

# ASSESSING UNIFORMITY OF TOTAL MIXED RATIONS

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**ABSTRACT.** *Whole shelled corn, black beans, white beans, and fuzzy whole cotton seed were used as tracers in blended total mixed rations to assess uniformity. Tracers were placed in varied locations of two mixers, but under the conditions of these experiments, tracer placement did not affect the coefficient of variation (CV; the uniformity measurement). This is an indication of mixer performance. With a paddle mixer blending a beef ration which did not have much long particle mass, each tracer performed similarly; as mixing time increased from 180 to 600 s, the CV did improve at a rate of 1% reduction per minute – starting at 24.8% with 180 s of mixing. With a reel-type mixer and a dairy ration containing 19% particle mass longer than 19 mm, the type of tracer affected CV. Slick tracers (corn, white beans, black beans) had higher CVs (28%, 33%, and 33%, respectively) than fuzzy whole cotton seed (18%); counts of slick tracers also decreased as the mixer emptied. The clingy whole cotton seed tracer suggested a more uniform blend (lower CV) and there was not a tendency for increase, nor decrease, in cotton seed counts as the mixer emptied. For the stationary reel mixer, increasing mixing time from 350 to 1100 s did not reduce CV. Uniformity of size particle size distribution among samples was better than uniformity of countable tracers for both mixers.*

**Keywords.** *Beef, Blending, Dairy, Feed, Livestock, Mixer, Particle size, Total mixed rations, Tracer, Uniformity.*

Total mixed rations (TMR) are the most popular confined feeding method for ruminants, especially for dairy cows. A TMR is composed of forages, byproducts, grains, protein, minerals, and vitamins that have been mixed together to make a balanced ration. Each bite of feed should contain the same proportion of forages and concentrates in order to guarantee the same nutrition. A uniform TMR has many potential advantages, such as improving the animals' health, decreasing the feed cost, and improving the meat production of beef and milk production of cows, etc. The uniformity is an important aspect of TMR delivery. When considering mix uniformity, there are two distinct types of variation: variation among similar batches and variation within a single batch. Variation among batches is controlled by monitoring feedstuff characteristics and using proper formulation, accurate moisture information, and calibrated scales for accurate weighing by diligent mixer operators (Buckmaster, 2009). Within batch variation is controlled with proper mixer operation which includes factors such as fill order (sequence of putting feedstuffs into the mixer), mixing

time, and mixing protocol (Rippel et al., 1998) and mixer maintenance (Oelberg, 2013). In the five-herd study of Predgen and Chase (2002), variation was higher between days than within days.

Among batch variation, Buckmaster and Muller (1994) applied uncertainty analysis to blended livestock rations and concluded that nutrient concentrations in forages likely contribute most to among batch variation in TMR nutrient concentrations. The sensitivity of actual ration uncertainty to ingredient characteristic uncertainty depends upon the makeup of the ration; there is compelling evidence that frequent and good sampling of forages (particularly wet forages or those from smaller lots) for chemical and physical quality attributes is necessary to keep the TMR properly formulated (Kertz, 1998; James and Cox, 2008).

Variability in crude protein concentration of TMRs delivered was reported by James and Cox (2008). With means near 17.2%, the standard deviations were 1.4% to 2.1% and the maximum to minimum range was as high as 12%. They noted significant differences between farms in loading accuracy, reflective of operator ability and diligence, and equipment differences. Silages, in general, had the highest amount deviations by load. Oelberg (2013) has provided evidence that mixer loading, mixing time, and fill order affect particle size distribution along the feedbunk and blend uniformity.

To close the loop in TMR delivery systems, the quality of the delivered TMR should be monitored. This could be done using physically or chemically observable tracers or simply particle size distribution. The tracer concept is useful for evaluating within batch variation (S380; *ASABE Standards*, 2011b); Bierman (2008) suggested salt, calcium, ionophores, or non-protein nitrogen. Physical

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tracers would provide a less expensive option than chemical tracers while also providing a “teachable moment” in outreach settings. However, Johnson et al. (2000) found countable tracers (cinnamon red hots (pearls), malted milk balls, and packaging peanuts) to have much higher coefficient of variation (CV, ranging from 35 to 81) than lab chemical attributes (dry matter, acid detergent fiber, crude protein; ranging from 0.2 to 3.0).

