Testing Mixer Performance

K·STATE Research and Extension

The mixing process is one of the most important steps in feed manufacturing. The goal of mixing is to meet label guarantees and produce a uniform feed that provides similar nutrient content to all animals consuming the feed.

Experiments demonstrate that a uniform feed mixture is important for optimal animal performance and to minimize animal food safety hazards related to nutrient toxicity. Research shows the species and age of the animal have an effect on the target coefficient of variation (%). Traylor et al. (1994) demonstrated decreasing %CV of the diet improved nursery pig performance. A higher %CV, however, did not affect finishing pig performance but could lead to toxicity or deficiency of certain minerals and vitamins. The uniformity test is not only a Current Good Manufacturing Practice but also is required for regulatory compliance. Mixer evaluation is a FDA requirement of 21 CFR part 225.30 (b) for a licensed feed mill and under 21 CFR 225.130 for a nonlicensed feed mill. Additionally, improperly mixed medicated feed particles can lead to FDA recalls or animal deaths.

The feed industry uses the chemical analysis of ten samples from a single batch to evaluate uniformity of a feed mixture. The selected chemical or nutrient, however, should come from a single ingredient source (i.e., salt, synthetic amino acids, trace minerals). The amount in each sample is used to calculate the coefficient of variation (CV). Another technique to evaluate uniformity is to compare the difference between the numbers of colored iron filings added and counted using a statistical evaluation.

Factors influencing mixer performance

The objective of the feed mixing process is to optimize throughput of a uniform mixture. The uniformity of mix can be affected by many factors, including equipment design, ingredient properties, and maintenance of equipment. Furthermore, the sequence of ingredient addition and amount of liquids can affect the uniformity of mix. The feed mill manager should evaluate these factors when testing the mixer and determining how to optimize the batching and mixing processes.

Equipment

The horizontal mixer is the most common mixer used in commercial and vertically integrated feed mills; whereas, the vertical mixer is commonly used in on-farm and small feed mills. Horizontal mixer designs continue to evolve and improve. The double shaft ribbon/paddle combination has replaced the traditional single shaft double ribbon used in many feed mills over the last 15 years. The double shaft design has the advantage of a shorter mixing cycle as a result of multi-directional flow of ingredients in the mixing zone, as well as a greater turn-down of the batch size. Double ribbon/single shaft mixers should be at least 50 percent full during operation, whereas double shaft ribbon/paddle mixers can operate at 25 percent of rated capacity without compromising the uniformity of mix.

While ingredients can be uniformly distributed with any type of mixer, the mixing time is dependent on the design and number of mixing zones within the mixer. For example, vertical mixers have two mixing zones, one at the top and one at the bottom of the center screw, double ribbon mixers create zones from the opposing direction of the ribbons as they rotate, and double shaft mixers have a multi-directional flow throughout the entire mixer.

Operation

Mixer capacity is based on the operating volume of the agitators (paddle or ribbons). Therefore, changes in feed density due to the amount and/or type of an ingredient can affect mixer operation. Filling the mixer beyond its rated capacity creates dead spots above the top of the ribbons or paddles, which can result in improper mixing. Research conducted by Wicker and Poole (1991) demonstrated that when a 5-ton mixer was used to mix 6 tons of a ration, increasing the mix time did not decrease %CV.

Maintenance

Preventive maintenance is an important management tool in feed mills to control manufacturing costs and maintain quality. A worn or improperly adjusted mixer can affect the efficiency of mixing. Wilcox and Unruh's study (1986) demonstrated that a worn outer ribbon on a 2-ton double-ribbon horizontal mixer could not produce an acceptable %CV (<10 percent) when the feed was mixed from 3 to 10 minutes. However, after the outer ribbon was replaced, the %CV was less than 10 percent when the feed was mixed at 4 minutes. Moreover, the build-up of molasses on the paddle and mixer body extended the mix time from 3.5 minutes to 5 minutes to reach the target %CV.

Testing mixer performance

Several different procedures are used in the feed industry to determine the uniformity of mix. The most common are chemical assays for drug, mineral, amino acid, and chloride ion. The marker should come from only one source, be approved for use in feed, and have a precision method of analysis in order to accurately evaluate the uniformity of mix (Fahrenholz and Stark, 2014). The marker also should have sufficient particles per gram to ensure the marker can be detected when the sample is obtained from the mixer. The most common marker used in feed mills is salt, which is usually added to the diet at 0.3 to 0.5 percent. The particle size of the salt should be less than 400 microns when conducting a mixer uniformity test using the Quantab® Chloride Titator method.

