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Effect of Organic Matter Addition to the Pen Surface on Feedlot Nitrogen Balance

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Feeding corn bran reduced nitrogen losses in winter and in summer but increased feed conversion. Sawdust application reduced nitrogen loss in winter but was ineffective during summer.

Summary

Two experiments, calves fed November to May (WINTER) and yearlings fed May to September (SUMMER), were conducted to evaluate effects of replacing dry-rolled corn with 30% corn bran or applying sawdust to the pen surface on feedlot nitrogen balance. Bran increased feed conversion during both experiments but reduced nitrogen losses in the WINTER. Sawdust application to the feedlot pen surface reduced nitrogen losses during the WINTER. Bran and sawdust treatments increased nitrogen recovered in manure during the WINTER. Adding OM to the pen surface did not impact nitrogen losses during the SUMMER.

Introduction

Nitrogen loss from feedlot manure occurs mostly through gaseous emissions, primarily ammonia (NH_3). One

potential option to reduce N loss is the manipulation of the carbon:nitrogen (C:N) ratio of feedlot manure. Adding C to manure increases microbial N immobilization, which reduces N losses. Previous research has shown that byproducts from wood manufacturing (*2002 Nebraska Beef Cattle Report* pp. 52-53) and corn wet milling (*2002 Nebraska Beef Cattle Report* pp. 54-57) industries increase manure C:N ratio and result in reduced N loss from feedlots. However these methods have not been compared to one another.

Corn bran has a lower digestibility than corn, causing animals to excrete additional C to the pen surface. Therefore, bran serves as C source for microbial N immobilization. However, cattle performance may be depressed by feeding corn bran due to the lower digestibility, which may limit the usefulness of this alternative.

Sawdust application to the pen surface provides an undigested C source for microbes. Sawdust applied to the pen surface does not affect diet characteristics and subsequent animal performance. The use of this alternative may increase labor and machinery costs required for delivery and application to the pen surface. One potential negative effect of adding C to the pens is the associated expense of increased manure removal. However, decreasing N loss may overcome any negatives.

The objective of these experiments was to compare the effects of adding organic matter (OM) to the pen surface through decreased diet digestibility or direct application of C as sawdust on N losses in open feedlots.

Procedure

Feedlot Experiment

Two experiments were conducted using 96 steers each, calves (716 + 29 lb BW) fed 180 days from November to May (WINTER) and yearlings (829 + 31 lb BW) fed 132 days from May to September (SUMMER), to evaluate impacts of applying additional organic matter (OM) to the pen surface on N balance in open feedlots. Steers were stratified by weight and assigned randomly to treatment (8 head/pen, 4 pens/treatment).

Design of each experiment led to 2 treatments and a control. The control (CONTROL) was designed to provide a typical feedlot diet and environmental management. A dietary treatment (BRAN) was devised to increase OM excretion to the pen surface by decreasing the OM digestibility of the diet. This diet contained 30% corn bran, replacing dry-rolled corn. Cattle assigned to the sawdust (SAWDUST) treatment were fed the CONTROL diet and sawdust was applied weekly to the pen surface (14 lb/steer/week). The SAWDUST application rate was formulated to match the amount of OM excreted by cattle on the BRAN treatment above CONTROL.

On day 1, WINTER steer calves were initially implanted with Synovex-S® followed by Revalor-S® on day 90. SUMMER yearling steers were implanted on day 1 with Synovex-C® and reimplanted on day 35 with Revalor-S®. Finishing diets for each trial were formulated to meet animal metabolizable protein requirements using NRC (1996) recommendations. Within each experiment, CONTROL and SAWDUST diets were identical (Table 1).

Carcass data were collected upon completion of experiments at a commercial abattoir. At harvest, hot carcass weights were recorded. Final weights were calculated using a common dressing percentage (63). Following a 24 hour chill, fat thickness at the 12th rib and *longissimus* area were collected. Yield and marbling score, determined by a USDA grader, were recorded.

Nutrient Balance

These nutrient balance experiments were conducted in 12 open feedlot pens with a stocking density of 332 ft^2 per steer. Six retention ponds constructed of soil collected runoff from the 12 pens. In the case of a runoff event, effluent was collected in the retention ponds, drained, quantified with an air-bubble flow meter (ISCO, Lincoln, NE) and sampled. Dry-matter, OM, total P and total N were analyzed on all samples.

