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Effect of Intake and Roughage Level on Digestion

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Story in Brief

Twenty-four Hereford-Angus steers (800 lb) were fed two roughage levels (10 and 50 percent) at two intake levels (1 and 2 percent of body weight). The diet included whole shelled corn (WSC), forage and 8 percent supplement. As intake increased, the digestibilities of organic matter, starch, fiber and nitrogen all decreased. Additional forage in the diet decreased organic matter digestion but increased digestibility of starch and fiber. Intake and roughage level effects on rumen retention time and ruminal pH may explain these results. Forages which increase retention of grain in the rumen may increase digestion of WSC. The influence of forage level on starch digestion may be less important with processed grains where fermentation is more rapid and starch digestion is higher.

Introduction

The digestibility of rations is depressed as the level of intake increases (Andersen et al., 1959). Reduced digestibilities at higher intakes may be the result of an increased rate of passage through the digestive tract and less time for digestion. Since forages may influence passage rates differently, the effect of increased forage intake may differ with physical and chemical characteristics of the forage. The objective of this research was to examine the influence of level of feed intake on digestibility of mixed diets containing whole shelled corn supplemented with various forage sources at two forage levels. Corn was fed in the whole form to enhance effects of intake and roughage level on digestibility.

Effects may have been different with corn fed in the rolled, ground, high moisture or steam flaked form.

Experimental Procedures

Twenty-four Hereford-Angus steers (800 lb) were fed six roughages including cottonseed hulls (CSH), prairie hay (PH), alfalfa (AH), sorghum plant silage (SS) and two types of corn plant silage (GCS — grain variety; FCS — forage variety). Steers were fed at 1 or 2 percent of body weight with feed presented twice daily. The diet (Table 1) consisted of 10 or 50 percent forage, 8 percent supplement and whole shelled corn (WSC). Supplements were formulated to ensure a minimum crude protein level of 10 percent. Chromic oxide was added to the supplement at .2 percent of ration dry matter as an indigestible marker to calculate digestibility from fecal samples. Animals were housed in individual pens with concrete slatted floors. Steers were fed their respective diets for 21 days. Fecal grab samples were collected at 0600 hr the last 5 days of each period. Fecal samples were analyzed for pH and frozen for future analysis. Feed and fecal samples were analyzed for organic matter, starch, acid detergent fiber (a fiber estimate) and nitrogen. Rumen samples were collected at 1330 hr the last day of each period. Rumen samples were analyzed for pH, ammonia and volatile fatty acid (VFA) content.

Table 1. Diet composition

	Forage level, %	
Feedstuff	10	50
Corn, whole shelled	82	42
Forage from one of six sources	10	50
Supplement	8	8

Results and Discussion

As feed intake increased, digestibility of organic matter, starch, fiber and nitrogen decreased markedly (Table 2). Data with dairy cattle suggests a 50 percent increase in feed intake results in an 11 percent reduction in rumen retention time (Campling et al., 1961). The faster WSC leaves the rumen, the lower the digestibility since little digestion of WSC occurs in the lower gastrointestinal tract. Substitution of roughage for grain in the diet reduced the digestibility of organic matter but increased fiber and starch digestion (Table 3). A reduction in ruminal retention and ruminal digestion of fiber would increase the amount of

Table 2. Effects of intake on digestibility

	Intake level[a], % of body weight		
Item	1	2	% change
Digestibility: (%)			
Organic matter	76.0[b]	69.7[a]	−8.4
Starch	91.3[b]	84.5[a]	−7.5
ADF	43.5	42.0	−3.5
Nitrogen	67.3[b]	60.9[a]	−9.5

[ab]Means in a row with different superscripts differ statistically ($P<.01$).

Table 3. Effect of roughage level on digestibility

	Roughage level, %		
	10	50	Difference
Digestibility: (%)			
Organic matter	74.8[b]	70.8[a]	−5.3
Starch	86.8	89.0	+2.6
ADF	36.6[a]	49.0[b]	+33.9
Nitrogen	64.9	63.2	−2.6

[ab]Means in a row with different superscripts differ statistically ($P<.01$).

material presented to the large intestine and colon for digestion. The small reduction in fiber digestion as intake was doubled in this study would suggest that fiber digestion in the large intestine and colon compensated for any reduction in digestibility in the rumen. Intakes of 1 and 2 percent of body weight approximate 1.2 and 1.9 multiples of maintenance, respectively. For each multiple of maintenance, organic matter digestibility was reduced 8.7 and 6.2 percent for the 10 and 50 percent roughage level diets, respectively. For example, increasing intake from 1X to 2X maintenance requirements would reduce organic matter digestion from 80 to 73 percent. These depressions are more than those suggested from experiments with dairy cows at higher intake levels. Differences may be due to the form of corn being fed. Studies with dairy cows indicate that form of corn definitely influences the degree of depression in digestibility due to feed intake (Moe and Tyrrell, 1977).

