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Effects of Feed Truck RPM on Pellet Quality, Unloading Speed, and Feed Line Location on Pellet Quality and Nutrient Segregation

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Effects of Feed Truck RPM on Pellet Quality, Unloading Speed, and Feed Line Location on Pellet Quality and Nutrient Segregation[1,2]

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Summary

Two separate studies were conducted at one commercial feed mill and six commercial wean-to-finish pig sites in northwest Iowa to determine the effects of feed truck unloading auger RPM on pellet quality and unloading time (Exp. 1) and the effects of feed line location on pellet quality and nutrient concentration of intact pellets and their fines (Exp. 2).

For Exp. 1, feed samples were taken from each compartment of an 8-compartment, 24-ton Walinga (Walinga Inc., Guelph, Ontario) feed truck. Feed was unloaded using 3 unloading speeds as determined by the truck RPM of 900, 1,150, and 1,400. Each compartment was timed during unloading, and percentage fines and PDI were determined from each sample taken. The same truck was used 6 times, allowing for 16 replications per unloading speed and 6 replications per compartment. The compartment located closest to the truck cab was denoted as compartment 1, and the compartment located closest to the rear of the truck was denoted as compartment 8.

An unloading speed × trailer compartment interaction ($P = 0.031$) was observed. The difference in unloading time for each compartment became progressively less, the closer the compartment was to the back of the truck. The percentage of fines formed was not significantly different among unloading speeds. The percentage of fines formed during unloading tended to increase (quadratic; $P = 0.081$) from the first to the eighth com-

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partment, with the maximum percentage of fines formed occurring in the fifth compartment.

In Exp. 2, pelleted feed was sampled as feed was unloaded into a commercial feed bin at 6 wean-to-finish barn sites. Each barn was equipped with 2 separate feed lines that transported feed from the bin into the barn. Feed samples were taken inside the barn at the feeder closest to the bin (20 ft), halfway from the bin (115 ft), and the farthest from the bin (250 ft) for each feed line. Samples were analyzed for percentage fines and PDI. During analysis, fines and complete pellets were separated, and a nutrient profile was determined for each. No interactions were observed between feed line location and nutrient profile of the fines and pellets. There was no effect of feed line location on pellet PDI, percentage fines, percentage fines formed, or pellet and fines nutrient profile. Fines had decreased ($P < 0.05$) CP and P but increased ($P < 0.05$) ADF, crude fiber, Ca, ether extract, and starch were observed when compared to the composition of pellets.

In conclusion, feed flow from the compartments closer to the cab resulted in fewer fines formed from loading to unloading. Decreasing unloading speed significantly increased the amount of time taken to unload a feed truck. No differences were observed in the amount of fines formed for any of the unloading speeds.

There appear to be no differences in pellet quality among feed line locations within a commercial wean to finish barn; however, there are significant differences in nutrient profile between fines and pellets.

Key words: feed line, feed mill, feed truck, fines, pellets, PDI

Introduction

Pellet quality and its subsequent effects on pig performance have been studied in recent years. Nemechek et al. (2012[8]) found that pellet fines should be minimized to achieve the maximum benefit from pelleting for finishing pig diets. It is expected that each 10% increase in pellet fines diminishes F/G by 1%. Thus, providing finishing pigs with high quality pelleted diets with a low percentage of fines is important to ensure the positive effects of pelleting on pig performance. Reducing the percentage fines can be accomplished in a number of ways, including but not limited to, manipulating diet formulation, conditioning time and temperature, or post-pelleting handling techniques. Recently, De Jong et al. (2015)[9] observed that when pellets are moved through a commercial mill from the pellet die to the load out, 11% fines were created. They also observed that pellets had a significantly different nutrient profile when compared to fines. In that study, CP and ether extract were lower and CP was higher in the fines as compared to pellets.

Moritz et al. (2013)[10] also observed that when pelleted diets were moved along a feed line in a turkey barn, a higher percentage of fines were present in feeders closer to the feed bin. This resulted in large differences in feed nutrient content between the front and back of the barn. These data suggest post-pellet liquid enzyme or fat application will

[8] Nemechek, J.E., Swine Day 2012, Report of Progress 1074, pp. 290–304.
[9] De Jong, J.A., Swine Day 2014, Report of Progress 1110, pp. 297-301.
[10] Moritz, J., Pellet quality performance tests: milling to bird performance. 2013. Ark. Nutr. Conf. Proc.

result in a higher concentration of the liquid-applied ingredient in the fines as compared to the pellets. The difference in nutrient profile between pellets and fines, along with the preference to consume whole pellets, is compounded when separation occurs in the feed line when transferring feed from the bins to the feeders. This variation in nutrient content may lead to increased growth performance variability within a single barn.

