Formation of Fines During the Pelleted Feed Manufacturing Process and the Resulting Differences in Nutrient Composition of Fines and Pellets[1,2]

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Summary

A 3-wk study was conducted at a commercial feed mill in northwest Iowa to determine where the formation of fines occurs during pelleted feed manufacturing and if differences are present in nutrient composition between fines and pellets. During the study, 1,781pelleted feed samples were collected from 4 swine and 2 turkey diets. Samples were collected from 4 different locations throughout the mill to determine progression of fines formation during the manufacturing process. These locations included the pellet mill, pellet cooler, fat coater, and at load-out. Samples were taken on 7 to 10 different runs for each diet throughout the 3-wk period. Pellet durability index (PDI) and percentage fines were determined for all samples, and nutrient analysis was determined on a pooled sample from each run within diet. Nutrient analysis was determined via near-infrared spectroscopy (NIR) at the processing site and via wet chemistry at a commercial lab.

Overall, PDI was different ($P < 0.05$) between locations in the mill. Pellet durability index increased from the pellet mill to the fat coater but then decreased between the fat coater and load-out. The largest increase in PDI was seen between the cooler and fat coater. Percentage fines decreased ($P < 0.05$) from the pellet mill to the cooler, but then increased as pellets went to the fat coater and then to load-out. The largest increase in fines was found between the cooler and fat coater and between the fat coater and load-out (5.6 and 6.5%). Dry matter and crude fiber were greater ($P < 0.05$) and fat tended to be greater ($P < 0.08$) in fines than in pellets as determined by NIR, whereas CP was significantly lower ($P < 0.05$) in the fines than in pellets. These differences were verified by wet chemistry results. Wet chemistry also found that fines tended to be higher ($P < 0.05$) in ADF, but fines were similar in Ca and P compared with pellets.

In conclusion, fines increased as pellets were moved from the pellet mill to the load-out area. Pellet durability index improved from the pellet mill to the fat coater due to the removal of moisture in the pellet but then worsened at load-out, most likely due to the addition of fat, which may have started to soften the pellets. Both NIR and wet chemistry found that fines were higher in fiber and fat but lower in CP than pellets. These differences in nutrient content of the pellets compared with fines and the possibility of

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fines refusal at the feeder may lead to poorer pig performance. More research is needed to determine if fines formation can be reduced in the mill and if differences in nutrient composition of fines compared with pellets could lead to performance differences in pigs.

Key words: feed mill, fines, pelleting, pellet durability index

Introduction

Pellet quality and its subsequent effects on pig performance have been extensively studied in recent years. Nemechek et al. (2012[5,6]) found that the percentage of fines should be minimized to achieve the maximum benefit from pelleting both nursery and finishing pig diets. Reducing the percentage of fines in pellets 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.

When pellets exit a pellet mill, they are not immediately loaded onto a truck for delivery, but instead take a much longer path through the feed mill. Pellets exiting a pellet mill must remain intact through a cooling process, fat application process, and then through load-out. Within each of these steps are various elevators and conveyors that move the pellets throughout the mill. The path that the pellets must travel through the mill is suspected to damage pellets and increase the percentage of fines; however, few studies have evaluated the pathways within a mill that can cause more or less damage to a pellet. If the formation of fines can be better understood, feed mills might be able to implement strategies to reduce pellet damage.

Researchers also have suggested that the nutrient composition of fines and pellets may differ. This is of importance to swine producers, because pigs normally prefer to consume whole pellets rather than fines.

Thus, the objective of our study was to determine where the formation of fines occurs during feed manufacturing and if nutrient composition of fines and pellets differ.

Procedures

A 3-wk study was conducted at a commercial feed mill in northwest Iowa. During the study, samples were collected from 4 swine and 2 turkey diets pelleted at the mill. Samples were collected when exiting 4 different locations throughout the mill to determine progression of fines formation during the manufacturing process. Samples were taken on 7 to 10 different runs for each diet throughout the 3-wk period. These locations included the pellet mill, cooler, fat coater, and at load-out. Pellet durability index (PDI), percentage fines, and bulk density were determined for all samples, and nutrient analysis was determined on a pooled sample from each run within diet.

Diets were selected at the start of the trial based on the greatest total tonnage made in an average week. Once diets were selected, sampling occurred every time a diet was manufactured. The first sampling port was located directly underneath the die on the pellet mill. Samples were taken and immediately placed in a bench-top pellet cooler

[5] Nemechek, J.E., Swine Day 2012, Report of Progress 1074, pp. 278–289.
[6] Nemechek, J.E., Swine Day 2012, Report of Progress 1074, pp. 290–304.

to reduce the temperature of the pellets to room temperature. The second sampling port was located under the drag immediately after the pellets exit the cooler. The third sampling port was underneath the fat coater where post-pelleting liquid fat was added to 5 of the 6 diets. The sixth diet was directed through the fat coater for the duration of the experiment to replicate the fat coating process. The last sampling occurred during load-out as feed was exiting the spout and going into feed trucks.

One 2-lb sample of pelleted feed was taken from each sampling port during 7 to 10 feed manufacturing runs for each diet approximately every 15 to 20 min throughout the duration of the run. The feed manufacturing runs varied from 60 to 148 tons of feed.

