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Summary

A steer finishing trial was conducted to evaluate level and source of dietary fiber on nitrogen, phosphorus, and organic matter excretion. One-hundred twenty steers were fed one of the following treatments: wet corn gluten feed (41.5% of diet DM), 7.5% roughage diet, and all concentrate diet. Nitrogen, phosphorus, and organic matter intake of steers fed wet corn gluten feed were greater than the other two treatments. Fecal nitrogen output was greatest with the wet corn gluten feed diet. All treatments lost about 50% of excreted nitrogen through volatilization. The all concentrate treatment had the highest percentage of phosphorus and organic matter in runoff compared to the other two treatments. All treatments had 65 to 78% of excreted phosphorus and 35 to 55% of excreted organic matter incorporated into the top three inches of the soil. The wet corn gluten feed treatment had the greatest percentage of excreted nitrogen, phosphorus, and organic matter removed from the pens when compared with the other treatments. Different diets can affect the amount of nutrients excreted and subsequently the retention or loss of nutrients from the waste.

Introduction

Development of better balanced diets, which reduce the amount of nitrogen (N) and phosphorus (P) excreted, will help assure continued growth in the livestock industry while reducing deleterious effects on the environment.

The degree of hindgut fermentation is affected by dietary sources of carbohydrates, which subsequently affects the amount of excreted fecal N and organic matter (OM). Often more hindgut fermentation occurs when fiber is fed compared to starch, because cellulose and hemicellulose have a slower rate of fermentation than starch. Therefore, ruminal digestion of fiber is limited, resulting in greater quantity of fiber reaching the hindgut undigested. Starch is extensively degraded in the rumen and small intestine, minimizing the amount of starch reaching the hindgut. Hindgut fermentation increases the amount of fecal N and decreases the amount of urinary N.

It has been estimated that 50% of N excreted on the feedlot surface is lost before pens are cleaned, decreasing the nutrient value of manure as a fertilizer. If more N is excreted in the feces versus urine then, more N should be retained on the feedlot surface. More N is retained when volatilization is decreased and it is assumed that volatilization is less from feces than urine. The objectives of this study were to reduce the loss of nitrogen from the feedlot surface by shifting the distribution of excreted N from urine to feces through increased hindgut fermentation from dietary carbohydrate source, and to evaluate retention and loss of N, P, and OM from excreta.

Procedure

A digestion trial was conducted in the metabolism area of the Animal Science Complex to determine the digestibility of three dietary treatments and their affect on the distribution of N between feces and urine. The digestibility values were used for various calculations for the trial conducted at the feedlot.

Finishing Trial

One hundred twenty crossbred yearling steers (741 lb) were stratified by weight and randomly allotted to one of the three dietary treatments on May 27, 1994. Dietary treatments were wet corn gluten feed (WCGF), 7.5% roughage (7.5% R), and all concentrate diet (All Con). The WCGF was used as an ingredient to increase fiber content of the diet and the All Con diet as a means of reducing fiber content compared to the conventional 7.5% R diet. The WCGF diet consisted (DM basis) of 41.5% WCGF, 43.5% dry rolled corn, 5% corn silage, 5% alfalfa hay, and 5% supplement. The 7.5% R diet consisted of 78.8% dry rolled corn, 5% corn silage, 5% alfalfa hay, 6.2% molasses, and 5% supplement. The All Con diet consisted of 88.8% dry rolled corn, 6.2% molasses, and 5% supplement. All diets were formulated to contain a minimum of 12% CP, .7% calcium, .3% phosphorus, .65% potassium and included 25 g/ton Rumensin and 10 g/ton Tylan per head daily. Because of a low CP content of the corn, actual CP content was 11.5, 11.3, and 10.9% for WCGF, 7.5% R, and All Con diets, respectively. Steers were adapted to final diets in 21 days by feeding 45, 35, 25, and 15% roughage diets for 4, 3, 7, and 7 days, respectively. Steers receiving the 7.5% R and All Con diets were fed the same adaptation diets with corn as the concentrate source and a mixture of corn silage and alfalfa hay as forage sources. Steers receiving the WCGF diet were fed adaptation diets with wet corn gluten feed replacing corn as the concentrate source and a mixture of corn silage and alfalfa hay as forage sources. Steers were implanted with Revalor. Steers were allowed ad libitum amounts of feed once daily and had access to water. The steers were adapted to final rations in non-test pens

and then moved to the test pens after seven days on the final ration. At slaughter, hot carcass weights and liver scores were recorded. After a 48-hour chill, 12th rib fat thickness, and quality grade were evaluated.

