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PARTICLE SIZE EVALUATION OF FEED INGREDIENT PRODUCED IN THE KUMASI METROPOLIS, GHANA

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ABSTRACT

The objective of this study was to evaluate the particle size of ground maize for poultry feed formulation in the Kumasi metropolis in Ghana. A survey of 2 commercial and 7 on-farm feed mills was conducted and a questionnaire regarding the operation of the mills was completed. Samples of ground maize were taken from each mill for particle size analysis. The geometric mean diameter (GMD) of the particles ranged from 628±1.93 to 1450±2.25 µm. The results showed that only one mill produced ground maize with particle size within the recommended range. From this study, it can be concluded that the particle size of ground maize for feed formulation in the metropolis was coarser than recommended for poultry.

Keywords: particle size, feed ingredient, geometric mean diameter, geometric standard deviation, quality control.

INTRODUCTION

Particle size of ingredients is important in the overall process of handling and mixing of ingredients to manufacture formulated feeds and is critical in achieving optimal utilization by animals. The manner in which ingredients are ground and the coarseness of that grind has a direct impact on the feed utilization efficiency of the birds. Nir *et al*. (1994) asserted that nutrient digestibility decreases when small particles are used because they cause gizzard atrophy and discrete intestinal hypertrophy, which is caused by bacterial fermentation. Particle size is established by the geometric mean diameter (GMD). However, complete information on particle size must include a measure of data variability. This measure is the geometric standard deviation (GSD), which establishes the range of variation among the different particle sizes (Nir *et al*., 1994). Particle size uniformity is described by geometric standard deviation GSD, a small GSD representing higher uniformity. Healy *et al*. (1994) reported the improvement in feed efficiency of 7 and 9% for maize and sorghum, respectively for poultry as particle size was reduced. Based on these results and taking into account the milling costs and throughput characteristics, Dritz and Hancock (1999) recommended a mean particle size of 600 to 800 µm for poultry. This is in fairly good agreement with the recommendation of 700 to 900 µm for broilers by Nir *et al*. (1994).

Lott *et al.* (1992) conducted two trials in which maize was ground to different particle sizes by hammer mill grinding and fed to chicks in either mash or crumbled form, for 1 to 21 days. In the first experiment, hammer mill screen sizes of 3.18 mm or 9.59 mm were used toproduce maize with GMD of 716 µm and 1,196 µm, respectively. Body weight was significantly higher and feed conversion significantly improved when chicks were fed the diets incorporating the maize ground on the 3.18 mm screen. In a second trial, maize was ground using a series of hammer mill screens ranging from 3.18 mm to 7.94 mm, resulting in maize with GMD ranging from 690 to 974 µm. Chicks fed crumbled diets incorporating maize with the various grind sizes did not differ in body weight or feed utilization. Particle size of the diet seems to have great importance in regulating the intake in broiler chickens that show preference for diets containing larger particles instead of those finely ground (Nir *et al*., 1994). Birds have difficulty in eating particles that are bigger or much smaller than the size of the beak (Moran, 1982 as quoted in Dahlke *et al*., 2003). Nir *et al.* (1995) suggested that particle digestion within the proximal small intestine is slower when particles are bigger, resulting in more peristaltic movements and maybe a better utilization of the nutrients. Thus, the consumption of diets with different characteristics may have a direct effect on the morphological structure of the digestive system of the birds, such that any alteration in the structure of the feed might have a significant effect on performance by restricting or making some nutrients unavailable (Macari *et al*., 1994 as quoted in Dahlke *et al*., 2003).

According to Beyer (2003), particle size is another manufacturing parameter that has received little attention in previous researches. In Ghana, the only study on feed particle size effect on poultry was recently reported by Oppong-Sekyere (2005). He investigated the effect of varying particle size of ground maize in mash feed on broiler performance. It was observed from the study that birds fed on diet with maize particle size of 713 ± 2.1 µm consumed least amount of feed but had better feed to weight gain ratio compared to those fed on coarser particle sizes of 1462 ± 1.97 µm and 1506.8 ± 1.9 µm. Opong Sekyere further found out that birds fed on diet with particle size of 713 ± 2.1 µm had the highest dressing percentage of 76.47%. It was concluded from the study that particle size of the feed had effect on body weight gain and feed conversion efficiency. Therefore, the hypothesis of this study was that maize being the major ingredient in mash feed produced by two commercial and seven on-farm feed producers in Kumasi metropolis, who do not examine feed particle size as a quality indicator during feed preparation, may be creating feed with particle size outside the recommended range of 600 to 900 µm.

Therefore, a survey of feed mills in the metropolis was carried out to determine if producers were creating feeds with optimum particle size.

MATERIALS AND METHODS

To assess the average particle size of ground maize produced in the Kumasi metropolis, a study was conducted at two commercial and seven on-farm mills in the Kumasi Metropolis. The capacity of the hammer mills ranged from 1.5 to5 t/h with the motor power ratings varying from 7.5 to 70 kW, whereas the screen size ranged from 5 to 6 mm.

