Impact of Dietary Cation-Anion Difference on Steer Performance and Carcass Characteristics

A.S. Leaflet R2859

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Summary and Implications

The data support the conclusion that Rumaferm (**LF**), liquid cattle feed, may be supplemented in feedlot cattle diets up to 5% DM in a concentrate-based diet if dietary cation-anion difference is balanced, as this product contains greater concentrations of sulfur and chloride contributing to a negative DCAD. Cattle receiving the LF diet showed decreased performance compared to the controls (**CON**) when DCAD was negative; however, when DCAD values were corrected to be positive, performance of the LF steers was recovered to similar values as the CON.

Introduction

The use of liquid supplements in cattle diets have been widely accepted in all aspects of the beef industry (Trenkle, 2002), and often supply protein to cattle grazing poor quality forages (Lalman et al., 2001; Sowell et al., 2003). In the feedlot, liquid supplements, such as urea/molasses mixtures or condensed corn distillers solubles (**CCDS**), may be used to increase the protein content of traditional corn-based finishing diets (Braman et al., 1973). Greater diet palatability and dust control are often benefits of liquid feed utilization. The liquid feed evaluated in this study, Rumaferm (Ajinomoto North America, Inc., Eddyville, IA), is a unique combination of three byproducts from Midwestern industries: Proteferm, CCDS, and vegetable oil refinery lipid. No previous research data are available concerning the use of Rumaferm in finishing cattle diets; therefore, the objective of this study was to examine the effects of supplementing Rumaferm on feedlot performance, dry matter digestibility, and carcass characteristics of steers.

Materials and Methods

The Institutional Animal Care and Use Committee (6-10-6984-B) at Iowa State University approved all animal experiments. In Experiment 1, crossbred, yearling steers (n = 40) individually weighed, dewormed with Ivomec Eprinex Pour-On (Merial Ltd., Duluth, GA), vaccinated with Bovi-Shield GOLD 5 (Zoetis, New York, NY) and One Shot Ultra 7 (Zoetis), and identified with an individual ear tag. Steers were adjusted to the finishing diet (Table 1) through four step-up diets. Two d consecutive weights were collected at the start of the study, and steers were blocked by initial body weight (**BW**; 436 ± 8 kg) and randomly assigned to 1 of 2 treatments (4 steers/pen, 5 pens/treatment): 1) CON diet or 2) LF diet. Throughout the remainder of the study, interim BW were collected every 28 d and final BW was determined before harvest. Due to a negative DCAD in the LF diet during the first 30 d of the trial sodium bicarbonate was added to the diet at 0.5% to increase DCAD to a positive, similar value as the CON diet during the second part of the trial. Therefore, the 82 d study was divided into 2 periods: period 1 (**P1**) the first 30 d and period 2 (**P2**) the final 52 d.

Feed offered to each pen and bunk scores were recorded daily, and samples of individual ingredients and total mixed rations (**TMR**) were collected weekly, and pen orts were collected, weighed, and sampled every 28 d for DM determination. Samples were dried in a forced air oven at 70°C for 48 h, and dry matter intake (**DMI**) was calculated. Feed efficiency (**G:F**) was determined from steer weight gain and total DMI for each 28 d weight period. From each treatment, TMR for P1 and P2 were analyzed for DCAD (Dairyland Laboratories; Arcadia, WI).

Steers were harvested when greater than 60% of steers in a pen were estimated by visual appraisal to have at least 1.27 cm of back fat. Steers were harvested at a commercial packing facility (Denison, IA) where individual identification was maintained with each carcass following harvest. Carcass were chilled for 24 h, ribbed between the 12th and 13th rib, and graded according to USDA standards by representatives of the Tri-County Carcass Futurity (Iowa State University Extension, Lewis, IA). Data collected from harvested steers (n = 40) included: hot carcass weight, marbling score, 12th rib backfat, kidney pelvic heart fat, ribeye area, and quality and yield grades.

