Mean particle size: Evaluation of variation within industry processed grains and determination of the effect of laboratory grinding

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ABSTRACT

This study aims to determine how the mean particle size (MPS) of corn grain, soybean meal, and full fat soybean used for dairy cattle feed varies throughout industry samples and the extent laboratory grinding through 6-mm and 4-mm screens has on the MPS. Samples were collected from multiple feed mills in the Midwest, and were analyzed for original MPS and classified into fine, medium, or coarse accordingly. Original samples were then ground through 6-mm and 4-mm screens and MPS was measured. Samples that were classified as fine did not have significant reduction in their MPS when ground through either screen. Medium classified samples saw a significant reduction in MPS when ground through a 4-mm screen only. Coarse classified samples saw the largest reduction in MPS by both 6-mm and 4-mm screens, reducing the original samples by over 50% from their original MPS. This study indicates that laboratory determination of digestibility may not reflect well the digestibility of the original feedstuffs if classified as medium or coarse MPS because of MPS reduction through sample grinding in the laboratory prior to digestibility assays.

INTRODUCTION

In the diet of dairy cattle, corn is a vital component due to its energy content provided primarily by the starch it contains (2). Fredin et al. (2015) reported that diets that include adequate starch have an advantage in milk and fat-corrected milk yields over those insufficient in starch. A key factor that contributed to the digestibility of starch was particle size (1). Rémond et al. (2004) reported that corn with greater kernel processing had reduced MPS and increased the digestibility in both the rumen and the small intestine. Reduced MPS also increased milk yield and content of protein in milk (4). Yu et al. (1998) reported that varying corn processing by feed mills, including coarse-ground, fine-ground, steam-flaked, or steam-rolled, resulted in digestibility and milk production differences in dairy cows fed these processed corn grains (5).

Various laboratory evaluations are used to determine the potential digestibility of feedstuffs for ruminant animals. Evaluations include in vitro or in situ determination of dry matter, starch and (or) neutral detergent fiber (NDF) digestibility. These evaluations usually require the grinding of samples in the laboratory to reduce sample errors with a small sample size (0.5-1.0 grams). NDF digestion measurements are usually performed using a 1-mm screen because determination of maximal extent of digestion potential is usually desired. Grains differ though in being ground through either a 6-mm or 4-mm screens in an effort to minimize the masking of particle differences between grains and the effect they have on the starch digestibility. However, the MPS of grains from feed mills, which use varying processing methods, roller mills, hammer mills, varying screens, etc. may display differing effects on sample MPS. This would in turn possibly distort the starch digestibility measurements relative to the actual feed samples (3). The objectives of this study were to determine the variation in MPS of commercial grain samples, and the extent of MPS reduction in feed mill processed corn grain, soybean meal, and full fat soybeans by laboratory grinding during sample preparation for digestibility determinations. These scientific findings will be useful to assess the significance of in vitro digestibility measurements in comparison to animal digestion and performance.

MATERIAL & METHODS

Twelve different samples of 3 different types of feedstuffs were used: corn grain, full fat soybean, or ground soybean meal. Samples were collected from various commercial feed mills throughout Wisconsin and Iowa and each sample was divided into three groups: original, 6-mm grind, and 4-mm grind. Each sample weighed approximately 110 g before measurements were performed. The 6-mm and 4-mm samples were ground through a Wiley Centrifugal Mill with corresponding screen size. Particle size of all samples, original and ground, was determined using a Ro-Tap Shaker and 8 sieves. Each sample was dry sieved for 10 minutes, and then the sieve plates were weighed. The proportion of sample weight in each sieve was used to calculate MPS using a log normal distribution. Original sample MPS determined classification of feedstuff as either fine, medium, or coarse. Fine was classified as having a MPS less than 900 µm, medium between 900-2000 µm, and coarse included samples that exceeded a MPS of 2000 µm. Average MPS, standard deviation, minimum MPS, and maximum MPS was calculated for all samples. For each screen size, the MPS reduction and percent reduction from the original was calculated. A t-test was used to determine the significance of the 6-mm and 4-mm groups versus the original mean of that group.

RESULTS

Sample Distribution:

- Corn grain contained 5 samples in the fine group, 3 samples in the medium group, and one coarse sample
- Soybean meal (SBM) consisted of two medium samples
- Full fat soybeans were classified as coarse

Table 1. Mean particle size (microns) of corn grain and soybean meal samples with average, standard deviation, minimums, and maximums.

