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Summary
Previous research has demonstrated the benefits of including large grain particle size in poultry diets on gizzard and gastrointestinal tract development. However, including these larger particles may decrease pellet integrity. Therefore, the objective of this study was to evaluate the effect of coarse corn inclusion level on pellet quality. A corn soybean meal-based finisher broiler diet with 1.5% mixer added fat was used in this experiment. Treatments were created by replacing 600 µm corn with 1,200 µm coarse rolled corn at 0, 10, 20, or 30% of the diet. Mash treatments were pelleted using a 30-horsepower pellet mill (Model 1012-2 HD, California Pellet Mill) equipped with a 3⁄16 × 1 ¼ in. die. Pelleting order was randomized within each replicate with 3 replicates per treatment. Target conditioning temperature was 185°F for 30 s retention time at a 34 lb/min production rate. Samples were analyzed for hot pellet temperature (HPT), fine to pellet ratio (%fines) and pellet durability index (PDI) using the standard tumble box (STD) and Holmen NHP100 (NHP) for 60 s. Data were analyzed using the GLIMMIX procedure of SAS. There were no differences among analyzed variables as the inclusion level of coarse corn was increased ($P > 0.05$). The %fines and PDI remained similar across treatments, regardless of method. In conclusion, increasing the concentration of coarse corn from 0 to 30% did not influence PDI.

Introduction
When considering the particle size reduction research, it is generally accepted that reducing the particle size of grains improves the feed efficiency of animals. However, birds use their gizzards instead of teeth for the mechanical breakdown of ingested feed particles. Previous research has demonstrated the benefits of large-grind particle size in diets on gizzard and gastrointestinal tract development. A well-developed gizzard reduces feed passage rate and increases the time the feed is in the gastrointestinal tract for exposure to digestive enzymes. Therefore, it has been demonstrated that coarse corn can result in increased body weight and improved feed conversion ratio. It was also shown to increase gizzard weight, increase digesta retention time, and improve apparent ileal digestibility.[1]

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[1] Xu. Y., C. R. Stark, P. R. Ferket, C. M. Williams, W. J. Pacheo, and J. Brake. 2015. Effect of dietary coarsely ground corn on broiler live performance, gastrointestinal tract development, apparent ileal digestibility of energy and nitrogen, and digesta particle size distribution and retention time. Poult. Sci. 94:53-60.

A majority of poultry feed is fed in pelleted form. Pelleting diets leads to an improvement in broiler performance; however, it is important to maintain pellet quality to maximize the performance response. Pellet integrity or quality is commonly judged by a pellet's ability to withstand tumbling and impact when being conveyed through the processing system. It has previously been demonstrated that increasing the particle size of corn can potentially reduce pellet quality. Therefore, the objective of this study was to determine the effect of coarse corn inclusion in broiler diets on pellet quality.

Materials and Methods

Diet manufacture

Feed was manufactured in accordance with Current Good Manufacturing Practices at the Kansas State University O.H. Kruse Feed Technology Innovation Center (Manhattan, KS).

A corn, soybean meal-based poultry finisher diet was manufactured to provide a base diet for all treatments. Treatments consisted of the corn, soybean meal-based control with coarse corn added at 0, 10, 20, and 30% of the complete diet. Corn was ground to approximately 600 μm using a hammermill (Model 22115, Bliss Industries LLC., Ponca City, OK). Coarse corn was ground to approximately 1,200 μm using a roller mill (RMS Model 924). A total of 1,000 lb of poultry feed per treatment was mixed in a 57.6 ft^3 twin-shaft counterpoise mixer (Hayes & Stolz, Fort Worth, TX). Each 1,000-lb batch per treatment was divided into three batches for pelleting. Each treatment was pelleted in 333-lb batches during 3 separate periods to provide 3 replicates per treatment. Time of processing served as a blocking factor and order of pelleting each treatment was randomized within each block. Diets were steam conditioned (10 in. width × 55 in. length Wenger twin staff pre-conditioner, Model 150) to a target conditioning temperature of 185°F for approximately 30 s and pelleted on a 30-horsepower pellet mill (1012-2 HD Master Model, California Pellet Mill, Crawfordsville, IN) equipped with a $\frac{3}{16}$ × 1 ¼ in. pellet die (L:D 6.6). The feeder was set at a constant rate to achieve a production rate of approximately 1 ton per hour. Pellet samples were cooled in an experimental counterflow cooler for 15 minutes to ensure cooled pellets were within 5°F of ambient room temperature.

A representative sample of ground corn and coarse corn were collected for particle size analysis. During the pelleting process, hot pellet temperatures were recorded at 3 time points throughout each run. Cooled pellet samples were collected at 3 time points throughout each run for analysis of percent fines, standard PDI and Holmen (60 s) PDI.

