systems (Mumpton, 1999).

Johnson et al. (1988) reported that ruminal pH increased when synthetic zeolite was added to the diet; however, the change in pH was only 0.2 units, and addition of the synthetic zeolite, with or without $NaHCO_3$, resulted in negative effects on feed intake, milk production, milk component yield, and nutrient digestibility in lactating Holstein cows. To our knowledge, there is a lack of experimental results regarding the effects of long-term feeding of lactating dairy cows with clinoptilolite, a natural zeolite, on its potential as a ruminal buffering agent.

The objectives of this study were 1) to investigate whether natural zeolite could replace $NaHCO_3$ as a buffer in the dairy cattle diet, and 2) to assess the effects of $NaHCO_3$ and natural zeolite additions on feed intake, milk production and composition, digestibility, and ruminal fermentation characteristics when added to a lactating dairy diet.

MATERIALS AND METHODS

Cows and Experimental Diets

The experiment was carried out using 30 Holstein cows consisting of 7 primiparous and 23 multiparous cows. At the start of the experiment, DIM averaged 52 ± 23.0. For 1 wk before feeding experimental diets, all cows were fed a diet without ruminal buffer. This 1-wk phase was used as the covariate period; thus milk yield and DMI were determined. At the end of the covariate period, 10 cows were assigned to 1 of 3 dietary treatments: control diet without ruminal buffer (**CD**), 1.4% sodium bicarbonate diet (**SBD**), and 1.4% clinoptilolite zeolite diet (**ZD**) on a DM basis. The cows were assigned to the dietary treatments based on previous milk yield, DIM, and parity. The experiment was conducted in a completely randomized design over 12 wk. Cows were weighed at approximately 0830 h at the beginning of the trial and end of wk 4, 8, and 12, and these weights were used to calculate the mean BW of cows for each month. Average BW was 676 ± 71.8 kg at the beginning of the experiment and 726 ± 70.2 kg at the end of the experiment. The dairy cows used in this study were cared for according to the Live Animal Use in Research Guidelines of Institutional Animal Care and Use Committee at Utah State University.

The diets contained 57% forage (67% alfalfa hay and 33% corn silage) and 43% concentrate mix on average (Table 1). The diets are typical for high-producing dairy cows in northern Utah, containing more alfalfa hay than corn silage, and baled alfalfa hay is commonly fed to provide 50 to 75% of the dietary forage, with total forage levels averaging 45 to 55% of the dietary DM. Diets were formulated based on NRC (2001) recommendations to provide sufficient NE_l and protein, vitamins, and minerals to produce 38 kg/d of milk with 3.5% fat and 3.0% true protein.

Table 1. Ingredient composition of the control diet

Ingredient	% DM
Alfalfa hay	37.9
Corn silage	19.3
Corn grain, steam flaked	13.7
Whole linted cottonseed	4.41
Cottonseed extender	2.82
Dried sugar beet pulp	5.69
Soybean meal, expeller	1.66
Canola meal	2.09
Molasses, sugar beet	1.20
Corn dried distillers grains with solubles	2.79
Corn hominy	5.47
Blood meal	1.10
Mineral and vitamin mix[1]	1.87

[1]Contained (per kg of DM) a minimum of 250,000 IU vitamin A, 65,000 IU vitamin D, 2,100 IU vitamin E, 400 mg Fe, 540 mg Cu, 2,100 mg Zn, 560 mg Mn, 15 mg Se, 35 mg I, 68 mg Co, and 19.6 g Rumensin (Elanco Animal Health, Greenfield, IN).

The clinoptilolite zeolite used in this study (RuMag™; ZeoTech Corporation, Fort Worth, TX) is a complex rumen buffer containing Mg- and Ca-exchanged zeolite and Mg and calcium hydroxide. The hydrothermal process used to chemically bond hydrate of Mg lime to high, cation-exchangeable and absorptive clinoptilolite zeolite results in a high-quality, prilled rumen buffer with bioavailable Mg and Ca conditioning properties of zeolite. The supplementation rate of clinoptilolite zeolite used in this study (1.4% DM) was based on the manufacturer's recommendation for an adult lactating dairy cow.

Cows were housed in individual tie stalls fitted with rubber mattresses, bedded with straw, and fed a TMR for ad libitum intake with at least 10% of daily feed refusal. All cows were individually fed twice daily at 0530 and 1630 h with approximately 60 and 40% of total daily feed allocation at each feeding, respectively. Feed offered and refused was recorded daily, and daily samples were collect-