The bottom of each pen was fenced off by electric wire to avoid build-up of waste material next to the fence line at the bottom of the pens. The pens had 644.8 ft^2 of pad space and 2439.6 ft^2 total pen area, leaving an area of 244 ft^2 per head. Pens were designed with a fence line between pens on top of the mound with the other fence line in the valley between mounds. Therefore, runoff from two pens that were assigned to the same dietary treatment, was collected in one retention pond. Retention ponds were constructed of dirt berms and lined with plastic.

Retention ponds were connected underground with 4-inch PVC pipe. The pipe had a riser in each retention pond which was used to determine the volume of runoff. Retention ponds were calibrated using known volumes of water. Pens were cleaned 30 days before the cattle being placed into the pens. Three core soil samples from each pen were taken to a 3-inch depth with a soil probe before cattle were placed in the pens and again after the cattle were removed and pens were cleaned. Pens were cleaned immediately after the cattle were removed. When cleaning the pens, only the waste material and minimal amounts of soil were removed. The material was piled on the concrete pad in the pen, mixed, sampled, then removed and weighed.

Input of N to the cattle was calculated by N concentration in ration times dry matter intake. Total N output by the cattle was the difference between N input and N retained by the animal. Retained N was calculated from performance data and using the NRC (1985) net protein gain equation. Fecal N (lb) was calculated by dry matter intake times DM indigestibility (from N digestibility trial) times the concentration of fecal N. Nitrogen contents of feces were similar in samples collected from the feedlot and from the digestion trial. Urinary N was the total N output minus fecal N. Nitrogen removed from the feedlot surface was determined by the amount of material removed after cleaning the pens times the N concentration of the manure sample. Nitrogen lost in runoff was calculated as the quantity of runoff times the N concentration of runoff samples. Nitrogen incorporated in the soil was the difference between 414.3 ft^3 of soil times N concentration of samples taken before and after the cattle were in the pens. Amount of N volatilized was the difference between amount of N excreted and that removed when the pens were cleaned, in runoff, and incorporated into the soil. Phosphorus calculations were the same except the amount of P retained by the animal was calculated by a P retention equation (NRC, 1984) and it was assumed that there was no P volatilization. Organic matter was calculated the same as P and N values, except OM excreted was calculated using the indigestibility of diets (from the digestibility trial) times OM in the feces, as determined by ashing the fecal samples taken from the pens during the feedlot trial.

Results

Steers consuming WCGF had a greater ($P < .04$) intake of nutrients compared with other treatments because a higher percentages of nutrients (N, P, and OM) were supplied by the WCGF diet coupled with a greater ($P < .05$) dry matter intake (Table 1). Subsequently, steers fed the WCGF diet retained the least ($P < .10$) and excreted the most nutrients ($P < .03$) as a percentage of intake. No differences in feed efficiency were observed among treatments.

Table 1. Performance and carcass characteristics of steers for entire feeding period (115 days)

Item	WCGF[a]	7.5% R[a]	All Con[a]
DM intake, lb/day	29.00[b]	26.02[c]	24.77[c]
Daily gain, lb	3.80[b]	3.46[c]	3.31[c]
Feed/gain[d]	7.70	7.41	7.27
Final weight, lb	1206[b]	1164[c]	1146[c]
Fat thickness inches	.51	.47	.47
Quality grade[e]	18.3	18.0	18.3

[a]WCGF = wet corn gluten feed diet; 7.5% R = 7.5% roughage diet;
All Con = all concentrate diet.
[b,c]Means with unlike superscripts within rows differ ($P < .05$).
[d]Feed/gain analyzed as gain/feed. Feed/gain is the reciprocal of gain/feed.
[e]18 = high select.

Tables 2, 3, and 4 show the major components of mass balance of nutrients in the feedlot. The values are expressed in two ways, in pounds of nutrient per head over the entire finishing period (87 days) and percentage of nutrient excretion. Fiber in WCGF increased the amount of fecal N compared to dry rolled corn. Previous research has determined that more post ruminal digestion of NDF occurs when cattle are fed WCGF versus dry rolled corn. Thus, WCGF stimulated hind

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Table 2. Nitrogen mass balance in the feedlot