Sampling and Sample Preparation

1. Representative samples should be taken from 10 different locations within the mixer or be obtained as near to the discharge point as possible.
2. Samples taken during discharge of the mixer should be at equally spaced time intervals.
3. Sample should be ground with a coffee grinder to achieve a uniform particle.

Example of a twin shaft horizontal mixer.

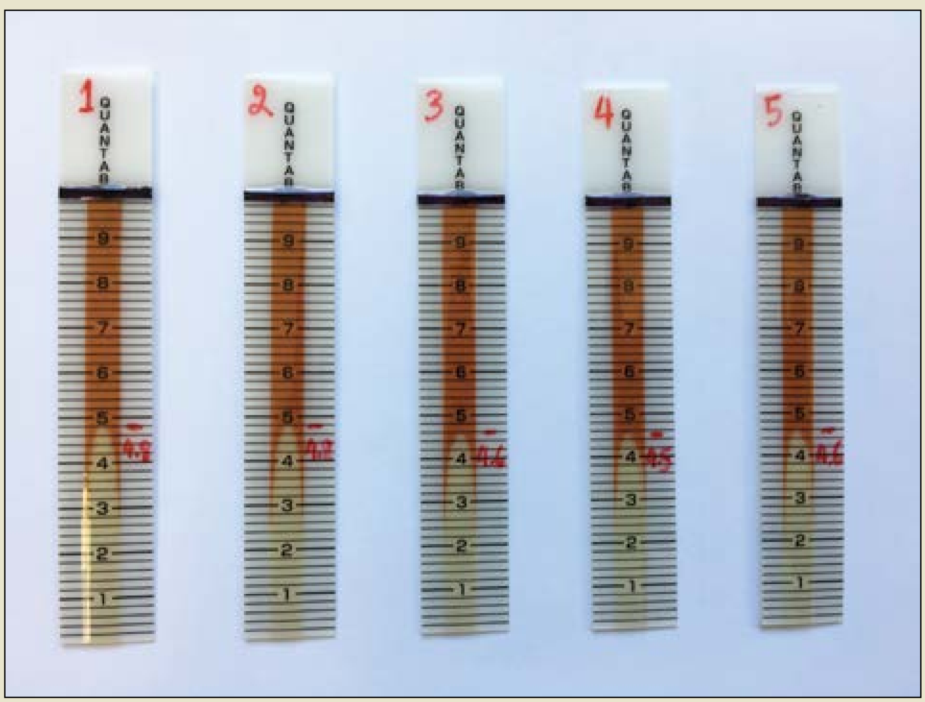
Sampling port near mixer discharge.

Uniformity test using the Quantab® Chloride Titator method

1. Weigh a 10-g sample of ground feed into a cup, then add 90-g of hot distilled water (140°F) to the cup using a 0.1-g readability scale for both sample and water.
2. Stir mixture for 30 seconds, allow to rest for 60 seconds and stir for another 30 seconds.
3. Place a folded filter paper into the cup and then insert a Quantab® strip range 30 to 600 mg/L (Hach Company, Loveland, CO) into the liquid at the bottom of the filter paper. The same lot of Quantab® strips should be used for all ten samples.
4. Read the Quantab® number at the top of the white peak after the color of the top band of the strip has changed from yellow to black, and then convert the Quantab® strip reading to %NaCl using the chart on the bottle.
5. Calculate the %NaCl of the sample by multiplying the %NaCl from the table on the bottle (from Step 4) by 10.
6. Compute a CV from the results of 10 samples within a batch to determine mixing uniformity. The CV for each batch is calculated by dividing the standard deviation by the average value multiplied by 100.

(Right): Quantab in filter paper.

(Below): Quantabs from mixer test.



Interpretation of results

Herrman and Behnke (1994) categorized mixer tests as excellent, good, fair, and poor based on %CV ranges. A %CV of less than 10 percent was excellent, 10 to 15 percent was good, 15 to 20 percent was fair and greater than 20 percent was poor. The corrective actions of these categories are presented in the table.

Table 1. Interpretation and corrective action of mixer tests (Herrman and Behnke, 1994)

Percent coefficient of variation	Rating	Corrective action
<10%	Excellent	None
10–15%	Good	Increase mixing time by 25 to 30 percent.
15–20%	Fair	Increase mixing time 50 percent, look for worn equipment, overfilling, or sequence of ingredient addition.
>20%	Poor	Possible combination of all the above. Consult extension personnel or feed equipment manufacturer.

References

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