The truck unloading process to bins on-farm is an additional area that may create more fines in pelleted diets. Feed is typically transported and unloaded through a high-output auger and then dropped vertically into the bin. Drivers, in many cases, are incentivized to be efficient in the delivery process, leading them to load bins as quickly as possible. However, no data currently exist to determine the effect of unloading speed on pellet quality.

The objectives of this study were to determine the effects of 1) feed truck unloading RPM on pellet quality and unloading time and 2) feed line location on pellet quality and nutrient concentration of whole pellets and their fines.

Procedures

Experiment 1

Exp. 1 used a single 8-compartment, 24 -ton Walinga high-output auger unit feed truck. To achieve different unloading speeds, the truck motor was set to each of the 3 speeds (900, 1,150, and 1,400 RPM). These 3 speeds were chosen based on the current unloading speed used by the mill (1,400: also the maximum attainable speed). The lowest attainable unloading speed was 900 RPM; therefore, 1,150 was chosen as the intermediate speed. A truck speed of 1,400 RPM resulted in the 3 augers within the trailer having speeds of 159, 318, and 354 RPM for the floor, vertical, and boom auger respectively. A truck speed of 1,150 RPM resulted in the 3 augers within the trailer having speeds of 122, 263, and 316 RPM for the floor, vertical, and boom auger respectively. A truck speed of 900 RPM resulted in the 3 augers within the trailer having speeds of 84, 207, and 280 RPM for the floor, vertical, and boom auger respectively. Unloading speeds were randomly assigned to each compartment within the truck. Six truckloads were used for the trial, which resulted in 16 replications per unloading speed and 6 replications per compartment. The compartment located closest to the truck cab was denoted as compartment 1, and the compartment located closest to the rear of the truck was denoted as compartment 8. The feed truck was equipped with a 12-in.-diameter floor auger, 16-in.-diameter vertical auger, and a 12-in.-diameter boom auger measuring 32 ft long.

As the truck was loaded with pelleted feed in the mill, samples were taken directly under the load-out spout for each compartment. Thus, a baseline value for percentage fines and PDI was determined for each compartment. Once filled, the truck was driven to an open area at the feed mill where it was unloaded into a different feed truck. The transfer of feed from the first to the second feed truck was used as the means to collect the samples and truck RPM data. Before offloading, the boom auger was equipped with an 8 ft ×12 in reinforced cardboard sleeve. The boom auger was raised until it was approximately 20 ft off the ground to simulate a typical bin height in the field. The sleeve allowed feed to be unloaded into a second feed truck without spilling.

During unloading, each compartment was timed, starting when the slide gate under the compartment was opened and stopped when feed was no longer coming out of the boom auger. Three separate samples were taken while each compartment was unloaded, and percentage fines and PDI were determined from each sample. Samples were taken underneath the sleeve attached to the boom auger.

Experiment 2

In Exp. 2, six identical wean-to-finish swine barns were used to determine the effects of feed line location on pellet quality and nutrient segregation. Feed samples were taken directly underneath the boom auger at the top of the bin to establish a baseline for pellet quality for each bin. Feed was allowed to flow into the barn for 24 to 36 h to ensure that feed initially sampled would be present at the feeders.

Each building was approximately 260 ft long by 40 ft wide. Each barn was equipped with two 20-ft-tall tandem bins located at the front. Two screw-conveyor feed lines were present in each barn, spanning approximately 250 ft from the bin to the final feeder on each line. At 24 to 36 h after placement, feed samples were taken from each feed line directly under the spout connection at the feeder closest to the bin (20 ft), halfway from the bin (115 ft), and farthest from the bin (250 ft) for each feed line. Feed line was used as the experimental unit, which resulted in 12 replications/feed line location sampled. Samples were analyzed for percentage fines and PDI.

