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A comparison of Bygholm feed sieve to standard particle-size analysis techniques

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A COMPARISON OF BYGHOLM FEED SIEVE TO STANDARD PARTICLE-SIZE ANALYSIS TECHNIQUES

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Summary

Three experiments were conducted to evaluate the Bygholm Feed Sieve particle size tester. The Bygholm Feed Sieve is an 11 inch $\times$ 2.25 inch $\times$ 4.25 inch plastic box divided into four compartments by three different screen sizes (3,000-, 2,000-, and 1,000-micron mesh). In Experiment 1, particle size was determined for 20 ground corn samples with a Ro-Tap 13-sieve stack (53- to 3,350-micron Tyler mesh screens). The particle sizes ranged from 543 to 1,741 microns. Samples were analyzed for particle size with the standard Bygholm Feed Sieve, operated according to the manufacturer's directions. In Experiment 2, two rubber balls were placed on the 2,000 micron screen and one ball was placed on the 1,000 micron screen in the Bygholm Feed Sieve to aid in moving particles through the screens. Samples were then analyzed for particle size, according to the manufacturer's directions. In Experiment 3, 24 additional samples with particle sizes ranging from 604 to 1,305 microns were analyzed to determine the accuracy of the regression equation created by Experiment 1. After initial analysis indicated that the equation didn't accurately predict particle size of samples with a large particle size, an additional 11 samples with particle sizes ranging from 1,054 to 1,741 microns were analyzed. After this analysis, all samples from Experiments 1 and 3 were used to develop a

new set of regression equations to calculate the particle size of samples over a wider micron range. The Bygholm Feed Sieve more accurately predicted the particle size of samples when rubber balls were not present within the system ($R^2 = 0.88$ versus 0.82). The regression equation created by Experiment 1 predicted 90% of the samples to be within 100 microns of the actual particle size when the samples were less than 1,000 microns. When samples are coarser than 1,000 microns, however, the regression equation created by Experiment 3 should be used; it predicts 85% of the samples to be within 100 microns of the actual particle size when the samples were larger than 1,000 microns and 98% of all samples to be within 150 microns of the actual particle size.

(Key Words: Particle Size, Ground Corn, Bygholm Feed Sieve.)

Introduction

Particle-size analysis of ground corn is recommended for swine diets. The importance of obtaining a particle size between 650 and 750 microns is stressed because of the improvement of feed efficiency due to the decrease of particle size. Particle-size analysis can also aid in determining when feed mill equipment maintenance is warranted. Sending samples to a commercial lab is recommended,

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but there is a need for equipment that can be used to measure particle size on the farm and in feed mills. The standard 13-screen method requires a large initial investment; both the 3- and 13-screen sieve systems require time and purchase of several components. As a result, the Danish Institute of Agricultural Sciences created the Bygholm Feed Sieve to simplify this process. The Bygholm Feed Sieve is an 11 inch $\times$ 2.25 inch $\times$ 4.25 inch plastic box divided into four compartments by three different screen sizes. The first compartment is 3.5 inches long and is divided from the second compartment by a 3,000-micron screen. The second, third, and fourth compartments are all 2.5 inches long. A 2,000-micron screen divides the second and third compartments, and a 1,000-micron screen divides the third and fourth compartments. Little research has been performed regarding the accuracy and usefulness of this feed sieve for ground corn. Therefore, our objective was to determine the accuracy of the Bygholm Feed Sieve to predict the particle size of ground corn. The second objective was to determine whether the accuracy of the sieve is improved by adding rubber balls, similar to those used in normal particle-size analysis, to the two lower screens.

Procedures

Experiment 1. To determine the accuracy of the standard Bygholm Feed Sieve, ground corn with a known particle size and standard deviation was placed in the largest compartment of the Bygholm Feed Sieve. According to the directions provided with the sieve, the lid was slid in, and the sieve was shaken vigorously for approximately 4.5 minutes, until no more sample could be shaken through each screen. The sieve was then placed lid-up and shaken to smooth the sample over the bottom of each compartment. The height of sample in each compartment was measured with the aid of incremental measurements on the side of the sieve and recorded. The heights were used

to calculate a percentage of each sample contained by each compartment. The percentages on each screen were used to develop a regression equation (Regression Equation 1) to determine whether the actual particle size could be accurately predicted. This was replicated with 20 ground corn samples with particle sizes ranging from 568 to 1,741 microns.

