INFLUENCE OF COTTONSEED HULLS OR WHOLE SHELLED CORN ON SITE OF DIGESTION OF ROLLED MILO

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Story In Brief

Three cannulated steers were fed rolled milo diets with either 7 percent cottonseed hulls (7H) or 14 or 21 percent whole shelled corn (14WSC and 21WSC) at 60 g/kg metabolic body weight (dry matter basis). Ruminal, duodenal and fecal pH were not markedly affected by diet. However, ruminal pH at 2 and 10 hr after feeding tended to be greater for 21WSC than for 7H. Ruminal fluid dilution rates and volumes were similar. At 2 hr after feeding, ruminal fluid buffering capacity from pH 7 to 5.5 was generally highest (P>.05) with the 7H diet. But, at 6 and 10 hours after feeding, treatments ranked from greatest to least, 21WSC, 7H and 14WSC. Ruminal organic matter digestion, microbial efficiency and microbial nitrogen flow to the duodenum tended to increase as other feeds were substituted for rolled milo. These results would indicate that corn grain in the whole shelled form has a "roughage value". In terms of ruminal pH and buffering capacity and ruminal fluid volume and dilution rate, whole corn appeared to have about one third the value of cottonseed hulls for these specific experimental conditions. This effect may be due to effects on salivary flow, ruminal mixing and/or rumination.

Introduction

Increasing production costs for irrigation of corn in the Western United States may force a shift towards substitution of sorghum grain (milo). The high costs for processing and the variability in quality of some processed forms of milo for beef cattle feeding has stirred interest in alternative processing methods.

Whole corn finishing diets are sometimes fed to cattle with no added roughage. In contrast, roughage is seldom omitted from processed corn diets due to digestive disorders. This would suggest that whole corn may possess certain factors intrinsic to roughage.

Mixtures of processed and whole shelled corn have been fed with varied responses. In most trials, roughages have been included. Relying solely on whole corn as a roughage would eliminate the high cost and handling of bulky roughages, increase energy density and prevent feed separation with bunk feeding in windy conditions. Whole corn could slow particulate flow from the rumen and increase the extent of ruminal digestion. Reduced flow of indigestible bulk through the intestines could decrease gut peristalsis, decrease intestinal passage rate and increase postruminal digestion. The objectives of this study were to study differences in site of digestion in steers fed rolled milo diets when either 7 percent cottonseed hulls or 14 or 21 percent whole shelled corn were added.

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Experimental Procedure

Three steers (1063 lb) fitted with duodenal cannulas were used in a 3 x 3 Latin square experiment. Diets were fed at 60 g dry matter (DM) per kg metabolic body weight. Substitutions for rolled milo were 7 percent cottonseed hulls (7H) or 14 or 21 percent whole shelled corn (14WSC and 21WSC). Diets were formulated to be isonitrogenous and similar in calcium and phosphorus concentrations. Chromic oxide was included as an indigestible marker. Periods lasted 10 days with sampling on the last two days of each period. Steers were fed at 12 hr intervals. A ruminal fluid marker (CoEDTA) was used for fluid dilution rate determination. Ruminal, duodenal and rectal samples were obtained at 2, 6, and 10 hr after feeding on both sampling days. The pH of samples was measured immediately and buffering capacity measured within one hr after sampling of ruminal fluid on day 9. Dried and ground feed, duodenal and fecal samples were subjected to all or part of the following analyses: DM, ash, kjeldahl nitrogen (N), starch, nucleic acid-N, ammonia-N and chromium. Fluid marker concentration in ruminal fluid also was measured.

Results and Discussion

Ruminal pH was higher than expected with these high concentrate levels (Table 1), probably because of the low feed intake level. At 2 and 10 hr postfeeding, pH with the 21WSC diet was higher than the 7H diet while values for the 14WSC were the lowest. Ruminal pH at 6 hr after feeding was slightly greater ($P>.05$) for 7H than for other treatments. Neither duodenal nor fecal pH differed. Ruminal fluid volume and dilution rate (Table 1) were similar. Fluid dilution rate was considerably lower than other reports with similar rolled milo diets (Goetsch et al., 1984). In that trial, a dietary buffer was fed and smaller animals and higher feed intakes were used.

At 2 hr after feeding, ruminal buffering capacity from pH 7.0 to 5.5 was generally highest for 7H, lowest for 14WSC and intermediate for 21WSC steers (Figure 1). Salivary buffers should have greatest influence in this pH range. However, at 6 and 10 hr after feeding, resistance to pH change from greatest to least was 21WSC, 7H and 14WSC (Figures 2 and 3; $P>.05$). Between pH 4.5 and 6.0, buffering capacity was consistently higher for the 21WSC diet. A number of factors may be responsible for buffering capacity differences. Intake of indigestible bulk and highly structured roughage was greatest with the 7H diet.

