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# Effect of Sample Preparation and Extended Mix Times with Different Salt Particle Sizes on the Uniformity of Mix of a Corn-Soybean Meal Swine Diet

## Abstract

The uniformity of a feed mixture is determined from the coefficient of variation (CV) of 10 samples in a single batch of feed. The feed industry standard is a CV of less than 10% using a single source tracer, such as salt, trace minerals, or iron filings. The objectives of these experiments were to determine the effects of 1) extended mix time, 2) particle size of the marker, and 3) sample preparation on the CV in a corn-soybean meal swine diet. In Experiment 1, treatments were arranged in a 3 × 7 factorial with main effects of 3 salt particle sizes (fine-350  $\mu\text{m}$ , medium-464  $\mu\text{m}$ , and coarse-728  $\mu\text{m}$ ) and 7 mix times (2, 3, 5, 15, 30, 45, and 60 min). In Experiment 2, treatments were arranged in 2 × 3 × 3 factorial with 2 sample preparations (unground vs. ground), 3 salt particle sizes (fine-350  $\mu\text{m}$ , medium-464  $\mu\text{m}$ , and coarse-728  $\mu\text{m}$ ) and 3 mix times (3, 30, and 60 min). There were 3 replicates per treatment and 10 samples per replicate. Salt concentrations were determined using a Quantab<sup>®</sup> Chloride Titrator. The result of Experiment 1 indicated no interaction between mix time and salt particle size. The extended mix time did not result in segregation ( $P = 0.307$ ). Particle size of the salt significantly affected the uniformity of mix ( $P < 0.0001$ ; 21.2, 8.6, and 7.9% CV for the coarse, medium, and fine salt, respectively). The results of Experiment 2 indicated no interaction of sample preparation, salt particle size, and mix time. However, there was interaction between sample preparation and salt particle size ( $P = 0.0002$ ). The difference in the CV% between unground and ground samples was significantly greater for the mixture with coarse salt (8.89 %) than the mixture with fine (1.35 %) and medium salt (2.59 %). The ground treatment had a significantly lower CV than the unground treatment ( $P < 0.0001$ ; 8.7 and 13.0 for ground and unground samples, respectively). The fine and medium salt treatments had significantly lower CV as compared to the coarse salt treatment. ( $P < 0.0001$ ; 7.4, 7.7, and 17.4 for fine, medium and coarse, respectively). These results indicated that feed did not segregate after mixing for up to 1 h. The greater number of particles per gram of the marker (in this case salt) increased the precision of the analysis, likely due to an increased probability that the marker was present in proportionate quantities in the sample tested. However, when coarse salt is used in the manufacturing process, the samples should be ground prior to analysis.

## Keywords

mix time, particle size, sample preparation, uniformity of mix

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## Effect of Sample Preparation and Extended Mix Times with Different Salt Particle Sizes on the Uniformity of Mix of a Corn-Soybean Meal Swine Diet

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### Summary

The uniformity of a feed mixture is determined from the coefficient of variation (CV) of 10 samples in a single batch of feed. The feed industry standard is a CV of less than 10% using a single source tracer, such as salt, trace minerals, or iron filings. The objectives of these experiments were to determine the effects of 1) extended mix time, 2) particle size of the marker, and 3) sample preparation on the CV in a corn-soybean meal swine diet. In Experiment 1, treatments were arranged in a  $3 \times 7$  factorial with main effects of 3 salt particle sizes (fine-350  $\mu\text{m}$ , medium-464  $\mu\text{m}$ , and coarse-728  $\mu\text{m}$ ) and 7 mix times (2, 3, 5, 15, 30, 45, and 60 min). In Experiment 2, treatments were arranged in  $2 \times 3 \times 3$  factorial with 2 sample preparations (unground vs. ground), 3 salt particle sizes (fine-350  $\mu\text{m}$ , medium-464  $\mu\text{m}$ , and coarse-728  $\mu\text{m}$ ) and 3 mix times (3, 30, and 60 min). There were 3 replicates per treatment and 10 samples per replicate. Salt concentrations were determined using a Quantab® Chloride Titrator. The result of Experiment 1 indicated no interaction between mix time and salt particle size. The extended mix time did not result in segregation ( $P = 0.307$ ). Particle size of the salt significantly affected the uniformity of mix ( $P < 0.0001$ ; 21.2, 8.6, and 7.9% CV for the coarse, medium, and fine salt, respectively). The results of Experiment 2 indicated no interaction of sample preparation, salt particle size, and mix time. However, there was interaction between sample preparation and salt particle size ( $P = 0.0002$ ). The difference in the CV% between unground and ground samples was significantly greater for the mixture with coarse salt (8.89%) than the mixture with fine (1.35%) and medium salt (2.59%). The ground treatment had a significantly lower CV than the unground treatment ( $P < 0.0001$ ; 8.7 and 13.0 for ground and unground samples, respectively). The fine and medium salt treatments had significantly lower CV as compared to the coarse salt treatment. ( $P < 0.0001$ ; 7.4, 7.7, and 17.4 for fine, medium and coarse, respectively). These results indicated that feed did not segregate after mixing for up to 1 h. The greater number of particles per gram of the marker (in this case salt) increased the precision of the analysis, likely due to an increased probability that the marker was present in proportionate quantities in the sample tested. However, when coarse salt is used in the manufacturing process, the samples should be ground prior to analysis.