	Corn		SBM
Feed Classification	Fine	Medium	Medium
Original average	765.49	1219.91	985.54
Original std. dev	88.31	276.07	57.57
Original min	630.26	987.93	944.85
Original max	864.57	1525.24	1026.26
6mm average	731.59^{NS}	964.72^{a}	888.47^{b}
6mm std dev	99.83	90.06	13.92
6mm min	577.58	868.20	878.62
6mm max	852.82	1046.51	898.31
4mm average	681.77^{a}	841.82^{a}	778.34^{b}
4 mm std dev	41.05	29.34	67.18
4mm min	616.39	807.94	730.84
4mm max	725.63	858.86	825.84

P-values test against original average
Averages with p-values < .05 are denoted ^{a}
Averages with p-values < .15 are denoted ^{b}
Non statistically significant averages are denoted ^{NS}

Original Laboratory Grinding:

- Data for original fine and medium corn grain and medium soybean meal samples is presented in Table 1.
- The coarse corn grain sample had a MPS of 2582.03 µm and the coarse full fat soybean sample had a MPS of 3081.88 µm.

RESULTS

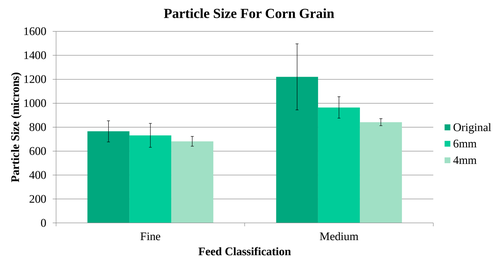

Figure 1. Particle size change from original to corresponding grinding screens for fine and medium corn grain samples. Bars in graph denote the standard deviation from the mean of the samples.

6-mm Laboratory Grinding:

- The fine corn grain samples ground through a 6-mm screen did not differ significantly from the original samples (p-value = .49).
- Medium corn grain samples were significantly different than original (p-value <.05) and medium soybean meal samples trended towards being significant (p-value <.15).
- Fine and medium corn grain samples were reduced by an average of 33.89 and 255.19 µm respectively.
- Medium soybean meal samples were reduced by an average of 97.09 µm.
- The coarse corn grain sample was reduced by 1345.35 µm (52.10% of original)
- The coarse full fat soybean sample was reduced by 1672.03 µm (54.25% of original)

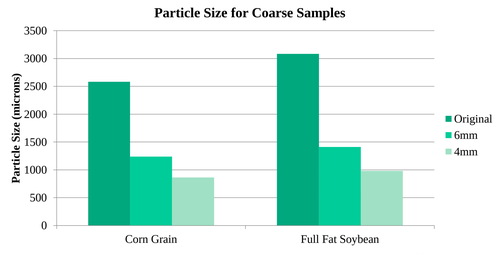

Figure 2. Change in particle size of coarse samples of corn grain and full fat soybean. Each type of feedstuff contained one sample, and this graph shows the regression of that sample through laboratory grinding. Reductions for corn grain 6-mm and 4-mm were 1345.35 and 1718.64 µm, respectively. For full fat soybean the reduction was 1672.03 and 2099.64 µm, respectively

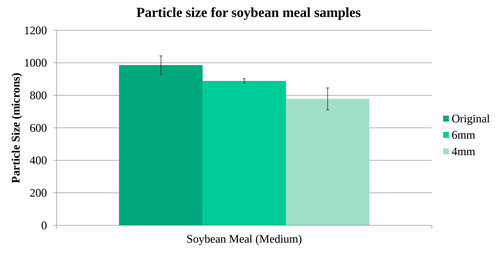

Figure 3: Change in particle size of soybean meal samples, all of which were classified as medium. Bars indicate the average of samples. The group consisted of two samples and the error bars on the graph indicate the standard deviations from the mean.

RESULTS

4-mm Laboratory Grinding:

- Both fine and medium corn grain samples were significantly different than original (p-value <.05) and medium soybean meal samples trended towards being significant (p-value <.15).
- Fine and medium corn grain samples were reduced by an average of 83.71 and 378.08 µm respectively.
- Medium soybean meal samples were reduced by an average of 207.22 µm.
- The coarse corn grain sample was reduced by 1718.64 µm (66.56% of original)
- The coarse full fat soybean sample was reduced by 2099.64 µm (68.13% of original)

DISCUSSION

- Grinding fine corn grain samples from industry through a 6-mm screen does not cause significant reduction in MPS.
- Fine corn grain samples had a statistically significant reduction from the original when using a 4-mm screen, but 83.71 µm reduction may not affect digestion.
- Medium samples from both corn grain and soybean meal groups show significant reduction when ground through both 6-mm and 4-mm screens, and this may affect digestibility data.
- All medium corn grain and soybean meal samples were reduced to a MPS of a fine sample after being ground through a 4-mm screen.
- Coarse samples from both the corn grain and full fat soybean group had their original MPS reduced by over 50% when ground through both the 6-mm and 4-mm screen which would most likely affect the evaluation digestibility in laboratory studies.
- More research needs to be done into the effect of varying MPS on the in vitro or in situ starch digestibility measurements to completely understand how significant the reduction of MPS during laboratory grinding.

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