Evaluation of Proteferm® as a Nitrogen Supplement for Finishing Steers

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Summary

Proteferm is a liquid by-product from the production of monosodium glutamate by fermentation that is 40% solids and contains 95% crude protein on a dry basis. Two trials were conducted with yearling steers to study the effects of different levels of Proteferm when added to 90% concentrate diets to replace corn and urea. Feeding Proteferm resulted in a decrease in urine pH, suggesting a metabolic acidosis that was probably caused by a negative cation–anion balance. Correcting the cation–anion imbalance resulted in an increase in feed intake and the performance of steers fed Proteferm as 1.5% of diet dry matter to be similar to the performance of control steers. Addition of sodium bicarbonate to the control diet or to the diet containing 1.5% Proteferm to produce a positive cation–anion balance did not improve performance. The results of these trials indicate that 1.5% Proteferm is the maximum that should be added to high concentrate diets fed to beef cattle without affecting performance or carcass value.

Introduction

Proteferm is a potential cattle feed supplement being developed from the by-products of production of monosodium glutamate by fermentation. Currently it is a liquid product, about 60% moisture, and contains a high percentage of nitrogen that is 95% protein equivalent on a dry basis. A major portion of the nitrogen is nonprotein nitrogen (ammonium chloride), but about 25% is associated with true protein of the bacterial cells. Based on chemical composition, the greatest potential of Proteferm as a feed for cattle is as a source of supplemental nitrogen. Proteferm also has value as a source of potassium (2% of dry weight) and sodium (5% of dry weight), two elements normally supplemented in high-corn rations fed to beef cattle. Increased feed intake from addition of moisture to very dry feeds also is a potential benefit for beef cattle.

Liquid supplements have been extensively accepted in the beef industry. A unique feature of Proteferm is the high concentration of chloride ion, about 31% on a dry basis. Cattle fed high forage diets tend to have high consumption of cations, so addition of an ingredient containing chloride could improve the cation–anion balance. However, due to the acidity caused by high starch consumption, excessive intake of anions causes acidosis and might cause a negative response in cattle fed high grain diets.

The purpose of this experiment was to evaluate Proteferm as a potential nitrogen supplement for yearling steers fed a corn-based finishing ration. The specific objectives were to measure growth performance and carcass value of yearling steers fed Proteferm.

Materials and Methods

Trial 1

Ninety-six crossbred steers of Continental and English breeds with an average weight of 804 lbs. each were sorted into weight outcome groups and randomly allotted to 16 pens of 6 steers each. Four pens were assigned randomly to each of 4 treatments. All steers were implanted with a combination of estradiol and trenbolone acetate (Component TE-S®) at the start of the experiment. The cattle were fed twice per day, and the amount of feed offered the cattle was gradually increased until their appetites were satisfied. If the amount of feed consumed decreased, they were offered less feed, and feed accumulated in the bunks was removed and sampled to determine dry matter. Steers were fed the experimental diets for 158 days.

The diets fed at the beginning of the trial are shown in Table 1. The corn was processed in a roller mill to break or crack a majority of the kernels. The concentrate portion of each diet was prepared as a mix and weighed separately from the corn silage. The grain mix and silage were mixed by hand in the feed bunk when the cattle were fed. Both the mixed concentrates and silage were periodically sampled for chemical analysis. The 4 treatments compared in this experiment were no addition and three concentrations of Proteferm at 1.5%, 2.25%, and 3.0% of diet dry matter. The low concentration of Proteferm was selected to provide the recommended quantity of ammonium chloride to feed cattle to reduce urinary calculi. Additions of Proteferm replaced portions of urea and corn in the diets. No supplemental preformed protein was added to the diets, and the crude protein content of the diets purposely was kept somewhat less than projected requirements in order to test the potential value of the microbial cells in Proteferm as a source of undegraded protein. After the steers had been on trial 63 days, the diets were changed to those shown in Table 2 in order to correct the negative cation–anion balances in the diets containing Proteferm.

Samples of urine were obtained from several steers fed each diet at 41 days after starting the trial when diets in Table 1 were fed and again at 21 and 94 days after the diets in Table 2 were fed. Urine pH was measured with a portable battery-powered pH meter and a glass electrode calibrated with standardized buffer solutions.

