

## Mixing Wet Distillers Grain in Beef Feed Rations

### A.S. Leaflet R2590

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#### Summary

Distillers grains use in beef feeding operations has become more popular over the recent years due to the growing ethanol industry; although, little is known about the order in which the ingredients should be added, optimum mixer design, and optimum mix time when using distillers grains. Not using the correct methods and equipment when mixing distillers grains cost beef producer's time and money. Recognizing the lack of information available on the mixing process, a joint effort by four professors and one junior undergraduate student from the Agricultural & Biosystems Engineering Department at Iowa State University was established. The results of the effort concluded that when adding distillers grains to feed rations, no major changes to the producers mixing process are needed. With this, the recommendations resulting from this study are to follow the manufacturer's recommended mix times, and to add distillers grains to the ration near the end of the mixing process.

#### Introduction

Throughout the United States, one of the most commonly used ingredients in the finishing ration of beef cattle is corn, and in 2009 the U.S. produced 331 million Mg (13 billion bushels) of corn. Corn can serve as the only grain source in backgrounding and finishing diets for beef, and is one of the most affordable, abundant, and sustainable grains in the U.S. Even though it is relatively low in protein, corn contains almost 70% starch. However, corn is also the number one export grain in the U.S., with roughly 56 million Mg (2.2 billion bushels) being exported in 2009 and because it is so high in starch, it is in demand for uses other than cattle rations, such as snack foods, cereal, alcohol, corn syrup, glucose, and ethanol production. This high demand for corn is leaving beef producers to look to corn alternatives for use in their rations. With the increase in the number of corn ethanol plants (140 across 22 states), and bio-fuels over the past few years, the corn substitute that beef producers are turning to is distillers grain. Distillers grains (DGs) are co-products of ethanol production. The two main sources of DGs are beverage alcohol brewers and the growing number of corn ethanol plants. In the ethanol production process, grains such as corn are ground coarsely and mixed with hot water. Next, after the mixture has cooled, yeast is added and the mixture then ferments for

several days to a week. The solids left after the fermentation process are distillers grains. There are two types of distillers grains: wet distillers grains (WDG), and dry distillers grains (DDG). DGs have become a major substitute option to corn for quite a few reasons. One of those reasons is that DGs are very flexible as a feed ingredient. They can be used for energy or as a protein supplement. This is an advantage over corn alone because of its low protein levels. DG is made up of the non-fermentable components of the corn and is, therefore, rich in cereal proteins, fat (energy), minerals, and vitamins. It is sometimes considered an even better ingredient than corn due to the fact that it provides energy comparable to corn, but from a non-starch source. This reduces the risk of digestive disorders such as acidosis. DG also is a great choice due to the fact that it improves fiber digestion in the rumen, and is also a very flexible component of feed rations. For instance, it can be used in creep rations, as a supplement in grazing and high roughage diets, in low phosphorus diets, wintering cows or developing heifers, and finish rations cattle. However, there are some disadvantages to DGs also. These include difficulty in storage and handling, transportation, amount used in ration, and the recent availability issue caused when ethanol plants close down due to unfavorable prices. Of course these disadvantages can lean more toward one type of distillers than another but these are the major issues with DGs.

#### Materials and Methods

As with any new ration ingredient, there are issues that must be resolved and methods to be refined so as to obtain the best possible mix. In a survey of 2000 beef producers who use WDG (Baskett et al. 2008), 94 of 228 responders stated that they had experienced problems with the mixing and storage of WDG. The problems they included (in order of decreasing occurrence):

- Order of ingredient addition
- WDG moisture variation
- Mixing time
- Frozen chunks of WDG
- Metering proper quantities
- Variation in particle size
- Mixer performance

Recognizing the lack of information available on the mixing process of WDGs, a joint effort by four professors and one junior undergraduate student from the Agricultural & Biosystems Engineering Department at Iowa State University was established. Through these efforts this list was narrowed down to three problems:

- Order in which the ingredients are added
- Mixer design (reel vs. vertical)

- Mix time (the time from when the last ingredient is added until pulling out of loading area)

The project testing was done at Jeff Schuler's feed yard, seven miles south of Atlantic, Iowa. Jeff feeds approximately 800 steers annually from a starting weight averaging 320 kg (700 lbs) to a final weight of 570 kg (1250 lbs). The ration used during testing was a finishing feed ration fed to steers weighing about 500 kg (1100 lbs). It was composed of ingredients already being fed, which included custom tub ground hay, rolled corn, WDG, and a liquid molasses-based protein. The custom ground hay was a mix of 2/3 alfalfa-brome grass and 1/3 corn stalks. Corn was rolled using a static Badger roller mill, model # 124X4, using corn at 16 to 18% moisture. The liquid protein (Rumensin 80 Core Max 30) was a molasses-based custom

medicated additive, and was purchased from Quality Liquid Feeds, Inc. The additive was delivered directly to the mixer via an electric pump. Random samples from the WDG pile were taken and measured for moisture which averaged 60% moisture and was purchased and delivered from the Green Plains Renewable Energy Plant in Shenandoah, Iowa.

