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Summary

Six mixes of feed were manufactured and analyzed to determine how sequence of ingredient addition into a feed mixer influences mixing characteristics when modified distillers grains (mDG) was used as a feed ingredient. Five mixes were manufactured using a 3-bar rotor mixer and one mix was manufactured using a staggered-rotor mixer. There were three diet types evaluated: 1) high-forage receiving diet; 2) high-grain finishing diet with ground grass hay (GH) as the roughage source; and 3) high-grain finishing diet with silage as the roughage source. Five samples were collected from each mix and were analyzed for particle size and nutrient composition to determine within load coefficient of variation (CV). Based on these data mDG should be added before GH. The within load CV for particle size, CP, ADF, and sulfur were lower for a diet containing silage and mixed in a staggered-rotor mixer compared with a diet containing GH mixed in a 3-bar rotor mixer.

Introduction

The ability to consistently mix what has been formulated by a nutritionist to supply feedlot cattle with the appropriate nutrients for expected growth is a daily expectation at all feedlots. As discussed by Pritchard and Stateler (1997), there are multiple characteristics of feed processing and mixing that influence cattle performance. Properties of feed such as particle size, particle shape, density, hygroscopocity, static charge, and adhesiveness can influence how a diet mixes (Behnke, 2005). Those ingredient characteristics along with mix time, mixer overload, worn/broken mixing components, ingredient build up, and/or improper sequence of ingredient addition can lead to non-uniformity within a mix of feed (Behnke, 2005). Using data from the South Dakota State University Feedlot Shortcourse, Wagner (1995) demonstrated that the sequence that hay is added to a mixer influences the mix quality. Additionally, Wagner (1995) reported that the length of time to obtain an adequate mix can differ dependent on the type of mixer being used. Daily diligence such as following the management practices outlined by Turgeon (Turgeon, 2006) is critical to prevent or at least minimize inconsistencies in the diets prepared and distributed.

Materials and Methods

Mixers: Six diets were evaluated to determine how sequence of ingredient addition affects uniformity of a mix of feed. Five of the diets were mixed in a ROTO-MIX 184-10 wagon-mounted mixer (RM184). This mixer wagon has two augers and a 3-bar rotor and is listed to have 180 ft^3 mixing capacity. One diet was mixed in a ROTO-MIX 620-16 truck-mounted mixer (RM620). This mixer has two augers and a staggered-rotor and is listed to have 620 ft^3 mixing capacity.

Mixing procedures: Three types of diets were mixed. Listed in Table 1 are the ingredients and the sequence they were added for each of the six mixes that were manufactured. Mixes 1 and 2 were receiving diets and mixes 3, 4, and 5 were finishing diets. These five mixes all contained ground grass hay as the roughage source and were mixed in the RM184. Mix 6 was a finishing diet that contained corn

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silage as the roughage source and was mixed in RM620. For each mix of feed, the mixer was on continuously as ingredients were loaded into the mixer. The mixer ran for three minutes after the last ingredient was added.

Table 1. Formulated diet composition and sequence of ingredient addition into feed mixers[a]

	---High-forage diet---		------------------High-grain diet------------------			
Item	MIX 1	MIX 2[b]	MIX 3	MIX 4[c]	MIX 5[c]	MIX 6
Ingredient level of inclusion and order of addition, % of DM (order of inclusion)						
Dry-rolled corn	33.50 (2)	(3)	58.50 (2)	(2)	(3)	43.73 (2)
Pelleted supp.	6.50 (1)	(2)	6.50 (1)	(1)	(2)	–
Liquid supp.	–	–	–	–	–	3.33 (1)
Silage	–	–	–	–	–	33.84 (3,5)[d]
Ground hay	35.00 (4)	(1)	10.00 (4)	(3)	(4)	–
mDG[e]	25.00 (3)	(4)	25.00 (3)	(4)	(1)	19.11 (4)
Formulated diet composition						
DM	74.85		75.03			47.82
	------------------------------------DM basis------------------------------------					
Crude protein, %	14.29		14.45			15.19
ADF, %	18.28		10.43			–
Sulfur, %	0.33		0.31			0.28
Monensin, g/ton	27		27			26

