

Evaluating Particle Size of Feedstuffs

Grain accounts for a major component and cost in livestock diets. The particle size of ground grain influences feed digestibility, feed efficiency, mixing performance, and pelleting. Therefore, periodic particle size evaluations are a necessary component of a feed-manufacturing quality assurance program and is recommended by nutritionists. This publication describes the equipment used, procedure, costs, and interpretation of particle size analysis.

The standard for particle size analysis by sieving is published by the American Society of Agricultural and Biological Engineers (ASABE). As stated in their publication, *Method of Determining and Expressing Fineness of Feed Materials by Sieving* (ANSI/ASAE S319.4 FEB 2008 R2012), “The purpose of this standard is to define a test procedure to determine the fineness of feed ingredients and to define a method of expressing the particle size of the material.”

The standard allows several variations for this testing procedure. Specifically, it allows the use of different sieve shakers, such as a Tyler Ro-Tap, Retsch, or equivalent unit. It also allows optional use of sieve agitators, such as small rubber balls and bristle sieve cleaners to help move particles around on finer sieves. Another option is to use a flow agent, also referred to as a dispersing or sieving agent, to help material move through the sieves. Finally, the time of sieving can range from 10 to 15 minutes in the official procedure.

Laboratories that test particle size may obtain differing results because they use different procedures. For quality control, it is important to know the procedure used by the testing laboratory and how it relates to your particle size goals. Research has demonstrated that differences in mean particle size resulted from differences in methodology (Kalivoda et al., 2015; Stark and Chewning, 2012; Fahrenholz et al., 2010).

Kalivoda et al. (2015) reported that sieve shaker, time, use of agitators and flow agent influenced mean particle size and the variation or distribution in particle size measured (Table 1). No significant difference due to time (10 or 15 min) was found for particle size when sieve agitators and flow agents were used together. Figure 1 depicts the shift in the amount of particles collected on each sieve (U.S. Sieve No. 40 to pan) facilitated by the addition of a flow agent moving particles to screens with small openings.

Most research on particle size has been measured using the Tyler Ro-Tap (Figure 2) with sieve agitators (Figure 3) using a 10 minute sieving time without a flow agent. The arrangement of sieves, rubber balls (13 mm), and bristle sieve cleaners used for particle size analysis are shown in Table 2. Screens are identified by the U.S. Sieve number, so care must be taken to use the correct sieve opening, since other sizing designations (e.g. Tyler) can have different opening diameters at the same number designations.

Definitions

Geometric diameter average d_{gw} : average particle size, in microns, of a sample.

Geometric standard deviation S_{gw} : measurement of the particle size variation around the d_{gw} .

Test Procedures

A stack of sieves (each sieve possessing a different diameter opening) separates feed particles according to size. They are identified by diameter opening in millimeters or microns. It is recommended that the U.S. Standard, 8-inch diameter, half height sieve with a brass frame and mesh be used (ANSI/ASAE S319.4 FEB 2008 R2012).

Sieve agitators (Table 2) should be used to ensure that every particle has the same chance to pass through the openings, and a flow agent will prevent blinding of material on the screens and agglomeration of particles among themselves.

It also is important that sieves be properly cleaned between samples. Literature from the American Society for Testing and Materials (1972) recommends that a soft brass wire brush be used to clean sieves coarser than U.S. Sieve No. 100 and a nylon bristle brush for sieves finer than U.S. Sieve No. 100. It also may be necessary to wash the sieves routinely to remove build-up of fat and feed particles that cannot be removed with a brush. Sieves should be washed in warm, soapy water and dried to prevent corrosion.

In the feed industry, computer software provides the easiest method for calculating particle size. Pfof (1976) described equations that can be used to calculate d_{gw} , S_{gw} , surface area, and particles per gram based upon a log-normal distribution of ground grain samples.

For further information on the calculation of d_{gw} and S_{gw} , refer to ANSI/ASAE S319.4 FEB 2008 R2012, *Method of Determining and Expressing Fineness of Feed Materials by Sieving*. The method for calculating the S_{gw} of samples was changed between ASAE S319.2 and ANSI/ASAE S319.3. ANSI/ASAE S319.4 used the method described in ANSI/ASAE S319.3 to calculate S_{gw} .

Steps in Particle Size Analysis

1. Obtain a representative sample of 100 ± 5 grams by following the procedures for collecting and splitting a representative sample as described in the K-State Research and Extension publication MF2036 *Sampling: Procedures for Feed*.
2. Ensure that each sieve is cleaned and agitators are in the proper arrangement with the sieve opening decreasing from top to bottom (as the U.S. Sieve No. increases, the opening size decreases; Table 2).
3. Weigh each sieve individually with the agitators to obtain a tare weight.
4. Weigh 0.5 grams of flow agent and mix with $100 \pm$ grams sample. Read safety data sheet for the flow agent before product use.
5. Place the mixture of sample and flow agent on the top sieve and place sieve stack on the shaker machine. Allow shaker machine to run for 10 minutes.
6. Remove the sieve stack from shaker machine.
7. Weigh each sieve and retained material together to obtain the weight of sample on each sieve.
8. Thoroughly clean each sieve and agitators.
9. Enter the sample weight values in the appropriate columns of the data spreadsheet.

