Effects of Diet Bulk Density on Mixing Uniformity

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Summary

The objective of this study was to determine how the time required to create a uniformly mixed batch of feed is influenced by diets that differ in bulk density. Three 60-lb batches of a corn-soybean meal–based diet (high bulk density) or a high-fiber diet (low bulk density) containing 30% dried distiller's grains with solubles (DDGS), and 19% wheat midds were prepared. The ingredients for each batch were placed in a 60-lb capacity experimental double-ribbon mixer with all batches containing 0.35% table salt. Ten samples were obtained from different parts of the mixer for each batch of feed after 60, 120, and 240 sec of mixing time. Ten additional samples were taken as the feed was discharged from the bottom of the mixer after 240 sec. The three batches of each diet type were mixed and sampled using the same procedures and were considered separate observations, making 3 replications for each mixing time within diet type. The CV among 10 samples collected at each mix time was used to determine mixer efficiency by measuring Cl concentration (Quantabs, Environmental Test Systems, Elkhart, IN). After 60 sec of mixing, the corn-soybean meal–based diet achieved a CV of less than 10%; however, the high-fiber diet required 240 sec to achieve a CV of less than 10%. In conclusion, using this experimental ribbon mixer, diet bulk density affected the time required to mix a batch of feed thoroughly, which suggests that feed manufacturers should reevaluate mixing times when using low-bulk-density ingredients such as DDGS and wheat midds. Further research is needed to verify these results in large-scale commercial mixers.

Key words: bulk density, diet type, mixing efficiency

Introduction

In general, a CV of less than 10% among 10 samples from a batch of feed is considered ideal when determining the time needed for adequate diet mixing. Mixing times for different types of mixers usually have been established for corn-soybean-meal diets; however, less information is available on the effects of low bulk density ingredients on mixing uniformity.

Generally, mixers are rated for an amount of material based on weight (i.e., a 1-ton mixer), but this rating does not consider the density of the material to be mixed. Based on its volume, a low-density, high-fiber diet may require more mix time than a corn-soybean meal diet, but data is not available to support this assumption. Therefore, the objective of this study was to determine the difference in mixing times needed to minimize CV of diets with different bulk density.

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Procedures

An experimental 60-lb capacity, 1.5-ft^3, double-ribbon mixer was used in this experiment. Two diets were formulated that differed in bulk density: (1) a typical corn-soybean meal–based diet (high bulk density), and (2) a corn-soybean meal diet containing 30% dried distillers grains with solubles (DDGS) and 19% wheat midds (low bulk density; Table 1). A total of 3 batches of each diet were prepared. Each batch was 60 lb and ingredients were weighed individually, separating the minor ingredients from the major ingredients. The major ingredients (corn, DDGS, wheat midds, soybean meal) were weighed into the bag in the reverse order they would normally be batched into a mixer. When the bags were dumped into the mixer, the ingredients were arranged in the order of major ingredients on the bottom, followed by the addition of minor ingredients.

After loading the mixer, the diet was blended for 60 sec, stopped and sampled, then blended for an additional 60 sec, stopped and sampled, and finally blended for an additional 120 sec before the final samples were obtained. Consequently, samples were obtained after 60, 120, and 240 sec of total mixing time for each batch. A total of 10 samples also were collected as the feed was discharged from the mixer after the final mix was completed. During the first 10 sec of mixing for each batch, the discharge slide was opened and a small amount of feed was collected into a bucket then returned to the mixer to eliminate any dead spots within the mixer. A stainless steel scoop was used to collect samples obtaining 1.0 ounce of the high-fiber feed and 1.3 ounces of the corn-soybean meal feed. At each sample time, samples were taken from 10 locations within the mixer. The mixer was thoroughly cleaned between each batch. A 2-lb sample was also collected at discharge to determine bulk density of the final mixed diet.

Mixing uniformity was determined using Quantab Cl titrators (Environmental Test Systems, Elkhart, IN). For each sample, 10 g were weighed and placed into a plastic cup. Ninety milliliters of hot (170°F) distilled water was added to the cup and stirred for 30 sec, let stand for 60 sec, then stirred for an additional 30 sec. Folded circular filter paper was then placed into the solution followed by the placement of the Quantab chloride titrator. The solution was allowed time to completely saturate the wick of the titrator until the indicator strip at the top turned from yellow in color to black. The titrator was then removed from the solution, read, and recorded. The strip values were converted to a percentage based on the dilution factor table provided by the titrators. These values were then used to calculate CV.