Table 1. Digestive tract measurements.

Item	Time after feeding	Treatment 7H	14WSC	21WSC
Ruminal pH	2 hr	6.14	6.05	6.16
	6 hr	6.22	6.17	6.17
	10 hr	6.36	6.25	6.45
Duodenal pH	Mean	2.31	1.94	2.56
Fecal pH	Mean	5.80	5.70	5.79
Ruminal fluid dilution rate, %/hr		3.2	3.2	3.3
volume, liters		89.9	88.0	86.3

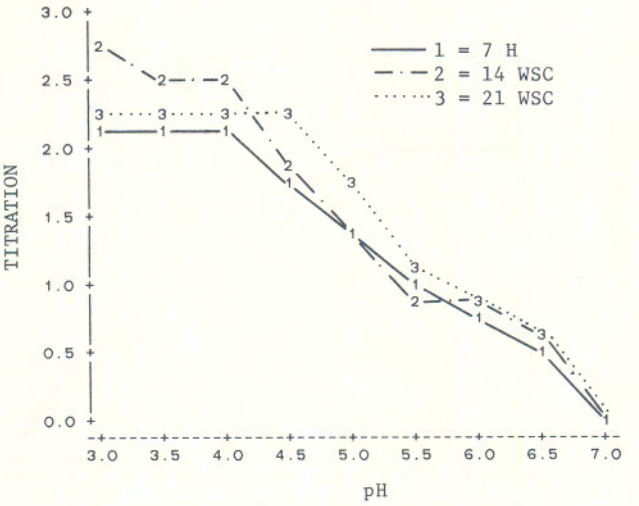

Figure 1. Buffering capacity at 2 hr postfeeding.

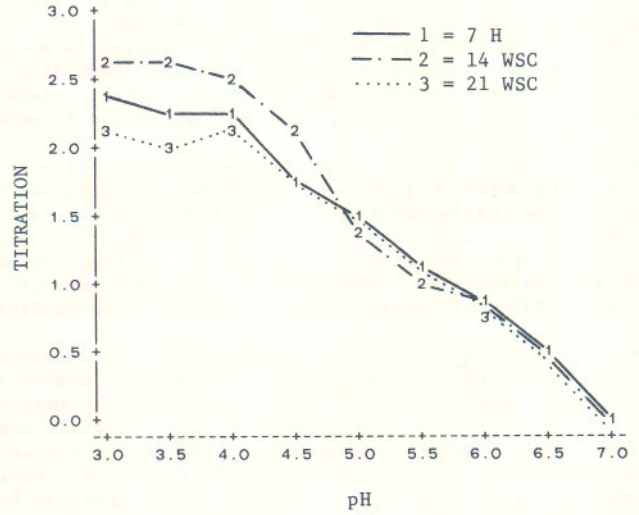

Figure 2. Buffering capacity at 6 hr postfeeding.

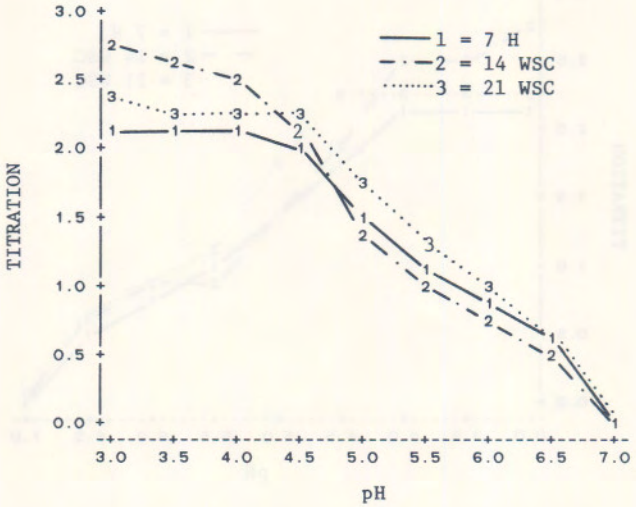

Figure 3. Buffering capacity at 10 hr postfeeding.

Roughage intake increases salivary buffer flow and should increase buffering shortly after feeding. But, because of the level of substitution for milo, total rumination and salivation during a 12 hr feeding interval may have been greatest with the 21WSC diet. If whole corn settles in the ventral rumen due to its density, less corn than hulls may be remasticated during each rumination which could increase the total time spent ruminating.