Although the chopped forage particle size standard (S424.1; *ASABE Standards*, 2011c) provides more points along the size distribution continuum, the simple, on-farm type method of evaluating TMR particle size distribution (Lammers et al., 1996; Kononoff et al., 2003) has been widely used in the industry; with it, identifying physical tracers in the mix is easier than ever before (Oelberg, 2009; Oelberg, 2013). A check of the particle size distribution within the mix can also be a tool in evaluating mix uniformity (Rippel et al., 1998; Jordan, 2001; Vegricht et al., 2007; Bierman, 2008; Dahlke and Strobehn, 2009). A CV of less than 10% seems to be the target, although there is no published data of effect of uniformity on animal performance (Rippel et al., 1998; Bierman, 2008). However many published reports and unpublished reports often have CVs higher than this and the CV reported depends upon the tracer or marker used.

Fan et al. (1970) critically reviewed several uniformity measures for reporting experimental results and mixing theory. The ASABE standard regarding solids mixing (S303.4; *ASABE Standards*, 2011a) calls for at least 10 samples taken and uses CV as the primary uniformity measure. ASABE standard S380 (*ASABE Standards*, 2011b), related to portable farm batch mixers, calls for 15 equally spaced samples with either a salt (at 0.5%) or whole kernel corn (at 5.0%) tracer; CV is also used as the uniformity measure. Rippel et al. (1998), used 10 and 5 samples per batch for analysis.

The goal of this work was to experiment with particle size and physical tracer methods for evaluating the uniformity of TMR. Using a protocol which included varying tracer types, varied tracer placement, and particle size analysis, the specific, objectives were:

- to compare alternative tracers with regard to their assessment of uniformity,
- to assess the use of particle size in evaluating blend uniformity,
- to evaluate uniformity and effect of mixer type and mixing time.

## METHODS

### TRACERS

Mixing experiments were conducted with two different mixers and several different tracers. Tracers needed to be relatively inexpensive, suitable for livestock ingestion, and reasonably easy to separate and count from samples. In addition to particle size mass fractions, the countable tracers used included white beans (WB), black beans (BB), fuzzy whole cotton seeds (WCS), mini penne pasta (which did not work out because the pasta breaks down); and

whole shelled corn (SC) (in rations which did not have whole corn kernels as a part of the ration). Tracer amounts were adjusted so that: (a) the count was large enough that a difference of one unit would nominally represent less than 5% variation and (b) the count was small enough to reduce the tedious labor of sample analysis. Targets were 15 to 30 countable units (beans, kernels, etc.) expected per 1 kg (2 lb) sample (table 1). The tracers were placed into the mixers in controlled locations (explained below) to enable evaluation of tracer placement (location) as well as tracer type on blend uniformity.

In addition to countable tracers, particle size distribution was measured using the device described by Kononoff et al. (2003). The four size ranges from the device include long (>19 mm), medium-long (8-19 mm), medium-short (1.2-8 mm), and small (<1.2 mm). Rather than individual fractions, the cumulative fractions of long (L), medium-long plus long (MLL), and all-but-small (ABS) were evaluated for uniformity. Ten samples per batch were taken and evaluated.

### MIXERS

A stationary Rotomix 354 reel mixer (Dodge City, Kans.) with the hay processor option was used for one set of experiments. This stationary version of the mixer has a drive unit different from the mobile models so that the power requirement is reduced. Actual mixing times tested were: 350, 600, and 1100 s; these correspond to rotor revolution counts of 16, 27, and 50 (which correspond to mixing times of 190, 330, and 600 s for trailer-mounted mobile designs). Batches were 908 kg (2000 lb) of a typical dairy TMR which was already blended (from another mixer); the mixer was filled to approximately 1/3 rated capacity but the material flow in this style of mixer should yield acceptable mixing at this fill level. The ration consisted of 48% whole plant corn silage, 20% haycrop silage, 10% high moisture corn, 4% grass hay, and the balance was small grains and finely ground supplements. In each batch, tracers were placed on top of feed already in the mixer in the following locations: rear (poured in a concentrated pile), front (poured in a concentrated pile), center (poured in a concentrated pile), and spread (distributed by hand over the entire area of the mixer). The rear, front, and center locations were over the fore-to-aft augers which constitutes the normal fill location for this mixer. The mixer was off during filling and after the designated mixing time, 10 samples of approximately 1.5 kg (3 lb) were taken. Neither the first nor the last material of the blend was sampled; with approximately equal time between sampling, samples were taken at the unloading chute when the mixer scales read 863, 772, 681, ... 45 kg (1900, 1700, 1500, ... 100 lb) (similar to the