Results and Discussion

The bulk density of the corn-soybean meal diet was 36.2 lb/ft^3, whereas the high-fiber diet containing 30% DDGS and 15% wheat midds had a bulk density of 28.8 lb/ft^3. As mixing time increased, CV decreased and the corn-soybean meal–based diet achieved a CV of 8% at 60 sec (Figure 1). The diet containing low-bulk-density ingredients required a mixing time of 240 sec to achieve a CV less than 10% (Table 2).

The difference in CV between the corn-soybean meal–based diet and the high-fiber diet are meaningful at the lower mixing times. Based on the amount of volume required by the low-density diet in the mixer compared with the high-density diet, optimum mixing time is affected (Figures 2 and 3). Our data demonstrate that differences in bulk density

affect the mixing time needed to acquire a uniform mixture. Feed manufacturers may need to consider different mixing times when using low-bulk-density ingredients such as DDGS and wheat midds. Additional research should be conducted using large-scale commercial mixers to determine the optimum mixing times of diets differing in bulk density.

Table 1. Diet composition

Item	Corn-soybean diet	High-fiber diet
Ingredient, %		
Corn	74.57	41.78
Soybean meal	22.92	6.34
DDGS[1]	-	30.00
Wheat middlings	-	19.00
Monocalcium P, (21% P)	0.4	-
Limestone	1.25	1.65
Sodium chloride[2]	0.35	0.35
L-lysine HCl	0.15	0.45
DL-methionine	0.03	-
L-threonine	0.015	0.065
L-tryptophan	-	0.045
Trace mineral premix	0.15	0.15
Vitamin premix	0.15	0.15
Phytase	0.015	0.015
Total	100	100
Calculated analysis, %		
Total lysine, %	0.98	1.04
CP,%	17.2	18.2
Ca, %	0.61	0.67
P, %	0.44	0.52
Available P, %	0.25	0.34
Bulk density, lb/ft^3	36.2	28.8

[1]Dried distillers grains with solubles.
[2] Table salt with a particle size of 393 μm was used.

Table 2. Effects of diet type and mixing time on feed uniformity[1]

	CV, %	
Item	Corn-soybean meal diet	High-fiber diet
Mixing time, sec		
60	8	33
120	9	15
240	7	7
Discharge	5	9

[1]Values represent the mean of 3 replicates per diet and mix time.

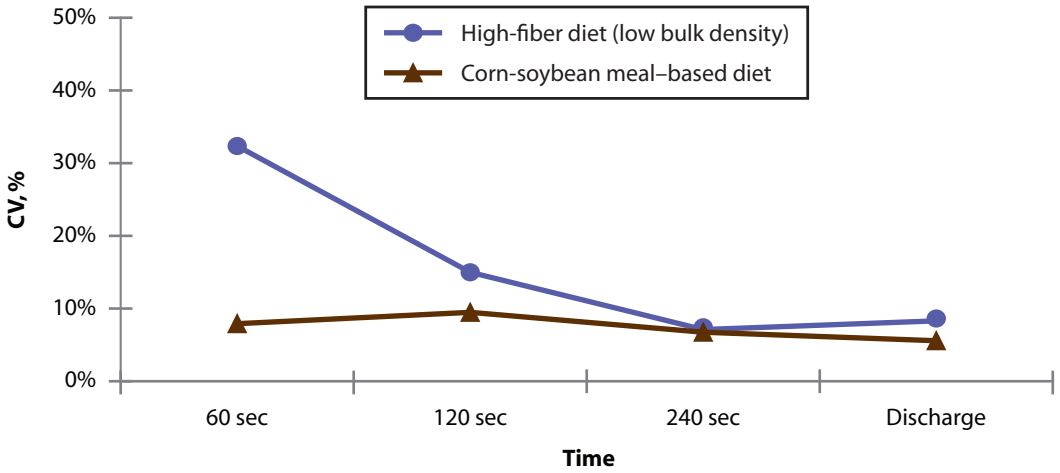

Figure 1. Effects of mixing time on feed uniformity. Coefficient of variation (CV) was measured by collecting ten 10-g samples at each mix time and analyzing for Cl concentration (Quantabs, Environmental Test Systems, Elkhart, IN). Values represent the mean of 3 batches (replications) for each diet. The discharge samples were collected as the diet exited the mixer from a slide on the bottom of the mixer after 240 sec of mixing. The time required to discharge the diet was approximately 120 sec.

Figure 2. The 60-lb double-ribbon mixer with the corn-soybean meal–based diet. The ribbons are visible when the mixer is filled to capacity.

Figure 3. The 60-lb double-ribbon mixer with the low-bulk-density ingredients. Unlike the corn-soybean meal–based diet, the ribbons are less visible, illustrating the extra volume that the low-bulk-density diet consumes in the mixer.