All samples collected were sub-sampled using a Riffle-type sample splitter (Humboldt Mfg. Co., Elgin, IL) to conduct a PDI test using a Holmen NHP200 (Tekpro Limited, Norfolk, UK). Percentage fines were determined on each individual sample. Fines were characterized as material that would pass through a #6 Tyler Sieve (3,360-μm opening) during 15 sec of manual shaking. While determining the percentage fines for Exp. 2, a subsample of both fines and pellets was taken from each sample. Subsamples of fines and pellets were retained and sent for chemical analysis for analysis of DM, CP, ADF, crude fiber, Ca, P, ether extract, and starch (Ward Laboratories, Inc., Kearney, NE). In Exp. 1 and 2, separate swine finishing diets were sampled. Diets were corn-soybean meal-based with 2.5 +/- 0.25% added fat applied at the mixer. Diets were pelleted on a CPM 7900 pellet mill (California Pellet Mill, Crawfordsville, IN). The mill was equipped to produce 3/20-in.-diameter pellets under conditioning temperatures of approximately 170°F.

Data were analyzed using the PROC MIXED procedure of SAS (SAS Institute, Inc., Cary, NC) with compartment or feed line as the experimental unit for Exp. 1 and 2 respectively. Preplanned contrasts were used to determine the interaction and linear and quadratic effect of unloading speed and compartment on pellet quality and unloading time for Exp. 1. The interaction of feed form and feed line location, linear and quadratic effect of feed line location, and the main effects of feed line location and feed form were determined for Exp. 2. Results were considered significant at $P \leq 0.05$ and a tendency at $P \leq 0.10$.

Results and Discussion

For Exp. 1, an unloading speed × trailer compartment interaction ($P = 0.031$; Table 2) was observed. The difference in unloading time for each compartment became progressively less, the closer the compartment was to the back of the truck. The percentage of fines formed was not significantly different among unloading speeds (Table 3). The percentage of fines formed during unloading tended to increase (quadratic; $P = 0.081$) from the first to the eighth compartment, with the maximum percentage of fines formed occurring in the fifth compartment (Table 4).

For Exp. 2, showed no effect of feed line location on pellet PDI, percentage fines, percentage fines formed (Table 5), or pellet and fines nutrient profile (Table 6). No interactions were observed between feed line location and nutrient profile of the fines and pellets. Fines had decreased ($P < 0.05$) CP and P but greater ($P < 0.05$) ADF, crude fiber, Ca, ether extract, and starch when compared to pellets. Fines percentage should have been similar or greater at the feeder when compared to the bin samples. The discrepancy in the amount of fines present at the bin and the feeder is not clearly understood but may be a result of the way feed bins empty and resulted in negative values for fines formed from the bin to the feeder. During discharge, bins may retain fines while a greater percentage of pellets are transferred to the feeders, especially in the early stages of emptying, with a higher percentage of fines being discharged when the bin is nearly empty. Because we only collected samples 24 to 36 h after loading the bins, we were not able to determine if this is indeed how feed flows through the bin. More research is needed to confirm this hypothesis.

In conclusion, unloading from the front compartments closest to the cab resulted in fewer fines formed. However, decreasing unloading speed significantly increased the amount of time required to unload a single compartment. This would increase the total amount of time needed to unload a full feed trailer. The extra time spent unloading may reduce a mill's efficiency and add cost to the diet; thus it needs to be balanced with the potential for improved pellet quality. It is important to note that percentage fines formed was only improved by 2% when unloading occurred at the 2 lowest speeds, which may not provide enough benefit when compared to the extra time needed. Once pellets were delivered to the farm, pellet quality was similar between feed line locations within a commercial wean-to-finish barn, regardless of the distance the pellets traveled in the feed lines. Significant differences were noted between the fines and pellet nutrient profiles. The decreased ether extract and starch content of pellets compared to the fines is cause for concern.

Table 1. Composition of experimental diets (as-fed basis)

Item	Exp. 1	Exp. 2
Ingredient, %		
Corn	85.54	74.95
Soybean meal (46.5% CP)	9.50	19.97
Animal/vegetable blend fat	2.75	2.57
Limestone	0.80	0.82
Monocalcium phosphate (21% P)	0.25	0.25
Salt	0.35	0.35
TBCC[1]	0.02	0.02
L-lysine	0.52	0.61
DL-methionine	---	0.09
L-threonine	0.09	0.16
L-tryptophan	0.03	0.03
Vitamin trace mineral premix	0.15	0.15
Ractopamine HCL, 9g/lb	---	0.03
Total	100	100

[1] Tribasic copper chloride; Micronutrients, Indianapolis, IN.