Trial 2

This trial was designed to test the effects of producing a positive cation–anion balance in a diet containing Proteferm by adding sodium bicarbonate. Ninety-six crossbred steers, predominantly black and black-white face, weighing 850 lbs. each were divided into weight outcome groups. Steers were randomly allotted from the weight outcome groups to 16 pens of 6 steers each. Four pens were allotted at random to each of the 4 dietary treatments. All steers were implanted with a combination of estradiol and trenbolone acetate (Component TE-S®) at the start of the experiment. The amount of feed offered the cattle was gradually increased until their appetite was satisfied. If the amount of feed consumed decreased during the trial, they were offered less feed, and feed accumulated in the bunks was removed and sampled to determine of dry matter before increasing the quantity of feed offered. Steers were fed the experimental diets for 126 days. For measurement of pH, samples of urine were obtained at 70 days of feeding Proteferm as described for Trial 1.

The 4 dietary treatments were the control diet, the control diet with 1.27% sodium bicarbonate, and diets with, respectively, 1.5% Proteferm and 1.5% Proteferm with 1.27% sodium bicarbonate (Table 3). The corn was processed in a roller mill to break or crack a majority of the kernels. The mixed grass hay was ground through a 2-in. screen. The concentrate portion of the diet was prepared as a mix in a mixer wagon and weighed separately from the corn silage and ground hay. After mixing, total mixed diets were fed to the cattle twice per day. Periodically the mixed diet, corn silage, hay, and Proteferm were sampled to determine dry matter and crude protein. Feed removed from the bunks was sampled for determination of dry matter.

The steers from both trials were sold to a commercial beef packer. The final weights were the average of 2 weights of each steer taken on consecutive days. Daily gain was calculated by difference between ending and starting weights for each steer, divided by the number of days fed. Weights of hot carcasses were taken after slaughter, and measurements on the carcasses were obtained after a 24-hr. postmortem chill. The federal grader in the plant called marbling score; percentage of kidney, pelvic, and heart fat (KPH); and yield grade of the carcasses. Ribeyes between the 12th and 13th ribs on the left side of the carcass were photographed with a digital camera, and fat thickness and muscle area were measured from the digital image using a calibrated computer software program.

Feed intake and gain data from Trial 1 were summarized for the first 56 days, when the steers were fed the diets in Table 1, and for the last 102 days, when the steers were fed diets corrected for the negative cation–anion balance. Average feed intake was calculated from total feed consumed by a pen of steers, divided by the number of steer-days in the pen. Feed consumption relative to body weight was calculated for each of the 2 periods by dividing average daily feed intake by average body weight. Both trials were completely randomized designs with 4 replications (pens) per treatment. Pen was used as the experimental unit in the statistical analysis for all measurements except urine pH, which used sample from individual animals as the experimental unit. Data were analyzed by analysis of variance, and treatment means were compared by Dunnett's test. The relationship of feed consumption with cation–anion balance of the rations was evaluated with linear regression.

Results and Discussion

Trial 1

Performance of the steers in Trial 1 is summarized in Table 4. During the first period, feeding Proteferm decreased feed consumption (statistically significant for the steers fed 2.25% and 3.0% Proteferm). The reduced feed consumption caused a decreased rate of gain. Feed efficiency as measured by feed required for gain was not changed by feeding 1.5% Proteferm and was not statistically changed until the concentration of Proteferm in the diet was increased to 3.0%.

During the second period, after reducing the negative cation–anion balance, there were no significant differences in feed consumption except for the steers fed 3.0% Proteferm. There were no differences in rate of gain. Feed efficiency tended to be numerically improved for the steers fed Proteferm during the second period, probably the result of some compensatory gain due to lower gain during the first period. Overall, steers fed Proteferm consumed less feed, gained less weight, and had statistically similar feed conversions. Feed efficiencies for the 158 days were identical for steers fed 0%, 1.5% and 2.25% Proteferm.

During the first period, steers fed the control diet consumed more feed relative to body weight compared to steers fed 2.25% and 3.0% Proteferm (Table 4). During the first period, feed consumption relative to body weight was related to cation–anion balance. However, during the second period when the negative cation–anion balance was corrected, the differences in feed consumption relative to body weight were not statistically significant (Table 4) and there was no significant relationship with cation–anion balance.

At each of the sample dates, urine from steers fed Proteferm was more acid than urine from the control steers (Table 5). At the first two sample dates, there were no significant differences among the Proteferm treatments, though those fed 2.25% Proteferm had numerically lower pH urine. At the last sample date, steers fed 2.25% Proteferm had more acid urine than the control steers and the steers fed 1.5% or 3.0% Proteferm. After the diets were changed to reduce the negative cation–anion balance, there was a trend for urine pH of steers fed Proteferm to increase. There did not appear to be any relationship of urine pH with occurrence of liver abscess. The incidence of liver abscess was 21% in the control cattle as well as in all the cattle fed Proteferm, although there were significant differences in urine pH between the two groups. The lowest incidence of liver abscess was 4%, in the group fed 2.25% Proteferm and having the most acid urine.

