

# Corn Processing and Alfalfa Level Effect on Digestibility

S.R. Rust, F.N. Owens  
and D.R. Gill

## Story in Brief

The influence of alfalfa level (0 to 92 percent) on nutrient digestibility of rations containing whole shelled corn or steam flaked corn was tested with 16 growing beef steers. Steers were fed *ad libitum*, and all rations contained more than 13 percent crude protein. Increasing the alfalfa level in the diet decreased organic matter intakes and digestibility, increased ruminal ammonia (up to 40 percent alfalfa), increased ruminal and fecal pH and decreased fecal starch. Starch from steam flaked corn was 6.2 percentage units more digestible than the starch from whole shelled corn. Studies with other types of roughages (silage, cottonseed hulls, etc.) indicate that starch digestion in the small intestine is depressed with added roughage. At intakes achieved in this study (2 percent of body weight), digestion in the cecum compensated so the starch digestibility was not depressed.

## Introduction

Starch is the main chemical component of high concentrate-finishing diets for feedlot steers. Therefore starch digestion is of considerable economic interest. The site as well as the extent of starch digestion can be influenced by grain processing, residence time in the rumen, roughage level, feed intake, protein level, salivary input and other factors. This study was conducted to measure digestibility of steam flaked and whole shelled corn rations with different levels of added chopped alfalfa.

## Materials and Methods

Sixteen steers (869 lb) were fed whole shelled or steam flaked corn rations with different levels of alfalfa (5, 15 and 40 percent). Steers were housed in individual pens and fed *ad libitum* with fresh feed added once daily. Feed refusals were visually observed for sorting and recorded daily. The diet (Table 1) was formulated to contain at least 13 percent crude protein. Chemical analysis of the ration components is provided in Table 2. The supplement was fed at 7.8 percent of the diet. The supplement (Table 3) was formulated to contain adequate concentrations of vitamins and minerals. Chromic oxide was added to the supplement such that the total diet contained .2 percent. This indigestible marker was used to determine nutrient digestibility. Fecal samples were gathered at 0600 hrs for 3 to 5 days after a 9- day adjustment period. Rumen samples were collected the final day of each period via stomach tube.

## Results and Discussion

As the roughage content of the diet increased, organic matter intake and digestibility decreased (Table 4). However, the digestibilities of starch and nitrogen were not altered. Added fiber in the ration can account for the reduced organic matter digestion. Other studies in this report suggest that roughage substitution for concentrate shifts the

site of starch digestion from the small intestine to the rumen and also reduces digestion in the small intestine. Remaining starch can be partially digested in the cecum and large intestine. At the feed intake of steers in this study (about 8 kg or 2 percent of body weight), digestion in the large intestine apparently compensated so that total starch digestion was unaltered. At higher intakes, the digestive capacity of the lower gut might

**Table 1. Ration ingredients.**

Roughage level	WSC <sup>a</sup>					SFC <sup>a</sup>		
	0	5	15	40	92	5	15	40
Corn <sup>b</sup>	92.16	87.16	77.16	52.16	0	87.16	77.16	52.16
Alfalfa	0	5.00	15.00	40.00	92.16	5.00	15.00	40.00
Supplement	7.84	7.84	7.84	7.84	7.84	7.84	7.84	7.84

<sup>a</sup>WSC = whole shelled corn; SFC = steam flaked corn.

<sup>b</sup>Ingredients expressed as a percentage of "as fed" ration.

**Table 2. Analysis of ration components.**

	SFC <sup>a</sup>	WSC <sup>a</sup>	Alfalfa
Dry matter, %	80.83	84.47	89.38
Crude protein <sup>b</sup>	9.76	9.72	18.73
Ash content <sup>b</sup>	1.38	1.47	8.93
Starch content <sup>b</sup>	64.58	64.97	5.43

<sup>a</sup>WSC = whole shelled corn; SFC = steam flaked corn.

<sup>b</sup>Percentage of dry matter.

**Table 3. Supplement composition.**

Ingredient	%
Ground corn	17.4
Alfalfa dehy	4.9
Soybean meal	39.3
Cane molasses	3.0
Dicalcium phosphate	2.6
Calcium carbonate	10.9
Potassium chloride	1.5
Salt	.2
Urea	8.8
Sodium sulfate	1.8
Chromic oxide	2.5
Trace mineral mix	.2
Vitamin A	+
Vitamin D	+

<sup>a</sup>Dry matter basis.

be exceeded, causing a depression in starch digestion. Older animals may have less ability to handle starch as well.