Pellet durability index analysis

Prior to PDI analysis using the tumble box or Holmen NHP100, cool pellets were sifted using a U.S. No. 5 sieve for separation of fines and pellets. Percent fines were then calculated as the weight of recovered fines divided by the initial sample weight. The sifted pellets were then used in subsequent PDI analysis.

For the standard tumble box method, sifted pellets were riffle divided into two 500 g aliquots for duplicate analysis. Each 500 g sample was placed in the designated chamber of the tumble box and rotated for 10 minutes. After tumbling, the sample was collected from the compartment and sifted using the same U.S. No. 5 sieve as previously described. The remaining sifted pellets were weighed with PDI being calculated by dividing the final sifted pellet weight by the 500 g initial sample weight.

For the Holmen method, sifted pellets were riffle divided into two 100 g aliquots for duplicate analysis. The 100 g sample was placed into the hopper of the Holmen NHP100 and the desired run time selected (60 s). Once completed, the sample was collected from the hopper and sifted using the same U.S. No. 5 sieve as before. The PDI was calculated by dividing the final sifted pellet weight by the 100 g initial sample weight.

Statistical analysis

Data were analyzed using the PROC MIXED procedure of SAS version 9.4 (SAS Institute, Inc., Cary, NC). Experimental unit was pelleting run treatment with a random effect of pelleting period. Results were considered significant if $P \leq 0.05$.

Results and Discussion

There was no evidence of a difference ($P = 0.112$) for hot pellet temperature when coarse corn was added to the diet at 10, 20, or 30% (Table 2). In addition, there was no evidence of difference ($P > 0.168$) in percent fines as well as PDI, regardless of method. It was hypothesized that increasing the percentage of coarse particles in the diet would reduce pellet quality. The lack of difference is potentially attributed to retention of the large corn particles on the No. 5 sieve used to separate the fines from the pellets. However, this was not quantified within this experiment. Future research is needed to quantify the effects on broiler performance and the percent of fines found at the feeder. In conclusion, when pelleting diets under conditions reported herein, increasing the concentration of coarse corn from 0 to 30% did not influence PDI.

Table 1. Diet composition[1,2]

Item, %	Control
Corn	70.18
Soybean meal (46.5% crude protein)	25.50
Choice white grease	1.50
Limestone	1.10
Monocalcium phosphate	0.40
L-Lys-HCl	0.17
DL-Met	0.24
L-Thr	0.06
Salt	0.23
Mineral-vitamin premix	0.25
Sodium bicarbonate	0.23
Choline chloride	0.10
Phytase[3]	0.04
Total	100

[1]A finisher poultry diet composed of corn (ground to 600 μm) and soybean meal with added synthetic amino acids was mixed in 57.6 ft^3 horizontal counterpoise mixer. Diets were steam pelleted (10 × 55-in. length Wenger twin staff preconditioner, Model 150) for approximately 30 s at 185°F targeted conditioning temperature on a 30-horsepower pellet mill (1012-2 HD Master Model, California Pellet Mill) with a 3⁄16 × 1 ¼ in. pellet die (L:D 6.57).
[2]Treatments were developed by replacing corn (600 μm) with 1200 μm coarse rolled corn at 0, 10, 20, or 30% of the diet.
[3]Ronozyme HiPhos GT 2700 (DSM Nutritional Products, Basel, Switzerland).

Table 2. Effects of including coarse corn in broiler diets on pellet quality[1]

	Coarse corn, %					Probability, *P* <	
Item	Control	10	20	30	SEM	Linear	Quadratic
Hot pellet temperature, °F	82.3	85.8	86.8	84.7	0.48	0.114	0.112
Percent fines,[2] %	9.1	9.8	8.7	9.5	0.70	0.990	0.948
Standard method,[3] %	60.4	60.5	64.0	60.1	1.30	0.673	0.168
Holmen NHP100 method (60 s),[3] %	65.4	65.0	66.2	63.4	4.50	0.823	0.799

[1]A finisher poultry diet composed of corn (ground to 600 μm) and soybean meal and with added synthetic amino acids was mixed in a 57.6 ft^3 horizontal counterpoise mixer. Diets were steam pelleted (10 × 55-in. length Wenger twin staff preconditioner, Model 150) for approximately 30 s at 185°F targeted conditioning temperature on a 30-horsepower pellet mill (1012-2 HD Master Model, California Pellet Mill) with a 3⁄16 × 1 ¼ in. pellet die (L:D 6.57).
[2]Reported values represent entire collected sample sifted (U.S. No. 5 sieve).
[3]Pellet durability index methods were run in duplicate on the 3 collected samples for each treatment.