### Test Equipment

The equipment used for the project included two test mixers, one mixer tractor, and one front end loader tractor. The mixer tractor was a 2008 New Holland Model # T6080 (Figure 1 a). This tractor is rated at 97 kW (130 hp). The front end loader tractor was a 2008 John Deere Model # 5425 (Figure 1 b), and is rated at 63 kW (85 hp).



(a)



(b)

**Figure 1. Tractors: 2008 New Holland Model # T6080 (a) 2008 John Deere Model # 5425 (b).**

The reel/auger mixer was a Kuhn Knight Reel Auggie Model # 3025 mixer (Figure 2 a) with a mixing capacity of 7.1 m<sup>3</sup> (250 ft<sup>3</sup>). This mixer uses a system of augers and a large rotating reel (Figure 2 b) to mix the ration by gently lifting and tumbling all the feed ingredients. The large 150 cm (60 in) diameter reel works together with the two side blending augers with diameters of 46 cm (18 in) to produce the end-to-end side-to-side mixing action. Each of the two

augers is equipped with knives to provide the mixer with the effective hay-handling capabilities needed for beef rations. The discharge from this mixer is a side exit, hydraulic motor-driven variable height slide tray using three augers. This wagon was outfitted with an electronic scale from Eaton Ag Electronics.



Figure 2. Kuhn Knight Reel Auggie Model # 3025 (a) reel and auger system (b).

The vertical mixer was a Schuler Single Vertical Model # 2820 mixer (Figure 3 a) with a mixing capacity of 7.93 m<sup>3</sup> (280 ft<sup>3</sup>). This mixer uses a single high speed vertical auger (Figure 3 b), to lift and disperse feed to the outside of the chamber, thus creating a whirlpool mixing action. This auger also has the option of being fitted with up to five knives to aid in the processing of high forage rations.

However, for our forage ration we included only two knives to help limit the overcutting of the forage since it was already ground. The discharge from this mixer is a front-to-side exit hydraulic motor driven conveyor. This wagon was equipped with an electronic scale from Avery Weigh-Tronix.



Figure 3. Schuler Single Vertical Model # 2820 (a) vertical auger system (b).

### Procedure

A decision was made to incorporate the mixing order and mixer that Jeff was already using and then to test an alternative against it. The test load was a 2200 kg (4800 lb) finishing ration that Jeff was feeding. This size of load corresponds to the manufacturer's recommendations of optimum load size. The two styles of mixers used were the Knight reel mixer and the Schuler vertical mixer. Standard mix times and addition orders were determined following manufacturer's recommendations for each mixer and incorporating the program that Jeff already had in place.

Both the manufacturers recommended 5 minutes of complete ration mixing. "Complete ration mixing" means that all ingredients are added and the time starts after the last ingredient has been added. To determine if this was in fact the optimal time, 3 and 7 minute complete ration mix times were also tested.

As for addition orders, the test had to involve adding the hay ration first because Schuler requires that hay be the first ingredient in order to maximize mixing efficiency. The Knight mixer recommendations were not order specific. To satisfy this recommendation the test included two ration

addition orders of hay, corn, protein, WDG and hay, WDG, protein, corn. Carrying out each combination of two addition orders, two mixer styles, and three replications resulted in 18 tests per mixer and 36 tests overall.

### Testing

Each test was conducted as follows. The mixer was started and in operation, mixing at a constant tractor engine speed of 1900 rev/min. This follows both manufacturers' recommendations. Once the mixer was at speed the first ingredient hay was added. The second ingredient was added 80 s later. This time interval was maintained to keep mixing times constant while an ingredient was not being added. This time of 80 seconds was chosen because it was the maximum time needed for the loader operator to get the next ingredient after adding the previous ingredient. Once the needed weight of the last ingredient was added, the timer was started and the set mix time for the test was carried out. At the end of the mix time the mixer was turned off so as

not to have any additional varying mixing time for the varying distances to each of the bunks.

### Sampling

Once a test wagon was mixed and ready to be unloaded, ration samples were drawn by having the wagon unload normally into the bunk, which had five evenly spaced 20 L plastic containers placed between the starting unloading point and ending unloading point (Figure 4 a). So as not to allow disturbance from the livestock, containers were collected from the bunk as soon as the mixer had passed. Once retrieved from the bunk, each container was dumped on a tarp and mixed (Figure 4 b). The sample was then divided using a quartering technique multiple times, saving the opposite quarters for analysis until the needed sample size (1 quart) was obtained.



