CORN PARTICLE SIZE AND PELLETING INFLUENCE ON GROWTH PERFORMANCE, FECAL SHEDDING, AND LYMPH NODE INFECTION RATES OF *SALMONELLA ENTERICA* SEROVAR TYPHIMURIUM

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Summary

Ninety-six pigs (initially 13.8 lb.) were used in a 28-d trial to determine the interactive effects between pelleting and particle size on *Salmonella* serovar Typhimurium shedding and colonization in a young growing pig model. The experiment was a 2 × 2 factorial arrangement consisting of meal or pelleted diets with fine or coarse ground corn. Pigs were fed the diets 1 wk pre-*salmonella* inoculation and allotted based on weight to one of four dietary treatments.

For the main effect of particle size, pigs fed finer ground corn had significantly improved feed efficiency ($P<0.01$) than pigs fed coarser ground corn for the 28 d trial. Pigs fed meal diets had greater ADG, ADFI, and improved F/G ($P<0.05$) than the pigs fed pelleted diets.

Fecal shedding of *salmonella* was low and variable, with no significant differences between main effects ($P<0.26$) or in treatments ($P>0.82$). There was no difference in salmonella infection rates of mesenteric lymph nodes obtained on d 28 between treatments or main effects. Finer grinding and meal diets generally improved growth, feed intake, and feed efficiency compared to pigs fed coarser ground or pelleted feeds. However, particle size or diet form did not alter fecal shedding or mesenteric lymph node infection rates of *salmonella* organisms in our study.

(Key Words: Weanling Pigs, Disease Challenge, *Salmonella*, Particle Size, and Pelleting)

Introduction

Emphasis has been placed on reducing *salmonella* contamination in the slaughter process; this includes implementing strategies on-farm that reduce the prevalence of *salmonella* infections in pigs. Increasing grain particle size and feeding meal diets have been advocated as methods to reduce *salmonella* shedding in growing pigs. European studies have indicated that meal diets that are high in fiber may help in preventing salmonellosis by decreasing the gastric pH content, since *salmonella* and other pathogenic organisms are sensitive to pH. Recently, studies in Denmark have indicated that coarser grinding of pelleted feeds with added formic acid also might reduce the amount of *salmonella* organisms within the intestinal tract but without affecting production. The objective of our study was to establish whether fine or coarse ground meal and pelleted corn based nursery feed affected growth and shedding rates of *Salmonella enterica* serovar Typhimurium.

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Procedures

Ninety-six pigs (initially 13.8 lb) were blocked by initial weight and allotted to one of four dietary treatments. Two pigs were assigned to a pen, with a total of 12 replicates per treatment.

The four dietary treatments were arranged in a 2 × 2 factorial, with main effects of fine or coarse ground corn and either a meal or pelleted form. All diets were identical in formulation (Table 1) with the only difference being the grain particle size and feed form. To ensure feed was not contaminated within the feed mill, swab samples were taken and cultured for the presence of *salmonella* within the mixer, pellet mill, cooler, as well as the feed ingredients and complete feed samples from each of the diets.

Table 1. Diet Composition (As-fed)[ab]

Ingredient	% of Diet
Corn	51.74
Soybean meal, 46.5% CP	27.94
Spray dried whey	10.00
Select menhaden fishmeal	4.50
Soy oil	3.00
Monocalcium phosphate, 21% P	1.20
Limestone	0.68
Salt	0.35
Vitamin premix	0.25
Trace mineral premix	0.15
Lysine HCl	0.15
DL-Methionine	0.05
Total	100.00%
Calculated Analysis	
Lysine, %	1.39%
ME, kcal/lb	1,553
Ca, %	0.90
P, %	0.80

[a]Diet fed for d 0 to 28 post-weaning.

[b]Diets did not contain antimicrobials or growth promoting levels of zinc oxide or copper sulfate.

All pigs were housed in two environmentally controlled rooms. One feeder and one water-nipple were in each pen to allow ad libitum access to feed and water. Fecal samples were obtained before inoculation to ensure that all pigs were not shedding *salmonella*. Pigs were acclimated to the test diets one week pre-inoculation. Pigs were inoculated on d 7 with 1.9×10^7 CFU of *Salmonella enterica* serovar Typhimurium. Rectal temperatures and feed intakes were determined daily for the first week post inoculation. Pigs were weighed and ADFI, ADG, and F/G were determined on d 0, 7, 14, 21, and 28. Fecal samples were collected on days 14, 21, and 28 to be cultured for the presence of s*almonella*.

A semi-quantitative method for evaluating *salmonella* shedding was developed for the experiment. *Salmonella* growth was classified into one of four categories that included confluent growth over the whole plate (Score 3), any number of wells with growth (Score 2), only growth that was obtained on enrichment (Score 1), or no growth detected (Score 0). On d 27 and 28 of the study, pigs were euthanized and in addition to the fecal sample, an ileocolic lymph node was collected and cultured for the presence of s*almonella*.

