MIN-AD

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A Comparison of MIN-AD® and MagnaBuf® in a Feedlot Steer Rumen Environment[1]

Abstract: Two experiments using an *in vitro* continuous culture system were conducted to evaluate the effects of Mg source on ruminal characteristics under typical feedlot diet conditions in a completely randomized design. Treatments included: 1) negative control (NC; no supplemental Mg or Ca); 2) positive control (PC; supplemental Mg from MgO and Ca from $CaCO_3$); 3) MIN-AD (MA; included at 1% of dietary DM); and 4) MagnaBuf (MB; included at 1% of dietary DM). Twice daily, each fermentor was fed 30 g of a 90% concentrate diet containing the appropriate treatment. Each fermentor was sampled at feeding and four hours after feeding for ammonia, short chain fatty acids, and pH. Effluent from each fermentor was compiled over three days for analysis of nitrogen, dry matter, organic matter, and purines. Bacterial cells from each fermentor were also analyzed for nitrogen and purines to calculate nitrogen flow and microbial efficiency. In Experiment 1, fermentors receiving the MA treatment produced more ($P < 0.05$) propionic acid and butyric acid than fermentors receiving any of the other treatments. Acetic acid production was greater ($P < 0.05$) for the PC treatment compared with the NC and MB treatments, but was not different from the MA treatment. There was a trend for microbial efficiency to be greater ($P < 0.10$) in the NC treatment than in the MB treatment, while the PC and MA treatments were intermediate. In Experiment 2, fermentors receiving MA produced more ($P < 0.10$) propionic acid than fermentors receiving the NC treatment. Propionic acid production of fermentors receiving the PC and MB treatments were intermediate and similar ($P > 0.10$) to the other two treatments. Measurable differences were observed among different sources of supplemental magnesium. The observations from these experiments suggest that addition of MIN-AD to typical feedlot diets increases volatile fatty acid production, specifically propionate, which could result in increased growth rates for cattle.

Introduction

MIN-AD has been successfully used in feedlot steer rations for over thirty years as a buffer and source of magnesium (Mg) and calcium (Ca). It is typically used in full replacement of magnesium oxide (MgO) and partial replacement of limestone. Numerous competitive products have entered the market during this time, but they generally have lower Mg than MIN-AD, more silica, and poorer solubility. However, a recently introduced product, MagnaBuf, has a similar

[1] These experiments were conducted at the University of Missouri under the guidance of Dr. Monty Kerley in late 2003 and early 2004.

chemical assay for Mg and Ca as MIN-AD. This bulletin reports on a series of fermentation studies that compare the effects of MIN-AD and MagnaBuf on diet digestion, fermentation characteristics, and microbial growth. It also helps to elucidate the previously observed positive production responses to feeding MIN-AD (see MIN-AD Bulletins B-1, B-2, and B-3).

Materials and Methods

Two experiments were conducted using continuous culture fermentors (n = 19) to measure the digestibility and fermentation characteristics of a typical feedlot diet supplemented with different sources of Mg. Three different sources of Mg and a negative control, arranged in a completely randomized design, were evaluated. These four treatments included: 1) a negative control (NC) that contained no supplemental Mg or Ca; 2) a positive control (PC) that contained supplemental Mg and Ca from MgO and limestone, respectively; 3) a MIN-AD treatment (MA) containing 1% (diet DM) MIN-AD and limestone; and 4) a MagnaBuf treatment (MB) containing 1% (diet DM) MagnaBuf and limestone. The 90% concentrate diet (Table 1) primarily comprised finely ground corn (75%) and soybean meal (11.5%). All diets were formulated to meet NRC (1996) requirements for minerals and vitamins, excluding Mg and Ca (Table 2). The three treatments containing Mg and Ca were formulated to contain equal proportions of these elements. Each fermentation vessel was fed 30 grams of its experimental diet twice daily. Feeding this amount yields a similar solids to liquids ration that is achieved in the rumen of steers consuming approximately 3% of their body weight.