Carcass weights followed weight gains and were significantly lighter from the steers fed 2.25% and 3.0% Proteferm (Table 6). There were no significant differences in dressing percentage due to diet. Marbling scores were the same for control steers and steers fed 1.5% and 2.25% Proteferm. Those fed 3.0% Proteferm had numerically lower marbling scores. Steers fed Proteferm had a tendency to have less carcass fat as measured by KPH, thickness of backfat, and yield grade; however, only those steers fed 3.0% Proteferm were statistically different from the controls. The number of USDA Choice grading carcasses and the number of carcasses with calculated yield grades of 1 and 2 were in agreement with the view that steers fed Proteferm deposited less fat. The differences in carcass measurements caused by feeding the high concentration of Proteferm, namely the reduction in several measures of fat content, can best be explained in terms of reduced feed consumption and reduced rate of gain.

Trial 2

A diet containing 1.5% Proteferm with the cation–anion balance corrected to zero did not significantly depress feed intake or gain (Table 7). The effects of Proteferm in this trial were similar to those observed in the second phase of Trial 1 (Table 4). Even though the cation–anion balance was corrected in both trials, urine pH was lower for steers fed Proteferm. Adding sodium bicarbonate, a buffer, increased urine pH in steers fed Proteferm, but it did not increase feed intake or gain. Feeding sodium bicarbonate to the control steers did not change performance as expected because pH of the urine from these cattle indicated there was no acidosis.

Feeding Proteferm did not affect any of the carcass measurements (Table 8). Additions of sodium bicarbonate to the control diet or the diet with Proteferm also had no effects on carcass characteristics.

The results of this study indicate that 1.5% Proteferm could be fed to finishing steers without significantly affecting performance and carcass value; however, the economic value of the Proteferm would be approximately that of the urea replaced in the control ration. The decrease in feed consumption by the cattle fed Proteferm at the beginning of Trial 1 prohibited expression of any potential value of the microbial proteins as a source of undegraded protein. There seemed to be some benefit in feeding Proteferm during the first 28 days of Trial 2 (data not shown), but this benefit did not continue throughout the trial.

Table 1. Composition diets fed in Trial 1 (dry matter basis).

Ingredient	Proteferm, % of ration DM			
	0	1.5	2.25	3.0
	----------% DMB----------			
Cracked corn	83.68	83.28	82.84	82.40
Corn silage	12.00	12.00	12.00	12.00
Cane molasses	0.75			
Urea	1.29	0.81	0.57	0.33
Proteferm		1.50	2.25	3.00
Limestone	1.32	1.34	1.34	1.34
Salt, NaCl	0.30	0.25	0.22	0.18
KCl	0.49	0.22	0.08	
K_2CO_3		0.27	0.39	0.45
Vitamin A premix[a]	0.08	0.08	0.08	0.08
Trace mineral premix[b]	0.024	0.024	0.024	0.024
Rumensin premix[c]	0.0195	0.0195	0.0195	0.0195
Elemental sulfur	0.041	0.026	0.018	0.010
Composition of ration (table values)				
Crude protein, %	11.5	11.5	11.5	11.5
Ca, %	0.50	0.50	0.50	0.50
P, %	0.32	0.32	0.32	0.32
Cation–anion balance[d]	-2.61	-7.19	-9.75	-13.2

[a]Contained 1.75 million IU of vitamin A, provided 1,400 IU of vitamin A activity per pound of dry matter.
[b]The trace mineral premix contained: (%) Ca 13.2, Co 0.10, Cu 1.5, Fe^{++} 10.0, Fe^{+++}0.44, I 0.20, Mn 8.0, S 5.0, and Zn 12.0.
[c]Contained 80 g of sodium monensin per pound of premix, provided 15.6 mg sodium monensin per pound of dry matter.
[d]Calculated as meq of [(Na + K) – (Cl + S)]/100 g of dietary DM.

Table 2. Composition of modified diets fed after 63 days in trial 1 (dry matter basis).

	Proteferm, % of ration DM			
Ingredient	0	1.5	2.25	3.0
	----------% of dry matter----------			
Cracked corn	83.50	83.40	82.21	81.75
Corn silage	12.00	12.00	12.00	12.00
Cane molasses	0.75			
Urea	1.29	0.82	0.59	0.34
Proteferm		1.50	2.25	3.00
Limestone	1.32	1.34	1.34	1.34
Salt, NaCl	0.30			
KCl	0.29			
$NaPO_4$		0.954	0.954	0.954
K_2SO_4	0.225	0.589	0.531	0.492
Vitamin A premix[a]	0.08	0.08	0.08	0.08
Trace mineral premix[b]	0.024	0.024	0.024	0.024
Rumensin premix[c]	0.0195	0.0195	0.0195	0.0195
Composition of ration (table values)				
Crude protein, %	11.5	11.5	11.5	11.5
Ca, %	0.50	0.50	0.50	0.50
P, %	0.32	0.57	0.58	0.58
Cation – anion balance[d]	1.40	0	-4.82	-9.64

[a, b, c]See footnotes for Table 1.
[d]Calculated as meq of [(Na + K) – (Cl + S)]/100 g of dietary DM.

