Particle size manipulation has recently become a “hot topic” as a means to improve the efficiency of poultry live performance. Interest has been driven by the juxtaposition of classic theory (i.e. finer grinds lead to improved digestion) with the relatively modern idea that coarse ingredients are necessary to complement the natural design and function of the gastro-intestinal tract (GIT). As with most animal performance research, evaluating the impacts of feed particle size largely concerns live performance criteria such as feed intake, body weight (BW), and feed conversion. Additionally, questions of particle size manipulation must also take into account the impact on feed manufacturing methodology. This impacts both feed mill efficiency (e.g. energy consumption and throughput) and finished feed characteristics, most specifically pellet quality and feed ingredient segregation.

Particle size reduction is the second-most common feed manufacturing process (mixing is first), and thus has a substantial performance impact in the global sense. Grinding is most typically associated with the size reduction of cereal grains. However, other ingredients, such as oilseeds and by-products, may also enter the grinding stream, especially in post-batch grind operations. In general, the reduction in particle size leads to increased ingredient surface area, leading to more intimate interaction with digestive acids and enzymes in the GIT. However, the presence of the gizzard and the physiological functions afforded by reverse peristalsis makes it obvious that the chicken did not evolve to consume only fine particles. The lack of adequate gizzard function, and resultant reduced GIT retention time, has a negative impact on live performance. Thus, the interest in coarse particle inclusion has grown recently.

It must be noted that there are many variables that come into play that can accentuate or diminish the impact of feed particle size manipulation on animal live performance. For example, litter type (size and texture) and management strategies will determine the access to non-feed coarse material. Also, differences in animal age, production stage, and purpose (e.g. meat vs. offspring production) must be considered. The following is a highlight of some of our recent work which has focused on the manipulation of feed particle size, in the presence of the aforementioned variables, and the overall impact on animal live performance as well as feed milling characteristics.

Chewning et al. (2012) conducted an experiment where corn particle size averaged 270 or 570 microns, and diets were fed to broilers as mash or pellets. The finer grind did
lead to an improved BW at 21 d, but not at 35 d and 44 d. Smaller particle sizes led to improved feed conversion ratio (FCR) in the mash diets, but there was no observed difference in the pelleted diets over the course of the experiment. It was concluded that reduced particle size did not improve live performance in a pelleted diet. On average, pellet durability (PDI) did improve with the finer grind (88% vs. 84%). While statistically significant, the decrease in pellet quality (and a corresponding increase in fines in the feeder) was apparently not large enough to have a negative effect on performance in comparison with the diet containing the finely ground corn. The upshot of these results is that bird performance was equal, while grinding costs would have been diminished.

The next step was to begin including coarsely ground grains as a component in the overall diet. This would generally be done by combining two product streams, a fine-grind corn and a coarsely ground corn at a substantially higher particle size. Xu et al. (2013) fed broilers two dietary treatments, with coarse corn (CC) making up 0 or 50% of the total dietary corn. Fine corn (hammermill ground to 270 microns) and CC (roller mill ground to 1,150 microns) were blended prior to pelleting to create the dietary treatments. The inclusion of CC led to improved BW and FCR. In order to evaluate the impact of litter availability, birds in this study were raised on multiple floor types, including netting as well as new and old litter. Birds on new wood chip litter had improved performance even in the absence of CC, reinforcing the theory that coarse material consumption aids GIT function.

A following study by Xu et al. (2015) evaluated three CC inclusions (0, 25, 50%) in a cage study. Feed was fed as crumbles and pellets, with pellets having been screened to remove the fines. Fine corn was approximately 295 microns, CC was approximately 1360 microns, and the mash diets containing 0, 25, and 50% CC were determined to have mean particle sizes of approximately 430, 541, and 640 microns, respectively. With the inclusion of 0, 25, and 50% CC, PDI was 92, 93, and 90%, respectively, showing no practical difference. As with previous studies, CC increased BW and improved FCR, and was also shown to increase gizzard weight, increase digesta retention time, and improve apparent ileal digestibility.