Below pH 5.5, buffering capacity was generally greater for 14WSC and 21WSC steers than for 7H steers. Due to greater intakes of potentially fermentable materials, production of volatile fatty acids (maximum buffering capacity of pH 4.8 to 4.9) should be highest with 14WSC and 21WSC diets. Resistance to pH change for 14WSC steers from pH 4.5 to 3.0 was consistently higher ($P>.05$) for 14WSC than for 21WSC and 7H diets, possibly reflecting a higher lactate concentration with the 14WSC diet.

Ruminal organic matter (OM) digestion tended to increase as other feeds were substituted for rolled milo (Table 2). Higher values for 14WSC and 21WSC steers than for 7H would be expected because of greater digestibility of whole corn vs cottonseed hulls. Possible explanations include effects on ruminal passage rates, pH, particle size reduction through mastication and increased microbial fermentation. Ruminal fluid dilution rate was negatively related to ruminal OM digestion ($r = -.72$; $P<.03$). In a previous study, particulate passage rate was not greatly different between rolled milo diets with either 12 percent cottonseed hulls or whole corn added (Goetsch et al., 1984). Microbial efficiency (Table 2) increased as substitution for rolled milo increased, being accompanied by differences in microbial (MN) and total nitrogen outflow (51 and 157, 68 and 175 and 78 and 191 g/day for 7H, 14WSC and 21WSC,

Table 2. Digestibilities.

Item	Treatment		
	7H	14WSC	21WSC
Organic matter digestion, %			
Ruminal, true	55.6	57.5	61.1
Postruminal	11.0	11.4	1.3
Total	66.6	68.9	62.4
Starch digestion, %			
Ruminal	75.4	70.0	79.6
Postruminal	12.6	17.7	.5
Total	87.9	87.6	80.1
Nitrogen			
Ruminal	15.6	13.8	10.9
Postruminal	20.9	21.8	21.3
Total	34.9	34.7	31.2
Microbial efficiency, gMN/kg organic matter fermented	16.6	21.0	22.5

respectively). Highly fibrous materials such as cottonseed hulls, with a slow rate and extent of ruminal digestion, may increase the extent of microbial colonization of particulates. Such fibrous digesta may pass slowly from the rumen and hence slow MN outflow. Also, hulls could provide a suitable habitat for protozoal colonization. Protozoal numbers also might have been lower for 14WSC and 21WSC diets than the 7H diet due to ruminal washout. Presence of protozoa could explain the trend for lower ruminal OM digestion and MN passage to the duodenum with the 7H treatment. Postruminal digestibilities for 7H and 14WSC were similar, while that of 21WSC was negligible. If whole corn kernels made up a large portion of digesta escaping ruminal fermentation with the 21WSC diet, then intestinal starch digestion may have been limited by particle size.

Ruminal starch digestion (Table 2) was slightly greater ($P>.05$) for 21WSC than 7H steers. Low ruminal digestion in 14WSC steers was compensated for by postruminal digestion. Hence, treatment trends in total starch disappearance were similar to OM measures. Starch digestibilities were all low compared with values expected with corn grain diets, but slightly greater than observed in a previous trail (Goetsch et al., 1984). Tannin level of the milo has not been determined, but may be involved in the low digestibility estimates.

Ruminal digestion of whole corn would be expected to be slower than of rolled milo due to a longer lag time prior to the onset of digestion and the need for remastication to increase surface area for digestion. Ingested whole corn might necessitate greater microbial attachment and colonization than rolled milo. In this manner, substitutions of greater quantities of whole corn for rolled milo could increase MN flow to the duodenum. If earlier suggestions of reduced protozoal populations in 14WSC and 21WSC steers are correct, and since protozoa pass more slowly from the rumen than bacteria do, increased duodenal MN flow would be expected in these animals. However, such an effect would not be expected from addition of whole shelled corn to diets which already contain roughage.

From ruminal buffering capacity, fluid volume, dilution rate and pH, 21 percent whole shelled corn appeared to have a roughage value equal to 7 percent cottonseed hulls. Use of whole corn as a sole dietary roughage shows promise since it may alter site of OM digestion and postruminal N flow. However, effects on total nutrient digestion measures as percents of nutrient intake, were not favorable in this trial.

Literature Cited

Goetsch, A.L., M.A. Funk, F.N. Owens and K.B. Poling. 1984. Okla. Agr. Exp. Sta. Res. Report MP-116.