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Effect of Feeding Greater Amounts of Calcium Oxide Treated Corn Stover and Micro-Aid® on Performance and Nutrient Mass Balance

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Summary

Feedlot performance and mass balance were evaluated on steers fed either 5% untreated corn stover (CON), 20% untreated corn stover (NONTRT), or 20% calcium oxide (CaO) treated corn stover (TRT) when fed with or without saponins (Micro-Aid) in a 3x2 factorial. In both WINTER and SUMMER experiments, ADG, F:G and HCW were improved (P < 0.01) in CON and TRT fed steers compared to NONTRT fed steers. Micro-Aid fed steers had slightly greater ADG and DMI in the SUMMER. Manure % nitrogen (N) was greatest when NONTRT and TRT were fed compared to steers on CON diet. However, neither diet nor Micro-Aid influenced manure N amounts or N losses across both seasons.

Introduction

Feeding more roughage or feeding less digestible diets has been shown to increase manure N and reduce N losses in the winter, but not always in the summer (*2003 Nebraska Beef Cattle Report*, p. 54*; 2005 Nebraska Beef Cattle Report,* p. 54). Two recent studies (*2011 Nebraska Beef Cattle Report,* p. 35; *2012 Nebraska Beef Cattle Report,* p. 106) evaluated calcium oxide (CaO) treated forages compared to untreated forages. In these two studies, it was determined that diets containing 20% CaO treated forages had improved digestibility and performance.

Recent trials (*2012 Nebraska Beef Cattle Report,* p. 98) evaluating performance and mass balance of steers fed Micro-Aid found no difference in performance and carcass characteristics between treatments. Cattle in the winter experiment fed Micro-Aid had more DM, OM, and nutrients removed in manure, and decreased N losses. However, there were no differences in manure N or losses in the summer experiment due to feeding Micro-Aid.

The objective of these studies was to evaluate the impact of increasing CaO treated and untreated corn stover and its influence on N mass balance and manure amounts. Given variable results across seasons due to Micro-Aid, more research related to nutrient mass balance was warranted.

Procedure

Cattle Performance

Two experiments were conducted using 192 steers in each study. Calves (694 ± 23 lb BW) were fed for 183 days from November to May (WINTER) and yearlings (866 ± 34 lb BW) were fed for 140 days from May to October (SUMMER) to evaluate the effect of feeding greater amounts of corn stover in combination with Micro-Aid. Micro-Aid (DPI Global, Porterville, Calif.) is manufactured from a phytogenic extract that contains saponins, which have natural detergent and surfactant properties. Steers were individually weighed two consecutive days (day 0 and day 1) to obtain an initial BW. Cattle were stratified by BW within two weight blocks (light and heavy) and assigned randomly to 24 pens (12 pens per block, 8 steers/pen). Six treatments were applied as a 3x2 factorial in a generalized randomized block design with factors being diet and Micro-Aid. The WINTER and SUMMER dietary treatments consisted of 1) control (CON) with 5% nontreated corn stover, 2) nontreated (NONTRT) with 20% nontreated corn stover and 3) treated (TRT) with 20% corn stover treated with 5% CaO. All diets in WINTER and SUMMER contained 40% MDGS and 4% supplement. Additionally, the WINTER diets contained a 50:50 blend of dry rolled corn (DRC) and high moisture corn (NONTRT and TRT diets replaced the corn blend with corn stover) while SUMMER diets only contained DRC as a corn source. Steers in both trials were fed grain adaptation diets for 21 days with corn replacing alfalfa while MDGS, corn stover and supplement were held constant. Supplements for all diets were formulated to provide 0 or 1 g/head/day of Micro-Aid, 30 g/ton of DM of Rumensin, and 125 mg/steer daily of thiamine. Nutrient compositions of the final diets (DM basis) are presented in Table 1.

Table 1. Nutrient composition of diets[1] fed in the WINTER and SUMMER (DM basis).

	CON[2]	NONTRT[3]	TRT[4]
WINTER			
CP %	15.6	14.6	15.0
Ca %	0.84	0.87	0.83
P %	0.52	0.48	0.49
K %	0.79	0.85	0.86
S %	0.35	0.34	0.34
SUMMER			
CP %	16.1	15.4	15.8
Ca %	0.93	0.97	0.90
P %	0.56	0.54	0.55
K %	0.83	0.90	0.90
S %	0.39	0.38	0.38

[1]Diets formulated to provide 0 or 1 g/steer Micro Aid and 125 mg/steer thiamine daily, and 30 g/ton of DM of Rumensin.
[2]CON = Control diet.
[3]NONTRT = Nontreated stover (20% DM inclusion) diet.
[4]TRT = Treated stover (20% DM inclusion) diet.