**Table 1. Tracer amounts used in mixing experiments.**

Tracer	Amount Added to the Blend (kg/kg)	Average Normalized Tracer Count in Samples (number/kg)
Whole shelled corn	0.006	17
Whole fuzzy cotton seeds	0.003	30
Black (turtle) beans	0.003	15
White (navy) beans	0.0045	15

procedure of ASABE Standard S380; *ASABE Standards*, 2011b).

A Calan Super Data Ranger paddle mixer (Northland, NH) was used for a second set of experiments. Each batch contained 450 kg (1000 lb) which was near rated capacity of this mixer. This ration was a grain blend with little (<10%) forage; since the ration included corn, whole shelled corn was not added as a tracer. For these experiments, BB, WB, and WCS tracers were placed in three locations: first (bottom of mixer), middle (after approximately half of the ration was in the mixer), and last (on top of all other ingredients). The mixer was off during filling and mixing time prior to the start of unloading was 180, 330, and 600 s. Similar to the procedure with the reel mixer, 10 samples of approximately 1.5 kg (3 lb) were taken after the designated mixing time; neither the first nor the last material of the blend was sampled and with approximately equal time between sampling, samples were taken at the unloading chute when the mixer scales read 409, 363, 318, ... 45 kg (900, 800, 700, ... 100 lb).

#### DATA ANALYSIS

Particle size distribution was expressed on an as-is mass basis. Tracer counts were normalized to actual sample size (number per kg) by dividing the count by sample weight. Means, standard deviations, and coefficient of variations (CV) were computed and the primary evaluation of uniformity was CV. Following the work of Maleki et al. (2006), a uniformity coefficient ( $U_c$ ) was also computed. This  $U_c$  is based on the least absolute deviation rather than least squares and is bounded from 0 to 1; it will approach 1 with perfect uniformity.

Multiple linear regression with indicator variables was used to determine the effects of mixing time, tracer type, tracer location, and sample number on measured uniformity.

## RESULTS AND DISCUSSION

Although the data collection and analysis procedures were similar for the experiments with the two different mixers, the rations blended and the results regarding uniformity factors were very different. The more straightforward results of the paddle mixer experiment will be presented first.

With the paddle mixer, the particle size fractions averaged 0.23% long, 42% medium long plus long, and 89% all-but-small. With the extremely small proportion of long particle mass, conclusions regarding uniformity of blending of the large particles are likely inaccurate. With a total of 9 batches, 90 samples were collected and analyzed for tracer counts and particle size distribution; the CV summary is contained in table 2. The average CV of the countable tracers was 21.9%.

There was no tendency of tracer counts to increase nor decrease as sample number (from 1 to 10) varied (data not shown). Multiple linear regression of CV as potentially influenced by mixing time (linear scale), tracer location (indicator variables for first/bottom, middle, last/top), and tracer type (BB, WB, WCS) yielded:

$$CV = 27.7 - 0.966T_{\min} - 0.312I_{\text{mid}} - 3.99I_{\text{last}} + 0.154I_{\text{BB}} + 4.58I_{\text{WB}} \quad (R^2 = 0.22)$$

(<0.001)      (0.10)      (NS)      (NS)      (NS)      (NS)

where

Values in parentheses are p-values indicating significance of the corresponding coefficients (NS means  $p > .25$ )

$T_{\min}$  = mixing time in minutes,

$I_{\text{mid}}$  = indicator variable for tracers placed in the middle of the batch (1, 0 otherwise),

$I_{\text{last}}$  = indicator variable for tracers placed added last to the batch (on top; 1, 0 otherwise),

$I_{\text{BB}}$  = indicator variable for black bean tracers (1, 0 otherwise),

$I_{\text{WB}}$  = indicator variable for white bean tracers (1, 0 otherwise).

