Effect of Increasing Dietary Corn Silage on Performance, Digestibility and Nitrogen Mass Balance in the Feedlot

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Increasing dietary corn silage in finishing diets decreased gains and increased manure nitrogen and organic matter without affecting N volatilization.

Summary

Three dietary corn silage levels (15, 30, and 45% of diet DM) were evaluated in corn finishing diets fed to calves through the winter/spring and yearlings during the summer to determine effects on performance and nitrogen mass balance in feedlot. Yearling gains decreased quadratically with increasing corn silage; however, N and OM removed in manure was greatest for the 30% silage treatment. Calf gains decreased linearly as silage increased; however, N and OM removed in manure was greatest for the 45% silage treatment. Increasing dietary corn silage resulted in decreased gains but did influence manure N with no effect on N volatilization.

Introduction

The imbalance between N:P ratio in manure relative to crop requirements is an emerging concern to feedlot producers. Management and nutritional techniques that will either increase N or decrease P in manure will improve the imbalance because typical manure contains a N:P ratio of 2:1 or lower and crop requirements are 5:1 or greater. Two contributing factors for the imbalance between N and P in manure relative to crop needs are P is overfed and N volatilizes off the pen surface presumably as ammonia.

One method to increase manure N is to increase OM (organic matter) supply on the pen surface. Feeding high fiber, less digestible diets may lead to improved retention of manure N and decreased volatilization due to increased OM on the pen surface. Corn silage may be a potential feedstuff that if fed at higher than typical levels, may improve N retention in manure because corn silage is less digestible than the corn it is replacing. However, based on previous research, increasing corn silage in finishing diets may be as profitable despite poorer feed conversions.

The primary objective of this research is to determine if increasing dietary corn silage can increase manure N and decrease N losses via volatilization. A second objective was to determine the effects of increasing dietary corn silage on animal performance, digestibility and nutrient balance in the feedlot.

Procedure

Two experiments were conducted, one with 96 yearling steers (BW=746 + 46 lb) fed through the summer months and the other with 96 steer calves (BW=692 + 22 lb) fed through the winter/spring months. Steers were randomly assigned (8 head/pen; 4 pens/treatment) to either 15, 30, or 45% (DM-basis) corn silage diets (Table 1). Yearlings were fed for 146 days from May to October and implanted initially with Synovex-S® followed with Revalor-S® 97 days from slaughter.

In the calf trial, steers were fed for an average of 194 days from November to May. Steers were implanted initially with

Table 1. Diet composition (% of DM) for yearlings and calves. Note: diet for digestibility trial was identical to the yearling diet except 1.5% urea was used to ensure abundant degradable nitrogen.

	Yearlings			Calves		
Ingredient[a]	15%	30%	45%	15%	30%	45%
Corn silage	15	30	45	15	30	45
DRC	70	30	0	80	65	50
HMC	10	35	50			
Supplement	5	5	5	5	5	5
Urea	.94	.92	.92	.88	1.01	1.15
Limestone	1.30	1.20	1.10	1.55	1.46	1.36
KCl	.67	.45	.23	.67	.50	.23
FM				1.20	.65	0
BM				.15	.08	0
Salt	.30	.30	.30	.30	.30	.30
Tallow	.10	.10	.10	.10	.10	.10
Tr. Min.	.03	.03	.03	.05	.05	.05
Vitamin ADE	.01	.01	.01	.01	.01	.01
Rumensin-80	.016	.016	.016	.017	.017	.017
Tylan-40	.013	.013	.013	.013	.013	.013
CP	11.3	11.3	11.4	12.1	12.0	11.8
DIP[b]	5.6	6.5	7.3	6.0	6.5	7.0
NE_m[c]	95.6	92.0	88.3	95.4	91.3	87.3
NE_g[c]	65.2	62.7	60.0	65.0	62.0	59.0

[a]DRC is dry-rolled corn, HMC is high-moisture corn, FM is feather meal, BM is blood meal, Tr. Min. is trace mineral premix.
[b]DIP was increased as corn silage increased because microbe efficiency is predicted to increase with higher levels of corn silage. DIP was increased from either a greater proportion of HMC in the yearling diets or from less feather meal/blood meal and more urea in the calf diets.
[c]NE values calculated using tabular values for ingredients.