Table 2. Finishing performance and carcass characteristics of steers fed during the WINTER trial.

Diet	CON	NONTRT	TRT	SEM	*P*-value
Performance					
Initial BW, lb	694	695	695	1	0.41
Live Final BW, lb[1]	1361[a]	1311[b]	1346[a]	9	<0.01
DMI, lb/day	22.4	22.9	22.4	0.26	0.42
ADG, lb[2]	3.67[a]	3.24[b]	3.61[a]	0.06	<0.01
F:G[3]	6.36[a]	7.05[b]	6.22[a]		<0.01
Carcass Characteristics					
HCW, lb	860[a]	812[b]	854[a]	7	<0.01
Dressing %	63.3[a]	62.0[b]	63.6[a]	0.002	<0.01
LM area, in^2	13.55	13.14	13.55	0.23	0.36
12th Rib Fat, in	0.51	0.41	0.48	0.03	0.07
Marbling[4]	582[a]	532[b]	551[a]	12	<0.01
Calculated USDA YG[5]	2.72	2.41	2.62	0.12	0.25

[a,b]Means within a row with unlike superscripts differ ($P < 0.05$).
[1]Live Final BW calculated: Avg. BW of pen shrunk 4%.
[2]ADG based on carcass-adjusted final BW = HCW/0.63.
[3]Analyzed as G:F, the reciprocal of F:G.
[4]Marbling: 500 = small^0, 600 = modest^0, etc.
[5]Calculated as 2.50 +(2.5*fat depth, in) – (0.32*LM area, in^2) + (0.2*2.5 KPH) + (0.0038*HCW, lb).

Table 3. Finishing performance and carcass characteristics of steers fed with or without Micro Aid during the WINTER trial.

Micro Aid level	0 g/head/day	1 g/head/day	SEM	*P*-value
Performance				
Initial BW, lb	694	695	1	0.40
Live Final BW, lb[1]	1331	1347	8	0.19
DMI, lb/day	22.5	22.7	0.30	0.47
ADG, lb[2]	3.47	3.54	0.07	0.39
F:G[3]	6.65	6.43		0.60
Carcass Characteristics				
HCW, lb	838	846	8	0.37
Dressing %	63.0	62.9	0.002	0.80
LM area, in^2	13.36	13.47	0.27	0.69
12th Rib Fat, in	0.47	0.46	0.03	0.69
Marbling[4]	559	551	10	0.60
Calculated USDA YG[5]	2.61	2.56	0.10	0.77

[1]Live Final BW calculated: Avg. BW of pen shrunk 4%.
[2]ADG based on carcass-adjusted final BW = HCW/0.63.
[3]Analyzed as G:F, the reciprocal of F:G.
[4]Marbling: 500 = small^0, 600 = modest^0, etc.
[5]Calculated as 2.50 +(2.5*fat depth, in) – (0.32*LM area, in^2) + (0.2*2.5 KPH) + (0.0038*HCW, lb).

Table 4. Finishing performance and carcass characteristics of steers fed during the SUMMER trial.

Diet	CON	NONTRT	TRT	SEM	*P*-value
Performance					
Initial BW, lb	866	868	866	1	0.88
Live FBW, lb[1]	1457	1441	1447	9	0.09
DMI, lb/day	26.8[a]	28.8[b]	27.6[a]	0.2	<0.01
ADG, lb[2]	4.18[a]	3.77[b]	4.04[a]	0.05	<0.01
F:G[3]	6.42[a]	7.65[b]	6.85[c]		<0.01
Carcass Characteristics					
HCW, lb	914[a]	878[b]	901[a]	5	<0.01
Dressing %	62.8[a]	60.9[b]	61.3[c]	0.001	<0.01
LM area, in^2	14.13	13.79	14.05	0.17	0.37
12th Rib Fat, in	0.59	0.53	0.57	0.2	0.16
Marbling[4]	574	537	556	11	0.09
Calculated USDA YG[5]	2.93	2.75	2.86	0.08	0.34

[a,b,c]Means within a row with unlike superscripts differ ($P < 0.05$).
[1]Live Final BW calculated: Avg. BW of pen shrunk 4%.
[2]ADG based on carcass-adjusted final BW = HCW/0.63.
[3]Analyzed as G:F, the reciprocal of F:G.
[4]Marbling: 500 = small^0, 600 = modest^0, etc.
[5]Calculated as 2.50 +(2.5*fat depth, in) – (0.32*LM area, in^2) + (0.2*2.5 KPH) + (0.0038*HCW, lb).