Table 2. Interactive effects of trailer compartment and unloading speed on unloading time (Exp. 1)[1]

	Truck speed, RPM				Probability, $P <$
Compartment[2]	900	1,150	1,400	Pooled SEM	Compartment × truck speed
1	222	153	127	17.4	0.031
2	228	145	107		
3	203	134	113		
4	173	132	98		
5	173	126	123		
6	174	119	90		
7	162	114	93		
8	152	118	90		

[1] Values represent the amount of time to unload 3 tons of feed. Six truckloads were used for the trial, which resulted in 16 replications per unloading speed and 6 replications per compartment.
[2] The compartments were numbered 1 through 8, starting with the compartment nearest the cab and ending with the compartment nearest the rear boom auger.

Table 3. Main effects of truck unloading speed on pellet quality (Exp. 1)[1]

	Truck speed, RPM				Probability, P <	
Item	900	1,150	1,400	SEM	Linear	Quadratic
PDI, %	83.9	80.8	84.5	2.06	0.826	0.192
Fines formed,[2] %	10.4	10.6	12.4	1.37	0.291	0.631

[1] Six truckloads were used for the trial, which resulted in 16 replications per unloading speed.
[2] Fines formed were calculated by subtracting the amount of fines present during loading from the amount of fines present during unloading per compartment.

Table 4. Main effects of trailer compartment on pellet quality (Exp. 1)[1]

	Compartment[2]									Probability P <	
Item	1	2	3	4	5	6	7	8	SEM	Linear	Quadratic
PDI, %	85.6	76.7	85.9	81.8	77.9	85.3	85.7	85.5	3.54	0.388	0.279
Fines formed,[3] %	8.2	7.3	11.9	9.9	16.3	11.9	12.5	10.7	2.27	0.083	0.081

[1] Six truckloads were used for the trial, which resulted in 6 replications per compartment
[2] The compartments were numbered 1 through 8, starting with the compartment nearest the cab and ending with the compartment nearest the rear boom auger.
[3] Fines formed were calculated by subtracting the amount of fines present during loading from the amount of fines present during unloading per compartment.

Table 5. Effects of feeder location on pellet quality (Exp. 2)[1]

	Feeder location				Probability, P <	
Item	Front	Middle	Back	SEM	Linear	Quadratic
PDI, %	87.9	87.5	87.3	0.40	0.838	0.270
Percentage fines, %	18.3	20.0	16.6	2.23	0.290	0.993
Fines formed, %	-5.0	-3.4	-6.7	3.11	0.449	0.995

[1] Two feed lines from 6 commercial wean-to-finish barns were sampled, which resulted in 12 replications per feeder location sampled.

Table 6. Effects of feed line location and feed form on nutrient composition (Exp. 2)[1]

	Feed form			Probability, $P <$
Item	Fines	Pellets	SEM[2]	Feed form main effect
CP, %				
Front[3]	12.3	15.2	0.14	0.001
Middle	12.4	15.5		
Back	12.5	15.2		
ADF, %				
Front	3.5	3.1	0.24	0.011
Middle	3.7	3.2		
Back	3.8	3.2		
Crude fiber, %				
Front	2.8	2.1	0.09	0.001
Middle	2.7	2.3		
Back	2.8	2.3		
Ca, %				
Front	0.48	0.46	0.012	0.003
Middle	0.48	0.43		
Back	0.45	0.44		
P, %				
Front	0.37	0.41	0.006	0.001
Middle	0.37	0.40		
Back	0.37	0.40		
Ether extract, %				
Front	6.2	5.2	0.11	0.001
Middle	6.3	5.3		
Back	6.1	5.2		
Starch, %				
Front	47.6	44.6	0.42	0.001
Middle	47.2	44.6		
Back	47.3	45.0		

[1] Two feed lines from 6 commercial wean-to-finish barns were sampled, which resulted in 12 replications per feed line location sampled.
[2] There were no interactions of feed line location and feed form and no main effect of feed line location.
[3] The front, middle, and back feeder were 20, 115, and 250 ft from the bin, respectively.