same ration which had no abscesses. The final 90 days of the feeding period accounted for the reduced trial gains. During the latter phase, gains were 4.1 and 9.9 percent slower for animals with liver abscess scores of 2 and 3, respectively. These data suggest that the adverse effects of liver abscesses on performance are evident only after 56 days on feed. Possibly animals which consume large amounts of feed and make rapid gains may overeat and be more susceptible to severe liver abscesses. Alternatively, the presence of minor liver damage might stimulate the immune system and increase animal performance.

The most severe abscess score was associated with a reduced dressing percentage (0.7 percentage points) and increased cutability (0.29 percentage points). The lower gains and carcass weights of abscessed cattle may account for the slightly lower dressing percentage, fat thickness and increased cutability.

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Influence of Roughage Level and Feed Intake Level on Digestive Function

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Story in Brief

The effects of roughage level and feed intake on site and extent of digestion were studied with three Angus steers equipped with dual re-entrant cannulas in the small intestine. The three treatments consisted of: 1) low roughage ration (20 percent hay, 80 percent concentrate) fed at 1.5 percent of body weight per steer daily, 2) this low roughage diet fed at 2 percent of body weight and 3) a higher roughage ration (40 percent hay, 60 percent concentrate) fed at 2 percent of body weight. Increasing roughage in the diet increased ruminal digestion and depressed intestinal digestion.

This depression is postulated to be due to the influence of roughage on residence time in the small intestine. Increased feed intake reduced ruminal digestion of organic matter and protein and increased ruminal bypass of dietary protein.

Materials and Methods

Three Angus calves (510 lb) with duodenal and ileal re-entrant intestinal cannulas were used to measure the influence of roughage level and intake on digestive function. Treatments (Table 1) consisted of: 1) a low roughage diet fed at 1.5 percent of body weight, 2) a low roughage diet fed at 2.0 percent of body weight and 3) a high roughage diet fed at 2.0 percent of body weight. Steers were fed at equal intervals twice daily. All estimates of digestion were based on analysis of composites of samples of intestinal or fecal material obtained simultaneously. Chromic oxide was fed as a digesta marker. With these types of cannulas there is no phase separation.

Results and Discussion

The influence of roughage level and intake on ruminal, small intestinal and cecal and large intestinal digestion is shown in Tables 2 through 5. Digestibility of concentrate and prairie hay would be expected to be about 85 percent and 50 percent, respectively, so digestibility for the high and low roughage diets would be 71 and 78

Table 1. Ration composition.

	Low roughage	High roughage
Prairie hay	20.00	40.00
Rolled corn	64.63	43.39
SBM	11.33	13.30
Molasses	2.00	1.50
TM Salt	0.30	0.30
$CaCO_3$	0.94	0.57
Di Cal	—	0.24
KC1	0.50	0.40
Cr_2O_3	.30	.30

Rations formulated to contain: CP, 13%; Ca, .45%; P, .35%.

Table 2. Influence of roughage level and level of intake on total apparent digestibility.

	Treatments			
	Low roughage (1.5% BWT)	Low roughage (2.0% BWT)	High roughage (2.0% BWT)	C.V. (%)
Organic matter	80.8	77.7	71.0	2.6
Starch	99.2	97.2	98.1	0.2
ADF	53.5	43.1	52.6	12.2
Nitrogen	68.9	64.9	62.2	4.2

Table 3. Influence of roughage level and level of intake on ruminal digestion.

	Treatments			
	Low roughage (1.5% BWT)	Low roughage (2.0% BWT)	High roughage (2.0% BWT)	C.V. (%)
Intake, g/day				
Organic matter	2846.8	4369.3	3852.9	
Starch	1534.9	2356.1	1559.5	
Nitrogen	63.9	98.1	77.8	
Acid detergent fiber	417.8	641.0	990.2	
Leaving abomasum, g/day				
Chyme[a]	28.7	46.5	41.7	15.2
Chyme pH	2.64	2.64	2.52	3.9
Organic matter	1497	2676	2211	7.8
Starch	338	956	443	27.2
Acid detergent fiber	254	395	549	14.9
Microbial nitrogen	27.8	41.8	43.5	11.2
Non-ammonia nitrogen	55.0	102.3	93.9	9.9
Rumen digestion, %				
Organic matter	56.8	48.5	53.7	5.9
Starch	78.5	60.4	71.2	12.5
Acid detergent fiber	39.8	37.6	45.1	4.4
Rumen digestion, % of total				
Organic matter	70.1	62.8	75.6	2.9
Starch	79.1	62.3	72.6	12.1
Acid detergent fiber	73.8	94.2	85.9	19.9
Microbial efficiency				
g MP/100g OMF[b]	8.9	10.0	10.5	15.0
g MP/100g DOMI[c]	6.1	6.2	8.0	13.1

[a]1/d.
[d]g microbial protein per 100g organic matter fermented in rumen.
[c]g microbial protein per 100g digestible organic matter intake.