Chemical treatment consisted of water, CaO (Granular - Standard Quicklime, Mississippi Lime Co, Kansas City, Mo.), and ground residue (3-inch. screen) weighed and mixed in Roto-Mix feed trucks. The mixture was calculated to be 50% DM with CaO added at 5% of the forage (DM basis). Feed trucks dispensed treated residue into a silage bag at least 7 days prior to feeding and was stored anaerobically in silo bags. Actual DM of the treated stover was 47% DM in the WINTER experiment and 53% DM in the SUMMER experiment.

Cattle on the WINTER trial were implanted on d 1 with Revalor-IS and reimplanted with Revalor-S on d 86. Yearling steers on the SUMMER trial were implanted with Revalor-S on d 36. Steers were harvested at a commercial abattoir (Greater Omaha, Omaha, Neb.) on d 184 and d 141 for the WINTER trial and SUMMER trial respectively. Hot carcass weight was recorded on the day of slaughter. Fat thickness, marbling scores and LM area were measured after a 48-hour chill. Final BW, ADG and G:F were calculated based on hot carcass weights adjusted to a common dressing percent of 63%. Live BW was collected for dressing percent calculation following a 4% shrink.

Nutrient Balance

Nutrient mass balance experiments were conducted using 24 open feedlot pens with retention ponds to collect runoff from 12 pens (statistics for runoff used data from only these 12 pens) balanced across treatments. When rainfall occurred, runoff collected in retention ponds, was drained and quantified using an air bubble flow meter (ISCO, Lincoln, Neb.). After cattle were removed from the pens, manure was piled on a cement apron and sampled (n = 30/pen) for nutrient analysis while being loaded. Manure was weighed after removal. Manure was either freeze-dried for nutrient analysis (n = 20; composited 2/pen) or oven dried (60° C forced air oven) for DM removal calculation (n = 10).

Feed ingredients were sampled monthly and feed refusals were used

(Continued on next page)

to determine nutrient intake using a weighted composite on a pen basis. Retained steer N and P were calculated using the energy, protein and P equations (Beef NRC, 1996). Nutrient excretion was determined from subtracting nutrient retention from intake (ASABE, 2005). Total N lost (lb/steer) was calculated by subtracting manure and runoff N from excreted N. Percentage of N lost was calculated as N lost divided by N excretion.

Statistical Analysis

Dietary treatments were fed in the same pens for both trials. All data were analyzed by experiment (season) using the MIXED procedure of SAS (SAS Inst. Inc., Cary, N.C.) with pen as the experimental unit. Interactions were tested between diet and Micro-Aid inclusion with simple (significant interaction) or main (no interaction) effects discussed. Treatments were included in the model as fixed effects and block was included as a random effect. *P*-values of 0.10 were considered significant.

Results

Feedlot Performance

In the WINTER, no interactions were observed between diet (stover) and Micro-Aid ($P \geq 0.42$). Among steers fed in the WINTER experiment, there were no differences ($P = 0.42$) among diet treatments for DMI. Steers fed CON and TRT had similar ADG and F:G ($P > 0.3$) yet both treatments had greater final BW and ADG, and improved F:G ($P < 0.01$) compared to NONTRT steers (Table 2). Steers fed CON and TRT diets had similar ($P \geq 0.11$) HCW, dressing percent, and marbling, which were greater than NONTRT steers ($P < 0.01$). There were no differences ($P \geq 0.07$) among dietary treatments for LM area, 12th rib fat, or calculated USDA yield grade (YG). Although ADG, F:G and LM area where numerically greater for steers fed Micro-Aid, no statistical differences ($P > 0.19$) were observed for feedlot performance or carcass characteristics in this experiment (Table 3).

Table 5. Finishing performance and carcass characteristics of steers fed with or without Micro Aid during the SUMMER trial.

Diet	0 g/head/day	1 g/head/day	SEM	*P*-value
Performance				
Initial BW, lb	867	865	1	0.11
Live Final BW, lb[1]	1447	1465	7	0.09
DMI, lb/day	27.3	28.1	0.2	<0.01
ADG, lb[2]	3.91	4.08	0.04	0.01
F:G[3]	7.02	6.93		0.33
Carcass Characteristics				
HCW, lb	891	905	4	0.02
Dressing %	61.6	61.8	0.001	0.18
LM area, in^2	13.87	14.11	0.14	0.25
12th Rib Fat, in	0.56	0.56	0.02	0.92
Marbling[4]	559	552	9	0.61
Calculated USDA YG[5]	2.85	2.84	0.07	0.89

[1]Live Final BW calculated: Avg. BW of pen shrunk 4%.
[2]ADG based on carcass-adjusted final BW = HCW/0.63.
[3]Analyzed as G:F, the reciprocal of F:G.
[4]Marbling: 500 = small^0, 600 = modest^0, etc.
[5]Calculated as 2.50 +(2.5*fat depth, in) – (0.32*LM area, in^2) + (0.2*2.5 KPH) + (0.0038*HCW, lb).