Experiment 2. To evaluate the effects of adding rubber balls to the sieve, two 5/8-inch rubber sieve-cleaning balls (Codema, Inc.) were added to the second compartment and one ball was added to the third compartment to aid in the movement of the sample through the 2,000 micron and 1,000 micron screens. Further procedures were carried out according to the manufacturer's directions as in Experiment 1. This was replicated with 30 ground corn samples. The percentages on each screen were used to determine whether the accuracy could be improved, compared with the accuracy of equations developed without the balls in Experiment 1.

Experiment 3. To evaluate the accuracy of the regression equation created in Experiment 1, an additional 24 samples with particle sizes ranging between 604 and 1,305 microns were analyzed by the Bygholm Feed Sieve. Because the regression equation from Experiment 1 was generated from a data set in which most of the samples were between the recommended ranges of 600 to 800 microns, we analyzed an additional 11 samples with particle sizes ranging from 1,054 to 1,741 microns. The same procedures outlined in Experiment 1 were used in this experiment. A new regression equation (Regression Equation 2) was created that combined all data from Experiments 1 and 3 to create an equation that could be used to predict the particle size of ground corn samples over a wider range of particle sizes.

Results and Discussion

Experiment 1. The original procedures developed for the Bygholm Feed Sieve are accurate, provided that all the sample gets shaken through the screens. Due to the small surface area of the screens and the limited amount of shaking space, this can prove to be difficult. It takes approximately 4.5 to 5 minutes to adequately shake all the sample through the sieves. If this is done properly, the sieve performs well in accurately predicting the particle size of ground corn. The equation developed from Experiment 1 (Table 1) demonstrates that particle size for 19 of the 20 samples was predicted within 100 microns of the actual particle size (Figure 1). The equation indicated that 88% of the variation in particle size was predicted by the percentage of particles on each screen in the sieve (R^2 of 0.88). Because almost all of the samples in this experiment were less than 1,000 microns, Regression Equation 1 should not be extended to samples with larger particle sizes.

Experiment 2. The deviation of the predicted particle size in microns was determined and graphed with an R^2 of 0.82 (Figure 2). The results of testing the Bygholm Feed Sieve with balls present to aid in particle movement through the sieve were compared with the ability of the sieve to accurately predict the particle size of ground corn without balls present. The procedure carried out without balls generally had less deviation of micron size from the known particle-size value (Figure 3). Thus, balls should not be used with the Bygholm Feed Sieve. We believe that the balls may displace some of the grain when measuring the percentage of sample on each screen and, thus, increase the error in the measurement.

Experiment 3. The first part of Experiment 3 was to expand the dataset to determine the accuracy of the equation established in

Experiment 1 for a wider range of particle sizes. Because the equation did not seem appropriate for samples with particle size larger than 1,000 microns, a second regression equation was developed. Regression Equation 1 was graphed for closeness of fit to the actual particle size, with the R^2 determined to be 0.87. The deviation in particle size, shown in Figure 4 demonstrates that the accuracy of Equation 1 becomes poorer, with greater deviation, as particle size increases. Regression Equation 2 was graphed for closeness of fit to the actual particle size, with the R^2 determined to be 0.92. The difference in accuracy between the two equations is particularly evident when comparing the prediction of particle size for coarser samples with particle size bigger than 1,000 microns (Figure 5).

Conclusions. The most accurate way to measure particle size is with a Ro-Tap 13-sieve stack, but the time commitment and initial cost of equipment makes that an impractical method of particle-size analysis on the farm or in most feed mills. The 3-screen sieve test previously recommended by Kansas State University works well for on-farm particle-size analysis, but the initial cost and requirement for an accurate scale for this system has led us to explore other options. The Bygholm Feed Sieve provides an alternative for producers, allowing them to predict the particle-size of their feed through a less expensive and less complicated mechanism. Adding rubber balls to more accurately mimic the standard Kansas State University 3-screen test increased the deviation of predicted micron size from the known particle size, because the surface area of the screens and compartments do not allow for these balls to easily be accounted for.