Synovex-S® followed with Revalor-S® 115 days from slaughter.

Initial weights were an average of weights taken on two consecutive days following a 5-day limit-feeding period. At slaughter, hot carcass weights and liver scores were recorded. Quality grade, yield grade and fat thickness at the 12th rib were recorded following a 24-hour chill. Final weights were calculated as hot carcass weight divided by a common dressing percentage (62).

Diets were formulated to meet steers' metabolizable protein (MP) requirement at 800 lb for yearlings and calves. In each diet, MP was overfed by the same amount. In the yearling diets, grain source was changed to keep UIP (undegradable intake protein) that was overfed constant across the three levels of silage. In the calf experiments, feather meal and blood meal were added in an 8:1 ratio to the 15 and 30% silage diets to keep overfed UIP constant.

Steers were fed in 12 open-dirt pens. Soil in pens was core sampled (0 to 6 inches) before the trial to estimate nutrient concentration on the pen surface. Pens were cleaned after the entire feeding period when the cattle were marketed. Manure was sampled during removal and pen soil samples were collected again to estimate nutrient balances after the feeding period. Soil sampling allows adjustment for inevitable cleaning differences from pen to pen. These pens also contain runoff collection basins to determine total runoff from pens on different treatments. Due to pen design, two pens drain into one pond; therefore, dietary treatments were assigned in blocks of two pens. All samples including feed and orts were analyzed for N and OM.

Digestibility trial

Six ruminally and duodenally cannulated steers (BW=1125 lbs) were used in a replicated, 3x3 Latin square digestibility trial. Diets were similar to yearling diets except 1.5% urea and .25% chromic oxide (DM-basis) were provided in the supplement. Steers were fed by automatic feeders with feed provided every two hours. DM digestibility was determined by total fecal collection on rubber mats. Periods were 14 days in duration with total feces and urine collected during the last five days. On the first three days of each five-day collection period, rumen, blood, and duodenal samples were collected at three-hour intervals from 10 am to 7 pm on the first day. On the second day, samples were collected from 11 am to 8 pm, and the third day, samples were collected from 12 noon to 9 pm at three-hour intervals. Rumen pH was recorded immediately and all samples were frozen. Feces was collected daily, weighed and one aliqout frozen and subsequently freeze-dried and the other aliqout was dried in a 60°C forced air oven for DM determination.

Table 2. Performance of yearlings fed 3 levels of silage for 146 days.

Item	15% silage	30% silage	45% silage	SE	linear	quad.
Initial wt., lb	768.2	768.4	767.8	2.1	.87	.89
Final wt., lb	1303.6	1231.5	1254.3	9.8	.01	.01
ADG, lb/day	3.64	3.15	3.31	.06	.01	.01
DM Intake, lb/day	23.9	23.9	23.6	.2	.32	.52
Feed/gain[a]	6.54	7.58	7.09	—	.02	.01
Carcass wt., lb	808	764	778	6.1	.01	.01
Marbling score[b]	502	513	485	7.6	.16	.07
Fat depth, in.[c]	.42	.39	.37	.01	.02	.67

[a]Analyzed as gain to feed, the reciprocal of feed to gain.
[b]Marbling score where Slight 50 = 450 and Small 50 = 550.
[c]Fat depth at the 12th rib in inches.

Table 3.Performance of calves fed 3 levels of silage for 194 days.

Item	15% silage	30% silage	45% silage	SE	linear	quad.
Initial wt., lb	690.4	692.2	693.1	1.0	.08	.71
Final wt., lb	1370.8	1349.2	1299.2	9.5	.01	.25
ADG, lb/day	3.51	3.39	3.12	.05	.01	.27
DM Intake, lb/day	20.3	21.5	21.4	.3	.01	.07
Feed/gain[a]	5.78	6.33	6.85	—	.01	.47
Carcass wt., lb	850	837	806	5.9	.01	.25
Marbling score[b]	553	506	474	13.6	.01	.65
Fat depth, in.[c]	.54	.50	.43	.04	.06	.74

[a]Analyzed as gain to feed, the reciprocal of feed to gain.
[b]Marbling score where Slight 50 = 450 and Small 50 = 550.
[c]Fat depth at the 12th rib in inches.