In Experiment 2, a 2×2 Latin Square design, with 2 diets (CON or LF), and 2, 12 d periods was conducted concurrently to the feeding trial to determine the influence of the liquid feed on DM digestibility. Two fistulated steers were adapted to either the CON or LF diet for 10 d, and on d 11 Dacron bags containing dried ground hay (4.7 g/bag; n = 3/steer; 10×20 cm, 50 μm pore) or dried ground corn (1.1 g/bag; n = 3/steer; 5×10 cm, 50 μm pore), plus 4 blank bags (2 of each bag size) were inserted into the rumen of each steer for a 31 h incubation. After 31 h, samples were removed, rinsed with water, and dried 70°C for 48 h to determine the percent DM disappearance of hay and corn for each steer on each diet.

Statistical analysis

Data were analyzed by ANOVA as a completely randomized design using the Mixed Procedure of SAS (SAS Institute Inc., Cary, NC). The model for DMI, ADG, G:F, BW, DM disappearance and carcass characteristics included the fixed effect of treatment, period, and the interaction. The experimental unit was pen for all data analysis in Experiment 1 (n = 5/treatment) and steer was the experimental unit in Experiment 2 (n = 2/treatment). Significance was declared at $P \leq 0.05$ and tendencies were declared from $P = 0.06$ to 0.10.

Results and Discussion

The negative DCAD in the P1 LF diet is likely due to an increase in the sulfur (0.28%) and chloride (0.98%) content of the LF product. The addition of sodium bicarbonate during P2 increased the DCAD from -15.13 to 1.96 mEq/100 g DM; therefore, the performance results (Table 2) are reported in three sections: P1 (first 30 d), P2 (final 52 d), and overall 82 d finishing period. No treatment difference ($P \geq 0.25$) was noted for final BW or the *in situ* DM digestibility data ($P \geq 0.31$; hay, 30.1% ± 3.71 and corn, 93.0% ± 2.37). The LF diet decreased DMI ($P < 0.01$) over the entire 82 d finishing period compared to CON steers. This difference is likely due to a lesser ($P = 0.004$) DMI of LF steers during P1, as P2 DMI was not different ($P \geq 0.15$) between treatments. The CON steers had greater ($P = 0.02$) 82 d ADG compared to LF steers. Similar reductions in performance, specifically DMI and ADG, have been reported as DCAD decreased in the diets of lambs and steers (Luebbe et al., 2011; Ross et al., 1994; Trenkle, 2002).

Trenkle (2002) observed a similar trend in performance when 0 to 3% Proteferm (a component of the current study's liquid feed) was included in a finishing steer diet. Proteferm resulted in a decreasing DCAD, -2.6 to -13.2 mEq/100 g DM, as the inclusion rate increased from 0 to 3%. The negative DCAD decreased DMI and ADG during the initial 56 d of the study, and when diets were adjusted to increase DCAD (+1.4, 0, -4.82, or -9.64, for 0, 1.5, 2.25, or 3% inclusion, respectively) no differences in DMI or ADG were noted when Proteferm was include at the 0, 1.5, or 2.25%, but lesser performance was still observed in the 3% inclusion rate. Alternately, Hersom et al. (2010) reported no difference in DMI or ADG of dairy cows consuming diets containing either -7.53 or +22.1 mEq/100 g DM. In the present study, G:F, regardless of period, was not different ($P \geq 0.28$) throughout the finishing period, which corresponds to findings reported by Trenkle (2002). Conversely, G:F increased when steers consumed a negative DCAD (-16 mEq/100 g DM) compared to a positive DCAD diet (+20 mEq/100 g DM; Luebbe et al., 2011), which authors indicate is related to a decreased DMI by steers consuming the negative DCAD diet while both treatments had similar ADG.

In the current study, carcass characteristics were not different ($P \geq 0.13$) due to treatment; however, the LF steers tended ($P = 0.06$) to have a lesser QG compared to CON (Table 3). These data are consistent with those reported by Ross et al. (1994) and Trenkle (2002). In conclusion, the present study indicates the importance of diet DCAD on steer performance, as after attaining a positive DCAD value in the LF diet steer performance improved and was similar to the corn-fed controls. Rumaferm may be fed up to 5% DM in a concentrate-based diet if considerations to balance DCAD are made.

Table 1. Ingredient composition of finishing diets (% DM basis).

