after harvest had almost as much effect on protein as ammoniation during chopping. *In vitro* digestibility tended to be greater with ammoniation.

In the second trial, very high levels of ammonia, urea or glucose were added. Levels of insoluble protein were much higher in this trial than the other. This reflects the high variability of corn silage. Recovery of nitrogen added as ammonia averaged 82 percent while all of the nitrogen added as urea was recovered. The amounts of insoluble crude protein present increased similarly with addition of both urea and ammonia. Addition of soluble carbohydrate (glucose) had no effect on insoluble protein content. Results suggest that NPN addition to corn silage may increase the content of insoluble, potential bypass protein. Whether this increased insoluble protein does escape ruminal digestion remains to be proven. A number of feeding studies from Michigan with ammoniated corn silage suggest that ammoniated corn silage is used more efficiently by cattle. If increased protein bypass is responsible, ammoniation should prove most useful for starting cattle fed low protein rations.

Roughage Levels in Feedlot Rations

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Story in Brief

Five levels of roughage (8 to 24 percent of ration dry matter) were fed with three corn types (high-moisture, steam-flaked and a mixture of the two) to 240 steers (747 pounds initially) for 121 days. Roughage was one-third ground alfalfa hay and two-thirds corn silage. Feed intake was about 7 percent less and metabolizable energy about 8.7 percent greater with steam-flaked than with high-moisture corn in the ration. Gains and efficiencies of feed use were greatest for steers fed 8-percent roughage with steam-flaked grain, 12-percent roughage with the corn mixture and 16-percent roughage with high-moisture corn grain. Although addition of roughage to the 8-percent roughage ration increased feed intake and replaced corn energy for steers fed high-moisture corn, it actually increased the amount of steam-flaked grain required per pound of gain. The greatest advantage for steam-flaked grain was with the lowest roughage level. Rumination tended to increase with added roughage, but ruminating steers gained weight at a slower rate (3.30 vs. 3.38 pounds daily) than non-ruminating penmates. The optimal level of roughage in a feedlot ration appears to depend on grain processsing.

Introduction

Roughages are included in high-concentrate rations for several reasons. First, dilution of the ration or the rumen contents with roughage helps avoid acidosis and founder. Second, added roughage increases rumination, which may increase digestion in the rumen both by reducing particle size and by increasing saliva flow and ruminal pH. Roughage may also aid ruminal mixing to avoid abnormal or slimy types of fermentation. Certain roughages also contribute protein, minerals and vitamins to the ration.

However, feeding high levels of roughage to feedlot cattle is not always advantageous. High roughage levels will decrease gains and feed efficiency of feedlot cattle by reducing 1) feed and energy intake and/or 2) fiber or starch digestion in the rumen or small intestine. In addition, certain regions of the US have a deficiency of roughage, and roughage is an expensive dietary constituent. Finally, the influence of roughage level on liver abscess incidence and animal behavior is an area needing further investigation. The objective of this experiment was to determine the influence of corn processing and roughage level on performance of growing feedlot steers.

Materials and Methods

Two hundred forty steers with an initial weight of 747 pounds were allocated to 30 pens of eight steers each at Panhandle State University, Goodwell, Oklahoma. One Angus, three black baldy, two Hereford and two exotic cross steers were in each pen. Steers were implanted with Ralgro at the start of the experiment (April, 1980) and again on day 56 of the trial. Two types of processed grain, high-moisture corn (24 percent moisture) or steam-flaked corn (26 lb/bushel), were each fed to 10 pens of steers. A mixture of 50-percent high-moisture and 50-percent steam-flaked grain was fed to another 10 pens of steers. Five levels of roughage were fed—8, 12, 16, 20 and 24 percent of ration dry matter (Table 1). The roughage consisted of 67 percent corn silage and 33 percent tub-ground alfalfa hay. This mixture permitted one supplement to be used across roughage levels with little change in protein, potassium or calcium concentrations. To bring steers on feed, the roughage level was 40 percent for the first 4 days, 30 percent for the next 5 days with further reduction by 4 percent each subsequent 5 days until the final roughage level was reached. All rations contained monensin and tylosin (Table 1). The number of animals ruminating during a 12-hour period was determined on day 118. Steers were fed for 121 days and then trucked to Booker, Texas, for slaughter. Carcass measurements were obtained at slaughter.