Auttawong et al. (2013) also fed broilers two dietary treatments, in this case having 0 or 35% CC. Fine corn was approximately 260 microns and CC was approximately 1,080 microns, and all diets were pelleted. Birds were fed ad libitum or on a time-limited basis. As in other experiments, CC improved FCR when the birds were fed ad libitum. However, when feed was time-limited fed the CC effect disappeared. We theorized that the restricted birds, being hungrier, consumed litter when feed was not available and consumed all feed regardless of pellet quality when given the opportunity. As in the study above, consumption of litter likely aided gizzard function in a similar manner to CC inclusion.

A second study by Attawong et al. (2014) again investigated CC inclusion (0, 10, 30%) in the presence of varying mixer-added fat application. Fine ground corn was approximately 290 microns, CC was approximately 805 microns, and mixer-added fat ranged from 0.75% to 3%. At 28 d, CC inclusion improved FCR, while 3% mixer-added
fat produced poorer FCR. Neither factor had an effect on BW and, by 35 d, there was no CC or post-pellet fat effect on FCR. Overall, with 3% mixer-added fat, FCR was poorer with CC inclusion compared to diets with fine corn. This likely demonstrates a pellet quality effect, as both CC and mixer-added fat led to reduced pellet durability. The data also demonstrated that, while 805 micron corn was sufficient to obtain the CC effect in younger birds (<28 d), a larger particle size was likely necessary thereafter.

Recalling the first-described experiment of Attawong et al., the results for time-limited fed birds raised questions concerning the impact of coarse material in certain situations, such as in breeding and laying operations. Lin et al. (2013) fed broiler breeders that have been placed in individual cages two mash diets from 24 weeks of age into production, one containing 0% CC and the other containing 50% CC. As is typical for breeders, birds were restricted-fed. The fine corn diet increased production (egg mass and number), while the CC produced smaller BW birds that began producing eggs later, and were unable to produce at the same rate. It was concluded that the fine corn provided the necessary energy under the restricted feeding conditions. However, these breeders had been grown on little floors so that they had fully developed gizzards at 24 weeks of age. Taking this experiment into account along with the others demonstrates how particle size must be manipulated, even within a single genetic line, based on feeding practices and production requirements.

Particle size reduction research has also been carried out on ingredients other than corn, most commonly co-products and by-products, such as soybean meal (SBM) and distillers dried grains with solubles (DDGS). These ingredients may arrive to the feed mill at a range of particle sizes depending upon supplier and manufacturing technique. In order to evaluate the impact of non-grain particle size on broiler live performance, a series of experiments was conducted by Pacheco et al. (2013, 2014). In the first experiment, DDGS with a particle size of 700 microns were obtained, and a representative fraction was ground to 350 microns. Birds fed pelleted diets containing 350 micron DDGS had greater BW at 42 d of age, and in general performed better. However, birds fed 700 micron DDGS had greater gizzard weights, again typical of experimental treatments with coarse material. In the next experiments, SBM particle size (410 or 1025 microns) and DDGS inclusion level (15 or 30%) and particle size (480 or 745 microns) were evaluated. The inclusion of fine SBM led to an improvement in pellet quality, but coarse SBM had an overall positive effect on live performance. Fine DDGS actually decreased pellet durability, as did an increased inclusion rate, but overall PDI values were similar. Fine DDGS led to an increased feed intake and BW, with no impact on FCR, and coarse DDGS increased gizzard weight.

There is a great deal of work remaining to be done on feed particle size manipulation relative to poultry live performance. This includes zeroing in on the appropriate distribution of particles, determining the best manufacturing methods, and looking at methods for product evaluation. However, here is what we know to this point: the inclusion of at least some coarse particles benefits meat-bird live performance; older birds can tolerate greater coarse material inclusion rates; coarse material may decrease pellet quality, but not as much as some might think, and it can be managed with good attention paid to the rest of the process.