Criteria[b]	WCGF[a]		7.5% R[a]		All Con[a]	
	lb[c]	%[d]	lb	%	lb	%
Input	45.2[e]	100	39.8[f]	100	36.6[f]	100
Retention	4.0[ef]	8.9[h]	4.1[f]	10.4[i]	3.85[e]	10.6[i]
Excreted	41.2[e]	100	35.7[f]	100	32.8[f]	100
Feces	14.5[e]	38.5[h]	10.2[f]	31.8[i]	7.4[g]	19.1[j]
Urine	23.0[e]	61.5[h]	21.7[e]	68.2[i]	19.9[f]	80.9[j]
Removed	8.5[e]	20.8[h]	5.1[f]	14.5[i]	3.1[g]	9.6[j]
Soil	4.5	11.1[h]	6.7	19.0[i]	5.2	16.1[hi]
Runoff	2.1[e]	5.1[h]	2.4[ef]	7.1[hi]	7.0[f]	21.4[i]
Volatilized	26.0[e]	62.9	21.5[ef]	59.4	17.5[f]	52.9

[a]WCGF = wet corn gluten feed diet; 7.5% R = 7.5% roughage diet; All Con = all concentrate diet.
[b]Retention = retention by the animal; removed = waste material removed from feedlot surface when cleaned; soil = nitrogen in the soil after the pens were cleaned.
[c]Pounds of nitrogen per head over the feeding period (87 days).
[d]Retention is expressed as percentage of nitrogen intake, the remaining values are expressed as percentage of excreted nitrogen.
[e,f,g]Unlike superscripts within a row under the pounds column differ ($P < .10$).
[h,i,j]Unlike superscripts within a row under the percentage column differ ($P < .10$).

Table 3. Phosphorus mass balance in the feedlot

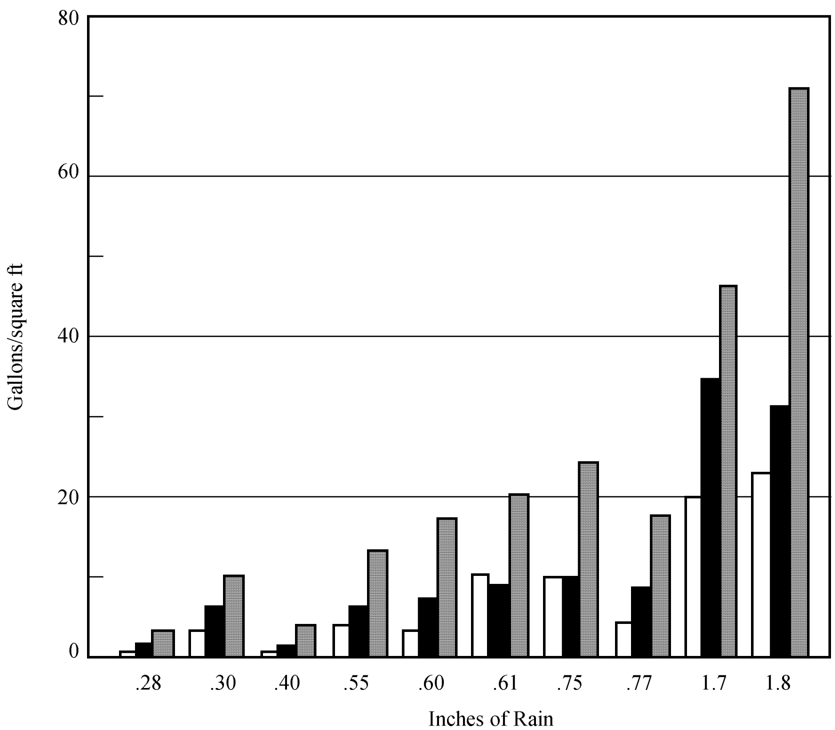
Criteria[b]	WCGF[a]		7.5% R[a]		All Con[a]	
	lb[c]	%[d]	lb	%	lb	%
Input	8.1[e]	100	5.4[f]	100	5.2[f]	100
Retention	.98[e]	12.0[h]	1.00[e]	18.5[i]	.94[f]	18.0[i]
Excreted	7.1[e]	100	4.4[f]	100	4.2[f]	100
Removed	2.8[e]	39.5[h]	1.5[f]	34.1[hi]	1.1[f]	26.2[i]
Soil	4.3[e]	60.5[h]	2.9[f]	65.4[hi]	3.1[f]	73.8[i]
Runoff	.002	.02	.001	.02	.006	.15

[a]WCGF = wet corn gluten feed diet; 7.5% R = 7.5% roughage diet; All Con = all concentrate diet.
[b]Retention = retention by the animal; removed = waste material removed from feedlot surface when cleaned; soil = phosphorus in the soil after pens were cleaned.
[c]Pounds of phosphorus per head over the feeding period (87 days).
[d]Retention values are expressed as a percentage of phosphorus intake, the remaining values are expressed as percentage of excreted phosphorus.
[e,f,g]Unlike superscripts within a row under the pounds column differ ($P < .10$).
[h,i,j]Unlike superscripts within a row under the percentage column differ ($P < .10$).

