

References:

1. Prigge, E. C., *et al.* 1975. Okla. Agri. Exp. Sta. MP-94, p. 63.
 2. Sprague, J. I. and G. W. Brenniman, 1969. *Feedstuffs* 46:20.
-

Nylon Bag Dry Matter Digestion of Corn as Influenced by Particle Size, Steam Flaking and High Moisture Processing

M. L. Galyean, D. G. Wagner and F. N. Owens

Story in Brief

Corn grain was sieved to obtain distinct particle sizes and incubated in nylon bags for varying time periods in the rumen of a mature Holstein steer. In Experiment 1, dry rolled corn sieved to provide sizes of 6.0, 3.0, 1.5, and 0.75 mm. was incubated for two, four, six or eight hours. Dry matter digestion (DMD) (averaged over all time periods) was similar for 6.0 mm. (4.98 percent), and 3.0 mm. (4.38 percent). However, DMD roughly doubled as particle size was halved to 1.5 mm. (9.74 percent), and 0.75 mm. (18.38 percent). Experiment 2 compared steam flaked (SF) and dry ground (DG) corn at 3.0 mm., 1.5 mm., and 0.75 mm. sizes for two, four, six or eight hours. SF had higher DMD within each particle size than DG. An approximate doubling of DMD as size was halved was not observed with SF as with DG. Experiment 3 was concerned with a comparison of ground, ensiled high moisture corn (HM) and DG at 3.0 mm., 1.5 mm., and 0.75 mm. sizes. Both HM and DG increased in DMD as size was reduced; however, HM generally had higher DM values within each particle size than DG. Particle size also had significant effects on the DMD of corn incubated for 12 or 24 hours, and on DMD of sorghum incubated for two, four, six or eight hours (Experiments 4 and 5, respectively).

This study indicates particle size has an important impact on digestion of processed as well as unprocessed corn, but is probably of greater importance with dry and high moisture, ensiled corn than with steam flaked corn.

Introduction

Particle size or physical form of grain has been demonstrated to be important relative to extent of digestion in cattle. Little is known, however, about the effect of particle size on ruminal digestion of grain. Available information would suggest that grains with greater digestion in the rumen result in improvements in feed efficiency compared to grains of lower ruminal digestion. Since large quantities of processed and unprocessed grains are routinely fed in commercial feedlots, information concerning the relationship of particle size to ruminal digestion may improve our ability to more efficiently produce beef.

Thus, this study was undertaken to investigate the influence of particle size on dry matter digestion (DMD) of unprocessed, steam flaked, and high moisture, ensiled corn, using a nylon bag, ruminal incubation technique. The DMD of sorghum was also considered.

Materials and Methods

Experiment 1

Dry rolled corn, obtained from the university feed mill was sieved through a set of standard sieves. Corn particles retained on screens with openings of 4.0 mm., 2.0 mm., 1.0 mm. and 0.5 mm. were separated to provide four distinct average particle sizes. Average size of the four groups were: 6.0 mm. (range 8.0 mm.-4.0 mm.); 3.0 mm. (range 4.0 mm.-2.0 mm.); 1.5 mm. (range 2.0 mm.-1.0 mm.) and 0.75 mm. (range 1.0 mm.-0.5 mm.). Approximately five grams of each of the four average particle sizes were weighed into 100 mesh nylon cloth bags. Bags were constructed of parachute material, sewn with nylon thread, and were approximately 5 X 12 cm. in size.

Duplicate bags of each size, attached to a nylon cord by fishing swivels, and anchored by an 80 gm lead weight were placed in the rumen of a mature, Holstein steer. Four such cords, one for each incubation period were used with eight bags per cord and incubated for two, four, six or eight hours. This entire procedure was replicated on another day to provide a measure of experimental error. The donor steer was fed a 62.75 percent dry rolled corn diet, *ad libitum* and housed in a slotted floor pen.

All bags were dried at 100°C and weighed prior to inclusion of particle size samples. After incubation, bags were washed under tap water and dried for 48 hours at 65°C followed by 2 to 4 hours at 100°C. Bags were then weighed to determine the percentage of dry matter digested.

Experiment 2

Corn obtained from a commercial feedlot was either steam flaked (atmospheric pressure, 100°C, approximately 20 min.) or left in the whole form. Both steam flaked and whole corn were ground through a 6 mm. screen, and sieved as in Experiment 1. Resulting average particle sizes were 3.0 mm., 1.5

mm., and 0.75 mm. for both steam flaked (SF) and dry ground (DG) corn. Nylon bag procedures described in Experiment 1 were used to compare the DMD of SF and DG.