Each week throughout the feeding period, pens assigned to SAWDUST received a sawdust application to the pen surface just behind the feed bunk on the cement apron. Cattle spend most of their time and presumably excrete the most N in this area.

Throughout the feeding period, feed refusals were collected when necessary. Fecal samples were collected every 2 weeks. After cattle were removed from the pens upon completion of the feeding period, manure was piled on the cement apron. As the manure was being loaded out of the pens, manure samples were taken. Manure was weighed on an as-is basis and hauled to the University of Nebraska compost yard. The manure then was composted.

Before initiation and upon completion of both experiments, soil core samples from each pen (6 inch depth) were taken from 16 designated locations evenly spaced throughout the pen and

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Table 1. Composition of diet (% DM) fed to steers during WINTER and SUMMER trials.

	TREATMENT					
	WINTER			SUMMER		
Item	CONTROL	BRAN	SAWDUST	CONTROL	BRAN	SAWDUST
Dry-rolled corn	74	44	74	75	45	75
Corn silage	15	15	15	15	15	15
Corn bran	—	30	—	—	30	—
Molasses	5	5	5	5	5	5
Supplement	6	6	6	5	5	5
Composition						
CP[a]	12.9	13.1	12.9	13.8	13.8	13.8
DIP[b]	7.2	8.0	7.2	6.6	8.9	6.6
P[c]	0.26	0.20	0.26	0.27	0.27	0.27

[a]Dietary crude protein content, on a DM basis.
[b]Degradable intake protein, expressed as a percent of diet DM.
[c]Phosphorus content of the diet, on a DM basis.

six samples from each retention pond. The same core pattern, or grid, was used for both experiments. Soil samples were used to correct for manure/soil mixing by cattle activity throughout the experiment and pen cleaning variation. All manure, soil, compost, refusal and feed samples were analyzed for DM, OM, total P and total N.

Nitrogen intake was calculated using analyzed dietary N concentration multiplied by DMI, corrected for N content of feed refusals. Retained energy and protein equations established by the NRC (1996) were used to calculate steer N retention. Nitrogen excreted (urine plus feces) was determined by subtracting N retention from N intake. Fecal N was determined by multiplying the total N concentration of fecal samples collected by the amount of feces excreted. Fecal excretion was determined by multiplying DMI throughout the feeding period, adjusted for refusals, by the DM digestibility of the diet (75.8% CONTROL/SAWDUST, 71.7% BRAN), (*2002 Nebraska Beef Cattle Report,* pp. 66-68). The digestibility (*2002 Nebraska Beef Cattle Report*, pp. 66-68) seem to over-predict the actual digestibility value for the BRAN treatment. Bierman et al. (1999), calculated the difference in DM digestibility between a 7.5% roughage diet to be 9.1 units higher than a wet corn gluten feed diet (41.5% diet DM). Therefore, the BRAN DM digestibility of 66.7% (75.8 minus 9.1) was also examined.

Total N lost (lb/steer) was calculated by subtracting manure N (corrected for soil N content) and runoff N from excreted N. Percentage of N lost was calculated as N lost divided by N excretion. All N values were converted to a lb/steer basis. Statistical analysis was conducted using the General Linear Models procedure of SAS.

Table 2. Performance of steer calves fed during WINTER.

Item	CONTROL	BRAN	SAWDUST	SE[a]	F-test[b]
Initial BW, lb	714	716	717	2	0.62
Final BW, lb	1350[f]	1301[g]	1345[f]	18	0.14
DM intake, lb	22.7	23.2	23.0	0.4	0.61
Average daily gain, lb	3.53[f]	3.25[g]	3.49[f]	0.09	0.11
Gain:feed	0.156[h]	0.140[i]	0.152[h]	0.003	0.01
Feed:gain[c]	6.43[h]	7.14[i]	6.59[h]	—	—
Hot carcass weight., lb	851[f]	819[g]	847[f]	11	0.14
Marb. Score[d]	5.28[fg]	4.95[g]	5.44[f]	0.15	0.11
Fat thick, in[e]	0.48[f]	0.38[g]	0.46[f]	0.03	0.10

[a]Standard error of the means.
[b]Data were analyzed using a protected F-test where numbers represent P-value for variation due to treatment.
[c]Analyzed as gain:feed.
[d]Marbling score: 4.5 = Slight^{50}; 5.0 = Small^{00}; 5.5 = Small^{50}.
[e]12th rib fat thickness.
[f,g]Means within a row with different superscripts differ (P < 0.10).
[h,i]Means within a row with different superscripts differ (P < 0.01).

