Measuring Feed Particle Size

Ken Stalder

Iowa State University

Feed Costs

- **Feed costs represent 75 to 80 percent of the cost of production for finishing market hogs in the U.S.**
- **When energy costs rise to the levels seen since 2008 producers become keenly aware feed efficiency:**
- **Finishing pig feed efficiency**
  - Wean - to - finish
  - Feeder pig - to - finish

Feed Efficiency

- **Items that can influence feed efficiency:**
  - Genotype
  - Market weight
  - Barrows vs gilts
  - Feed type (mash vs pelletted)
  - Feeder adjustment
  - Pen space allowance
  - Diet composition
    - Fat
    - Fiber content
    - Type of cereal grain
    - Etc.

Common Feed Processing Questions?

- **What is feed particle size?**

  Feed particle size refers to the average mean diameter of individual particles of feed or simply "the fineness of grind" of the feed.

- **How do we determine feed particle size?**

  Feed particle size is determined by passing the feedstuff through a series of sieves with progressively smaller openings.

Common Feed Processing Questions?

- **How does feed particle size impact feed efficiency and nutrient utilization?**
- **Attaining the optimal feed particle size will improve nutrient digestibility by increasing the total surface area of the feed volume.**
- **The pig's digestive system will digest the feed better because the digestive enzymes have more surface area to act upon the in the nutrients in the feed.**
  - Digestibility of protein, energy and other nutrients is generally improved with at the more optimal feed particle size.
  - Improving digestibility should result in improved feed conversion. In addition.

Common Feed Processing Questions?

- Attaining the optimal particle size can influence how uniformly feed is mixed and reduce the amount of segregation, which occurs delivering feed to the animal.
- It should be noted that the benefits of providing a well balanced diet could be lost, if adequate care is not taken in manufacturing of the feed.

Importance of Particle Size

- **Feed particle size should be maintained from 650 to 750 microns.**
- **Greater particle size results in poorer feed efficiency**
  - Every 100 microns greater than optimal results in approximately 65 cents additional feed costs per pig (Kansas State University)
  - If a producer takes feed particle size from 1000 to 700 microns, it will result in a savings of approximately $2 per market hog.

Importance of Particle Size

- **Feed particle size should be maintained from 650 to 750 microns.**
- **Smaller particle size results in other problems**
  - Increased energy of grinding or rolling
  - Feed bridging in;
    - Storage bins
    - Feeders
  - Increased incidence of ulcers in finishing pigs
  - Dusty feeds may cause reduced feed intake
  - May increase respiratory problems
  - Higher feed processing costs.

Reducing Feed Particle Size

- **Hammer mills reduce particle size by:**
  - Smashing due to direct impact with hammers,
  - Cutting by the edge of the hammers and screen, and
  - Rubbing action between different particles.
- **Roller mills reduce particle size by:**
  - The rolls move with a differential drive of one roll moving 50 to 75 percent faster than the other
  - Rolls have corrugations to help slice the grain,
  - Corrugations have a 1- to 2-inch spiral to increase the shearing potential and eliminate fines.

Factors Influencing Feed Particle Size

- **Routine equipment maintenance – Hammer Mills**
- **Worn hammers**
  - Each hammer typically has 4 corners that can be used
  - Turn the hammers to a side that has not been used once they have become overly rounded

Importance of the Hammer Mill Screen

- **Make sure the proper screen is being used**
  - The size of the openings in the hammer mill screen greatly determines the size of particles which are produced.
  - Using a 1/8 to 3/16-in. screen will have a mean particle size from 600 to 800 microns.
  - Using a 1/4 to 3/8 in. normally produce particle size from 800 to 900 microns.
  - Make sure the screens are not worn excessively (not rounded out or pitted)

Importance of the Hammer Mill Screen

- **It is difficult to relate screen size to a specific microns because:**
- **Equipment used such as:**
  - Portable grinder mixer
  - Stationary mill
- **Equipment variability such as:**
  - Tip speed,
  - Wear,
  - Moisture content,
  - Grain type, etc.

Roller Mill Criteria for Proper Processing

- **Desired corrugations per inch of roll being:**
  - 8 to 10 for corn,
  - 10 to 12 for wheat, barley, and oats, and
  - 12 to 14 for milo;
- **Particle size controlled by**
  - The setting of the rollers,
  - Corrugations, spiral roller versus non-spiral, and
  - Speed differential of the rollers.
- **Roller mills are limited to non-fibrous products.**

Factors Influencing Feed Particle Size

- **Routine equipment maintenance – Roller Mills**
  - Spirals have to be rebuilt periodically

- **Roller mills can process grain with half the energy of a hammer mill and give equal particle size.**

- **Magnets are important to remove any metal objects from the grain and increase the longevity of hammers, screens, and rollers.**

Comparison of Hammer Mills and Roller Mills

- Easier maintenance
- Higher horsepower
- Greater throughput per unit of size
- Process wider variety of feeds
- Greater range of particle size
- Nosier
- Create more dust