(a)



(b)

**Figure 4. Containers evenly placed in bunk (a) 5 bunk samples combined into one pile (b).**

### Sample Processing

After a sample was gathered from each of the five containers, the remaining feed was combined into a single pile and mixed. Another quart sized sample was taken. The first five samples that came from each individual container were tested on location with the PSU Forage Particle Separator (Figure 5 a), and the sixth sample from the combined containers was sent to Dairyland Laboratories, Inc to have their TMR (total mixed ration) mixing evaluation performed. To do this the Dairyland samples were bagged, labeled, and shipped the same day. The shaker samples were then run through the PSU Particle Separator (Penn State University, 324 Henning Building

University Park, PA 16802) shown on the right in Figure 5 a. After one cycle of shaking, each sample was broken down by the separator into four particle size categories. The material on the top sieve remained on top of a 19 mm (0.75 in) sieve, material on the second sieve remained on top of a 7.9 mm (0.31 in) sieve and passed through a 19 mm (0.75 in) sieve, material on the third sieve remained on top of a 1.8 mm (0.07 in) sieve and passed through a 7.9 mm (0.31 in) sieve, and material on the bottom pan passed through a 1.8 mm (0.07 in) sieve. Each of the different trays and their contents are shown in Figure 5 b starting with the top tray on the left.

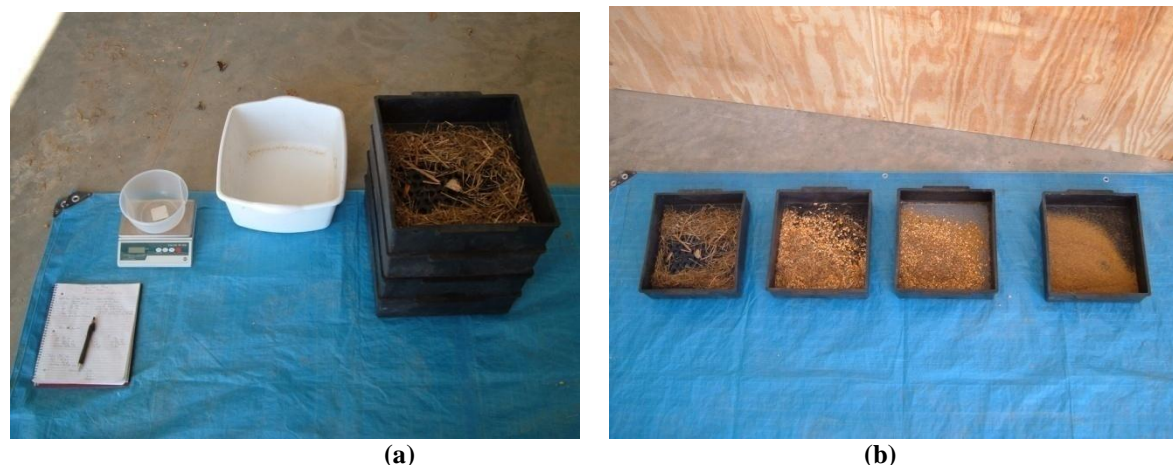


Figure 5. Penn State Particle Separator on the far right (a) 4 separator sieves and contents (b).

After the shaking was completed material on each sieve was weighed. From these weights, coefficients of variation (CV's) were calculated. Combinations with CV's of < 10% were considered well mixed. From these CV's and in test observations, results were then calculated to show which combination of mixer, which addition order, and which mix time was the most efficient. The results were calculated by first converting the weight in each tray to a percent of the entire sample weight on all four trays. This percent was calculated for each individual tray and the top two trays combined. From the percents, CVs were then calculated for each tray based on the five obtained samples. The CV was calculated by finding the standard deviation of the five samples, and then dividing that by the average of the five samples. This was done for all 36 of the tests. Then, since each combination was tested three times the average CV

was found for the three. It was then this set of numbers that was used to compare to the other combinations. The best combination is the one with the lowest average CV's or the lowest variation in the mix for each tray.

### Results

Table 1 shows the averages of percent moisture, dry matter, percent crude protein, calcium, an D F, phosphorus, magnesium, potassium, sulfur, sodium, and chloride for the samples. For the samples the moisture content of the TMR (total mixed ration) averaged around 26% and dry matter 74%. The percent crude protein averaged 12% dry basis for each of the tests. Table 1 below shows these results, and the tables in Appendix A give the mean and standard deviations for the constituents for each individual combination.

Table 1. Ration Constituents.