Results

Performance-yearlings

Increasing corn silage from 15 to 45% in the yearling trial resulted in no differences ($P > .20$) in DMI; however, there was a quadratic response ($P < .01$) for ADG (Table 2). Steers fed the 30 and 45% corn silage diets gained less than steers fed 15% corn silage. Final weights and feed conversion, expressed as lbs of DM per lb of gain responded similar to ADG across silage levels. Fat depth, carcass weight and marbling score all indicate that steers fed the 30 and 45% corn silage diets were not as fat or as finished as steers fed 15% corn silage.

Performance-calves

In the calf trial, DMI response was quadratic ($P < .10$) with calves fed the 30 and 45% corn silage diets consuming more DM than the 15% silage treatment (Table 3). ADG decreased linearly ($P < .01$) across silage level and feed required per lb of gain increased linearly ($P < .01$) across silage level. Based on fat depth and marbling scores, calves on the 45% silage diets were not as fat and probably should have been fed longer to be sold at a similar endpoint as calves on the low silage diets. Based on gains, calves on the 45% silage diet should have been fed another 23 days. Assuming a fattening rate of .003 inches per day, to reach the same fat depth, calves should have been fed another 37 days.

Our hypothesis was that in both the calf and yearling trials, steers would consume more feed at the higher levels of corn silage. Despite feeding a lower

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energy diet by replacing corn with corn silage, ADG would be offset by the increased DM intake which would lead to poorer feed conversions with increasing silage. However, in both trials, ADG was depressed by feeding either 30 or 45% corn silage when compared with 15% silage. DM intake was unaffected in the yearling trial but did increase in the calf trial as predicted. Similar intakes across treatments in the yearling trial may be due to the HMC replacing DRC as silage level increased. DM intake may have been lower for the 30 and 45% silage treatments than if DRC was used. This experiment was conducted in the summer so feed condition in the bunk would be a concern; however, DM intake was still as high as the 15% silage treatment which suggests that feed condition was not a factor.

Diet cost was decreased by feeding the higher level of silage in both the calf and yearling experiments (Table 4). Despite the lower diet cost, cost of gain was increased by feeding the higher levels of silage to yearlings from $41.76 per 100 lb gain to $46.99 and $43.99 for the 30 and 45% silage diets, respectively. For calves, cost of gain increased from $38.82 to $40.81 and $43.06 for the 30 and 45% silage diets, respectively. The increase in cost of gain is due to lower gains and increased yardage and interest for the higher levels of silage. Calculated breakevens were similar to trends in cost of gain.

Table 4. Cost of gain, breakeven, and economic comparisons of cattle performance for both the calf and yearling experiments.

Item	15% silage	30% silage	fed to same wt. 30% silage	45% silage	fed to same wt. 45% silage
Yearlings					
Diet cost, $/ton[a]	74.85	73.04	73.04	71.28	71.28
Total gain, lb	536	464	536	486	536
Feeding costs[b]	223.86	220.65	251.88	215.93	235.80
Total costs[c]	838.26	835.05	866.28	830.33	850.20
Cost of gain, $/cwt.	41.76	47.55	46.99	44.43	43.99
Breakeven, $/cwt.	64.28	67.78	66.43	66.21	65.20
Calves					
Diet cost, $/ton[a]	75.94	73.74	73.74	71.46	71.46
Total gain, lb	681	657	679	606	678
Feeding costs[b]	264.37	268.80	277.10	263.26	291.98
Total costs[c]	850.87	857.00	865.30	852.31	881.03
Cost of gain, $/cwt.	38.82	40.91	40.81	43.44	43.06
Breakeven, $/cwt.	62.06	63.53	63.11	65.61	64.26

[a]Based on $2 per bu. corn, silage price based on silage value assuming 50% grain, 35% DM (NebGuide, G74-99; $20.93/ton as-is).
[b]Yardage-$0.30 per day, health cost of $25, and interest on cattle and feed of 9%.
[c]Assuming $0.80 per lb for 768 lb yearlings and $0.85 per lb for 690 lb calves.