Regression Equation 1 was successful in predicting the particle size of ground corn smaller than 1,000 microns. For samples larger than 1,000 microns, however, or samples whose approximate particle size is unknown,

Regression Equation 2 is recommended. Although either the Bygholm Feed Sieve or 3-screen test can be used to estimate particle size in feed mills, producers should send monthly samples from their mill to a lab for a complete 13-screen sieve analysis. The results

can be used to confirm the results of the on-farm analysis and will provide a standard deviation of the ground grain, which can not be determined from the Bygholm Feed Sieve or 3-screen test.

Table 1. Regression Equations Developed in Experiments 1 and 3

Equation	Regression Parameters ^a	R ²
1	$= -25.1 + 22.363w + 16.777x + 3.894y + 6.968z$	0.88
2	$= -1172 + 69.709w + 25.297x + 0y + 25.518z - 1.173w^2 + 0.1151x^2 + 0.2139y^2 - 0.055z^2$	0.92

^aWhere w, x, y, and z are the percentages of the sample above the 3,000-, 2,000-, 1,000-micron screens, and pan, respectively.

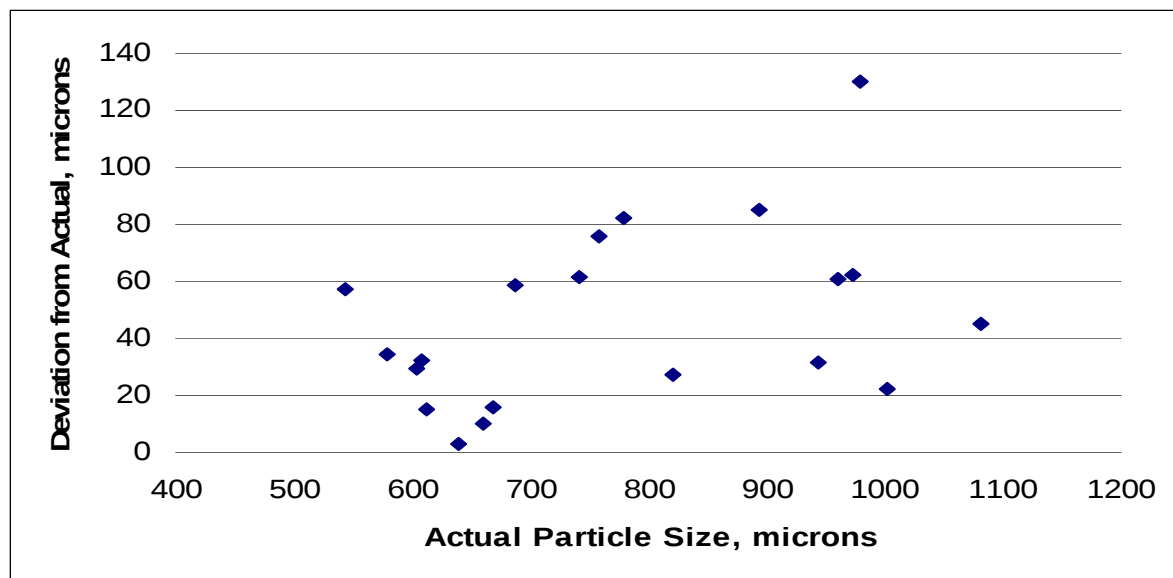


Figure 1. Deviation of Particle Size Predicted with the Bygholm Feed Sieve from Actual Particle Size (Experiment 1).

