Defining Sieving Methods Used to Determine and Express Fineness of Feed Materials

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The nutritional and economical benefits associated with reducing the particle size of swine diets has been recognized for many years (Healy et al., 1994; Wondra et al., 1995a; and Wondra et al., 1995b). As a general rule of thumb, for every 100-micrometer reduction in particle size, a 1.2 percent improvement in feed efficiency may be realized (Wondra et al., 1995a). The net benefits of reducing feed particle size depend on other factors such as ingredient and grinding costs, feed processing production rate requirements, and whether diets are fed as mash or pellets.

In addition to particle size, the uniformity of particle size (s_{gw}) is also commonly touted for its nutritional importance. However, less evidence directly supports such claims, unless the topic is being discussed in the context of particle size uniformity effects on bridging in the feeder, and consequently, out-of-feed occurrences. Groesbeck et al. (2006) suggested, that as particle size uniformity decreased, the occurrence of feed bridging in a feeder increased, thus resulting in a higher occurrence of pigs not having access to feed for a period of time. The significance of this relationship depends largely on whether or not the feed is pelleted. Reduced bridging occurs with pelleted feed, and thus, so does the importance of feed particle size uniformity relative to feed bridging. Nonetheless, measuring a feedstuff's particle size and distribution remains a fundamental aspect of most quality assurance programs within the feed and swine industry.

To provide a brief review of how particle size is determined and expressed, a 100-gram sample of feed or ground grain is placed onto the top of a series of 13 sieves or screens. The sieves are stacked, from top to bottom, according to mesh size, with the largest mesh size at the top. The sieve stack is placed into a sieve shaker. The feed or grain particles pass through the sieves as they are being agitated, until reaching a sieve with a mesh too small for the particles to pass through. The weight of material remaining on each of the sieves can then be measured and used to calculate the geometric mean particle size (d_{gw}) and the geometric standard deviation (s_{gw}), which represents the median particle size, and particle size uniformity, respectively. A much more detailed description of the test equipment and manner in which mean particle size (d_{gw}) and partical size standard deviation (s_{gw}) are calculated can be found in *ASABE Standards* S319.4.

There are an increasing number of questions and concerns expressed regarding discrepancies between particle size analyses results obtained from different laboratories. Questions like: "I've sent representative samples to three different labs and received three different results, why?" The basis for the concerns expressed was that feed mills were being penalized for not delivering diets or producing ground grains of a specified minimum mean particle size (d_{gw}) and maximum particle size standard deviation (s_{gw}). However, in some cases, the determining factor as to whether or not any penalties were enforced was subject to discrepancies between laboratories conducting the particle size analyses.

These inquires prompted a re-examination the accepted standard for determining and expressing fineness of feed materials by sieving (ASABE S319.4). It was discovered that, within the *ASABE Standards*, there was considerable latitude relative to the accepted test equipment and methods of sieving. In the following article, sections within the *ASABE Standards* are discussed that are not defined in absolute terms, as well as, the results from research conducted at Kansas State University to quantify how this leeway within the standard affects particle size analyses results.

More specifically, the following sections of the *ASABE Standards state*: *1.) Section 4.2 - A sieve shaker, such as a Tyler Ro-Tap, Retsch, or equivalent unit, is required; 2.) Section 4.4 - Sieve agitators such as plastic or leather rings, or small rubber balls may be required to break up agglomerates on finer sieves, usually those smaller than 300mm in opening (ISO 3310-1) or US sieve No. 50; 3.) Section 4.5 - A dispersion agent can be used to facilitate sieving of high-fat or other material prone to agglomeration; and 4.) Section 5.2 - Place the charge on one sieve or the top sieve of the nest of test sieves and shake until the mass of material on any on sieve reaches end point. End point is decided by determining the mass on each sieve at 1-minute intervals after an initial sieving time of 10 minutes. If the mass on the smallest sieve containing any material changes by 0.1 percent or less of the charge mass during a 1-minute period, the sieving is considered complete. For industrial applications, the end-point determination process can be omitted, and the end-point is set to be the sieving time of 15 minutes.*