Results and Discussion

Daily gains of steers are presented in Tables 2 and 3. Roughage level and grain processing had little effect on live weight gain, but similar to most trials with various roughage levels, less roughage produced slightly higher dressing percentages, which gave the lower roughage level an advantage when gain was calculated from carcass

Table 1. Ration composition

Item		%
Roughage		
Alfalfa hay, tub ground	1/3	8-24
Corn silage	2/3	
Concentrate		
Corn grain		69-85
Soybean meal		2.4
Cottonseed meal		2.6
Urea		.35
Limestone		.80
Dicalcium phosphate		.20
KC1		.15
Dehydrated alfalfa meal		.20
Salt		.30

Trace mineral mix, monensin (30 g/ton), tylosin (9 g/ton), vitamin A. added.

Table 2. Daily gain (final live wt – 4 percent)

	Roughage level (% of DM)					
Corn	8	12	16	20	24	$\bar{x}$
HMC	3.04	3.07	3.20	3.01	3.11	3.09
½ HMC, ½ SF	3.06	3.22	3.05	3.21	3.12	3.13
SF	3.26	3.09	3.07	3.05	3.10	3.11
$\bar{x}$	3.12	3.13	3.10	3.09	3.11	

Table 3. Daily gain (carcass wt/62 percent)

	Roughage level (% of DM)					
Corn	8	12	16	20	24	$\bar{x}$
HMC	3.31	3.45	3.48	3.36	3.34	3.39
½ - ½	3.52	3.57	3.34	3.50	3.49	3.48
SF	3.70	3.35	3.33	3.28	3.49	3.43
	3.51	3.45	3.38	3.38	3.44	

Table 4. Daily feed

	Roughage level (% of DM)					
Corn	8	12	16	20	24	$\bar{x}$
HMC	19.5	20.0	20.3	20.8	21.7	20.5[c]
½ - ½	19.0	20.3	19.5	20.9	19.6	19.8[b]
SF	18.6	18.1	19.1	19.0	20.2	19.0[a]
	19.0[a]	19.5[a]	19.7[ab]	20.2[b]	20.5[b]	

[abc]Means in a row or column with different superscripts differ significantly (P<.05).

Table 5. Daily concentrate intake

	Roughage level (% of DM)					
Corn	8	12	16	20	24	$\bar{x}$
HMC	17.3	17.1	16.7	16.4	16.4	16.8
½ - ½	16.8	17.4	16.1	16.5	14.7	16.3
SF	16.4	15.5	15.8	15.0	15.2	15.6
	16.8	16.7	16.2	16.0	15.4	

weight. The optimal roughage level for rate of gain differed with grain processing. With high-moisture corn, 16 percent roughage produced the greatest gain while with steam-flaked corn, gain was greatest with 8 percent roughage in the ration. Feed and concentrate intakes were about 7 percent less for steam-flaked than high-moisture grain. Since gains were equal, this indicates that the increased energy availability was reducing feed intake.