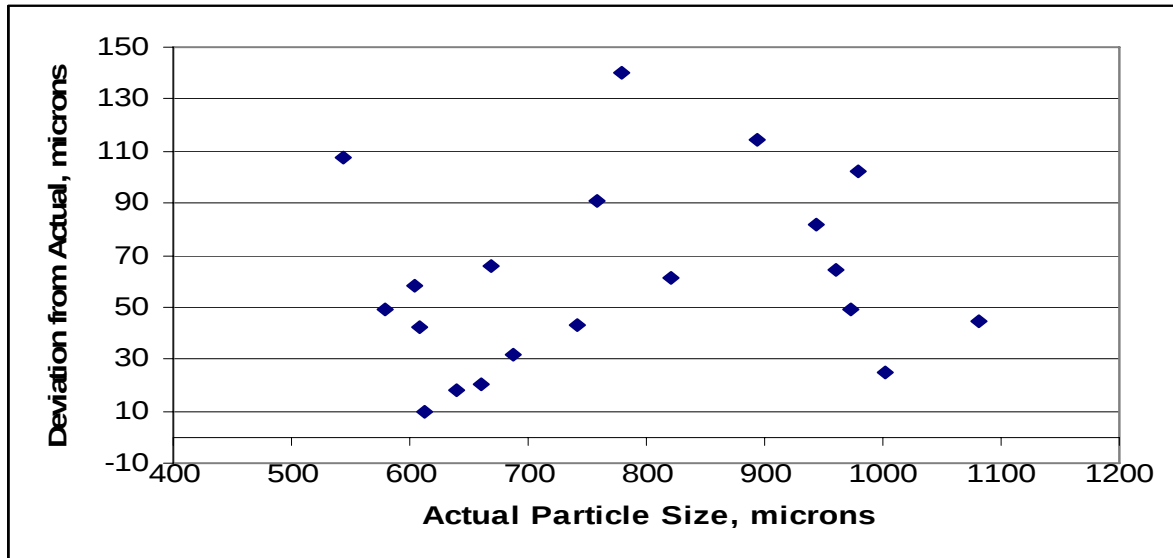


Figure 2. Deviation of Predicted Particle Size Predicted with the Bygholm Feed Sieve from Actual Particle Size, with Balls Present.

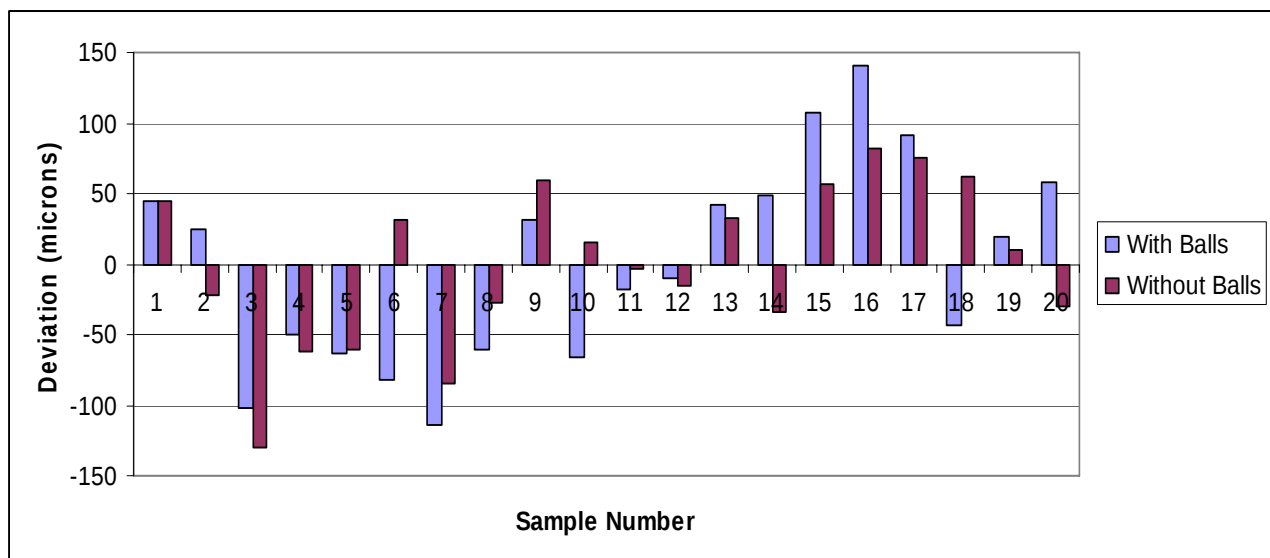


Figure 3. Deviation of Actual Particle Size from Particle Size Predicted with the Bygholm Feed Sieve, With or Without Balls on the Lower Two Sieves during Testing.