Key words: mix time, particle size, sample preparation, uniformity of mix

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## Introduction

The composition of a diet directly impacts growth rate and feed conversion of animals. Nutritionists formulate diets based on the assumption that animals will receive all the nutrients needed for maintenance and growth each time they go to the feeder. Researchers have demonstrated that poorly mixed feed can negatively affect the feed conversion of nursery pigs (Traylor et al., 1994).<sup>3</sup> In addition to meeting the nutrient requirements of the animal, variation within a mixture of feed can lead to toxicity or deficiency of minerals and vitamins. Several factors can affect the uniformity of mix, such as mixer design, particle size of the ingredients, and mixing time. The goal of the feed mixing process is to create a uniform mixture of feed in the minimum amount of time, in order to maximize process efficiency. However, there is also a concern that extended mixing may lead to ingredient segregation due to inherent sifting by weight or static charge generated during the mixing process. There are little data available to confirm if overmixing, indeed, does lead to segregation.

The selection of an appropriate tracer is also important when determining the uniformity of the mix. Groesbeck et al. (2004)<sup>4</sup> conducted two experiments to determine the effect of various salt particle sizes and different sample preparation on mixing uniformity. The researchers observed an interaction CV decreased when the particle size of the salt decreased from 3,000 to 440 microns, mix time was increased, and samples were ground. However, this has not been considered when evaluating mixing time. The objectives of the current study were to determine the effect of extended mixing time, salt particle size, and sample preparation on the uniformity of mix.

## Procedures

### *Materials and Methods*

#### Experiment 1

Treatments were arranged in a 3 × 7 factorial with main effects of salt particle size (fine-350 μm, medium-464 μm, and coarse-728 μm) and mix time (2, 3, 5, 15, 30, 45, and 60 min) to determine their effect on uniformity of mix. A swine growing diet was mixed in a 2-ft<sup>3</sup> double ribbon mixer (Hayes and Stolz model HP2SSS-0106, Fort Worth, TX). A total of 10 samples were obtained from 10 different locations in the mixer. There were 3 replicates per treatment. The salt concentration of the samples was analyzed using Chloride Quantab® Test Strips (Hach #2751340, Loveland, CO) using the method described by McCoy (2005).<sup>5</sup>

#### Experiment 2

Treatments were arranged in 2 × 3 × 3 factorial of sample preparation (unground and ground), salt particle size (fine-350 μm, medium-464 μm, and coarse-728 μm), and mix time (3, 30, and 60 min) to determine their effect on uniformity of mix. A swine growing diet was mixed in the same 2-ft<sup>3</sup> double ribbon mixer used in Experiment 1. The diet was mixed for 3, 30 and 60 min. A total of 10 samples were obtained from 10 different locations in the mixer. The samples were ground with a coffee bean grinder for 30 sec. There were 3 replicates per treatment.

<sup>3</sup> Traylor, S.L., Hancock, J.D., Behnke, K.C., Stark, C.R. and Hines, R.H. 1994. Mix time affects diet uniformity and growth performance of nursery and finishing pigs. In KSU Swine Day Report, 171-175. Kansas State University, Manhattan, KS.

<sup>4</sup> Groesbeck, C., R. D. Goodband, M. D. Tokach, J. L. Nelssen, J. M. DeRouchey, and S. S. Dritz. Effects of salt particle size and sample preparation on results of mixer-efficiency testing. 2004 Kansas State University Swine Day Report, 177-181.

<sup>5</sup> McCoy, R. A. 2005. Chapter Appendix D: Mixer Testing. In Feed manufacturing technology V, 620-622. ed. E. K. Schofield and American Feed Industry Association, Arlington, VA. American Feed Industry Association.