Table 4. Influence of roughage level and level of intake on small intestinal digestion.

	Treatments			
	Low roughage (1.5% BWT)	Low roughage (2.0% BWT)	High roughage (2.0% BWT)	C.V. (%)
Leaving ileum, g/day				
Chyme[a]	9.5	13.5	18.6	2.6
Chyme pH	7.06	7.19	7.70	1.9
Organic matter	715.0	1132.0	1280.0	6.8
Starch	40.2	129.6	81.9	34.4
Acid detergent fiber	233.6	375.7	548.5	18.5
Non-ammonia nitrogen	21.2	30.4	30.5	7.9
Small intestinal digestion, %				
Organic matter	52.0	56.7	41.7	14.5
Starch	87.7	84.3	72.3	14.3
Non-ammonia nitrogen	61.6	69.3	68.0	2.0
Small intestinal digestion, % of total				
Organic matter	34.8	44.5	33.6	24.4
Starch	19.0	34.9	23.5	24.8

[a] 1/d.

Table 5. Influence of roughage level and level of intake on cecal and large intestinal digestion.

	Treatments			
	Low roughage (1.5% BWT)	Low roughage (2.0% BWT)	High roughage (2.0% BWT)	C.V. (%)
Excreted, g/day				
Feces	2924.7	5300.8	6199.3	10.0
Fecal pH	6.32	5.75	6.57	1.4
Organic matter	543.9	956.8	1117.0	12.3
Starch	10.6	63.0	27.7	7.0
Acid detergent fiber	193.7	355.8	472.3	18.1
Microbial N	8.7	14.6	12.7	8.6
Non-ammonia nitrogen	19.8	33.9	29.4	8.3
Cecal and large intestinal digestion, %				
Organic matter	23.8	15.1	12.5	69.0
Starch	70.8	50.8	56.7	32.1
Acid detergent fiber	16.0	5.3	13.8	145
Cecal and large intestinal digestion, % of total				
Organic matter	7.2	4.8	6.4	69.0
Starch	1.9	2.8	3.9	84.0
Acid detergent fiber	16.2	6.5	14.6	306

percent, respectively. These values were precisely what was observed. This suggests that added roughage did not reduce digestibility of the concentrate. Despite no adverse "associative effect" on total digestion, site of digestion was shifted by added roughage. This was similar to the results from the buffer study reported elsewhere in this publication. Increasing roughage level from 20 to 40 percent of the diet increased the percent organic matter and starch digested in the rumen but decreased that digested in the small intestine. The positive effect of added roughage on rumen fermentation was similar to that of added buffers. This might be expected from the slower rate of feed consumption and increased rumination which would increase the chance for secretion of saliva and buffering of rumen contents. However, the negative effect which roughage had on small intestinal digestion is less appreciated. In this experiment, the increase is undigestible bulk presented to the small intestine increased flow rate by 38 percent. Particles spent an average of 4.5 hours in the small intestine of steers fed the low roughage diets, compared with 3.16 hours for the higher roughage diet. These retention times contrast with digesta retention times more than 24 hours in the rumen and over 18 hours in the cecum and large intestine. Time for digestion in the small intestine may be a major limitation to starch digestion and absorption.

A 33 percent increase in level of feed intake led to a general decrease in ruminal organic matter digestion with a resultant increase in ruminal bypass of dietary protein. The depressing effect of increased feed intake on overall nutrient digestibility is generally understood. However, the influence of intake level on sites of digestion, particularly for starch and protein, has received little attention. The increase (21 percent) in protein escaping degradation in the rumen as a result of increasing level of intake is very large. This point is often overlooked in research on "high bypass" protein feeds. Ruminal destruction of feed proteins may be much lower in practice than would be anticipated from research trials in which feed is often provided at low levels of intake. Synthesis of microbial protein (microbial protein per unit organic matter intake) is decreased at higher levels of feed intake since ruminal organic matter fermentation is depressed. This means that the protein reaching the small intestine contains less bacterial protein. However, this decrease is partially compensated by an increase in microbial efficiency (more protein synthesized per unit organic matter fermented).