A COMPARISON OF DIFFERENT PARTICLE SIZE ANALYSIS TECHNIQUES

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Summary

In this study, we compared different methods of testing particle size of ground corn. Forty-four corn samples were analyzed for particle size with a Ro-Tap tester equipped with a 13-sieve stack (53 to 3,350 :m tyler mesh screens). Mean particle size of the 44 samples ranged from 422 to 1,143 :m. These samples were then analyzed by placing 280 g on a #14 sieve (1,400 :m). The sieve was shaken by hand as the manufacturer recommended (one-sieve method). In a second procedure, samples were analyzed by placing 50 g of corn on a stack of three sieves: US #12 (1700 :m), #30 (600 :m), and #50 (300 :m: three-sieve method) with balls and carnucles. The three-sieve method was much more reliable in predicting average particle size of ground corn than the one-sieve method when compared to the 13-stack standard operating procedure. In summary, the three-sieve procedure may be a more accurate method to quickly determine particle size than the one-sieve method.

(Key Words: Ground Corn, Particle Size, Procedures.)

Introduction

The particle size of grain fed to swine and poultry has a major impact on feed efficiency. Because of the economic importance of particle size, nutritionist and consultants recommend frequent particle size analysis. The standard method for determining particle size is time consuming and requires a large initial investment. As a result, many swine producers use a fast, simple, one-sieve method for determining particle size. It is believed that the one screen method, although not as precise as the standard method, would be a suitable alternative to the standard procedure. However, recent variability in results between the one-sieve and standard method of particle size analysis led us to question the accuracy of the one sieve method. Therefore, the objective of our experiment was to compare results of a one- and three-sieve particle size analysis method to the standard Ro-Tap tester equipped with a 13-sieve stack. A second objective was to determine the required amount of time the three-sieve method needed to be shaken.

Procedures

Experiment 1. In our three-sieve method, 50 g of corn was placed on a stack of three sieves: US #12 (1700 :m), #30 (600 :m), and #50 (300 :m). There was one ball and one carnucle on the #30 sieve and one ball and two carnucles on the #50 sieve. A lightweight lid was placed on top of the stack to prevent spilling while a small pan was added on bottom to collect dust. The sieves were shaken vigorously by hand for five 30-second intervals. The sample left on each screen was then weighed between each interval.

This was repeated for 10 different corn samples. The change in the amount of grain left on each screen after every 30-second period was plotted to determine the most effective shaking time. We used this optimum shaking time in Exp. 2.

Experiment 2. We collected 44 samples of ground corn and determined particle size with a Ro-Tap tester equipped with a 13-sieve stack. The screens used included: US #6 (3,350 :m), #8 (2,360 :m), #12 (1,700

:m), #16 (1,180 :m), #20 (850 :m), #30 (600 :m), #40 (425 :m), #50 (300 :m), #70 (212 :m), #100 (150 :m), #140 (106 :m), #200 (75 :m), and #270 (53 :m). The corn samples ranged from 422 to 1,143 :m in particle size.

One-Sieve Method. According to directions provided with the one-sieve particle analysis kit (IFA, Stanly, IA), 280 g (10 oz) of grain was placed on a #14 sieve (1,400 :m). The sieve was shaken by hand until it appeared that all the small particles had fallen through the screen. The sample was weighed and an average particle size was predicted by comparing the amount remaining on the screen to an equation we calculated from the information provided with the kit. According to kit instructions, particle size is calculated by the weight of the material remaining on the #14 screen rounded to the nearest ounce and correlating the weight to a particle size of 700, 800, 900, 1,000, and 1,200 microns. We developed the following equation to best fit the results to the values given by the instructions:

$$\text{Particle Size} = 12X+560$$

where X is the amount (g) of sample left on the screen. We then developed our own regression equation by correlating the known particle size of the sample to the amount of material left on the sieve for each sample. This second equation was (R^2=0.74):