### ***Data Collection***

The salt concentration of the samples was determined with the Quantab® chloride titrator method. A 10 g sample was weighed into a cup, and 90 g of hot distilled water (60°C) was added to the cup. The mixture was stirred for 30 sec, allowed to rest for 60 sec, and stirred for another 30 sec. A folded filter paper was placed into the cup and the Quantab® strip was inserted into the liquid at the bottom of the filter paper. The result of 10 samples per batch were used to compute a coefficient of variation to determine mixing uniformity. The coefficient of variation for each batch was calculated by dividing the standard deviation by the average value multiplied with 100. The particle size of the 3 types of salt (fine, medium and coarse) was determined with a Ro-Tap model RX-29 (W.S. Tyler Industrial Group, Mentor, OH) using the method of determining and expressing fineness of feed materials by sieving (ANSI/ASAE S319.4) without a flow agent for 15 min.

### ***Statistical Analysis***

Data were analyzed using the GLIMMIX procedure of SAS. Means were separated by least squares means adjustment for Bonferroni's multiple comparisons. Results were considered significant if  $P \leq 0.05$ .

## **Results and Discussion**

### ***Experiment 1***

There was no interaction between mixing time and particle size of the salt. Mix time did not affect CV (Table 1), and suggested that salt particles did not segregate during the extended mixing process. However, mixing with coarse salt increased CV compared to the fine and medium salt treatments ( $P < 0.0001$ : 7.9, 8.6, and 21.2 for fine, medium, and coarse, respectively). Coefficient of variation decreased as the number of marker particles (salt) per gram increased. Notably, there was a decline in CV when the mixture included coarse salt after 2 minutes of mix time. This reduction may be due to a reduction in salt particle size due to friction between particles.

### ***Experiment 2***

There was no interaction observed between sample preparation, salt particle size, and mix time. However, there was a sample preparation  $\times$  salt particle size interaction ( $P < 0.001$ , Table 2) observed. Specifically, the sample form (ground vs. unground) impacted CV in treatments containing coarse salt, but not those containing medium or fine salt. The main effect of mix time again did not impact CV (11.5, 11.0, and 10.0 for 3, 30, and 60 min. mix time, respectively). Treatments containing coarse salt again had greater CV ( $P < 0.0001$ ; 4.0, 7.7, and 17.4 for fine, medium and coarse, respectively). Groesbeck et al. (2004)<sup>4</sup> reported a lower CV after the particle size of the sample that contained coarse salt ( $\geq 730$  microns) was reduced from 700 compared with 400 micron salt. Sample preparation method also affected CV ( $P < 0.0001$ ), with ground samples having a more repeatable result (8.7% CV) than unground samples (13.0% CV).

In summary, an extended mix time up to 60 minutes did not lead to segregation of salt particles, even when coarse salt was used. However, if coarse salt is used in the feed manufacturing process, samples should be ground prior to mixer uniformity analysis.

**Table 1. Main effect of mix time on the uniformity of mix as determined by the coefficient of variation (CV) of feed (Experiment 1)<sup>1</sup>**

Item	Mix time, min							SEM	Probability, <i>P</i> =
	2	3	5	15	30	45	60		
CV, %	11.5	13.8	12.9	13.1	13.9	11.7	11.3	0.98	0.307

<sup>1</sup>Three particle sizes (350, 464 and 728 microns for fine, medium, and coarse, respectively) of salt were added to a swine grower diet and mixed in a 2.0 ft<sup>3</sup> double ribbon mixer for varying mix times to evaluate the role of salt particle size, mix time, and sample preparation on mix uniformity as measured by the chloride titrator strip method described by McCoy (2005).<sup>5</sup> Ten samples were collected from varying locations throughout the mixer and used to determine the coefficient of variation among samples. Lower values indicate less variation and a greater uniformity of mix across the mixer location.

**Table 2. Interactive effects of sample preparation and salt particle size on the coefficient of variation (CV) of feed mixed (Experiment 2)<sup>1</sup>**

Sample preparation	Salt particle size			SEM	Probability, <i>P</i> =
	Fine	Medium	Coarse		Sample preparation × particle size
Unground	8.1 <sup>a</sup>	9.0 <sup>a</sup>	21.8 <sup>c</sup>	0.88	0.0002
Ground	6.7 <sup>a</sup>	6.4 <sup>a</sup>	13.0 <sup>b</sup>		

<sup>abc</sup> Means with different superscripts are significantly different ( $P \leq 0.05$ ).

<sup>1</sup>Three particle sizes (350, 464, and 728 microns for fine, medium, and coarse, respectively) of salt were added to a swine grower diet and mixed in a 2.0 ft<sup>3</sup> double ribbon mixer for varying mix times to evaluate the role of salt particle size, mix time, and sample preparation on mix uniformity as measured by the chloride titrator strip method described by McCoy (2005).<sup>5</sup> Ten samples were collected from varying locations throughout the mixer and used to determine the coefficient of variation among samples. Lower values indicate less variation and a greater uniformity of mix across the mixer location.