Table 5. DM, OM, and N digestibility results from replicated Latin square digestibility trial using the yearling diets fed to ruminally and duodenally cannulated steers.

Item	15% silage	30% silage	45% silage	SE	F-test
DM intake, lb/day	24.5[a]	25.2[a]	22.7[b]	.7	.06
DM digestibility, %	80.6	79.1	79.3	1.1	.53
OM intake, lb/day	23.1[a]	23.9[a]	21.5[b]	.7	.10
OM excreted, lb/day	4.42	4.72	4.17	.30	.21
OM digestibility, %	81.2	80.3	80.5	1.2	.82
N intake, grams/day	217.9[a]	213.4[a]	195.2[b]	4.5	.07
N excreted, grams/day					
In feces	25.9	35.0	44.9	14.1	.46
N digestibility, %	88.1	83.9	77.2	4.5	.34
Rumen pH	5.78[a]	5.85[a]	5.99[b]	.10	.03
pH deviation[c]	.167[a]	.179[ab]	.240[b]	.026	.08

[a,b]Means with different superscripts differ (P < .10)
[c]Standard deviation calculated from 12 pH measurements from 3-day rumen fluid collection

Digestibility trial

In the digestibility trial, DM intake was depressed (P < .10) by feeding the 45% silage diet compared to the 15 and 30% silage diets (Table 5). OM intake and N intake responded similar to DM intake with the 45% silage treatment resulting in lower intakes (P < .10) than 15 and 30% silage treatments. Because the diets were all similar in concentration of N and OM, the decreasing nutrient intakes are directly related to the depression in DM intake. DM, OM, and N digestibilities were unaffected (P > .10) by silage level. Our hypothesis was that DM and OM digestibility would decrease linearly as silage level increased. However, the response was different than expected. Grain source was different between levels of silage to supply more DIP and less UIP to yearlings in the summer. The high-moisture corn may have increased digestibility on the 45% silage diet. Also, because DM intake was lower on the 45% silage treatment, digestibility would be higher than if DM intake was constant between treatments as was the case with the yearlings in the feedlot trial. Rumen pH increased linearly (P < .10) as silage level increased from 15 to 45% of diet DM.

Nutrient balance-yearlings

N intake and excretion were not different (P > .30) across silage levels in the yearling feedlot trial (Table 6). N removed in manure at cleaning responded quadratically (P < .03) with more N removed from the 30% silage treatment than the 15 and 45%. N in runoff was not a large proportion of N excreted (3 to 7%). In the summer yearling trial, 32 to 34 lb per steer of the 55.5 to 56.2 lb of N excreted volatilized during the summer. Level of silage did not affect (P > .60) N volatilization or percentage volatilized which averaged 59%. Volatilization estimates for previous summer feeding trials ranges from 60 to 70% of what the animal excretes (1999 Nebraska Beef Report, pp. 60-63).

OM intake decreased linearly (P < .02) as silage level increased. OM excretion was quadratic (P < .01) with the greatest amount excreted for the 30% silage treatment and similar amounts excreted for the 15 and 45% silage

Table 6. Nitrogen (N) and organic matter (OM) mass balance of yearlings fed 3 levels of silage for 146 days. Values are expressed as total pounds per steer.

Item[a]	15% silage	30% silage	45% silage	SE	linear	quad.
N intake	62.8	63.2	62.7	.6	.90	.55
N retained	7.4	7.0	7.1	.05	.01	.01
N excretion	55.4	56.2	55.6	.6	.84	.33
N removed	10.4	14.3	10.6	1.2	.94	.03
N soil	8.5	8.1	8.0	2.9	.91	.97
N runoff	3.9	1.7	2.9	.3	.05	.01
N volatilized	32.6	32.1	34.1	3.2	.75	.75
% volatilized[b]	58.9	57.1	61.2	5.6	.77	.68
OM intake	3249	3215	3135	30	.02	.54
OM excretion	611	633	611	6	.95	.01
OM removed	202	300	248	21	.16	.02
OM soil	113	149	118	35	.93	.45
OM runoff	87	30	75	20	.69	.07
OM volatilized	210	154	171	46	.57	.53

[a]N retained in the animal, N removed in manure, N soil is the soil core balance between soil sampled before and after cattle were fed and pens cleaned, N volatilized is the difference between N excreted and N removed, N soil balance, and N runoff.
[b]% volatilized is percentage of N excreted lost to volatilization.