The term "associative effect" is used to describe the non-additive response in digestibility when two feedstuffs are fed in combination. Several studies have reported the presence of associative effects between feedstuffs. Increased intake level or accumulation of bulky feeds can increase ruminal passage rates and thus decrease digestion of organic matter in the rumen. Increased passage rate may be responsible for a portion of the associative effect. Passage rate should be greater at higher levels of feed intake and with higher forage diets.

Intake effects on digestibility within roughage levels are shown in Table 4. Since effect of intake level on digestibility was similar at both roughage levels, and effect of roughage level was similar across both intake levels, the overall effects of intake and roughage level on digestibility were calculated (Table 5). Digestion of organic matter was decreased for both increased intake and roughage. Effects of these two factors on starch and fiber digestion differed markedly. Deviation from expected digestion at the high intake and high forage diet can be used to calculate how much of the digestibility response can be explained by intake and roughage level. This interaction is often termed an associative effect. Difference between the observed and predicted digestibility of the high roughage-high intake diet is

Table 4. Roughage-intake level interaction effects on digestibility

Intake, % of BW	Roughage,%	Organic matter	Nutrient Digestibility, %		
			Starch	Fiber	Nitrogen
1	10	78.4	90.3	37.3	68.6
2	10	73.6	83.2	35.9	61.3
1	50	71.3	92.3	49.8	66.0
2	50	68.1	85.7	48.2	60.5

Table 5. Effect of intake and roughage level on digestibility (% change)

	Organic matter	Starch	Fiber	Nitrogen
Intake (% of BW)	−8.4	−7.5	−3.5	−9.5
Roughage level	−5.3	+2.6	+33.9	−2.6
Associative effect, %[a]	+.6	−.2	−.8	+.3

[a]Percentage difference between observed and predicted value for high intake and high roughage level diet.

listed as "associative effect" in Table 5. The size of the associative effects noted, from only .2 to .8 percent, indicates that associative effects beyond those attributable to intake and feed composition differences are small. Many of the associative effects noted with feeds in the past may be attributable to feed intake. Effects of specific roughage sources on organic matter digestibility of the diet are presented in Table 6. As intake increased, digestibility depressions were similar with all roughages tested. The influence of roughage level on digestibility can be attributed primarily to the differences between the digestibility of the specific roughage source and that of the rest of the diet, which is being displaced by added roughage.

Table 6. Influence of roughage source on digestibility

	Depression in organic matter digestibility (%)	
Roughage source	Intake level	Roughage level
CSH	−6.1	−12.9
PH	−7.6	−13.2
AH	−10.1	−2.8
SS	−9.7	−1.1
GCS	−9.5	+6.5
FCS	−7.0	−7.0

Since intake and roughage level influence digestibility of nutrients differently, one can suggest why these effects occur. High levels of intake and of roughage probably increase passage rate and decrease digestion, especially of grain. Because of the lower density and large particle size of forage, retention time would be influenced less. Added forage alone may increase chewing during feed consumption as well as rumination. With equal amounts of chewing and less grain fed in the higher roughage ration, starch digestion might be expected to increase. Another explanation relates to ruminal pH. High levels of grain intake reduce ruminal pH and alter volatile fatty acid concentration (Table 7). Work from USDA has shown fiber digestion and volatile fatty acid production is significantly reduced at ruminal pH values below 6.0. Ruminal ammonia values were highest for the low intake-high roughage diet. This is probably the result of increased protein degradation in the rumen due to greater retention time and higher pH. No relationship between ruminal ammonia levels and digestion was apparent in this study. The high grain diets produced greater concentrations of propionate and lower levels of acetate than the high roughage diets.

Increasing dietary intake had a larger effect on organic matter digestion and acetate and propionate concentrations with the low level than with the high level

Table 7. Roughage intake level interaction effects on ruminal parameters

Intake, % of BW	Roughage	Rumen		Volatile fatty acid			
		pH	NH_3	Total	Acetate	Propionate	Butyrate
1%	10%	6.25	10.1[d]	81.5	63.1[b]	20.3[b]	11.1
2%	10%	6.01	11.0[d]	85.8	57.6[a]	25.6[c]	10.6
1%	50%	6.54	14.0[e]	75.2	67.0[c]	16.6[a]	11.8
2%	50%	6.38	10.9[d]	87.9	66.1[c]	16.6[a]	12.8

[abc] Means in a column with different superscripts differ statistically ($P<.05$).
[de] Means in a column with different superscripts differ statistically ($P<.10$).

of roughage. This suggests finishing diets are more susceptible to intake effects on digestion than higher forage diets, and the depression in digestibility is due to reduced ruminal retention time.

In summary, altered digestibility seen with roughage addition to high concentrate diets can be subdivided into effects of level of feed intake and effects of level of roughage. Both would appear to alter passage rate through the gastrointestinal tract and influence ruminal pH. Passage rate and ruminal pH, in turn, influence the rate and extent of ruminal fermentation. Feeding forage sources which increase ruminal retention time or rate of digestion should maximize digestibility but, through fiber accumulation in the rumen, roughages retained in the rumen may decrease feed intake.

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