The results clearly show that feeding 3.0% of the ration as Proteferm decreased gain, feed efficiency, and carcass value. The decrease in feedlot performance seemed to result from decreased feed consumption. During the first period of Trial 1, steers fed Proteferm had significantly reduced urine pH. At this time, all the Proteferm containing rations had a negative cation–anion balance. However, urine pH was not directly related to negative cation–anion balance or feed intake, because the steers fed the 2.25% Proteferm ration had the lowest urine pH. With a large negative dietary cation–anion balance, cattle may decrease consumption of the feed to reduce impact on pH of metabolism. Some of the decrease in gain might have resulted from increased energy required for the cattle to cope with metabolic acidosis. During the second phase of Trial 1 and during Trial 2 when the cation–anion balance of the diet containing 1.5% Proteferm was corrected to zero, acid urine persisted. Adding sodium bicarbonate to the diet increased urine pH but did not affect feed intake or gain.

Table 3. Composition diets fed in trial 2 (dry matter basis).

	Diets			
Ingredient	Control	Control + Bicarb	1.5% Proteferm	1.5% Proteferm + Bicarb
	% of Dry matter			
Cracked corn	81.39	80.09	80.41	79.26
Proteferm			1.50	1.50
Corn silage	10.0	10.0	10.0	10.0
Chopped hay	5.0	5.0	5.0	5.0
Molasses	0.75	0.75		
Urea	0.86	0.89	0.41	0.43
Limestone	0.92	0.92	1.34	1.34
Dicalcium phosphate	0.63	0.63	0.14	
Monosodium phosphate			0.48	0.48
Sodium bicarbonate		1.27		1.27
Potassium sulfate			0.60	0.60
Salt	0.30	0.30		
Vitamin A[a]	0.08	0.08	0.08	0.08
Trace minerals[b]	0.024	0.024	0.024	0.024
Rumensin[c]	0.0195	0.0195	0.0195	0.0195
Elemental sulfur	0.0276	0.0276		
Composition of ration (table values)				
Crude protein, %	11.0	11.0	11.0	11.0
Ca, %	0.57	0.057	0.57	0.57
P, %	0.42	0.42	0.41	0.41
K, %	0.59	0.58	0.84	0.83
Na, %	0.14	0.48	0.17	0.51
Cl, %	0.27	0.26	0.52	0.52
S, %	0.13	0.13	0.23	0.23
Cation – anion balance[d], meq/kg	56	204	0	150

[a, b, c]See footnotes for Table 1.

[d]Calculated as meq of [(Na + K) – (Cl + S)]/100 g of dietary DM.

Table 4. Performance of yearling steers fed different levels of Proteferm (Trial 1).

	Proteferm, % of ration DM			
Item	0	1.5	2.25	3.0
0-56 days				
Starting wt., lbs.	860.5	859.3	861.5	860.3
Ending wt., lbs.	1051.2[a]	1038.0[a]	1013.1[b]	991.9[c]
Gain, lbs./d	3.41[a]	3.19[a]	2.71[b]	2.35[b]
Feed/d, lbs. DM	19.7[a]	18.6[a]	17.3[b]	16.5[b]
Feed/gain	5.81[a]	5.82[a]	6.41[a]	7.05[b]
Feed/d, intake/body wt.	0.0206[a]	0.0196[a,b]	0.0184[b,c]	0.0178[c]
56-158 days				
Starting wt., lbs.	1051.2[a]	1038.0[a]	1013.1[b]	991.9[c]
Ending wt., lbs.	1350.0[a]	1321.3[a]	1314.9[a]	1271.5[b]
Gain, lbs./d	2.93	2.78	2.96	2.74
Feed/d, lbs. DM	23.1[a]	21.5[a,b]	21.6[a,b]	20.5[b]
Feed/gain	7.88	7.75	7.31	7.54
Feed/d, intake/body wt.	0.0192	0.0182	0.0185	0.0181
0-158 days				
Starting wt., lbs.	860.5	859.3	861.5	860.3
Ending wt., lbs.	1350.0[a]	1321.3[a]	1314.9[a]	1271.5[b]
Gain, lbs./d	3.10[a]	2.92[b]	2.87[b]	2.60[c]
Feed/d, lbs. DM	21.9[a]	20.5[b]	20.1[b]	19.1[b]
Feed/gain	7.06	7.00	6.99	7.35

[a,b]Means within a row without a common superscript differ ($P < 0.05$).