Digestibilities of the mixed rations may be compared with digestibility of alfalfa hay alone or the higher concentrate ration to see if associative effects were present. Organic matter digestibility was reduced by 3, 4 and 6 percent at 5, 15 and 40 percent alfalfa levels, respectively. This slight drop in digestibility can be costly to feed efficiency and cattle feeding profits. Therefore, alfalfa level in rations should probably be either high or low to maximize digestibility. Ruminal ammonia concentration was highest at the 40 percent level of alfalfa (Table 5). Ruminal and fecal pH decreased as level of roughage increased. Fecal starch percentage was directly related to the proportion of corn in the diet.

**Table 4. Roughage effects on digestibility of whole shelled corn diets.**

Roughage level					
Intake (kg/day)					
Dry matter	7.19	7.51	7.58	6.51	5.75
Organic matter	6.94 <sup>ab</sup>	7.22 <sup>a</sup>	7.23 <sup>a</sup>	6.08 <sup>bc</sup>	5.19 <sup>c</sup>
Digestible dry matter	5.78 <sup>ab</sup>	5.79 <sup>a</sup>	5.67 <sup>ab</sup>	4.49 <sup>bc</sup>	3.60 <sup>bc</sup>
Digestible organic matter	5.64 <sup>ab</sup>	5.66 <sup>a</sup>	5.49 <sup>a</sup>	4.33 <sup>bc</sup>	3.41 <sup>bc</sup>
Digestibility (%)					
Dry matter	80.8 <sup>d</sup>	77.3 <sup>d</sup>	74.9 <sup>de</sup>	68.8 <sup>ef</sup>	62.9 <sup>f</sup>
Organic matter	81.7 <sup>d</sup>	78.7 <sup>de</sup>	76.2 <sup>de</sup>	71.0 <sup>ef</sup>	65.8 <sup>f</sup>
Starch	91.1	91.9	89.4	91.9	89.5
Nitrogen	71.6	68.9	71.7	70.0	72.9
Ash	56.0	43.8	48.1	36.6	35.8

<sup>abc</sup>Means in a row with different superscripts differ statistically ( $P < .01$ ).

<sup>def</sup>Means in a row with different superscripts differ statistically ( $P < .05$ ).

<sup>gh</sup>Means in a row with different superscripts differ statistically ( $P < .005$ ).

**Table 5. Roughage effects on ruminal and fecal parameters.**

Roughage level	0	5	15	40	92
Rumen characteristics					
Ammonia (mg/dl)	12.9 <sup>d</sup>	15.4 <sup>d</sup>	20.5 <sup>de</sup>	31.0 <sup>e</sup>	13.5 <sup>d</sup>
pH	5.6 <sup>a</sup>	5.8 <sup>a</sup>	5.9 <sup>ab</sup>	6.3 <sup>b</sup>	7.1 <sup>c</sup>
Fecal dry matter (%)	29.4 <sup>a</sup>	27.4 <sup>ab</sup>	25.6 <sup>b</sup>	21.3 <sup>c</sup>	19.5 <sup>c</sup>
Fecal characteristics (% of dry matter)					
Organic matter	91.9 <sup>a</sup>	90.2 <sup>a</sup>	90.0 <sup>a</sup>	86.8 <sup>b</sup>	83.3 <sup>c</sup>
Starch	26.9 <sup>a</sup>	20.3 <sup>a</sup>	21.2 <sup>a</sup>	10.1 <sup>b</sup>	1.7 <sup>c</sup>
Nitrogen	3.09 <sup>d</sup>	2.99 <sup>d</sup>	2.64 <sup>de</sup>	2.58 <sup>e</sup>	2.33 <sup>e</sup>
pH	5.9 <sup>a</sup>	6.1 <sup>a</sup>	6.2 <sup>a</sup>	6.7 <sup>b</sup>	7.4 <sup>c</sup>

<sup>abc</sup>Means in a row with different superscripts differ statistically ( $P < .01$ ).

<sup>def</sup>Means in a row with different superscripts differ statistically ( $P < .05$ ).

**Table 6. Corn processing effects on digestibility.**

	WSC <sup>a</sup>	SFC <sup>a</sup>
Intake (kg/day)		
Dry matter	7.17	7.23
Organic matter	6.81	6.88
Digestible dry matter	5.28	5.53
Digestible organic matter	5.13	5.39
Digestibility (%)		
Dry matter	73.7 <sup>d</sup>	76.5 <sup>e</sup>
Organic matter	75.3 <sup>d</sup>	78.4 <sup>e</sup>
Starch	91.1 <sup>b</sup>	97.3 <sup>c</sup>
Nitrogen	70.6	68.8
Ash	42.8	39.0

<sup>a</sup>WSC = whole shelled corn; SFC = steam flaked corn.