Table 3. Performance of yearling steers fed during SUMMER.

Item	CONTROL	BRAN	SAWDUST	SE[a]	F-test[b]
Initial BW, lb	829	829	829	2.0	1.0
Final BW, lb	1265	1254	1279	8.8	0.19
DM intake, lb	23.6[f]	25.1[g]	23.6[f]	0.3	0.01
Average daily gain, lb	3.29	3.22	3.40	0.07	0.24
Gain:feed	0.139[f]	0.128[g]	0.144[f]	0.002	<0.01
Feed:gain[c]	7.18[f]	7.79[g]	6.94[f]	—	—
Hot carcass weight., lb	793[hi]	790[h]	805[i]	5	0.13
Marb. Score[d]	5.05	4.70	4.83	0.14	0.27
Fat thick, in[e]	0.45	0.46	0.43	0.03	0.70

[a]Standard error of the means.
[b]Data were analyzed using a protected F-test where numbers represent P-value for variation due to treatment.
[c]Analyzed as gain:feed.
[d]Marbling score: 4.5 = Slight^{50}; 5.0 = Small^{00}; 5.5 = Small^{50}.
[e]12th rib fat thickness.
[f,g]Means within a row with different superscripts differ (P < 0.01).
[h,i]Means within a row with different superscripts differ (P < 0.10).

Results

Feedlot Performance

Performance of steers assigned to CONTROL and SAWDUST treatments for either experiment was not different between treatments, because diets were identical (Tables 2 and 3). Steers consuming the BRAN had lower average daily gain (ADG) than the steers fed the CONTROL/SAWDUST diet in WINTER (P < 0.10), whereas the yearlings fed BRAN were not different from CONTROL or SAWDUST. The BRAN steers had higher feed conversion compared to CONTROL or SAWDUST during WINTER and SUMMER (P < 0.02). During WINTER, calves on the BRAN diet had similar DMI but lower gains causing the increase in feed:gain. The yearlings fed BRAN, however, had higher DMI and similar gains, resulting in increased feed conversion. This would indicate that calves and yearlings did not respond alike. Hot carcass weights tended to be lighter for BRAN cattle than CONTROL, whereas SAWDUST was intermediate during the WINTER feeding period (P = 0.14). During SUMMER, BRAN hot carcass weights tended to be lower than SAWDUST, whereas CONTROL was intermediate (P = 0.13). Marbling score and 12th rib fat thickness were also lower for BRAN cattle than CONTROL or SAWDUST (P < 0.10) during WINTER, but not during SUMMER (P > 0.10). Feeding BRAN for 14 additional days during WINTER would have allowed for final weights and carcass characteristics equivalent to CONTROL. Additional days on feed were not required for SUMMER steers because carcass characteristics and gains were similar to CONTROL.

Table 4. Nitrogen mass balance during WINTER expressed in lb/steer.

Item	CONTROL	BRAN	SAWDUST	SE[a]	F-test[b]
N intake	83.5	87.5	84.5	1.3	0.15
N retention[c]	10.4^{j}	9.6^{k}	10.3^{j}	0.2	0.09
N excretion[d]	73.2^{j}	78.1^{k}	74.3^{j}	1.1	0.03
Fecal N[e]	23.6^{l}	27.6^{m} (32.8^{m})^{n}	22.5^{l}	0.7	<0.01
Manure N[f]	36.0^{l}	54.9^{m}	53.9^{m}	3.6	0.01
Runoff N	0.9^{j}	0.6^{k}	0.6^{k}	0.1	0.10
N lost[g]	36.2^{j}	22.7^{k}	19.8^{k}	3.7	0.03
Adjusted N lost[h]	36.2^{j}	24.5^{k}	19.8^{k}	4.1	0.05
N loss, %[i]	49.4^{l}	29.1^{m}	26.8^{m}	5.1	0.01
Manure C:N ratio	9.3^{l}	11.3^{m}	12.5^{m}	0.3	<0.01