Measuring Feed Particle Size

- **Equipment Required**
- **Three 8” diameter, 1” depth brass frame and cloth sieves**
  - US #12 (1700µm)
  - US #30 (600µm)
  - US #50 (300µm)
- **Brass sieve cover and 1” receiver pan for the 8” diameter sieves**

Measuring Feed Particle Size

- Equipment Required
- Two balls and three carnucle brushes
- Scale capable of accurately weighing within one-tenth of a gram
- Brush to clean sieves
- Compressed air to clean sieves

Procedures for Determining Feed Particle Size

1. Set up sieves by placing one ball and one carnucle in sieve #30, and one ball and two carnucles in sieve #50 and not balls or carnucles in sieve #12 or the pan.

2. Weigh the empty sieves with balls and carnucles, and record the empty weights of each

Step 1: Prepare sieves with appropriate number of balls and carnucle brushes.

Step 2: Weigh each empty sieve along with its ball and carnucle(s).

Pictures from Kansas State University Swine Extension

Procedures for Determining Feed Particle Size

3. **Stack the sieves on top of the pan in increasing numerical order**
   1. Sieve #12 on top
   2. Sieve #30 in the middle
   3. Sieve #50 on the bottom
   4. Pan attached to the bottom of the #50

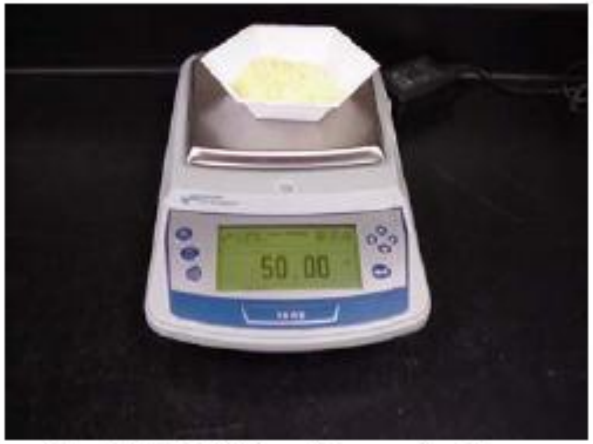
Step 3: Stack sieves in proper order.

Pictures from Kansas State University Swine Extension

Procedures for Determining Feed Particle Size

4. **Weigh 50g of an accurate representation of the feed sample to be evaluated and pour it into the top sieve (#12). Securely place the cover on the sieve stack.**

5. **Shake the stack of sieves vigorously from side to side by hand for 90 seconds.**



Step 4: Weigh 50g of sample & pour into stack, placing lid on top.

Step 5: Shake sample side to side for 90 seconds.

Pictures from Kansas State University Swine Extension

Procedures for Determining Feed Particle Size

6. **Weigh the sieves with balls, caruncles and sample collected on each sieve, and record the gross weight.**

Step 6: Weigh each sieve with its ball, carnucle(s), and sample collected.

Procedures for Determining Feed Particle Size

7. **Enter the initial weights of sieves into the "Empty" colum of each sieve number and the final weights into the "Gross" column of each sieve number in the yellow portions of the Microsoft Excel Worksheet.**
   1. This will automatically compute the net sample acquired by each sieve and calculate the particle size of the sample.
   2. It will also plot this particle size on the monitoring graph to easily track the variations in particle size.

8. **Thoroughly clean the sieves before running another sample.**
   1. The best method of cleaning sieves is with a sieve brush and compressed air to blow particles through the sieve openings.

Example Particle Size Calculation

The empty sieves weighed: After shaking, the sieves weighed:

#12: 357.09g	#12: 365.42g
#30: 361.13g	#30: 384.40g
#50: 346.34g	#50: 353.01g

K-State Particle Size Calculator

Enter Information in yellow cells

	Weight, g										
Sample	**#12 Gross**	**#12 Empty**	**#12 Net**	**#30 Gross**	**#30 Empty**	**#30 Net**	**#50 Gross**	**#50 Empty**	**#50 Net**	**Date**	**Particle Size**
1	365.42	357.09	8.33	385.4	361.13	24.27	353.01	346.34	6.67	6/29/2005	708.169738
			0			0			0	7/6/2005	-149.978
			0			0			0	7/13/2005	-149.978

=18.892*(2*D6)+10.87*(2*G6)+1.1827*(2*K6)-149.978

Spreadsheet from Kansas State University Swine Extension

Example Particle Size Calculation

- **Additional columns have been added to the original spreadsheet to record some additional items that might be useful in the future including:**
  - Producer
  - Sample no.
    - Sample number collected within a day or producer
  - Location where sample was collected
    - Mill, storage, feeder, other (list cite if other)
  - Type of mill sample came from
    - Roller or Hammer Mill
  - Type of cereal grain evaluated
    - Corn, wheat, barley, other (list grain if other)
  - Diet or phase of production for the diet evaluated
    - Gestation, lactation, nursery, grow - finish

Example Particle Size Calculation

- Might want to consider starting a separate sheet for each producer and check it quarterly or every 6 months.
- Are there other useful things you would like to record?
- Consider submitting the data back to the IPIC office for evaluation yearly.
- Over time we can build a data base and report the results if they prove to be useful.