	Period 1		Period 2	
Ingredient, %	CON[a]	LF[a]	CON[a]	LF[a]
Ground corn	76.0	70.6	76.9	71.6
Chopped hay	11.9	11.9	11.0	11.0
Dried distillers grains with solubles	10.0	10.0	10.0	9.50
Rumaferm liquid feed[b]	--	5.04	--	5.04
Limestone	1.32	1.32	1.32	1.32
Potassium carbonate[c]	--	0.60	--	0.60
Sodium bicarbonate[d]	--	--	--	0.50
Salt	0.33	0.33	0.33	0.33
Urea	0.27	--	0.27	--
Vitamin A premix[e]	0.12	0.12	0.12	0.12
Trace mineral mix[f]	0.04	0.04	0.04	0.04
Rumensin80[g]	0.01	0.01	0.01	0.01
DCAD, mEq/100 g diet DM[hi]	4.43	-15.13	-3.71	1.96
Calculated composition, %				
Fat	4.97	5.13	4.83	4.95
Crude protein	12.18	12.83	12.21	11.97

[a]Treatments include: CON, control diet; LF, liquid feed diet period

[b]Donated by Ajinomoto North America, Inc., Eddyville, IA. Composition includes: 23.5% CP, 15.8% NPN, 8.2% fat, 0.09% Ca, 7.7% Cl, 0.93% K, 1.2% Na, 0.6% P, 0.64% S

[c]Potassium carbonate contains 48.5% minimum K

[d]Sodium bicarbonate contains 43.4% minimum Na

[e]Vitamin A premix contained 4,400,000 IU/kg DM

[f]Provided/kg of diet DM: 30 mg Zn as $ZnSO_4$; 20 mg Mn as $MnSO_4$; 0.5 mg I as $Ca(IO_3)_2(H_2O)$; 0.1 mg Se as Na_2SeO_3; 10 mg Cu as $CuSO_4$; and 0.1 mg Co as $CoCO_3$

[g]Provided Rumensin80 at 27 g/ton (dontated by Elanco Animal Health)

[h]Dietary cation-anion difference, mEq/100 g diet DM: [(Na + K) – (Cl + S)]

[i]Dairyland Laboratories, Arcadia, WI

Table 2. The effect of supplementing a liquid cattle feed on dry matter intake, average daily gain, and feed efficiency of yearling finishing steers.

				P value		
Item	CON[a]	LF[a]	SEM	Treatment	Period	Trt*Prd[b]
Initial BW, lbs	959	959	17.7	0.99	--	--
Final BW, lbs	1298	1263	20.3	0.25	--	--
DMI						
Overall[c], lbs/d	31.22	29.15	0.374	<0.001	0.07	0.12
Period 1[d], lbs/d	31.13	27.92	0.528			
Period 2[e], lbs/d	31.28	29.77	0.528			
ADG						
Overall[c], lbs/d	4.71	4.14	0.154	0.02	0.59	0.14
Period 1[d], lbs/d	4.84	3.92	0.220			
Period 2[e], lbs/d	4.60	4.38	0.220			
G:F						
Overall[c]	0.154	0.149	0.005	0.28	0.73	0.26
Period 1[d]	0.161	0.145	0.007			
Period 2[e]	0.150	0.150	0.006			

[a]CON: control; LF: Rumaferm liquid cattle feed
[b]Treatment by period
[c]Overall steer performance for the 82 d finishing period
[d]Period 1, first 30 d of study
[e]Period 2, final 52 d of the finishing period

Table 3. The effect of supplementing a liquid cattle feed on carcass characteristics of finishing steers.

Item	CON[a]	LF[a]	SEM	*P* Value
Hot carcass weight, lbs	821	805	13.6	0.43
Ribeye area, in^2	12.82	12.74	0.248	0.82
Kidney pelvic heart fat, %	1.80	1.93	0.13	0.53
Marbling score[b]	425	408	7.18	0.13
12th rib back fat, in	0.46	0.40	0.03	0.16
Yield grade	3.05	2.89	0.15	0.46
Quality grade[c]	2.85	2.55	0.10	0.06

[a]CON: control; LF: Rumaferm liquid cattle feed
[b]Marbling score: Traces: 200, Slight: 300, Small: 400, Modest: 500
[c]Quality grade: 2: $Select^+$, 3: $Choice^-$, 4: $Choice^0$