Table 1. Composition of diets (% of dry matter) fed to fermentation vessels.

Ingredient	NC[a]	PC	MA	MB
Corn, fine ground	74.69	74.69	74.69	74.69
Soybean meal	11.5	11.5	11.5	11.5
Soybean hulls	10.0	10.0	10.0	10.0
Premix[b]	2.0	2.0	2.0	2.0
MIN-AD	0	0	1.0	0
MagnaBuff	0	0	0	1.0
Limestone	0	1.37	0.81	0.81
Magnesium oxide	0	0.21	0	0
Solka floc	1.81	0.23	0	0

[a]NC = negative control; PC = positive control; MA = MIN-AD; and MB = MagnaBuf
[b]Premix was composed of 6.75% salt, 0.0011% cobalt acetate, 0.07% copper sulfate, 0.0033% potassium iodide, .23% manganese sulfate, .0004% sodium selenite, .17% zinc sulfate, and 92.78% solka floc.

Table 2. Calculated chemical composition of experimental diets[a].

Item	NC[b]	PC	MA	MB
NEm, Mcal/kg	2.07	2.07	2.07	2.07
NEg, Mcal/kg	1.42	1.42	1.42	1.42
Crude protein, %	14.28	14.28	14.28	14.28
Ca, %	0.11	0.58	0.60	0.60
Mg, %	0.14	0.29	0.28	0.28

[a]All values are expressed on a dry matter basis.
[b]NC = negative control; PC = positive control; MA = MIN-AD; and MB = MagnaBuf

Fermentation was achieved with single-phase continuous culture fermentors. In order to reduce animal-to-animal variation, ruminal inoculum was collected from three steers fed a typical feedlot type diet, similar to that described in Table 1. Each fermentor was inoculated 1:4 with rumen fluid and McDougall's artificial saliva. The saliva was pumped peristaltically into the fermentation vessels at a rate of 4% volume per hour. Prior to initiation of the experiment, each fermentor was allowed to turn over four fermentor volumes to achieve steady state conditions of the microbial population.

Sampling of fermentors was conducted over a three-day period following stabilization. On collection days, the total fermentor effluent was collected into vessels suspended in an ice bath with added formalin to cease microbial activity. Daily collections were composited and frozen until analysis. In addition to effluent collection, contents from each fermentor were also obtained daily at feeding and four hours after feeding.

Fermentor contents were subjected to differential centrifugation to isolate bacteria. This bacterial preparation was then used to establish a nitrogen to RNA ratio of bacteria for calculating microbial efficiency. In addition, the pH and ammonia concentration of the fermentor contents were also measured. The combined effluent was also centrifuged and then lyophilized to determine dry matter, organic matter and nitrogen composition. Concentrations of acetic acid, propionic acid, and butyric acid were also determined from the effluent.

All measurements were analyzed as a completely randomized design using the GLM procedure of SAS. Means were separated using a protected Fisher's least significant difference test. Standard errors presented in the results section represent the largest (most conservative) estimate because the number of replications per treatment was unequal.

Results

Experiment 1

Results from Experiment 1 are shown in Table 3. Organic matter digestibility was similar (P > 0.10) among all treatments, ranging from 61 to 63%. Fermentor pH also was not different (P > 0.10) among diets, ranging from 5.59 to 5.90. Fermentors receiving the NC treatment had a greater (P < 0.10) microbial efficiency than fermentors receiving MB. The microbial efficiency of fermentors receiving the PC and MA treatments were intermediate to and not different (P > 0.10) from the other two treatments. Propionic acid production of fermentors receiving the MA treatment was 9.10% greater (P < 0.05) than fermentors receiving the PC treatment and 20.2% greater (P < 0.05) than fermentors receiving the NC or MB treatments. Acetic acid production was greatest (P < 0.05) for the PC treatment compared with the NC and MB treatments, while the MA treatment was intermediate, but not different (P > 0.05) from the other three treatments. Butyric acid concentration was greatest (P < 0.05) in fermentors on the MA treatment compared with the other treatments. Total volatile fatty acid (VFA) production in the MA and PC treatments was greater (P < 0.05) than production in the NC and MB treatments.