Table 5. Summary of urine pH and liver abscesses (Trial 1).

	Proteferm, % of ration DM			
Item	0	1.5	2.25	3.0
	------------Means±SEM------------			
First sample[a]	7.22±.21	5.91±.08	5.71±.12	6.09±.12
Second sample[b]	7.14±.06	6.18±.14	5.89±.15	6.19±.18
Third sample[c]	7.53±.14	6.20±.16	5.74±.06	6.14±.14
Liver abscess[d], No.	5	7	1	7

[a]Sample on 8-7-00, 41 days after beginning of trial, steers were being fed rations in Table 1.
[b]Sample on 8-28-00, 21 days after changing to rations in Table 2.
[c]Sample on 11-9-00, 94 days after changing to rations in Table 2.
[d]Liver condemnation because of abscess as determined by USDA inspector.

Table 6. Summary of carcass data (Trial 1).

	Proteferm, % ration DM			
Item	0	1.5	2.25	3.0
Carcass wt., lbs.	841.5[a]	819.5[a,c]	806.5[b,c]	784.8[b]
Dressing %[d]	62.3	62.0	61.3	61.7
Marbling score[e]	560.0	562.1	565.4	518.8
Quality grade, No. carcasses				
Prime		1	1	
Choice	19	17	16	9
Select	5	6	7	15
KPH, %	2.38[a]	2.12[a]	2.16[a]	1.67[b]
Backfat, in.	0.36[a]	0.32[a]	0.34[a]	0.26[b]
Ribeye area, sq in.	13.72	14.01	14.14	13.94
Yield grade, No. carcasses				
1	3	5	6	13
2	13	18	15	10
3	8	1	3	1
Calculated yield grade, avg.	2.68[a]	2.34[a]	2.32[a]	2.00[b]

[a,b,c]Means within a row without a common superscript differ ($P < 0.05$).
[d]Dressing percent calculated from hot carcass weight and final live weight at the research farm.
[e]Marbling score is 400 = slight[0], 500 = small[0], and 600 = modest[0].

Table 7. Performance of yearling steers fed Proteferm with or without sodium bicarbonate (Trial 2).

	Diets			
Item[a]	Control	Control + Bicarb	1.5% Proteferm	1.5% Proteferm + Bicarb
Starting wt., lbs.	850	848	845	848
Ending wt., lbs.	1286	1278	1271	1244
Days fed	126	126	126	126
Daily gain, lbs.	3.46	3.42	3.39	3.15
Feed DM per day, lbs.	21.1	21.0	20.8	20.6
Feed/gain	6.09	6.18	6.16	6.54
Urine pH	7.56±.28[b]	7.81±.13	6.04±.63	7.53±.49

[a]Differences in performance were not statistically significant ($P > .05$).
[b]Standard error of the mean.

Table 8. Summary of carcass data (Trial 2).

	Diets			
Item[a]	Control	Control + Bicarb	1.5% Proteferm	1.5% Proteferm + Bicarb
Carcass wt., lbs.	779.6	788.1	782.4	764.2
Dressing percent[b]	60.5	61.6	61.5	61.4
Fat thickness, in.	0.35	0.34	0.35	0.37
Ribeye area, sq in.	13.3	13.8	13.6	13.5
Marbling[c]	530	514	515	542
Quality grade, % of carcasses				
Percent Choice	23.8	8.3	21.7	25.0
Percent Choice -	33.3	54.2	34.8	33.3
Percent Select	42.9	33.3	43.5	41.7
Yield grade, % of carcasses				
Percent Yield Grade 1	9.5	16.7	9.1	12.5
Percent Yield Grade 2	71.4	70.8	77.3	62.5
Percent Yield Grade 3	14.3	12.5	13.6	25.0
Percent Yield Grade 4	4.8			
Called yield Grade, avg.	2.17	1.96	2.04	2.12

[a]Differences in carcass measurements were not statistically significant (P > .05).
[b]Dressing percent calculated from hot carcass weight and final live weight at the research farm.
[c]Marbling score is 400 = slight^0, 500 = small^0, and 600 = modest^0.

Implications

The results of this study suggest that Proteferm can be fed to feedlot cattle as a source of nonprotein nitrogen, but the amount fed should not exceed 1.5% of diet dry matter.

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