The intercept term of 27.7 reflects the least squares mean of the CV of WCS tracers placed in first (bottom of the mixer). Only mixing time ( $p=0.10$ ) had any significant effect on CV; tracer type nor tracer location influenced CV ( $p>0.25$ ). Over the range of mixing times tested, each additional minute of mixing time reduced CV by about 1.0%. The CV of 18.1% after 600 s of mixing is higher than recommended levels even with the effective tumble action (Rippel et al., 1998; Bierman, 2008). It is noteworthy that the uniformity as indicated by smooth

**Table 2. Coefficients of variation within 9 batches from a paddle mixer (10 samples per batch).**

Batch	Mix Time (s)	Coefficient of Variation <sup>[a]</sup>					
		Black Beans	White Beans	Whole Cotton Seeds	Long Particles	Medium Long Plus Long Particles	All-but-Small Particles
1	180	15.0 <sup>b</sup>	39.6 <sup>c</sup>	28.2 <sup>a</sup>	31.4	0.6	0.4
2	330	21.0 <sup>b</sup>	9.3 <sup>c</sup>	16.2 <sup>a</sup>	25.9	0.6	0.6
3	600	19.6 <sup>b</sup>	17.5 <sup>c</sup>	17.1 <sup>a</sup>	77.8	17.4	4.4
4	180	38.5 <sup>c</sup>	16.5 <sup>a</sup>	26.1 <sup>b</sup>	32.7	9.5	2.7
5	330	16.9 <sup>c</sup>	35.0 <sup>a</sup>	24.3 <sup>b</sup>	34.7	10.8	2.4
6	600	18.6 <sup>c</sup>	38.9 <sup>a</sup>	21.5 <sup>b</sup>	31.3	13.7	2.6
7	180	23.5 <sup>a</sup>	33.0 <sup>b</sup>	20.2 <sup>c</sup>	46.5	11.7	1.5
8	330	21.3 <sup>a</sup>	20.2 <sup>b</sup>	24.1 <sup>c</sup>	50.7	16.4	3.3
9	600	13.5 <sup>a</sup>	14.3 <sup>b</sup>	11.7 <sup>c</sup>	30.1	4.7	2.8

<sup>[a]</sup> a placed in first

b placed in the middle

c placed in last

tracers (BB, WB) no different than with the more clingy fuzzy WCS in this ration ( $p>0.25$ ).

Uniformity of different particle size ranges was different for the samples taken from the paddle mixer.

$$CV = 35.3 + 0.785T_{\min} - 30.7I_{\text{MLL}} - 37.8I_{\text{ABS}}$$

(<0.001)      (0.25)      (<0.001)      (<0.001)

$$(R^2 = 0.76)$$

where

$I_{\text{MLL}}$  = indicator for medium plus long-sized particles (1, 0 otherwise),

$I_{\text{ABS}}$  = indicator for all but small particles (1, 0 otherwise).

The CV of mass of large (L) particles averaged 35% (intercept of regression model) and was higher ( $p<0.001$ ) than CV of medium long plus long (4.6%) and all but fine (2.5%) particles.

In summary, the paddle experiment showed that each tracer performed similarly, longer mixing time did slightly improve uniformity, and location of tracer placement did not affect the uniformity measure. The lack of effect of tracer placement location itself is some assurance of mixer effectiveness; it illustrates that material placed in the mixer moved adequately to disperse even “pockets” of tracers which were initially concentrated in one location. Long particles were less uniformly distributed than other size particles, but this may be, in part, due to the very small amount (<0.5% of the mix) present. CV of tracer counts was much higher than CV of medium and small particle size fractions expressed as mass percentages.