Feed and concentrate intakes are presented in Tables 4 and 5. Averaged across corn type, for every percentage of the ration in which roughage substituted for grain, feed intake increased by .5 percent. Amounts of feed and concentrate required per pound of gain are presented in Tables 6 and 7. As a higher roughage level was used, feed required per pound of gain increased. Flaking half the grain improved feed efficiency by 5.7 percent, and total flaking improved feed efficiency by 8.2 percent compared with high-moisture grain. Metabolizable energy (ME) provided by the rations, calculated from steer weights and gains, is presented together with standard values from the literature in Table 8. Metabolizable energy was 6.3 percent greater for steam-flaked

Table 6. Feed/gain (based on carcass gain)

Corn	Roughage level (% of DM)					
	8	12	16	20	24	x̄
HMC	5.92	5.80	5.83	6.18	6.52	6.05[b]
½ - ½	5.39	5.69	5.85	5.96	5.60	5.70[a]
SF	5.03	5.41	5.75	5.79	5.78	5.55[a]
	5.47[a]	5.63[ab]	5.81[bc]	5.98[c]	5.97[c]	

[abc]Means in a row or column with different superscripts differ significantly (P<.05).

Table 7. Feed/gain (concentrate portion only)

Corn	Roughage level (% of DM)					
	8	12	16	20	24	x̄
HMC	5.24	4.96	4.85	4.88	4.91	4.96[b]
½ - ½	4.78	4.87	4.82	4.71	4.22	4.68
SF	4.45	4.63	4.74	4.57	4.36	4.55[a]
	4.82	4.82	4.78	4.72	4.50	

[ab]Means in a column with different superscripts differ significantly (P<.05).

Table 8. Metabolizable energy of ration (Kcal/g)

Corn	Roughage level (% of DM)					
	8	12	16	20	24	x̄
HMC	3.28	3.23	3.23	3.09	3.02	3.16[a]
½ - ½	3.36	3.31	3.21	3.20	3.27	3.27[b]
SF	3.57	3.39	3.28	3.27	3.26	3.36[c]
	3.38[a]	3.31[ab]	3.24[bc]	3.19[c]	3.19[c]	
Literature value for rations	3.11	3.08	3.05	3.02	2.99	

[abc]Means in a row or column with different superscripts differ significantly (P<.05).

Table 9. Metabolizable energy advantage of rations above literature values (%)

Corn	Roughage level (% of DM)					
	8	12	16	20	24	x̄
HMC	+ 5.4	+ 4.9	+ 5.9	+ 2.3	+ 1.0	+ 3.6
½ - ½	+ 8.0	+ 7.5	+ 5.2	+ 6.0	+ 9.4	+ 7.2
SF	+14.8	+10.1	+ 7.5	+ 8.3	+ 9.0	+10.2
	+ 8.7	+ 7.5	+ 6.2	+ 5.6	+ 6.7	

than high-moisture rations, so the grain alone had 8.7 percent more metabolizable energy in the flaked than in high-moisture form. Literature values for the ME of the ration were lower than the observed ME in all cases. Added roughage decreased metabolizable energy value of the ration by an average of .35 percent for every 1 percent roughage. Comparisons with specific rations are shown in Table 9. The advantage in ME for steam-flaked grain and the mixture of grains was greatest with 8-percent roughage while with the high-moisture corn, the 16-percent roughage exceeded calculated ME the most. Results again indicate that adding 8-percent roughage to high-moisture corn tends to replace the corn whereas adding a similar amount of roughage to steam-flaked corn is detrimental. This suggests that the associative effect of adding

Table 10. Carcass traits or measurements across roughage levels

Corn	HMC	½ - ½	SF
Carcass wt	719	722	721
Dress, %	61.4	61.8	61.5
Liver abscess incidence, %	7.5	5.2	6.2
Cooler shrink, %	1.6	1.7	1.5
Rib eye area, in.^{2}	12.1	12.4	12.3
Fat thickness, in.	.59	.62	.60
KHP, %	3.14	3.05	3.06
Marbling score[a]	14.1	14.2	14.0
Cutability, %	48.8	48.8	48.9
Dark cutters, %	5.2	5.0	7.5
Fed grade[b]	13.0	13.0	12.9
Choice, %	74.8	74.8	73.8

[a]13 = small minus; 14 = small.
[b]12 = high good; 13 = low choice.