$$\text{Particle Size} = 11.8637X + 435.2123.$$

Three-Sieve Method. Corn samples (50 g) were shaken for one minute and thirty seconds using the same three-sieve stack described in Exp. 1. The sample remaining on each sieve was weighed and then regressed to determine a predicted equation for particle size (R^2=0.88):

$$\text{Particle Size} = 18.892(X\#12) + 10.870(X\#30) + 1.1827(X\#50) - 149.978;$$

where X equals the percentage of sample on the respective screens. Predicted average particle sizes by the two procedures were compared to the particle size determined by the standard procedure using the Ro-Tap tester.

Results and Discussion

Experiment 1. Most of the grain was found to pass through the screens during the first minute and a half of shaking (Figure 1). This amount of time was both effective and practical (from the shakers standpoint). We then used this as the shaking time in Experiment 2.

Experiment 2. The results of the one- and three-sieve methods were compared to the results of the Ro-Tap tester in this experiment. The one-sieve method, using the regression equation provided by the manufacturer, was able to predict 14 of the 44 samples within 75 :m of their actual size (Figure 2). Its prediction was off by more than 150 :m on 20 samples, eight of which were predicted over 200 :m from the actual particle size. Using the regression formula we developed for the one-sieve method, particle size was predicted slightly better with 11 samples off by more than 100 :m (Figure 3).

The three-sieve method predicted 40 of the 44 samples to within 75 :m and only 1 sample was off by more than 150 :m (Figure 4). Fourteen of the samples were predicted within 25 :m of the actual value. The advantage to the three-sieve method is that it requires no more time in shaking than the one-sieve and more accurately predicts particle size. However, there will be slightly more initial expense because three rather than one screens must be purchased. From our results, the three-sieve appears to be more accurate than the one sieve method.

While the three-sieve method predicts the average particle sizes more accurately than the one-sieve, it is still not as precise as the standard Ro-Tap tester and 13-sieve stack. If using either the one- or three-sieve methods, we recommend conducting multiple tests. In addition, samples should be sent periodically (i.e., once a month) to a laboratory that regularly performs particle size analysis to verify results of either the one- or three-sieve method.

Figure 1. Average Amount of Grain Passing through the Three Screens During Each Time Interval.

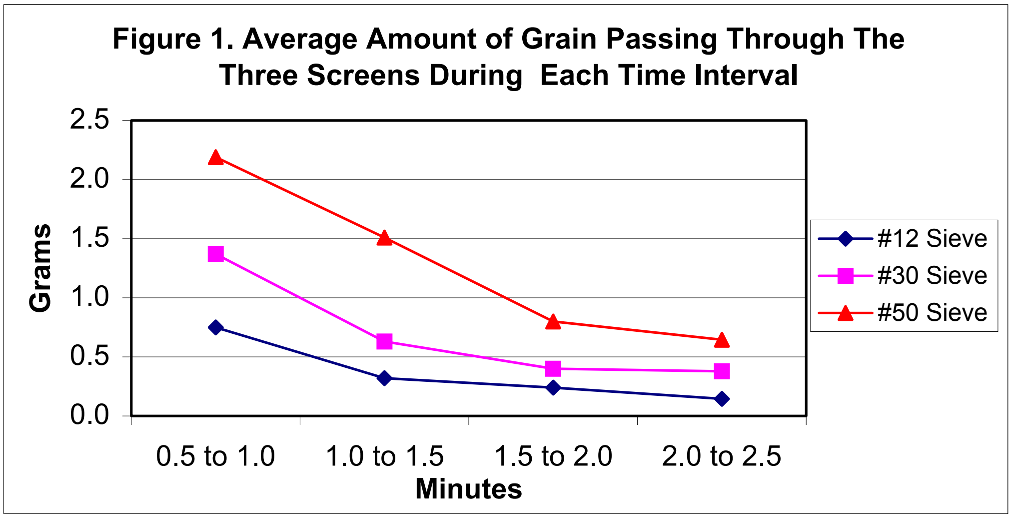

Figure 2. Distance from Actual Particle Size for Each Sample for the One Sieve Method following the Manufacturers Instructions (Particle Size = 12X + 560).