Constituent	Mean (%)	St Dev	C of V (%)
Moisture Content	25.7	1.32	5.14
Dry Matter	74.3	1.32	1.78
Crude Protein*	11.9	0.74	6.22
aN D F*	18.3	1.60	8.74
Calcium*	0.44	0.08	18.18
Phosphorus*	0.41	0.02	4.88
Magnesium*	0.18	0.01	5.56
Potassium*	0.64	0.05	7.81
Sulfur*	0.20	0.02	10.00
Sodium*	0.12	0.02	16.67
Chloride*	0.21	0.03	14.29

\*dry basis

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Tables 2 and 3 below show the average CV and standard deviation of the top two trays which contained the forage and the bottom tray which contained the highest percentage of DG. The complete tables are in Appendix B which show each mixer with the addition orders and mix times listed across the top. CVs for the three different times each one of the same combination was tested are shown as CV (1,2,3) based on their respective tray locations in the

PSU separator. The results of the trays that contained the highest percent of DG have been highlighted in red. So based on the results shown in the tables, the best combinations can be determined for each specific addition order, mix time, and mixer style by summing up the average CV's from each tray for each particular addition order, mix time and mixer style.

**Table 2. (Average CV's and standard dev. for top 2 trays).**

	Knight Mixer CV (sd)		Schuler Mixer CV (sd)	
	HCPW	HWPC	HCPW	HWPC
3 min	6 (3.6)	4.67 (2.3)	5.33 (2.1)	6.33 (2.5)
5 min	10.33 (4.0)	7 (1.7)	8.33 (1.5)	8.67 (2.5)
7 min	7.33 (1.5)	9.67 (0.6)	6 (1)	9.33 (1.2)

**Table 3. (Average CV's and standard dev. for bottom tray).**

	Knight Mixer CV (sd)		Schuler Mixer CV (sd)	
	HCPW	HWPC	HCPW	HWPC
3 min	10.67 (4.5)	9.33 (2.1)	6 (2.6)	7.33 (2.3)
5 min	9 (1.7)	10.33 (0.6)	7 (1)	10 (3)
7 min	11.33 (3.5)	8.33 (4.0)	5 (1.7)	8 (2.6)

Pending complete statistical analysis it appears that these will be the outcomes:

**Order** - From the CV's results and in test observations the best addition order (most thoroughly mixed) overall for each of the mixers and mix times looks to be the hay, corn, protein, WDG order. This order has a lower total average CV vs. the hay, WDG, protein, corn order. So in order to have the most effective feed ration when using DG based on the tests, it appears it is best to add DG toward the end of the mixing addition order, and add the more dense ingredients first, especially any liquids.

**Mixer** - The mixers' performances were very close although the Schuler mixer slightly outperformed the Knight with a lower total vs. the Knight's. Where the

Schuler mixer showed the most improvement was in the forage tray (top tray) with CV variances as low as 13% to the Knights 21%. However, when it came to the trays containing the highest percentages of DG (highlighted in red) both mixers were very close, usually within 2% of variance of each other. Based on these results the Schuler mixer may be a better choice for high hay rations, but in deciding on a mixer style to incorporate DG into your ration both the Schuler and Knight mixer styles look to perform equally well.

**Mix time** - For mix times the 3 minute proved to be a long enough period to be effective with DG, even outperforming the 5 and 7 minute times in the total average CV comparison. This shows that adding DG to your feed

ration would not lead to a need for increased mix time as 3 minutes is enough time to properly mix DG and since this is below the already recommended 5 minute mix times set by manufacturers, any mix times that are currently in place would be sufficient.

### Bundle Formation

The observation made during the test regarding the addition orders was that with the hay, wdg, protein, corn order, large bundles of hay and the liquid protein would



Figure 6. Hay and liquid protein bundle (a) Close-up of inside of a hay liquid protein bundle (b).

### Conclusion

Adding WDG to a feed ration is not a process that requires major changes to any current mixing process a producer may have. The manufacturers' recommended mixing time of 5 minutes is enough time to adequately mix WDG into most feed rations and may even be as low as 3 minutes if needed. For the order of ingredients it is necessary to add WDG last or at least after any liquid additives to avoid clumps from forming in the mix. This is especially important if using a liquid based protein that has a higher viscosity. Depending on the mixer, it may be best to add the roughage first and then corn, protein, WDG in that order. Adding the corn second and before the liquid

protein provides the protein with a hard surface to attach to within the mix and prevent the possible unwanted clumps from forming. As for mixer style either the reel or vertical will perform equally well in mixing WDG. The choice between the two styles of mixers to use would be more a question of the roughage content and the size of loads to be mixed. The vertical mixer would perform better with higher roughage rations but may be unable to produce as consistent results on smaller load sizes as a reel mixer of equal mix capacity. Additional research may need to be conducted on different rations to confirm these findings when using different ingredients or different overall mix moisture contents.