Table 3. Digestibility and fermentation characteristics of supplemental Mg sources in Experiment 1.

Item	NC[a]	PC	MA	MB	SE[b]
No. of replicates	4	5	5	5	-
OM digestion, %	61.8	61.4	62.6	63.4	1.89
Bacterial N flow, g/d	0.61	0.56	0.57	0.53	0.02
Microbial efficiency, g N/kg OM	10.7[c]	9.8[cd]	10.0[cd]	9.2[d]	0.40
Acetic acid, mM	49.9[f]	56.1[e]	51.9[ef]	47.5[f]	2.05
Propionic acid, mM	62.8[g]	69.2[f]	75.5[e]	62.8[g]	1.95
Butyric acid, mM	17.3[f]	18.0[f]	20.3[e]	14.6[g]	0.86
Total VFA, mM	130.0[f]	143.2[e]	147.7[e]	124.9[f]	3.67
pH	5.59	5.90	5.60	5.64	0.10

[a]NC = negative control; PC = positive control; MA = MIN-AD; and MB = MagnaBuf.
[b]Pooled standard error term.
[cd]Means with different superscripts differ (P < 0.10).
[efg]Means with different superscripts differ (P < 0.05).

Experiment 2

Results from Experiment 2 are shown in Table 4. Similar to Experiment 1, there were no differences (P > 0.10) among treatments for organic matter digestibility. Fermentor pH ranged from 4.64 to 4.70 and was similar (P > 0.10) among all treatments. Microbial efficiency in Experiment 2 was similar to Experiment 1; however, there were no differences (P > 0.10) between treatments. Propionic acid production in the MA treatment was 21.6% greater (P < 0.10) compared with the NC treatment. Propionic acid production in the PC and MB treatments were intermediate and similar (P > 0.10) to the MA and NC treatments. Unlike Experiment 1, production of acetic and butyric acids and total VFA production in Experiment 2 was not different (P > 0.10) among the four treatments.

Table 4. Digestibility and fermentation characteristics of supplemental Mg sources in Experiment 2.

Item	NC[a]	PC	MA	MB	SE[b]
No. of replicates	4	5	5	5	-
OM digestion, %	68.4	69.9	68.3	72.1	1.31
Bacterial N flow, g/d	0.41	0.45	0.44	0.42	0.03
Microbial efficiency, g N/kg OM	9.62	10.16	10.18	9.18	0.68
Acetic acid, mM	83.7	89.5	91.8	94.3	5.24
Propionic acid, mM	77.9[d]	88.3[cd]	94.7[c]	88.0[cd]	3.93
Butyric acid, mM	23.2	18.6	23.8	24.8	2.08
Total VFA, mM	184.7	196.4	210.2	207.1	8.86
pH	4.64	4.70	4.68	4.67	0.05

[a]NC = negative control; PC = positive control; MA = MIN-AD; and MB = MagnaBuf.
[b]Pooled standard error term. [cd]Means with different superscripts differ (P < 0.10).

Summary and Discussion

There were observable differences in fermentation patterns with different sources of supplemental Mg. In Experiment 1, which most closely mimicked the rumen pH conditions in feedlot steers, there was higher (P < 0.05) propionic acid production with MIN-AD than with either MgO or MagnaBuf. Propionic acid production with MIN-AD was 9% higher than with MgO and over 20% higher than with MagnaBuf. Total VFA production with the MIN-AD treatment was 18% higher than the MagnaBuf treatment. The increased acid load did not result in a reduced pH. The pH levels measured in Experiment 2 were much lower than those in feedlot steers, nevertheless, there was still a tendency for increased propionic acid production with the MIN-AD treatment. Since propionic acid is the primary precursor to glucose production in the ruminant, this ruminal response could have a positive impact on energy metabolism, potentially increasing growth and marbling in feedlot cattle.