Table 6. Effect of diet on nitrogen mass balance during the WINTER[1] trial.

Variable	CON	NONTRT	TRT	SEM	*P*-value
N intake	101.1[a]	94.5[b]	97.6[b]	1.2	<0.01
N retention[2]	14.3[a]	12.7[b]	14.1[a]	0.2	<0.01
N excretion[3]	86.8[a]	81.8[b]	83.6[b]	1.0	<0.01
Manure N, %[4]	1.18	1.32	1.31	0.06	0.18
Manure N	42.3	44.7	43.4	2.3	0.76
N runoff	5.20[a]	2.20[b]	5.75[a]	0.26	<0.01
N lost	41.9	36.0	37.3	2.3	0.18
N Loss %[5]	48.3	44.0	44.4	2.7	0.47
Manure DM, %	62.26[a]	55.67[b]	57.62[b]	1.15	<0.01
DM removed	3597	3437	3314	181	0.55
OM removed	710	838	787	42	0.13

[a,b,c]Means within a row with unlike superscripts differ ($P < 0.05$).
[1]Values expressed as lb/steer over entire feeding period of calf-feds (183 DOF) unless specified.
[2]Calculated using NRC net protein and net energy equations.
[3]Calculated as N intake – N retention.
[4]N content of manure expressed as a percent.
[5]Calculated as N lost divided by N excretion.

Table 7. Effect of Micro-Aid on nitrogen mass balance during the WINTER[1] trial.

Variable	0 g/head/day	1 g/head/day	SEM	*P*-value
N intake	96.9	98.5	0.9	0.24
N retention[2]	13.6	13.8	0.2	0.54
N excretion[3]	83.3	84.8	0.8	0.22
Manure N, %[4]	1.31	1.23	0.05	0.22
Manure N	43.6	43.3	1.9	0.94
N runoff	4.20	4.57	0.21	0.26
N lost	37.6	39.1	1.8	0.57
N Loss %[5]	45.1	46.1	2.2	0.75
Manure DM, %	58.78	58.26	0.94	0.70
DM removed	3333	3565	148	0.28
OM removed	774	783	34	0.85

[1]Values expressed as lb/steer over entire feeding period of calf-feds (183 DOF) unless specified.
[2]Calculated using NRC net protein and net energy equations.
[3]Calculated as N intake – N retention.
[4]N content of manure expressed as a percent.
[5]Calculated as N lost divided by N excretion.

Table 8. Effect of diet on nitrogen mass balance during the SUMMER[1] trial.

Variable	CON	NONTRT	TRT	SEM	*P*-value
N intake	94.2	97.0	94.0	1.1	0.12
N retention[2]	11.9[a]	10.8[b]	11.5[a]	0.2	<0.01
N excretion[3]	82.3[a]	86.2[b]	82.5[a]	1.0	0.03
Manure N, %[4]	1.02[a]	1.41[b]	1.40[b]	0.07	<0.01
Manure N	16.1	17.4	15.9	1.2	0.63
N runoff	1.9[a]	1.0[b]	1.8[a]	0.12	<0.01
N lost	65.3	68.3	65.7	1.5	0.35
N Loss %[5]	79.3	79.2	79.5	1.5	0.99
Manure DM, %	71.58[a]	63.43[b]	66.18[b]	1.12	<0.01
DM removed	1670	1261	1176	186	0.16
OM removed	314	376	321	23	0.14

[a,b]Means within a row with unlike superscripts differ ($P < 0.05$).
[1]Values expressed as lb/steer over entire feeding period of yearlings (140 DOF) unless specified.
[2]Calculated using NRC net protein and net energy equations.
[3]Calculated as N intake – N retention.
[4]N content of manure expressed as a percent.
[5]Calculated as N lost divided by N excretion.

Table 9. Effect of Micro-Aid on nitrogen mass balance during the SUMMER[1] trial.