[a] Mixes 1 – 5 mixed in a 184 ft^3 3-bar rotor ROTO-MIX; Mix 6 mixed in a 620 ft^3 staggered-rotor ROTO-MIX
[b] Similar composition as diet used in MIX 1
[c] Similar composition as diet used in MIX 3
[d] Approximately 1/3 of the corn silage was added after the dry-rolled corn with the remainder added after the mDG
[e] Modified distillers grains

For RM184, the pelleted supplement was weighed on a stationary balance and placed in the bucket of the loader along with a partial scoop of dry-rolled corn (DRC). The liquid suspension supplement in the RM620 mix was added to an empty mixer. The liquid pooled in the front of the mixer compartment. Approximately 1/3 of the corn silage was added after the DRC with the remainder of the silage added after the modified distillers grains (mDG).

Sampling procedures: There were five samples collected from each mix of feed. The samples from the RM184 were collected on the discharge spout. Each load of feed from the RM184 weighed 1,500 lb. The first sample was obtained with <100 lb discharged from the mixer. Each subsequent sample was obtained after approximately 375 lb of feed was discharged. An 18,000 lb load of feed was prepared in the RM620. The samples from the RM620 were collected from the feed in the bunk at equally spaced intervals.

Sample analysis: Particle size was determined for each sample using the Penn State Forage Particle Separator following the procedures and calculations of Heinrichs and Kononoff, 2002. Crude protein (analyzed as nitrogen; AOAC 990.03), ADF (AOAC 973.18), and sulfur (AOAC 923.10) concentrations were determined in the Olsen Biochemistry laboratory. Chloride was measured using Quantab® titrators (Environmental Test Systems, Elkhart, IN). Monensin concentration was determined for 10 samples (two mixes) at the Eurofins Animal Health Testing Laboratory (Memphis, TN) a service provided by Elanco Animal Health (Greenfield, IN).

Results and Discussion

The first objective of this experiment was to evaluate how the sequence of ingredient addition affected the uniformity of particle size and nutrient distribution within a mix of feed. Mixes 1 and 2 were diets similar in composition to a receiving cattle diet. Ground hay was added either as the first or last ingredient. The two diets were mixed on separate days explaining the dissimilar diet particle size (Table 2). There were differences in the particle length of the ground hay between days. Because of this it is difficult to ascertain whether the increase in variation of the distribution of particle size is due to the sequence of ingredient addition or to the change in particle length of the hay. In this case, the authors believe that both factors influenced the outcome. When hay was added first, the top auger pushed enough hay to the back of the mixer that the hay was trickling over the side of the mixer wagon. The heterogeneous composition of ground GH leads to variation in how well diets can be mixed.

Table 2. Effect of ingredient addition sequence on particle size and particle size distribution within mixes of feed

	---High-forage diet---		---------------------High-grain diet---------------------			
Item	MIX 1	MIX 2	MIX 3	MIX 4	MIX 5	MIX 6
Particle size, mm (CV, %)						
	4.75 (8.5)	6.79 (19)	5.54 (6.0)	4.72 (7.9)	4.71 (6.0)	8.69 (2.9)
Distribution of particles on each sieve or pan, % on sieve or pan (CV, %)[a]						
Upper	6.9 (37)	31 (39)	3.8 (32)	6.7 (37)	8.0 (13)	5.1 (8.9)
Middle	35 (6.8)	20 (42)	48 (6.5)	39 (9.3)	34 (6.4)	66 (3.1)
Lower	37 (7.5)	29 (21)	32 (6.5)	30 (3.3)	32 (3.9)	26 (7.5)
Pan	21 (9.3)	20 (14)	16 (8.1)	25 (10)	24 (7.2)	3.2 (11)
Cumulative particles under each sieve, % under						
Upper	93 (2.8)	69 (18)	96 (1.3)	93 (2.7)	92 (1.2)	95 (0.5)
Middle	58 (6.5)	49 (13)	49 (6.6)	54 (5.8)	56 (4.5)	29 (7.3)

[a] Within a column the percent retention on the sieves and pan are means of five samples and may not equal 100%

Mixes 3, 4, and 5 were prepared in the RM184. The variation in particle size of those diets was similar among mixes. Comparison of these mixes with Mix 6 (prepared in RM620), demonstrates the decrease in variation of particle size when silage is used rather than ground GH.