Table 11. Carcass traits and rumination averaged across corn types

Roughage, %	8	12	16	20	24
Carcass weight	723	722	716	721	723
Dress, %	62.0	61.5	61.3	61.4	61.6
Liver abscess, %	6.2	6.2	6.2	8.6	4.2
Cooler shrink, %	1.6	1.6	1.5	1.7	1.5
Rib eye area, in.^{2}	12.5	12.3	12.4	12.1	12.1
Fat thickness, in.	.58	.63	.57	.62	.62
KHP, %	3.03	3.03	3.09	3.17	3.07
Marbling score	13.7	13.8	13.9	14.0	14.8
Cutability, %	49.1	48.7	49.1	48.5	48.6
Dark cutters, %	8.6[a]	8.3[a]	4.1[ab]	8.3[a]	0.0[b]
Federal grade	12.9	12.9	12.9	12.8	13.2
Choice, %	76.8	70.8	77.1	70.5	77.1
Ruminating, %	17	22	37	31	45

[ab]Means in a row with different superscripts differ significantly ($P<.05$).

roughage to grain varies with grain processing, being greater with steam-flaked than with high-moisture grains. Previously, it had been assumed that one would expect adverse effects of roughage with poorly processed grain only. Since roughages differ in their ruminal retention time, digestibility and effect on intestinal transit time, the degree of any associative effect also varies with the type of roughage fed (Teeter *et al.*, 1980).

Grain type and roughage level effects on rumination and carcass composition were small (Tables 10 and 11). The percentage of steers observed ruminating during a 12-hour observation period tended to increase with roughage level in the ration. Incidence of liver abscesses was greatest with 20-percent roughage rather than the lower roughage levels. This suggests that liver abscesses probably reflect feed management, engorgement and acidosis more than ration composition.

Because incidence of ruminantion increased with roughage level in the ration, performance and carcass characteristics of steers ruminating were compared with non-ruminating penmates (Table 12). Despite the trend for increased rumination of cattle fed higher roughage levels, there is no indication that performance or health was superior for ruminating steers. Ruminating steers actually gained weight less rapidly than non-ruminating steers and had a slightly higher incidence of abscessed livers.

Table 12. Comparison of ruminating with non-ruminating penmate steers

Item	Non-ruminating	Ruminating
Daily gain	3.38[a]	3.30[b]
Abscess incidence, %	6.7	7.4
Marbling score	14.3	14.2
Cutability, %	48.7	48.9
Fat thickness	.62[c]	.58[d]
Choice, %	76	76

[ab]Means differ at the 5 percent probability level.
[cd]Means differ at the 10 percent probability level.

Higher roughage rations will simplify management, but, again, the type and form of roughage may be more important than the level of roughage in the ration. Some recent trials with high intakes of high-concentrate rations indicate that no fiber is digested in the rumen. If roughage simply dilutes grain in the rumen to prevent acidosis, the amount of roughage needed depends primarily on the residence time of the roughage. If roughages are fed as a safety factor, price premiums for more digestible forage for feedlot cattle are not justified. Instead, factors influencing ruminal retention time, such as particle size, density and bulk of the roughage, are of major interest.

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Influence of Level of Feed Intake on Digestive Function. I. Nitrogen Metabolism

R. A. Zinn and F. N. Owens

Story in Brief

Four Angus steers (568 pounds) equipped with "T" cannulas in the proximal duodenum and distal ileum were used to study the influence of feed intake level on nitrogen metabolism. Treatments consisted of an 80-percent concentrate diet fed at 1.6, 1.8, 2.0 and 2.2 percent of body weight. Increasing level of intake from 1.6 to 2.2 percent resulted in a 52-percent increase in bypass and a 59-percent increase in metabolizable protein content of feed. There was an apparent curvilinear relationship between level of feed intake and bypass which led to the following conclusions: 1) under the given conditions of this study, the break point at which feed intake is directly related to rumen retention occurs in the neighborhood of 1.8 percent body weight; 2) as feed intake