Variable	0 g/head/day	1 g/head/day	SEM	*P*-value
N intake	93.2	96.9	0.9	<0.01
N retention[2]	11.1	11.6	0.1	0.01
N excretion[3]	82.0	85.3	0.8	0.01
Manure N, %[4]	1.21	1.35	0.06	0.10
Manure N	16.9	16.0	1.0	0.56
N runoff	1.48	1.69	0.09	0.17
N lost	64.4	68.4	1.2	0.04
N Loss %[5]	78.5	80.2	1.2	0.33
Manure DM, %	66.74	67.38	0.92	0.63
DM removed	1500	1238	151.8	0.24
OM removed	347	327	18.5	0.45

[1]Values expressed as lb/steer over entire feeding period of yearlings (140 DOF) unless specified.
[2]Calculated using NRC net protein and net energy equations.
[3]Calculated as N intake – N retention.
[4]N content of manure expressed as a percent.
[5]Calculated as N lost divided by N excretion.

In the SUMMER, no interactions were observed between diet and Micro-Aid ($P \geq 0.13$) except for DMI (data not shown; P = 0.03). Steers fed CON without Micro-Aid had the lowest DMI but feeding Micro-Aid in the CON diet increased DMI which led to the interaction. Steers fed NONTRT diets had the greatest DMI and steers fed TRT diets were intermediate in DMI regardless of whether Micro-Aid was included. Cattle fed in the SUMMER experiment on CON and TRT diets had greater ADG ($P < 0.01$) than NONTRT steers (Table 4). Feed conversion was different among all three treatments ($P < 0.01$), with the lowest F:G for CON, followed by TRT, and the greatest F:G for NONTRT. Steers on the CON and TRT diets had greater HCW compared to NONTRT steers ($P < 0.01$). Steers fed Micro-Aid diets had greater ($P < 0.01$) DMI compared to the steers fed diets without Micro-Aid. Additionally, Micro-Aid fed steers had greater final BW ($P = 0.02$), ADG ($P = 0.01$) and HCW ($P = 0.02$). However, F:G was similar ($P = 0.34$) between steers fed Micro-Aid and those which were not (Table 5). Dressing percentages were different among all three treatments ($P < 0.01$) with cattle fed NONTRT having the lowest dressing percentage illustrating why HCW should be used for performance calculations, particularly at greater levels of roughage inclusion. There were no differences among treatments for LM area, 12th rib fat, marbling and calculated yield grade.

Nutrient Balance

Steers in the WINTER experiment fed NONTRT and TRT diets had lower N intake ($P < 0.01$) than steers fed the CON diet (Table 6). Steer fed NONTRT and TRT diets had similar ($P = 0.22$) N excretion that was lower than ($P < 0.01$) steers fed the CON diet. Nitrogen retention was similar ($P = 0.63$) between steers fed CON and TRT diets, but greater compared to NONTRT steers ($P < 0.01$). Runoff N was lowest for NONTRT diets ($P < 0.01$), and there was a diet by Micro-Aid interaction ($P < 0.01$). The addition of Micro-Aid tended to lower runoff N ($P = 0.06$) in CON diets and increase runoff N in TRT diets ($P < 0.01$) which is difficult to explain. Likewise, runoff is a relatively small portion of total N mass balance. Manure % N was numerically lower for steers on the CON diet compared to NONTRT and TRT steers ($P = 0.18$) and N loss (as a percent) was numerically greater for steers on the CON diet compared to the NONTRT and TRT steers ($P = 0.18$). Micro-Aid fed steers did not differ ($P \geq 0.22$) from non Micro-Aid fed steers in manure N or N loss (Table 7). Overall, dietary treatments had little impact on amount of manure N or amount lost.

In the SUMMER experiment, steers on the NONTRT diet had greater N excretion ($P = 0.03$) compared to CON and TRT, which were similar ($P = 0.90$; Table 8). Manure N concentration, as a percent, was similar ($P = 0.94$) between steers fed NONTRT and TRT diets and greater compared to steers on the CON diet ($P < 0.01$). Diet treatment did not affect amount or percent N loss ($P > 0.35$). In the SUMMER experiment, steers fed Micro-Aid (Table 9) had greater N intake, retention, and excretion ($P \leq 0.01$). There was a tendency for Micro-Aid fed steers to have a greater % N in manure ($P = 0.10$), but feeding Micro-Aid did not influence amount of N removed in manure ($P = 0.56$). Amount of N loss was slightly greater for steers fed Micro-Aid ($P = 0.04$), but not as a percentage of N excretion ($P = 0.33$) suggesting this was due to greater excretion. Similar to WINTER, diet did not dramatically impact manure N or N losses.

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