Table 4. Organic matter mass balance in the feedlot

Criteria[b]	WCGF[a]		7.5% R[a]		All Con[a]	
	lb[c]	%[d]	lb	%	lb	%
Input	2291[e]		2046[f]		1957[f]	
Excreted	597[e]	100	368[f]	100	269[g]	100
Removed	206[e]	34.5[h]	123[f]	33.7[hi]	69.7[g]	26.3[i]
Soil	209	34.8[h]	207	55.4[i]	139	50.8[hi]
Runoff	7.1[e]	2.6[h]	8.4[e]	4.0[h]	19.1[f]	15.6[i]
Volatilized	166.4[e]	28.0[h]	24.4[f]	6.9[i]	17.6[f]	7.3[i]

[a]WCGF = wet corn gluten feed diet; 7.5% R = 7.5% roughage diet; All Con = all concentrate diet.
[b]Removed = waste material removed from feedlot surface when cleaned; soil = organic matter in the soil after pens were cleaned.
[c]Pounds of organic matter per head over the feeding period (87 days).
[d]All values expressed as percentage of excreted organic matter.
[e,f,g]Unlike superscripts within a row under the pounds column differ ($P < .10$).
[h,i,j]Unlike superscripts within a row under the percentage column differ ($P < .10$).



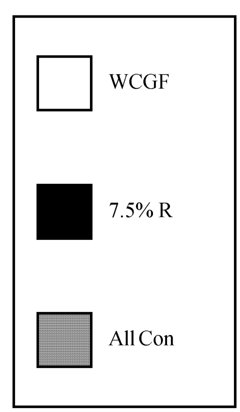


Figure 1. Effect of dietary treatments on quantity of runoff.

gut fermentation and increased the amount of fecal N output compared to the 7.5% R treatment. The WCGF treatment increased ($P < .03$) fecal N and reduced ($P < .10$) urinary N compared to the other treatments.

The quantity of manure removed from the feedlot was greatest ($P < .04$) for the WCGF treatment. The quantity of material removed for WCGF, 7.5% R, and All Con treatments was 2.6, 1.7, and 1.2 tons per pen (DM basis), respectively. The amount of excreted N that was removed from the feedlot surface by cleaning was only 18.8, 12.8, and 8.5% of N intake for WCGF, 7.5% R, and All Con treatments, respectively. It is assumed that nutrients in the soil would eventually be removed as manure in subsequent cleanings.

A significant amount of OM volatilized from pens on the WCGF treatment because that treatment had the greatest percentage of excreted OM. Thus, more OM was exposed to the environment and lost through volatilization. Even though more of the nitrogen excreted by the cattle fed WCGF was in the form of fecal N rather than urinary N, the percentage losses of N were similar among all three treatments (Table 2). Our hypothesis that more N would be retained in the manure from cattle fed the WCGF appears to be incorrect. It was visually observed that pens on the WCGF treatment were

wetter than pens assigned to other dietary treatments. When the pen is wet, microbial activity is stimulated and subsequently volatilization of N as ammonia may be increased. The amount of N (lb/animal) volatilized from pens of cattle fed the WCGF diet was greater ($P < .10$) than that volatilized from the All Con diet because a greater amount of N was excreted. More N was removed from the pens in the manure from the cattle fed WCGF compared to the 7.5% R and All Con diets, also because more N was excreted.

Pens on All Con diets had the greatest quantity ($P < .01$) of runoff (Figure 1) because there was less fecal material in these pens to "trap" rainfall on the surface. The pens on the 7.5% R and WCGF treatments had greater accumulations of fecal material on the feedlot surface, causing some pooling of water. The variation in quantity between runoff events was due to variation in precipitation and the degree of soil saturation. More runoff from the All Con treatment ($P < .01$) resulted in a greater ($P < .10$) percentage of excreted nutrients lost in the runoff. The percentage of excreted N lost in runoff was 5.1, 7.1, and 21.4% for WCGF, 7.5% R, and All Con treatments, respectively. These percentages are in agreement with the 3 to 6% loss of excreted material to runoff reported by previous research. The percentages of excreted P and OM lost in runoff were less than 1%.

The results from this trial indicate that fiber apparently increased the amount of hindgut fermentation, resulting in increased N excretion in feces and less in urine. There were no significant differences among treatments in the percentage of excreted N volatilized, however, there was significantly greater total quantity of N volatilized from the WCGF treatment when compared to the All Con treatment. Shifting N excretion to feces did not reduce the percentage of N lost through volatilization. The goal of the waste management system may dictate what dietary feed sources are best.

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