Once samples were collected, they were split to conduct a PDI test using a Holmen NHP200 (Tekpro Limited, Norfolk, United Kingdom: Tables 1 and 2). Percentage fines were also determined on each individual sample. Fines were characterized as material that would pass through a #6 Tyler Sieve (3,360-µ opening) during 15 sec of manual shaking. While determining the percentage fines, a small subsample of both fines and pellets was taken from each sample. These subsamples were then combined separately (fines or pellets) within a diet and manufacturing run for near-infrared spectroscopy (NIR) analysis (FOSS NIRS 5000, Feed and Forage Analyzer, Hillerod, Denmark). Combined samples of both fines and pellets from 4 diets were retained and sent for chemical analysis to Ward Laboratories, Inc. (Kearney, NE) for analysis of DM, CP, ADF, crude fiber, Ca, P, and crude fat (Table 3).

Data were analyzed using the PROC MIXED procedure of SAS (SAS Institute, Inc., Cary, NC) with location or feed form (pellet vs. fines) as the experimental unit for the physical and chemical analysis, respectively. Location, run, and location within run were considered a random effect for physical analysis. Pairwise comparisons were used to determine differences. Results were considered significant at $P \leq 0.05$ and a trend at $P \leq 0.10$.

Results and Discussion

Overall, PDI was different ($P < 0.05$) between pellets collected at different locations in the mill. Pellet durability index increased from the pellet mill to the fat coater but then decreased at load-out (Table 1). We found no evidence that fines increased in the pellet cooler. Fines did increase ($P < 0.05$) as pellets went to the fat coater and to load-out. The change in PDI was greatest ($P < 0.05$) when moving from the cooler to fat coater and fat coater to load-out than from the pellet mill to the cooler (Table 2). The largest increase in fines was seen between the cooler and fat coater as well as between the fat coater and load-out (5.6 and 6.5% percentage point change).

Dry matter and CF were greater ($P < 0.05$) and fat tended to be greater ($P < 0.08$) in the fines than in the pellets as determined by NIR, whereas CP was lower ($P < 0.05$) in the fines than in pellets. Wet chemistry confirmed these results. Additional wet chemistry analysis found that fines tended to be higher ($P < 0.08$) in ADF but were similar in Ca and P compared with pellets.

Fines increased as pellets moved from the pellet mill to load-out. Pellet durability index improved from the pellet mill to the fat coater but then worsened at load-out. This was most likely due to the addition of liquid fat, which may have begun to soften the pellets. In this feed mill, most of the fines were created between the cooler and load-out. Characterizing the location where higher amounts of fines are produced will allow millers to focus resources on these areas to obtain the largest benefit and eventually reduce fines presented to the pig at the feeder. Another potential area to evaluate that was not addressed in this study is fines formation during the transport and unloading process from the feed mill to the farm. Once fines formation from the mill to the feeder is characterized, steps can be taken to improve the manufacturing and transport process and present the best possible pellet to the pig.

Table 1. Mill effects on pellet durability and percentage fines[1]

Item	Pellet mill	Cooler	Fat coater	Load-out	SEM	Probability, *P* <
PDI[2], %	77.0[d]	78.3[c]	84.6[a]	81.9[b]	0.82	0.001
Percentage fines, %	9.44[c]	8.54[c]	14.20[b]	20.46[a]	0.77	0.001

[1] Eight to 10 samples were taken from each location in the mill within a run for 8 runs over 3 weeks.
[2] Pellet durability index.
[a,b,c,d] Superscripts within a row are different (*P* < 0.05).

Table 2. Mill effect on the incremental changes in pellet durability and percentage fines[1,2]

Item	Pellet mill to cooler	Cooler to fat coater	Fat coater to load-out	SEM	Probability, *P* <
PDI[3], %	1.46[b]	6.10[a]	-1.77[c]	0.41	0.001
Percentage fines, %	-0.83[b]	5.56[a]	6.45[a]	0.64	0.001

[1] 1,781 samples were taken over 3 weeks, with 5 to 10 samples per location across 8 runs of 7 diets.
[2] Values represent changes in PDI or percentage fines from the previous sample location.
[3] Pellet durability index.
[a,b,c] Superscripts within a row are different (*P* < 0.05).

Table 3. Nutrient composition of fines and pellets[1]

						Probability, *P* <	
Analytic procedure:	Commercial lab[2]		NIR[3]			Commercial lab	NIR
Item	Fines	Pellets	Fines	Pellets	SEM	Fines vs. pellets	Fines vs. pellets
DM, %	88.83	88.32	87.08	86.61	0.16	0.031	0.001
CP, %	13.58	15.24	14.36	16.16	0.48	0.021	0.001
ADF, %	4.09	3.59	---	---	0.20	0.087	---
Crude fiber, %	---	---	2.43	2.17	0.05	---	0.001
Ca, %	0.74	0.74	---	---	0.07	0.975	---
P, %	0.50	0.53	---	---	0.02	0.354	---
Fat, %	9.00	7.71	9.03	8.10	0.42	0.039	0.083

[1] Samples from the fat coater and load out were combined within run and form (pellets or fines) for analysis.
[2] One turkey and 3 swine diets were sent to a commercial lab with 5 replications within diet for a total of 20 samples of both fines and pellets.
[3] Near-infrared spectroscopy. All 7 diets were utilized for analysis. One composite sample of fines or pellets within each diet and run was tested for a total of 111 samples.