With the Rotomix reel mixer, results were very different. As figure 1 illustrates for just one tracer and one mixing time, the count of WB as a tracer decreased as the mixer was emptied and samples were taken ( $p<0.01$ ). This was generally true for the other “slippery” tracers (BB, SC; data not shown). However, this was different than the random variation of counts of the WCS (fig. 2) which neither increased nor decreased, as unloading occurred. These factors are likely related to the cleanout nature of this

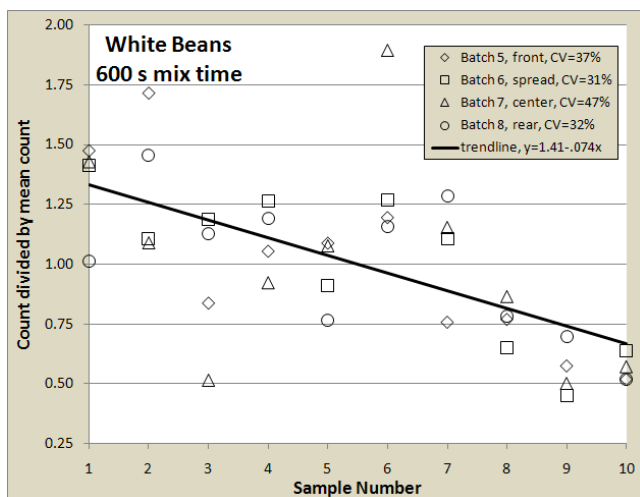


Figure 1. Normalized tracer counts for white beans with 600 s of mixing.

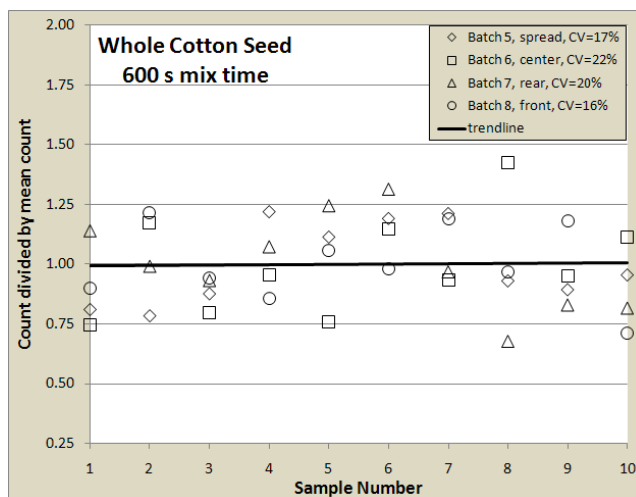


Figure 2. Normalized tracer counts for whole cotton seeds with 600 s of mixing.

specific mixer; at the time of these experiments, there was a gap between the reel and the mixer bottom surface due to wear on the plastic sweep. Linear effects of normalized count versus sample number, with a mixing time correction, were determined for each of 12 batches for each of the 4 tracers:

$$TC_{\text{corn}} = 24.1 - 0.00203T_{\min} - 0.981SN \quad (R^2 = 0.36)$$

(<0.001)      (0.077)      (<0.001)

$$TC_{\text{WCS}} = 26.9 + 0.00135T_{\min} + 0.202SN \quad (R^2 = 0.02)$$

(<0.001)      (NS)      (NS)

$$TC_{\text{BB}} = 16.0 + 0.00236T_{\min} - 0.737SN \quad (R^2 = 0.25)$$

(<0.001)      (0.041)      (<0.001)

$$TC_{\text{WB}} = 14.1 + 0.00325T_{\min} - 0.703SN \quad (R^2 = 0.25)$$

(<0.001)      (0.005)      (<0.001)

where

$TC$  = tracer count (#/kg) with the subscript indicating the type of tracer,

$SN$  = sample number (1 to 10) within the batch.

The significant coefficients to  $SN$  in these multiple linear regressions indicated that there was a tendency for fewer tracers later in the mix for tracers other than WCS; i.e., the slick tracers behaved differently than the fuzzy cotton seeds.