Experiment 3

Ground, high moisture ensiled corn from a commercial feedlot was sieved to provide sizes of 3.0 mm., 1.5 mm., and 0.75 mm. and compared to DG corn using previously described procedures.

Experiment 4

The four average sizes of corn discussed in Experiment 1 were incubated for either 12 or 24 hours to see if particle size was still important beyond the eight hour periods previously studied. Procedures were equivalent to those described previously.

Experiment 5

Dry rolled sorghum obtained from the university feed mill was sieved as before and incubated in nylon bags for two, four, six or eight hours. Particle sizes used were 3.0 mm., 1.5 mm., and 0.75 mm.

Statistical analysis were conducted on the data from the five experiments, and significant differences between means are denoted as superscripts in the tables.

Results and Discussion

Experiment 1

DMD of the four sizes of dry rolled corn (DR) is given in Table 1. DMD means are reported either average over time (size means) or size (time means). Size means indicate 6.0 mm. (4.98 percent), and 3.0 mm. (4.38 percent) sizes were very similar in DMD; however, DMD increased as size was reduced from 3.0 mm. to 1.5 mm. (9.74 percent), and 0.75 mm. (18.38 percent). This suggests that DMD is approximately doubled as average size is halved from sizes 3.0 mm. and below. Time means show that DMD increased as length of incubation increased from two to eight hours. The magnitude of DMD change

Table 1. Nylon bag dry matter disappearance (DMD) of four particle sizes of dry rolled corn

Particle size (mm)	Average DMD ^d		Hours of incubation	Average DMD ^e	
	Percent	Hrs.	Percent	Percent	
6.0	4.98 ^a	2	6.65 ^a		
3.0	4.38 ^a	4	8.98 ^b		
1.5	9.74 ^b	6	9.98 ^{bc}		
0.75	18.38 ^c	8	11.87 ^c		

^{abc}Means in a column with different superscripts are significantly different ($p < .05$).

^dAveraged over times (2, 4, 6 and 8 hr.).

^eMeans averaged over all sizes (6.0, 3.0, 1.5, 0.75).

with time, however, was not as great as change due to particle size, suggesting that particle size has a greater effect on DMD than time with unprocessed corn; at least for the short incubation periods used in this experiment.

Experiment 2

Table 2 shows DMD values for SF and DG corn, averaged over time or size. SF corn had higher DMD (size means) within each particle size than DG. These results are in agreement with other studies which have shown steam flaked corn is more completely digested in the rumen than dry, unprocessed corn. Comparing particle sizes within a corn type shows that DMD increased as particle size was reduced from 3.0 mm. (23.81 percent) to 1.5 mm. (28.51 percent), and 0.75 mm. (32.92 percent). Changes in DMD with reduced size of DG corn were similar to those observed in Experiment 1, with an approximate doubling of DMD as size was halved. These results suggest that although particle size affects DMD of SF corn, the magnitude of DMD change with reduced particle size (i.e. a doubling effect) is not as great as with DG. As can be seen by time means, significantly more dry matter disappeared within each time period for SF than for DG.

Experiment 3

More DMD was noted within each particle size for HM than for DG. (Table 3). Furthermore, comparison within corn type indicates that reducing particle size in both HM and DG resulted in increased DMD. In contrast to SF corn (Experiment 2), the magnitude of change in DMD with HM was quite large as size was reduced. This suggests that corn particle size may be an important consideration with regard to ruminal digestion of high moisture corn. The effect of incubation period (time means) was slight for HM and was similar to previous results in regard to DG.

Experiment 4

DMD increased as size decreased from 6.0 mm. (16.12 percent) to 3.0 mm. (19.43 percent) to 1.5 mm. (30.83 percent) to 0.75 mm. (46.32 percent),

Table 2. Nylon bag DMD of steam flaked and dry ground corn

Corn	Particle size DMD means ^c		
	3.0 mm.	1.5 mm.	0.75 mm.
SF	23.8 ^a	28.5 ^a	32.9 ^a
DG	4.7 ^b	8.4 ^b	17.7 ^b
Corn	Incubation time means ^d		
	2	4	6
SF	21.3 ^a	24.4 ^a	29.3 ^a
DG	7.8 ^b	8.1 ^b	10.8 ^b
	8		
			14.3 ^b

^{a,b}Means in a column with different superscripts are significantly different ($p < .05$)

^cMeans averaged over all times (2, 4, 6, 8 hr.) within a corn type.