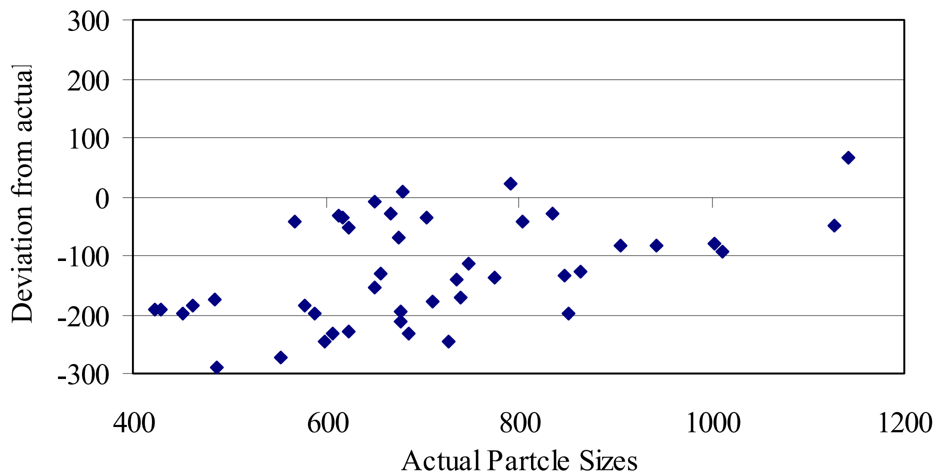

Figure 3. Distance from Actual Particle Size for Each Sample for the One Sieve Method using a Regression Equation Developed from the samples (Particle Size = 11.8637X + 435).

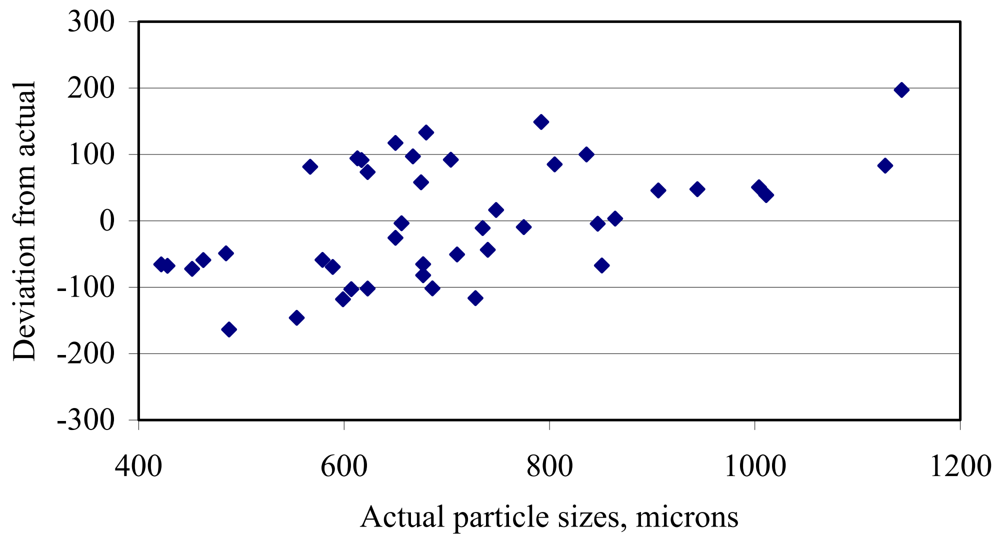

Figure 4. Distance from Actual Particle Size for Each Sample using the Three Sieve Procedure (Particle Size = 18.892(X#12) + 10.870(X#30) + 1.1827(X#50) – 149.978)