Table 7. Nitrogen (N) and organic matter (OM) mass balance of calves fed 3 levels of silage for 194 days. Values are expressed as total pounds per steer.

Item[a]	15% silage	30% silage	45% silage	SE	linear	quad.
N intake	75.3	79.8	79.4	1.0	.01	.07
N retained	9.6	9.5	9.2	.05	.01	.16
N excretion	65.8	70.4	70.3	.9	.01	.07
N removed	41.3	41.0	44.6	2.3	.33	.51
N soil	-.4	-.8	-1.5	2.3	.73	.97
N runoff	1.7	.7	1.0	.3	.08	.10
N volatilized	23.1	29.4	26.2	2.2	.35	.12
% volatilized[b]	35.2	41.7	37.4	3.2	.65	.20
OM intake	3736	3958	3939	47	.01	.07
OM excretion	915	1069	1063	13	.01	.01
OM removed	783	926	1002	46	.01	.57
OM soil	84	88	6	48	.28	.49
OM runoff	24	12	14	3	.06	.12
OM volatilized	24	44	41	58	.83	.89

[a]N retained in the animal, N removed in manure, N soil is the soil core balance between soil sampled before and after cattle were fed and pens cleaned, N volatilized is the difference between N excreted and N removed, N soil balance, and N runoff.
[b]% volatilized is percentage of N excreted lost to volatilization.

treatments assuming, OM digestibility was similar across silage levels. OM digestibility was based on results from the digestibility trial. OM removed in manure was quadratic (P < .02) with more OM removed on the 30% silage diet which was similar to N removal and OM excretion.

Nutrient balance-calves

N intake and excretion were increased linearly (P < .01) by silage level in the winter/spring calf trial (Table 7). However, N removed in manure was not different between treatments. Runoff did not constitute much of what the calves were excreting, resulting in 1 to 2.6% of N excreted lost in runoff from pens. N volatilized was not different (P > .10) between treatments when expressed as total lb (average = 26.2 lb) or as percentage volatilized (average = 38.1%). The winter/spring feeding trial resulted in less N volatilization compared to the summer trial when expressed as either total lbs per steer or as a percent of N excreted which agrees with previous feeding trials.

OM intake increased linearly (P < .02) as silage increased from 15 to 45% of diet DM. The OM intake differences reflect differences in DM intake due to similar OM concentrations in the diet between treatments. OM excretion in the calf trials was not based on digestibility trial results because grain source was dry-rolled corn. OM excretion was calculated based on average digestibilities from three sources in the literature where dry-rolled corn was replaced with corn silage. OM digestibility values used for calculating OM excretion were 75.5, 72.3, and 72.3% of OM intake for 15, 30, and 45% silage treatments, respectively. OM excretion was quadratic (P < .01) with more OM excreted from calves fed the 30 and 45% silage treatments. OM in manure responded linearly (P < .02) with more OM removed from the 30 and 45% silage treatments. Runoff from pens resulted in 1.1 to 2.6% of OM that was excreted being lost from pens. OM volatilized estimates are relatively low and may not differ from zero considering the variation associated with the estimate.

In the feedlot trials, our hypothesis was that more OM would be removed from the 45% silage treatment compared to 15% silage. The increased OM in manure would "trap" more N in manure for the 45% silage treatment. However, the 45% silage treatment did not result in more N being removed from pens in the winter, calf feeding trial or the summer, yearling trial. More N was removed from the 30% silage treatment in the summer and numerically more was removed from the 45% treatment in the winter/spring trial. The 30 and 45% silage treatments did not affect N volatilization as predicted, but more OM was removed in manure from these treatments. Since P content of each treatment diet was similar, N:P ratio should only be influenced by amount of N in manure and reflect those differences.

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