All data were analyzed as a 2 × 2 factorial in a randomized complete block design replicating over time using the MIXED model procedure of SAS. All means presented are least-squares means.

Results

A particle size x diet form x week interaction was observed for ADG ($P<0.01$), F/G ($P<0.01$), and a tendency in ADFI ($P<0.08$; Table 2). In the first week of the trial, the pigs fed coarse pelleted diets had lower ADG ($P<0.01$) and worse F/G ($P<0.01$) than all other treatments. While the growth and feed efficiency of this treatment only tended to be the lowest in the other weeks after challenge. The magnitude of the difference in this treat-

ment in the week prior to challenge was responsible for the three-way interaction. Also, there were no significant interactions between week of the study and the main effects of corn particle size or diet form. Therefore, the main effects for pig growth performance corn particle size and diet form were further evaluated (Figures 1 and 2).

For the overall d 0 to 28 period pigs fed meal diets grew faster ($P<0.05$) compared to those fed pelleted diets (Figure 1). Main effect of corn particle size indicated pigs fed fine ground corn had improved feed efficiency ($P<0.01$) compared to pigs fed the coarse ground corn (1.57 vs. 1.85, respectively; Figures 2). Meal-fed pigs had better ($P<0.05$) F/G than those fed pelleted diets.

Fecal samples evaluated for shedding of *salmonella* were collected on d 14, 21, and 28. Since there were no differences in shedding scores by treatment across week or interactions between corn particle size or diet form ($P> 0.79$) main effects are presented in Figure 3. There were no differences ($P>0.23$) in fecal shedding scores due to grain particle size or diet form. In general, shedding was low and variable. An interaction between grain particle size and diet form was not observed for lymph node infection rate ($P>0.82$). Lymph nodes were collected on d 28 for presence of salmonella organisms, and no significant differences were found for main effects of particle size ($P>0.50$) and diet form ($P>0.26$; Figure 4).

Discussion

Finer grinding of the corn improved feed conversion compared to the coarse-ground corn diets. This response to the decreased particle size was as expected, since smaller particles allow for a greater particle surface area to aid digestion of starches. Meal-fed pigs showed improved ADG, ADFI, and feed conversion over the pigs fed pelleted diets. While this result is contradictory to many other studies, we believe this was the result of a feeder by pelleted diet interaction, which may explain this phenomenon, rather than a physical effect of the pelleting process. This was especially evident when feeding the coarse-ground pelleted diet in the first week of the study. The coarse-pelleted diets had a large amount of fines that led to a significant amount of feed wastage. In subsequent weeks, pigs fed the pelleted diets had a significant amount of fines in their feed pan. These fines were collected and weighed back against the amount of feed consumed. However, some of the fines were pushed out of the feeder by the pigs in order to consume more pellets. This loss of fines may explain the discrepancy of F/G and we believe the poorer F/G, was due to feed wastage of the pelleted diets.

This study seems to indicate that the increased amount of *salmonella* shedding associated with pelleted feeds may be due to other factors than an effect of the feed processing methods on the gastro-intestinal environment of the pig. For example the humid environment of the pellet cooler and holding bins may increase the risk of post pelleting contamination. In our study we extensively sampled the feed processing equipment prior to the manufacturing to ensure that the feed was not contaminated during the manufacturing process. Additionally, we evaluated the individual ingredients and the complete feed after manufacture to reduce the risk of introducing a source of salmonella other than the challenge. Additionally, some of the studies evaluating feed processing as a risk factor may have confounded the processing method with the source of ingredients. In these studies, meal based diets were more likely to be manufactured on-farm, while pelleted diets were more likely to be obtained from a large centralized commercial feed mill. These large feed mills may have a higher probability of obtaining ingredients from a larger number of sources and using alternative products that are known to have a higher risk of salmonella contamination. Another factor may be the type of cereal

grain. Many of the studies associating the increased risk have been with wheat or barley based diets. Differences in carbohydrate composition of the diet have been shown to influence the composition of the intestinal microflora. Wheat and barley have different carbohydrate composition, especially in regard to non-starch poly saccharides that may influence the rate of salmonella shedding.

Feed processing has been shown to have beneficial effects on growth. The trial demonstrated improvements in growth and efficiency. However, in contrast to previous research, pelleting did not result in an improvement in growth and feed efficiency. Using this model, we were unable to detect influences of feed processing on fecal shedding and colonization of mesenteric lymph nodes with *salmonella*. Therefore, it appears that the increased risk of fine grinding and pelleting of feeds associated with salmonella shedding reported in other studies may be due to factors other than those confined to the intestinal tract intestinal environment.