[a] Standard error of means.
[b]Data were analyzed using a protected F-test where numbers represent P-value for variation due to treatment.
[c]Calculated using NRC (1996) net protein and net energy equations.
[d]Calculated as N intake minus N retention.
[e] Calculated as fecal N concentration multiplied by lb of excreted feces.
[f]Corrected for N concentration before and after trial.
[g]Calculated as N excretion minus manure N (corrected for soil), and runoff N.
[h]N lost includes 14 additional days for WINTER.
[I]Calculated as N lost divided by N excretion.
[j,k]Means within a row with different superscripts differ (P < 0.10).
[l,m]Means within a row with different superscripts differ (P < 0.01).
[n]Values in parenthesis represent fecal excretion values calculated using 66.7% DM digestibility.

Table 5. Nitrogen mass balance during SUMMER expressed in lb/steer.

Item	CONTROL	BRAN	SAWDUST	SE[a]	F-test[b]
N intake	68.8	69.4	68.9	2.3	0.98
N retention[c]	7.9	7.8	8.2	0.2	0.28
N excretion[d]	60.9	61.6	60.7	2.2	0.96
Fecal N[e]	18.9^{k}	22.9^{l}(26.9^{l})^{m}	19.4^{k}	0.6	<0.01
Manure N[f]	23.0	26.5	21.3	2.8	0.45
Runoff N	0.004^{i}	0.004^{i}	0.003^{j}	0.002	0.10
N lost[g]	37.9	35.1	39.4	3.8	0.73
N loss, %[h]	62.2	56.4	64.8	5.3	0.54
Manure C:N ratio	8.1^{k}	8.2^{k}	11.3^{l}	0.5	<0.01

[a]Standard error of means.
[b]Data were analyzed using a protected F-test where numbers represent P-value for variation due to treatment.
[c]Calculated using NRC (1996) net protein and net energy equations.
[d]Calculated as N intake minus N retention.
[e]Calculated as fecal N concentration multiplied by lb of excreted feces.
[f]Corrected for pen soil concentration and soil N concentration before and after trial.
[g]Calculated as N excretion minus manure N (corrected for soil), and runoff N.
[h]Calculated as N lost divided by N excretion.
[i,j]Means within a row with different superscripts differ (P < 0.10).
[k,l]Means within a row with different superscripts differ (P < 0.01).
[m]Values in parenthesis represent fecal excretion values calculated using 66.7% DM digestibility.

Nutrient Balance

All N mass balance results are reported on a per-steer basis (Tables 4 and 5). Nitrogen intake (lb DM) for BRAN cattle was higher (numerically) than CONTROL or SAWDUST in WINTER (P = 0.15) and similar across treatments in the yearling trial (P > 0.90). Nitrogen retention was based on gains and final weights. Therefore BRAN calves retained less N than CONTROL and SAWDUST calves (P < 0.10) due to lower ADG, but yearling N retention was similar (P > 0.25). Differences in N retained are subtle and calculated N retentions are often quiet low (10-13% of N intake). Reduced N retention caused BRAN calves to excrete more N during WINTER than CONTROL or SAWDUST (P < 0.10). Nitrogen excretion was similar across treatments for SUMMER (P > 0.95). Fecal N content was greater for the BRAN steers than the other two treatments for both experiments, using both 71.2 and 66.7% digestibility values.

Precipitation during WINTER totaled 12.76 inches, while SUMMER precipitation totaled 16.7 inches. Runoff is not a large contributor to N loss. Runoff N from pens assigned to CONTROL treatment was higher (P < 0.10) than pens designated to other treatments during WINTER. During SUMMER, BRAN and CONTROL lost equal amounts of N via runoff, and more than SAWDUST (P < 0.10). Runoff accounted for less than 1% of all N excreted across all treatments.

Pens receiving OM had higher amounts of manure removed from the pen surface than the CONTROL in both experiments (Table 6 and 7). Logically, hauling more OM into the pen would require more material to be hauled from the pen. Manure (corrected for soil contamination) from the BRAN and SAWDUST treatments contained more N during WINTER than CONTROL (P < 0.01). During SUMMER, manure N content did not differ among treatments; however, numerically, BRAN was highest. Preserving excreted N in manure by increasing the C:N ratio prevented volatile N losses.