^dMeans averaged over all sizes (3.0, 1.5, 0.75 mm) within a corn type.

Table 3. Nylon bag DMD high moisture and dry ground corn

Corn	Particle size DMD means ^c		
	3.0 mm.	1.5 mm.	0.75 mm.
HM	16.8 mm. 7.9 ^b	23.8 ^a 12.4 ^b	38.9 ^a 22.2 ^b
Corn	Incubation time means ^d		
	2hr	4hr	6hr
HM	25.1 ^a	25.0 ^a	26.4 ^a
DG	10.6 ^b	12.6 ^b	15.0 ^b
	8 hr		
	29.6 ^a		19.3 ^b

^{ab}Means in a column with different superscripts are significantly different ($p < .05$).

^cMeans averaged over all incubation times with a corn type.

^dMeans averaged over all particle sizes within a corn type.

suggesting that longer time for incubation did not overcome the effect of particle size on DMD. Increased length of incubation did, however, result in large increases in DMD as can be seen by time means.

Experiment 5

To determine if relationships between particle size and DMD observed previously with corn occur in other grains, three sizes of sorghum were incubated for two, four, six or eight hours. Little difference was observed in DMD between 3.0 mm. and 1.5 mm. within a time period, but 0.75 mm. sorghum was higher than 3.0 mm. and 1.5 mm. in all cases. Thus, one could safely assume particle size has an important impact on the DMD of sorghum as well as corn.

In conclusion, this study suggests particle size has significant effects on nylon bag dry matter digestion of both corn and sorghum. Moreover, processing grain by steam flaking or high moisture has an additional effect on DMD above that due to particle size alone. Some alteration of whole or near whole kernels appears to be necessary to achieve maximum ruminal digestion of unprocessed corn and may also be necessary with high moisture corn. Whether diets of small particle size would be more completely digested in the

Table 4. Nylon bag DMD of four particle sizes of dry rolled corn with extended incubation times

Size	Particle size means ^g	Time	Incubation time means ^h
mm	Percent	hr	Percent
6.0	16.1 ^a		
3.0	19.4 ^b	12	22.0 ^c
1.5	30.8 ^c	24	34.4 ^f
.75	46.3 ^d		

^{abcd}Means in a column with different superscripts are significantly different ($p < .05$).

^eTime effect significant ($p < .002$).

^gMeans averaged over all incubation times.

^hMeans averaged over all particle sizes.

Table 5. Nylon bag DMD of three particle sizes of sorghum

Time	Particle size		
	3.0 mm.	1.5 mm.	0.75 mm.
2	8.4 ^a	8.1 ^a	22.8 ^b
4	15.5 ^a	9.7 ^b	24.4 ^c
6	15.4 ^a	12.1	28.8 ^b
8	20.9 ^a	16.3 ^b	36.2 ^c

^{abc}Means in a row with different superscripts are significantly different ($p < .05$)

rumen than those of layer size is dependent on the other factors. If large particles are held back in the rumen for longer times than small particles, diets of large size may be digested to the same extent as diets of small particle size. More information relative to ruminal outflow rate of grains of different particle sizes is needed to fully understand *in vivo* particle size, digestion relationships.

Influence of Particle Size and Level of Intake on Site and Extent of Digestion in Steers Fed Corn Based Diets

M. L. Galyean, D. G. Wagner, F. N. Owens and K. L. Mizwicki

Story in Brief

Four young Hereford X Brown Swiss steers were utilized to examine the site and extent of dry matter, organic matter and starch digestion in corn based diets. Corn ground through either 3.18, 4.76 and 7.94 mm. screens or left in the whole form was fed in 72 percent corn diets to determine the influence of corn particles size on site of digestion (Trial 1). In Trial 2 a basal corn diet (84 percent corn) was fed at 1.00, 1.33, 1.67 or 2.00 times calculated maintenance dry matter needs in an effort to investigate the influence of level of intake on site of digestion.

Results of Trial 1 showed that total tract dry matter (DMD) and organic matter (OMD) digestion tended to increase as particle size increased. Rumi-