<sup>b,c</sup>Means in a row with different superscripts differ statistically ( $P < .01$ ).

<sup>d,e</sup>Means in a row with different superscripts differ statistically ( $P < .05$ ).

**Table 7. Corn processing effects on ruminal and fecal parameters.**

	WSC <sup>a</sup>	SFC <sup>a</sup>
Ruminal characteristics		
Ammonia (mg/dl)	20.5 <sup>b</sup>	10.3 <sup>c</sup>
pH	6.0	6.0
Fecal dry matter (%)	24.9 <sup>b</sup>	21.8 <sup>c</sup>
Fecal characteristics		
(% of dry matter)		
Organic matter	88.9	87.3
Starch	17.4 <sup>b</sup>	5.2 <sup>c</sup>
Nitrogen	2.70 <sup>b</sup>	3.22 <sup>c</sup>
pH	6.4	6.2

<sup>a</sup>WSC = whole shelled corn; SFC = steam flaked corn.

<sup>b,c</sup>Means in a row with different superscripts differ statistically ( $P < .01$ ).

Steam flaked corn had a higher digestion coefficient for organic matter and starch than whole shelled corn. Increased digestibility of steam flaked corn reduced fecal starch concentration. Ruminal ammonia concentrations were lower with the steam flaked corn. This may reflect greater use of ammonia for microbial protein synthesis with steam flaked corn as the amount of carbohydrate digested in the rumen should be greater.

The roughage effects on intake, digestibility and ruminal and fecal parameters within each corn processing type are presented in Tables 8 and 9. Similar trends were noted with increasing roughage levels with both corn types for all parameters monitored except fecal starch. Fecal starch declined as roughage increased with whole shelled corn; however, roughage had no effect on fecal starch with steam flaked corn. Failure of added roughage to depress starch digestion was surprising; corn silage levels

**Table 8. Roughage effects on digestibility of whole shelled corn and steam flaked corn diets.**

Roughage level	WSC <sup>a</sup>			SFC <sup>a</sup>		
	5	15	40	5	15	40
Intake (kg/day)						
Dry matter	7.42	7.58	6.51	7.21	7.45	7.03
Organic matter	7.13	7.23	6.08	6.95	7.11	6.58
Digestible dry matter	5.74	5.68	4.48	5.88	5.73	4.98
Digestible organic matter	5.62	5.51	4.32	5.78	5.59	4.81
Digestibility (%)						
Dry matter	77.4	74.9	68.8	81.6	77.0	70.9
Organic matter	78.8	76.2	71.0	83.2	78.7	73.2
Starch	91.8	89.4	91.9	98.5	97.4	96.1
Nitrogen	70.2	71.7	70.0	69.4	69.2	67.7
Ash	43.6	48.1	36.6	39.4	40.4	37.0

<sup>a</sup>WSC = whole shelled corn; SFC = steam flaked corn.

**Table 9. Roughage effects on ruminal and fecal parameters with whole shelled corn and steam flaked corn.**

Roughage level	WSC <sup>a</sup>			SFC <sup>a</sup>		
	5	15	40	5	15	40
Ruminal characteristics						
Ammonia (mg/dl)	10.1	20.5	31.0	6.3	6.8	17.9
pH	5.8	5.9	6.3	5.8	5.8	6.3
Fecal dry matter (%)	27.7	25.6	21.3	24.0	22.1	19.2
Fecal characteristics (% dry matter)						
Organic matter	89.9	90.0	86.8	87.6	88.1	86.1
Starch	21.0 <sup>b</sup>	21.2 <sup>b</sup>	10.1 <sup>c</sup>	5.0 <sup>d</sup>	5.6 <sup>d</sup>	4.8 <sup>d</sup>
Nitrogen	2.87	2.64	2.58	3.59	3.08	3.00
pH	6.2	6.2	6.7	5.9	6.0	6.6

<sup>a</sup>WSC = whole shelled corn; SFC = steam flaked corn.

<sup>bcd</sup>Means in a row with different superscripts differ statistically (P = .06).

above 5 percent depress gain and feed efficiency of feedlot steers fed whole corn grain. Perhaps digestibility of starch may vary with roughage type and animal age as well as roughage level. Alternatively, feedlot performance does not always parallel digestibility. How site of digestion influences metabolizable energy value of a feed for growing and finishing steers needs closer examination.