All N unaccounted for is presumed to be N volatilized as ammonia. Adding OM to the pen surface reduced N losses during WINTER (P < 0.05). Nitrogen lost (lb/steer) from the BRAN and SAWDUST treatments were 13.5 and 16.4 lb, respectively, lower than CONTROL. There were no differences in N lost (lb/steer) during the SUMMER. BRAN reduced lb of N lost by 38% and 8% during WINTER and SUMMER, respectively, while SAWDUST reduced N lost by 45% in WINTER and had no impact during SUMMER, when compared to the CONTROL.

As previously stated, the cattle assigned to the BRAN treatment required 14 additional days to achieve a similar carcass end point as cattle assigned to CONTROL or SAWDUST. Therefore, to account for the additional N lost during the extended feeding period, adjusted N lost was calculated. The amount of N lost by CONTROL and SAWDUST were held constant. The additional 14 days on feed for the BRAN steers would increase N lost by 1.8 lb.

Reducing diet digestibility by substituting dry-rolled corn with corn bran and applying SAWDUST during WINTER

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lowered percentage of N loss compared to CONTROL ($P < 0.10$). BRAN had the lowest percentage of N lost during SUMMER (numerically), while SAWDUST treatment lost the largest percentage (numerically). When compared to previously cited research (*2002 Nebraska Beef Cattle Report,* pp. 54-57), BRAN volatile N losses in this study were lower during winter months (59.8 vs 29.1%, respectively) and summer months (57.6 vs 56.4%, respectively). These differences may be due to year-to-year climatic variation. The average temperature during WINTER of the present study was 33°F with 12.76 inches of precipitation, while the average temperature during the winter (*2002 Nebraska Beef Cattle Report,* pp. 54-57) study was conducted was 43°F with 8.21 inches of precipitation. However, SUMMER temperatures were similar for the present study (71°F) (*2002 Nebraska Beef Cattle Report,* pp. 54-57; 73°F). The present study received an additional 6 inches of precipitation compared to Erickson et al. Warmer conditions cause volatile N losses to increase. Volatile N losses from the present SAWDUST treatment are comparable to losses reported by Lory et al. (*2002 Nebraska Beef Cattle Report,* pp. 52-53) during the summer months (60.6 vs 66.1%, respectively).

Table 6. Manure removed from the pen surface during WINTER expressed in lb/steer.

Item	CONTROL	BRAN	SAWDUST	SE[a]	F-test[b]
As-is weight removed	4639[c]	6401[d]	6429[d]	529	0.06
% DM	72.4[e]	65.7[f]	65.5[f]	1.3	0.01
DM weight removed	3351	4199	4230	364	0.21
% OM	18.8[e]	26.2[f]	28.6[f]	1.1	<0.01
OM weight removed	626[e]	1098[f]	1192[f]	77	<0.01
C:N ratio	9.3[e]	11.3[f]	12.5[f]	0.3	<0.01

[a]Standard error of means.
[b]Data were analyzed using a protected F-test where numbers represent P-value for variation due to treatment.
[c,d]Means within row with different superscripts differ ($P < 0.10$).
[e,f]Means within row with different superscripts differ ($P < 0.01$).

Table 7.Manure removed from the pen surface during SUMMER expressed in lb/steer.

Item	CONTROL	BRAN	SAWDUST	SE[a]	F-test[b]
As-is wt removed	1706[c]	2253[d]	2026[d]	88	0.01
% DM	61.0[e]	56.2[f]	54.4[f]	2	0.05
DM wt removed	1040[e]	1268[f]	1102[e]	68	0.10
% OM	23.5[e]	25.5[e]	31.9[f]	3	0.09
OM wt removed	245[c]	322[d]	344[d]	18	0.01
C:N ratio	8.1[c]	8.2[c]	11.3[d]	0.5	<0.01

[a]Standard error of means.
[b]Data were analyzed using a protected F-test where numbers represent P-value for variation due to treatment.
[c,d]Means within row with different superscripts differ ($P < 0.01$).
[e,f]Means within row with different superscripts differ ($P < 0.10$).

Nitrogen volatilization may be enhanced by warm, moist conditions, such as those experienced during the summer months. These conditions cause the N pool to be lost at a much faster rate. Therefore, increasing the C:N ratio was not as effective during the SUMMER as WINTER. However, adding more OM to the pen surface will increase the amount of material removed from the pen, potentially increasing production costs. However, reducing N losses may overcome any additional economic costs.

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