Table 3 summarizes the CV data for the 12 batches. Over all batches (including the varied mixing times), the average CVs for the countable tracers SC, WCS, BB, and WB were 27.7%, 18.2%, 33.4%, and 33.4%, respectively. Interaction terms were all insignificant ( $p>0.25$ ), so the multiple linear regression result without interaction terms is shown here:

**Table 3. Coefficients of variation within 12 batches from a reel mixer (10 samples per batch).**

Batch	Mix Time (s)	Coefficient of Variation <sup>[a]</sup>						
		Shelled Corn	Black Beans	White Beans	Whole Cotton Seeds	Long Particles	Medium Long Plus Long Particles	All-but-Small Particles
1	350	30.8 <sup>b</sup>	39.3 <sup>c</sup>	38.9 <sup>a</sup>	Nd	24.6	6.15	1.022
2	350	24.6 <sup>c</sup>	34.5 <sup>a</sup>	33.9 <sup>d</sup>	Nd	14.0	2.72	0.718
3	350	27.5 <sup>a</sup>	32.7 <sup>d</sup>	25.8 <sup>b</sup>	Nd	16.8	4.75	0.478
4	350	26.4 <sup>d</sup>	42.7 <sup>b</sup>	21.7 <sup>c</sup>	18.7 <sup>a</sup>	14.5	2.41	0.536
5	600	30.3 <sup>b</sup>	33.1 <sup>c</sup>	38.6 <sup>a</sup>	18.0 <sup>d</sup>	21.9	4.17	0.475
6	600	25.3 <sup>c</sup>	34.3 <sup>a</sup>	32.2 <sup>d</sup>	17.0 <sup>b</sup>	12.4	3.11	0.727
7	600	24.0 <sup>a</sup>	32.9 <sup>d</sup>	43.6 <sup>b</sup>	16.2 <sup>c</sup>	26.2	3.65	0.562
8	600	33.0 <sup>d</sup>	29.5 <sup>b</sup>	29.7 <sup>c</sup>	16.1 <sup>a</sup>	28.5	3.88	0.540
9	1100	21.2 <sup>b</sup>	34.5 <sup>c</sup>	27.8 <sup>a</sup>	15.0 <sup>d</sup>	28.1	4.23	0.560
10	1100	27.4 <sup>c</sup>	28.7 <sup>a</sup>	34.2 <sup>d</sup>	22.2 <sup>b</sup>	26.8	4.81	0.730
11	1100	37.1 <sup>a</sup>	32.4 <sup>d</sup>	41.7 <sup>b</sup>	16.2 <sup>c</sup>	18.2	3.47	0.586
12	1100	24.4 <sup>d</sup>	24.7 <sup>b</sup>	32.9 <sup>c</sup>	24.5 <sup>a</sup>	17.1	5.14	0.538

<sup>[a]</sup> Nd no data.  
<sup>a</sup> placed in front.  
<sup>b</sup> placed in the center.  
<sup>c</sup> placed in rear.  
<sup>d</sup> spread over the mixer area.

$$CV = 27.7 - 0.000691T_{\min} - 9.49I_{WCS} - 5.67I_{BB}$$

( <0.001 )      ( NS )      ( <0.001 )      ( 0.011 )

$$+ 5.82I_{WB} + 1.46I_F + 0.438I_C - 0.307I_R \quad (R^2 = 0.22)$$

( 0.0098 )      ( NS )      ( NS )      ( NS )

where

$I_F$  = indicator for tracers placed in the front of the mixer (1, 0 otherwise),

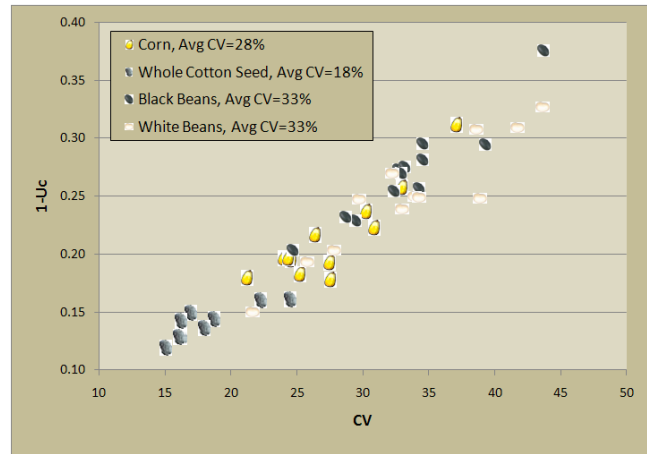
$I_C$  = indicator for tracers placed in the center of the mixer (1, 0 otherwise),

$I_R$  = indicator for tracers placed in the rear of the mixer (1, 0 otherwise).