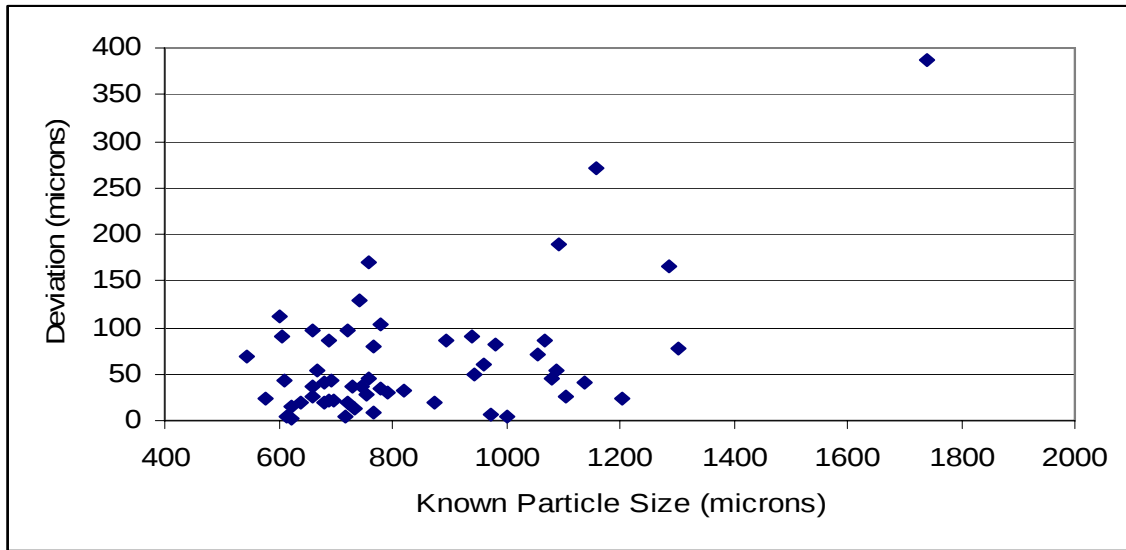


Figure 4. Deviation of Actual Particle Size from Particle Size Predicted with Equation 1 in Experiment 3.

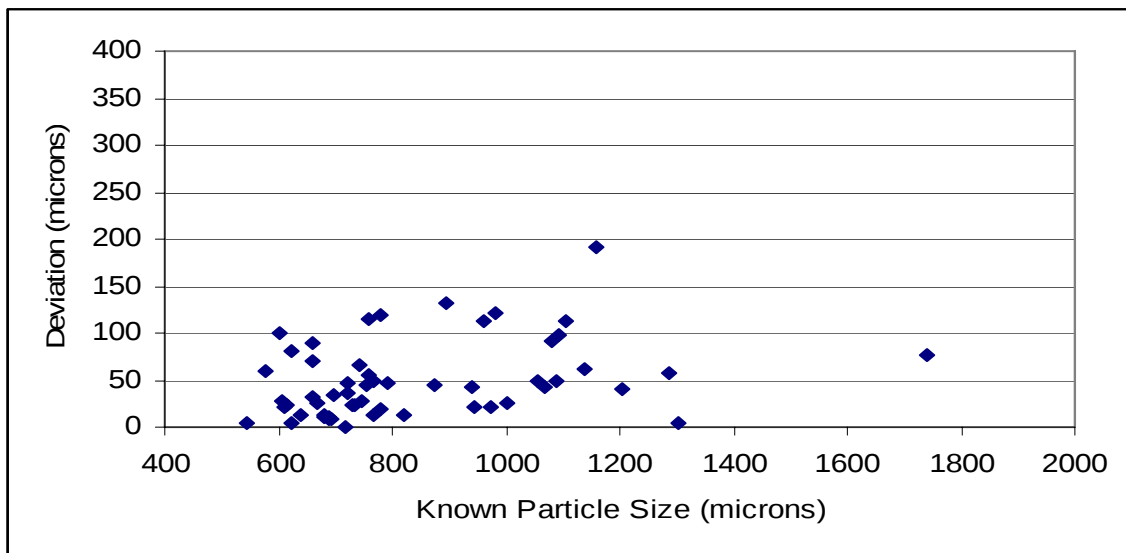


Figure 5. Deviation of Actual Particle Size from Particle Size Predicted with Equation 2 in Experiment 3.