Comparison of shakers

The Tyler Ro-Tap sieve shaker is the most commonly used sieve shaker in the feed industry. However, as the *ASABE Standards* states, a Retsch sieve shaker can be used instead. Although both sieve shakers facilitate the passage of feed particles through the sieve stack, one could argue that the motion of feed particles within the sieve stack is different when comparing a Retsch and a Tyler Ro-Tap sieve shaker. It was consistently observed that a lower mean particle size (d_{gw}) ($\approx$ 90 micrometers) and higher particle size standard deviation (s_{gw}) ($\approx$ 0.42) would be obtained using a Retsch sieve shaker compared to a Tyler Ro-Tap sieve shaker. If for example, a sample was split and sent to two different quality control labs, the first equipped with a Tyler Ro-Tap sieve shaker and the other with a Retch sieve shaker; and the results obtained from the first lab were: mean particle size (d_{gw}) = 600 micrometers and particle size standard deviation (s_{gw}) = 2.0, observations would suggest that the results from the second (Retch) lab would be: mean particle size (d_{gw}) = 510 micrometers and particle size standard deviation (s_{gw}) = 2.42.

Sieve agitators and sieving time

It would be uncommon for a quality control laboratory not to use sieve agitators of some kind. Additionally, most labs sieve for a total of 10 minutes and do not measure the mass on each sieve at 1-minute intervals after 10 minutes to determine an end point. However, this study was interested in quantifying the extent to which sieve agitators and sieving time affects particle size results. In order to evaluate these variables, a sample of ground corn was split into multiple samples using a Boerner Divider. Each of the sub-samples was then evaluated for particle size and uniformity using a sieve stack with and without sieve agitators and a sieving time of either 10 or 15 minutes as suggested in the *ASABE Standards*. All treatments were evaluated using a Tyler Ro-Tap sieve shaker and replicated three times. On average, the sieve agitators reduced the mean particle size (d_{gw}) by 80 micrometers and increased the particle size standard deviation (s_{gw}) from 1.87 to 2.15. Sieving time also seemed to markedly affect the results. Sieving for 15 minutes rather than 10 resulted in a lower mean particle size (d_{gw}) (approximately 40 micrometers) and a slightly higher particle size standard deviation (s_{gw}) (2.15 vs. 2.31).

Dispersion agents

Use of a dispersion agent such as Supernat 22-S or Cab-O-Sil has seemed to become more common in the feed industry. Goodband et al. (2006) examined the affects a dispersion agent has particles size results, evaluating more than 600 ground corn samples ranging from 400 micrometers to 1,000 microns. They found that the use of a dispersion agent reduces the mean particle size (d_{gw}) approximately 80 micrometers, and produces a greater particle size deviation. This was consistent across the range of particle sizes evaluated. Further evaluation of dispersion agents has resulted in similar results (a reduction in the mean particle size (d_{gw}) of 75 micrometers).

Conclusion

It is not the intent of this publication to suggest which procedure is the correct method for measuring particles size, but to point out that significant deviation can exist between labs that are following the *ASABE Standards*, but not the same procedures. Feed mills being pressured to produce ground grain with a specific mean particle size (d_{gw}) and particle size standard deviation (s_{gw}) may face challenges if their in-house quality control laboratory is following different procedures compared with an outside lab. Furthermore, it raises questions as to the nutritional importance of particle size standard deviation (s_{gw}) considering the fact that the sieving equipment chosen, the sieving time, the use of dispersion agents, and the use of sieve cleaners can result in a tremendous difference in that measurement. In addition, studies at K-State failed to find any significant difference in swine performance due to the inherent range of particle sizes (S_{gw}) in grain ground to approximately the same particle size (Wondra, et al, 1995b)

Literature cited

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MF-2952 October 2010

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