Equipment

- Ro-tap Sieve Shaker
- Scale accurate to at least 0.1 gram
- Sieves
- Sieve balls (PDT–Balls) and brushes (PDT–Cleaner)
- Flow Agent: Read safety data sheet before product use (PDT–Agent)
- Brass sieve brush
- Nylon sieve brush

Seedbuero Equipment Company

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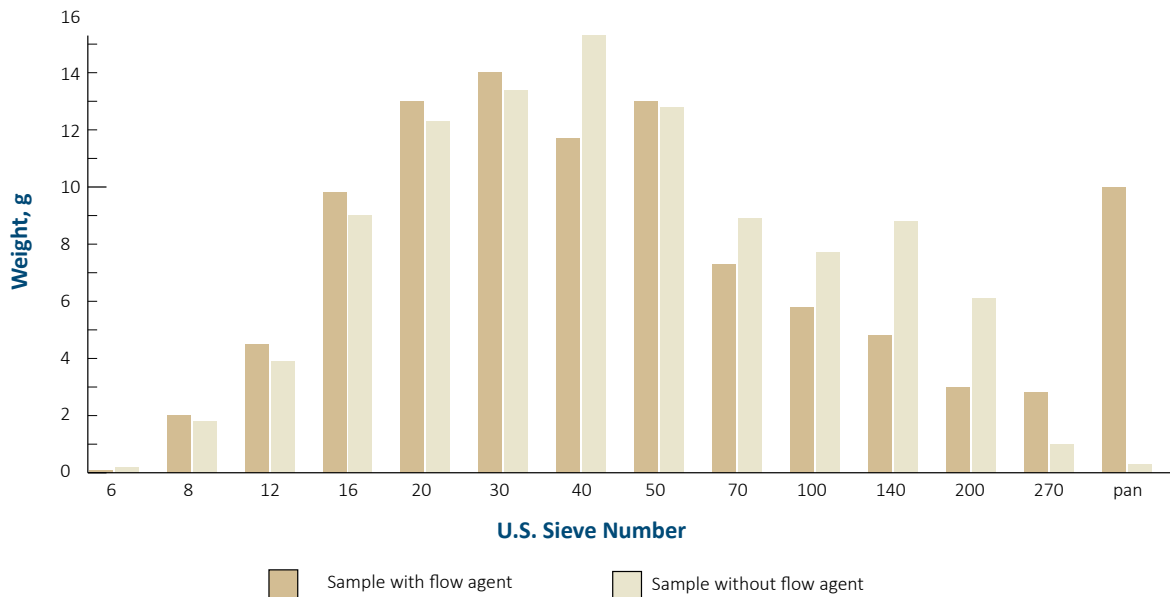


Figure 1. Distribution graph depicting the quantity of particles collected on each sieve for a corn sample ground using a hammermill comparing when flow agent was used and not used (Kalivoda et al., 2015).



Figure 2. Tyler Ro-tap shaker machine with sieve stack.



Figure 3. Example of one rubber ball and one bristle sieve cleaner.

Table 1. Main effect of analytical method on geometric mean diameter and geometric standard deviation of various grains (Kalivoda et al., 2015)

Shake time, min	Method				
	10	10	15	15	15
Sieve agitator inclusion	Yes	Yes	No	Yes	Yes
Flow agent inclusion	No	Yes	No	No	Yes
Mean particle size (d_{gw}), μm	586	554	615	576	540
Standard deviation (S_{gw})					
ANSI/ASAE S319.2	2.23	2.62	2.09	2.27	2.63
ANSI/ASAE S319.4, μm	485	576	467	487	567

Table 2. Sieve and agitator arrangement

U.S. Sieve No.	Sieve opening (μm)	Sieve agitator(s)
6	3,360	None
8	2,380	None
12	1,680	Three rubber balls
16	1,190	Three rubber balls
20	841	Three rubber balls
30	595	One rubber ball; one bristle sieve cleaner
40	420	One rubber ball; one bristle sieve cleaner
50	297	One rubber ball; one bristle sieve cleaner
70	210	One rubber ball; one bristle sieve cleaner
100	149	One bristle sieve cleaner
140	105	One bristle sieve cleaner
200	74	One bristle sieve cleaner
270	53	One bristle sieve cleaner
Pan	-	None

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Charles Stark

Associate Professor
Grain Science and Industry
Kansas State University

Julie Kalivoda

Grain Science and Industry
Kansas State University

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