Table 2. Corn Particle Size and Pelleting Influence on Growth Performance, Fecal Shedding, and Lymph Node Infection Rates of *Salmonella enterica* Serovar Typhimurium[ab]

	Meal		Pelleted		
Item	Fine	Coarse	Fine	Coarse	SE
D 0 to 7					
ADG, lb	0.56^{c}	0.55^{c}	0.51^{c}	0.28^{d}	0.038
ADFI, lb	0.78^{c}	0.89^{d}	0.73^{c}	0.76^{c}	0.049
F/G	1.44^{c}	1.63^{c}	1.44^{c}	2.89^{d}	0.107
D 7 to 14					
ADG, lb	0.98^{c}	0.99^{c}	0.77^{d}	0.70^{d}	0.065
ADFI, lb	1.37^{cd}	1.56^{c}	1.29^{c}	1.22^{c}	0.079
F/G	1.41^{c}	1.61^{cd}	1.72^{d}	1.85^{de}	0.077
D 14 to 21					
ADG, lb	1.08^{c}	1.06^{de}	0.93^{d}	0.98^{e}	0.054
ADFI, lb	1.63	1.73	1.54	1.56	0.091
F/G	1.51	1.64	1.66	1.60	0.057
D 21 to 28					
ADG, lb	1.17^{c}	1.10^{ce}	0.92^{d}	0.99^{e}	0.054
ADFI, lb	1.86^{c}	1.97^{c}	1.52^{d}	1.77^{cd}	0.102
F/G	1.59^{c}	1.81^{d}	1.78^{d}	1.79^{d}	0.068
D 0 to 28					
ADG, lb	0.95^{c}	0.93^{c}	0.78^{d}	0.74^{d}	0.040
ADFI, lb	1.41^{cd}	1.54^{c}	1.27^{d}	1.33^{d}	0.067
F/G	1.49^{c}	1.67^{d}	1.65^{d}	2.03^{e}	0.046

[a]Ninety-six weanling pigs (initially 13.8 lbs) were used with two pigs per pen and 12 replications (pens) per treatment and inoculated on d 7 with 1.9 x 10^{7} CFU of *Salmonella enterica* serotype Typhimurium.

[b]Fine and coarse ground corn was ground to 500 and 1000 microns respectively. A Particle Size*Diet Form*Week interaction was observed for ADG ($P<0.01$), F/G ($P<0.01$), and a tendency for ADFI ($P<0.08$).

[cde]Treatment means in the same row with different superscripts differ ($P<0.05$).

Corn Particle Size and Pelleting Influence on Growth Performance, Fecal Shedding, and Lymph Node Infection Rates of *Salmonella enterica* Serovar Typhimurium

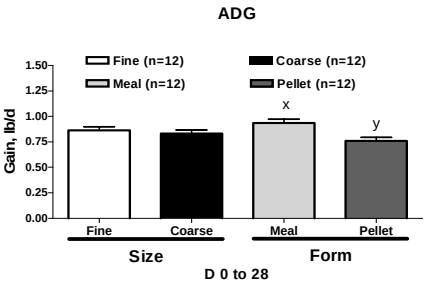

Figure 1.

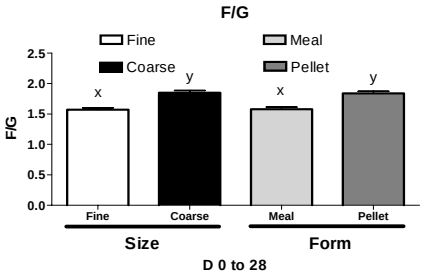

Figure 2.

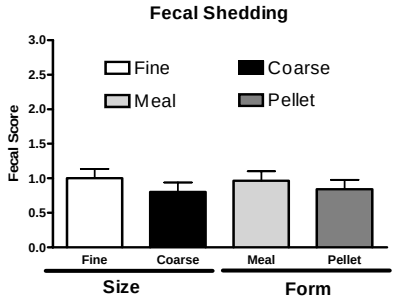

Figure 3.

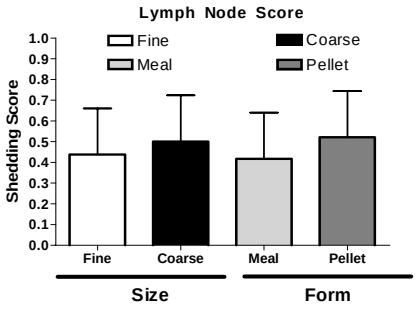

Figure 4.

[a]Ninety-six weanling pigs (initially 13.8 lbs) were used two pigs per pen and 24 replicate pens per main effect of feed processing for ADG, F/G, and lymph node score and 72 replicate pens per main effect for fecal shedding. Inoculated on d 7 with 1.9×10^7 CFU of *Salmonella enterica* serotype Typhimurium.

[xy] Main effects with different superscripts differ ($P<0.05$).