CORN GRAIN PROCESSING AND SITE OF DIGESTION BY HEIFERS

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Story in Brief

Whole shelled (WSC), rolled (RC) and steam flaked (SFC) corn based diets were fed to heifers and site of digestion was measured. Total tract digestibilities of dry matter, organic matter and starch were highest with SFC. However, organic matter digestibility in the rumen, adjusted for microbial organic matter, was not markedly different among treatments (65, 69 and 70 percent for WSC, RC and SFC). Efficiency of microbial protein synthesis was highest for WSC which may reflect more rapid turnover of ruminal liquids. Digestibility of starch in the rumen, small intestine and large intestine all increased with processing of grain when expressed as a percentage of starch entering each segment. This supports the concept that particle size or surface exposure limits ruminal and intestinal digestion of starch. Total starch digestion, expressed as amount or percent of dietary starch digested in the total tract, tended to be greater in the small and large intestine with WSC than with SFC.

Introduction

Grains are processed to improve feed efficiency. Processing often increases digestibility of grains but may depress digestibility of roughages. Processing usually reduces particle size of grains, and particle size often limits the extent of digestion by ruminant animals. Processing may alter the site of digestion of feedstuffs. Some forms of processing may not be economical in the future as the price of energy increases. Since large quantities of processed and unprocessed grains are fed in commercial feedlots, a fuller understanding of grain processing, particle size and animal digestion is needed.

This study was conducted to examine the effect of processing on nutrient digestion of whole shelled, rolled and steam flaked corn.

Materials and Methods

One batch of dent yellow corn was obtained from Ark Valley Feeders, Arkansas, OK in the SFC or WSC form. Part of the WSC was rolled prior to feeding to form the RC treatment. All corn was stored frozen prior to feeding. Diets used were 90 percent corn, 4.9 percent cottonseed hulls and 5.1 percent supplement. Chromic oxide was included as an indigestible marker. Heifers were fed diets at 1.7 percent of body weight (dry matter) twice daily at 0800 and 2000 hr. Ruminal, duodenal, ileal and fecal samples were collected in the morning and afternoon of each sampling day.

Results and Discussion

Total digestibility of organic matter (OM) was highest for SFC and lowest for WSC (Table 1). Ruminal OM digestion tended to be greater for

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Table 1. Effect of processing on organic matter digestion and passage.

Item	Processing method		
	WSC	RC	SFC
OM Intake, lb.	9.4	6.8	6.4
Duodenal OM, lb.	3.4	3.0	2.8
Microbial OM, lb.	1.05	.88	.86
Ileal OM, lb.	1.4	1.4	1.2
Fecal OM, lb.	1.4	1.0	.8
Digestibility[c]			
Rumen	49.4	56.0	56.0
Rumen, adjusted	64.9	69.1	69.8
Small intestine	58.0	55.2	58.1
Large intestine	3.3	22.8	30.8
Total tract	79.5[b]	85.6[ab]	87.4[a]
Microbial efficiency	17.1[a]	13.4[b]	14.2[ab]

[ab]Means in a row with different superscript differ (P<.05).
[c]Percent of OM entering each gut segment.

SFC and RC than for WSC heifers. More extensive grain processing will rupture the kernel and provide more surface area for digestion by microbes and digestive enzymes. The small difference in ruminal OM digestion between RC and SFC treatments may have been due to the moderate intake level. Duodenal passage of microbial OM tended to be greatest for WSC (Table 1). This may reflect faster fluid passage rate and(or) greater microbial cell association with particulates with this diet.

Starch digestibilities in the rumen and small and large intestines (Table 2) were highest for SFC, intermediate for RC and lowest for WSC. This contrasts with the common belief that digestion in the small intestine will increase to compensate for reduced digestion in the

Table 2. Effect of processing on starch digestion and passage.

Item	Processing method		
	WSC	RC	SFC
Starch intake, lb	4.9	4.9	4.5
Duodenal starch, lb	1.2	1.1	.8
Ileal starch, lb	.4	.4	.1
Fecal starch, lb	.3	.2	.03
Digestibility[c]			
Rumen	74.6	77.6	82.3
Small intestine	66.8[c](17.0)[d]	70.7 (15.8)	88.0 (15.6)
Large intestine	32.6 (2.8)	39.2 (2.6)	61.2 (1.3)
Total tract	94.5[b]	96.4[ab]	99.3[a]

[ab]Means in a row with different superscript differ (P<.05).
[c]Percent of starch entering each gut segment.

rumen. Some intestinal compensation may occur when ruminal digestion is depressed by high levels of feed intake. But results of this study indicate that particle size may limit both ruminal and intestinal digestion. This is not surprising, since whole grains which escape ruminal digestion usually pass through the intestinal tract unscathed. Results indicate that physical alternation of the whole corn grain, beyond normal mastication, with a high concentrate diet is needed to maximize starch digestion.

Ruminal bypass of nitrogen (N) did not greatly vary (Table 3). Total N digestion was slightly lower for WSC than for other treatments. Greater hindgut starch fermentation with WSC heifers (Table 2) may have elevated fecal N loss via microbial cell passage in feces. In partial support of this concept, ruminal ammonia-N concentration was lower for WSC (4.7 mg/dl) than for RC and SFC animals (7.0 mg/dl). Ruminal acid detergent fiber (ADF) digestion tended to be greatest for WSC. Suspected lower pH with SFC, due to shorter digestion lag time and faster rate of digestion of starch containing material increasing microbial acid production, may be involved. Also, greater competition between microbial fermentation of starch and fiber may be present with SFC because of faster initiation of starch fermentation. With WSC, greater necessitation of fiber digestion to facilitate access to starch containing matter, especially hemicellulose contained in the seed kernel, could have existed. Changes in OM digestibility with processing may be used to calculate the relative value of these processing methods. Considering the corn grain alone, rolling and flaking increased OM digestibilities by 8.6 and 11 percent. These compare with increased value of corn for feedlot cattle as summarized from feeding trial results (Hale, 1980) of 10.9 percent for SFC above WSC or RC. Ionophores were not fed in this experiment. Previous studies indicate that organic matter digestion of whole shelled corn is increased by 2 to 5 percent with added ionophores while changes are expected to be smaller or absent with processed corn. With ionophores, benefits of these processing methods may be reduced to 5.3 and 7.5 percent. In addition to processing cost, factors which must be considered when comparing processing methods include roughage availability, animal health and management, bunk life of diet and diet handling and mixing capacity (Thornton et al, 1978; Ferrell et al, 1981).

Table 3. Effect of processing on nitrogen and ADF digestion.

Item	Processing Method		
	WSC	RC	SFC
Nitrogen			
Ruminal bypass of feed N, %	49.5	47.2	51.6
Total N dig., %	69.4	70.9	75.2
ADF digestibility, %[a]			
Rumen	50.4	46.5	31.1
Small intestine	10.2	11.6	10.7
Large intestine	1.0	7.7	19.0
Total tract	58.0	58.9	53.4

[a]Percent of ADF entering each gut segment.

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