The most variation in particle size distribution for diets containing hay occurred for the larger particles which was nearly all attributed to hay. For the diet containing silage, though there was much less variation, the majority of the particles were retained on the middle two sieves. Most variation occurred for the large particles (primarily cob) and for the fines. In all diets, the fine particles that sifted to the pan were primarily mDG.

Table 3 contains the DM and nutrient distribution of the six mixes. In comparison of Mixes 1 and 2, the most variation occurred for ADF within each mix. The increase in ADF variation in Mix 2 vs Mix 1 was again due in part to the particle length of the hay and the addition sequence with most variation due to differences in hay. Of note is the concentration of ADF between diets relative to the formulated value (Table 1). Within Mix 1 and 2, the ADF content generally increased from the first sample to the last sample, more than doubling from the first sample to the last sample within Mix 2. Additionally the protein and sulfur content had similar fluctuations within Mix 1 and 2 demonstrating non-uniform mixing (or discharge) of mDG.

Table 3. Effect of ingredient addition sequence on nutrient distribution within mixes of feed

	---High-forage diet---		------------------High-grain diet------------------			
Item	MIX 1	MIX 2	MIX 3	MIX 4	MIX 5	MIX 6
	Means of nutrients DM basis (CV, %)					
Dry matter, %	69.2 (1.3)	72.1 (1.5)	71.3 (8.2)	71.8 (1.4)	71.4 (0.55)	48.8 (1.2)
Crude protein, %	16.0 (2.8)	14.9 (5.5)	15.2 (1.6)	15.4 (2.8)	15.2 (2.7)	14.5 (1.2)
ADF, %	10.7 (13)	18.6 (23)	8.7 (6.9)	8.5 (12)	9.3 (5.4)	12.7 (3.8)
Sulfur, %	0.41 (9.2)	0.44 (6.2)	0.34 (4.2)	0.38 (7.1)	0.38 (2.0)	0.34 (2.6)
Monensin, g/ton	–	–	19 (14)	–	–	31 (15)
Quantab Cl^-, %	91.0 (8.5)	197 (12)	133 (29)	149 (16)	137 (9.3)	–

In Mixes 3 and 4 mDG and GH switched places in the loading sequence, with mDG charged before GH in Mix 3 and the opposite in Mix 4; whereas, in Mix 5 mDG was the first ingredient charged into the mixer and GH was the last. On the basis of nutrient analysis, ADF concentration was the most variable when mDG was added last in the sequence. This also caused the most fluctuations in sulfur. The second sample obtained from Mix 4 was lowest in crude protein, sulfur, and chloride. The variation in DM and chloride in Mix 3 were due to those variables being the most concentrated in the first sample from that mix.

Mix 6 was prepared in a staggered-rotor mixer. Though the composition of this diet was quite different than the diets prepared in the 3-bar rotor mixer, the low CV demonstrate consistency within this load of feed.

Of all variables measured, analysis of monensin is the most sensitive due to its content being confined to one feed ingredient. In Mixes 1 through 5 the pelleted supplement contained monensin and in Mix 6 the liquid contained monensin. Monensin concentration was measured in Mixes 3 and 6. Both mixes had high CV, 14 and 15% for mixes 3 and 6, respectively. For example, if each of the five samples obtained from Mix 3 represented a sample taken from feed delivered to five pens of cattle, the amount of monensin delivered would have ranged from 174 to 241 mg/head. For Mix 6, it would have ranged from 284 to 400 mg/head.

Another point to consider is the comparison between formulated diet nutrient composition and analyzed nutrient composition. In this experiment, the formulated vs analyzed values were not as close as they should be.

From these data, the authors recommend that in diets containing mDG and ground grass hay, mDG should be added before the hay and the diet should be mixed no less than 3 minutes after the last ingredient has been added.

Implications

Consistent inconsistencies in feed mixing will result in feed deliveries that do not have the formulated nutrient content. This should result in altering cattle performance from what was expected or predicted. As previous authors have indicated, analysis of an ionophore is the most sensitive measurement to use when evaluating mix quality. Another analytical approach is to measure two nutrients that are concentrated in one ingredient allowing insight into which ingredient is creating inconsistencies in the mix. Use of the Penn State Forage Separator or other similar tools can give a quick determination of mix quality.

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