The intercept term of 27.7 reflects the least squares mean of the CV of SC tracer spread over the top of the mixer. Mixing time (over the range of 350 to 1100 s) did not affect uniformity ( $p > 0.25$ ). The CV of WCS was significantly ( $p < 0.001$ ) lower than the CV of SC; the CV of BB and WB were similar and both were higher ( $p < 0.01$ ) than that of SC. This suggests that shape and surface traits of the tracers (clingy WCS, slippery SC, BB, and WB) influenced the uniformity measure. The placement of the tracer into the mixer (front, center, rear, spread) did not affect measured uniformity ( $p > 0.25$ ).

Figure 3 illustrates the comparison of blend uniformity determined with tracer counts expressed using CV (a least squares computation) and the uniformity coefficient (a least absolute difference calculation) for the 12 batches made with the reel mixer. With a near linear relationship, the choice of measure does not influence results. The lower variation (1-Uc or CV) of WCS compared to SC, BB, or WB can be seen in figure 3.

For the TMR blended in the Rotomix reel mixer, the particle size fractions averaged 19.4% L, 48.0% MLL, and 82.1% ABS. This type of mixer is relatively gentle and likely does not cause much reduction in the long particle mass. The CV of long particle mass averaged 16.7% and was not affected by mixing time ( $p > 0.25$ ). The CV of MLL fraction averaged 3.6% and it also was not affected by



**Figure 3. Uniformity coefficient versus coefficient of variation for four different tracers in batches.**

mixing time. The CV of the ABS fraction averaged less than 1% with no effect of mixing time. The better uniformity of small sized particles is consistent with Bierman (2008).

In summary, the reel mixer experiment exposed different behaviors of tracers which have different surface characteristics. Reasonably long mixing time still resulted in CV based on tracer counts exceeding 20%. Analysis of uniformity via particle size distribution fractions suggested higher uniformity than analysis of tracers. Both tracers and particle size fractions imply something about blend uniformity. CVs of both should be low to instill confidence that blending of all ration elements is thorough. If the initial location of concentrated “pockets” of tracers is not undetectable (not affecting CVs) in the delivered ration, that, in itself, is some evidence of adequate material flow for blending.

## CONCLUSION

Alternative tracers were compared with regard to their utility to assess uniformity; tracers used were shelled corn, white beans, black beans, and fuzzy whole cotton seed.

Additionally, tracers were placed in various locations to determine if placement was a factor for the types of mixers tested. For a paddle-type mixer and a blend which did not include very much long particle mass, neither tracer-type nor tracer placement within the mixer influenced measured uniformity. With a reel-type mixer blending a ration which had significant long particle mass, the type of tracer (slick or clingy) influenced the measured CV significantly; tracer type was more significant than mixing time.

Particle size distribution was also used to evaluate blend uniformity. For the blends and mixers used, uniformity results from particle size analysis were much better than with tracer counts. Effects of mixing time and sample number were similar with size analysis as with tracer counts, but the variation magnitudes with size analyses were smaller. However, when the fraction of a certain size range (for example, long material) is small; assessment of uniformity through particle size analysis is difficult.

Although sample collection and analysis is straightforward and computation of CV is simple, characterization of blend uniformity is a complex issue. Tracer surface attributes caused different distribution within samples taken at the exit chute. Even with typical mixing time – likely adequate for most production situations – measured tracer-based CVs of typical rations exceeded 15%, sometimes 30%. Even with a wide range of mixing times which were expected to uncover uniformity differences (350 to 1100 s with a stationary reel mixer), neither CV of tracer counts nor CV of particle size fractions were affected by mixing time. CVs of tracer counts were affected by mixing time when a paddle mixer was operated from 180 to 600 s.

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