Feed Particle Size Determination Kits

- **Currently two kits have been put together for your use that includes:**
  - Sieves (one each #12, #30 and #50)
  - A bottom pan
  - A lid
  - Balls
  - Carnucles
  - Brush
  - Can of compressed air
  - Electronic scales
- **Thumb drive containing:**
  - Spreadsheet
  - Copy of procedures
- **Notebook with a hard copy of the procedures**

Checking Out Kits for Your Use

- **We have 4 kits available to check out**
  - If demand warrants we will put together additional
- **Contact Ken Stalder**
  - Phone – 515-294-4683
  - Cell – 515-460-4630
  - E-mail stalder@iastate.edu
- **Jane Runneals**
  - Phone – 515-294-4103
  - E-mail – janerun@iastate.edu
- **If you have trouble or questions contact Ken**

Thank You for Your Time and Attention

Effect of particle size of corn and sorghum based diets on starter pig performance

Grain	Mill Type	Mean particle size diameter (microns)	Average daily gain (lb)	Daily feed intake[b] (lb)	Feed/ gain[b]
Corn	Hammer	624	1.00	1.72	1.70
	mill	877	.99	1.77	1.78
	Roller	822	1.02	1.85	1.81
	mill	1,147	1.04	2.00	1.92
Sorghum	Hammer	539	.96	1.72	1.78
	mill	722	1.00	1.79	1.79
	Roller	885	1.00	1.91	1.92
	mill	1,217	.94	1.82	1.94

[a]Ohh et al., 1983. Values represent means from 192 weanling pigs initially 15 to 18 pounds with a final weight of approximately 51 pounds.
[b]Difference between hammermill and roller mill ($P < .05$).

Effects of particle size of corn and sorghum on apparent digestibilities

Particle size (microns)	Digestibility, %			
	Dry Matter	Protein	Energy	Feed/gain
<700	86.1	82.9	85.8	1.74
700 to 1,000	84.9	80.5	84.4	1.84
>1,000	83.7	79.1	82.6	1.92

[a]Adapted from Ohh et al., 1983.

Effect of diet particle size on growth performance of starter pigs

	Particle Size, microns			
Item	900	700	500	300
ADG, lb	.84	.80	.85	.78
ADFI, lb[b]	1.29	1.21	1.23	1.19
F/G[c]	1.55	1.52	1.46	1.53
Production rate, t/h	4.06	2.84	1.63	.85

[a]Adapted from Healy et al., 1994. Data represent means of pigs fed either corn and hard or soft endosperm milo ground to the respective particle sizes.

[b]Linear effect of particle size ($P < .08$).

[c]Quadratic effect of decreasing particle size ($P < .01$).

Effect of barley particle size on finishing diets

Item	Grain:	Milo	Barley	Barley	Barley	Barley
	Screen Size, inches:	3/16	1/8	3/16	1/4	Rolled
	Particle Size, microns:	698	714	902	1,146	2,200
Average daily gain, lb		2.05[b]	1.96[b]	1.80[c]	1.78[c]	1.74[c]
Average daily feed intake, lb		6.93[b]	6.47[c]	6.20[c]	6.49[c]	6.49[c]
Feed efficiency		3.39[b]	3.32[b]	3.58[c]	3.65[c]	3.72[c]

[a]Goodband and Hines, 1987.

[bc]Means on the same row with different subscripts differ (P < .02).

Effects of lactation diet particle size on sow and litter performance

	Particle size, microns				
Item	1,200	900	600	400	SE
Litter size, d 21	9.1	9.0	9.5	8.9	.2
Sow wt loss, lb	23.1	23.1	15.9	18.1	2.2
Sow bf loss, in.	.12	.13	.12	.11	.6
Litter wt, lb	103.4	107.4	111.3	110.4	1.7
Litter wt gain, lb[b]	76.9	80.7	84.2	85.1	1.4
Feed intake, lb[b]	9.23	9.35	9.70	9.77	.09
Diet dry matter digestibility, %	84.2	85.1	86.4	88.3	.4
Ulcer score	1.3	1.4	2.7	.9	.1
Keratinization score	1.2	2.1	1.5	2.7	.1

[a]Wondra, 1993.

[b]Linear effect of particle size ($P < .05$).

Comparison of Tyler and USA sieve numbers

Opening in microns	Tyler Number (meshes/inch)	USA Number
3360	6	6
2380	8	8
1680	10	12
1191	14	16
841	20	20
594	28	30
420	35	40
297	48	50
212	65	70
150	100	100
103	150	140
73	200	200
53	270	270