From each ground maize samples of 1 kg sample from a hammer mill with initial moisture content between 11 and 13% wet basis, a 200 g sub-sample was dried at 40°C for 6 h to attain equal moisture content of 9%. (A total of 10 replicates were collected from each hammer mill). Five replicates of the samples were screened through five sieves with a sieve shaker (Retsch GmbH and Co. KG, Germany) and the weight of the ground maize particles not filtering through each screen was determined and recorded (ASAE, 2003). The fine particles that filtered through all screens were collected in the pan and weighed. The size of screen openings (μm) used were 2360, 1600, 1180, 710, 425, 250 and 100. The weights values of particles collected on each screen were entered in the appropriate columns in Microsoft Office Excel 2003 to determine the average particle size GMD and GSD according to equations (1), (2) and (3) (ASAE, 2003):

$$d_i = (d_u \times d_o)^{0.5} \quad (1)$$

where

d_i = diameter of *i*th sieve in the stack
d_u = diameter opening through which particle will pass (sieve proceeding *i*th)
d = diameter opening through which particle will not pass (sieve proceeding *i*th)

Because it is not practical to count each particle individually and calculate an average, the average particle size can be calculated on a weight basis. This was done with the following equation:

$$d_{gw} = \log^{-1}\left[\frac{\Sigma Wi(\log di)}{\Sigma Wi}\right] \quad (2)$$

where

d_{gw} = geometric mean diameter (μm)
W_i = mass on ith sieve, g

The standard deviation was calculated from equation (3):

$$S_{gw} = \log^{-1}\left[\frac{\Sigma Wi(\log di - \log dgw)^2}{\Sigma Wi}\right]^{0.5} \quad (3)$$

RESULTS AND DISCUSSIONS

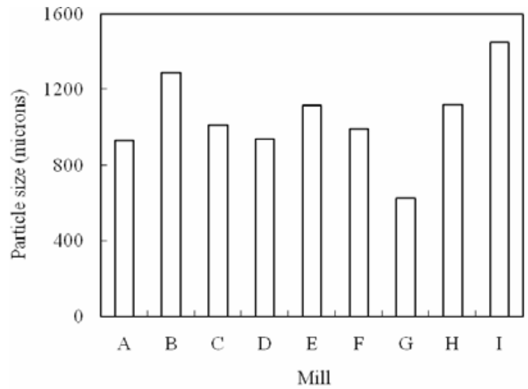

Fig. 1. Variations in mean particle size among the feed mills.

Figure-1 shows the results of particle size analysis of the samples collected from the mills. The average GMD particle size among the 9 mills was 1054 μm (SD = 234, CV= 22%), and ranged from 628 μm in mill G to 1449 μm in mill I. Thus there is considerable variation in average GMD particle size of ground maize originating from these producers in Kumasi. Mill I had the highest GMD particle size of 1449 μm followed by mills B and H with GMD particle sizes of 1291 and 1122 μm respectively. Mills C and E produced the next highest GMD particle sizes of 1015 and 1116 μm, respectively whilst mills F, D and A produced lower GMD particle sizes of 993, 942 and 933 μm, respectively. As a point of reference, the target mean particle size for mash diets for poultry is 600-900 μm (Nir *et al.*, 1994; Dritz and Hancock, 1999) and only mill G was within this target range. All other mills (89%) in the metropolis produced coarser particles suggesting that further grinding of maize may be warranted to improve the mean particle size, improve particle size uniformity, and optimise nutrient digestibility of the ground ingredient in a complete mixed feed.

The distribution of particle size fractions collected over the sieves is shown in Figures 2-10. There were different distributions of particle size among all mills. A total of almost 45% of the ground maize in mill A was larger than 710 μm, the desired average size. The highest proportions were collected on the 1600 and 1180 μm screens. In the case of mill B, the highest amounts were collected on 2360, 1600 and 1180 μm screens. These represent almost 65% of the ground sample which is larger than 710 μm. Likewise, about 48% of the ground sample from mill C was coarser than 710 μm with 1600 μm sieve retaining about 18%. In the case of mill E about 55% of the ground was coarser than 710 μm, but mill F produced about 46% ground coarser than 710 microns. For mill G, the ground contained the lowest percentage (26%) of materials greater than 710 μm whereas mills D and H produced about 48 and 54% materials coarser than 710 microns respectively. The highest amount of materials (72 %) coarser than 710 μm was produced by mill I.

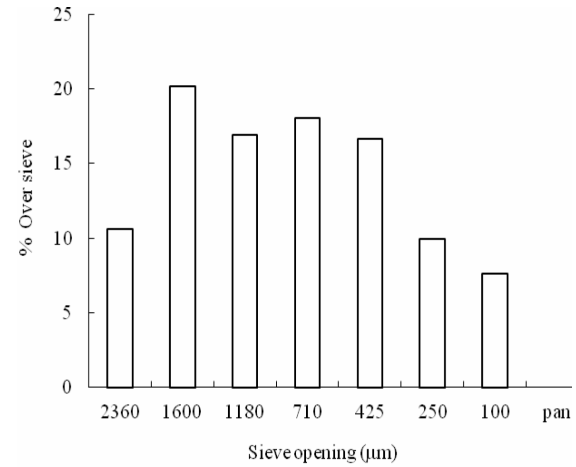

Fig. 2. Ground maize particle size in sample A.

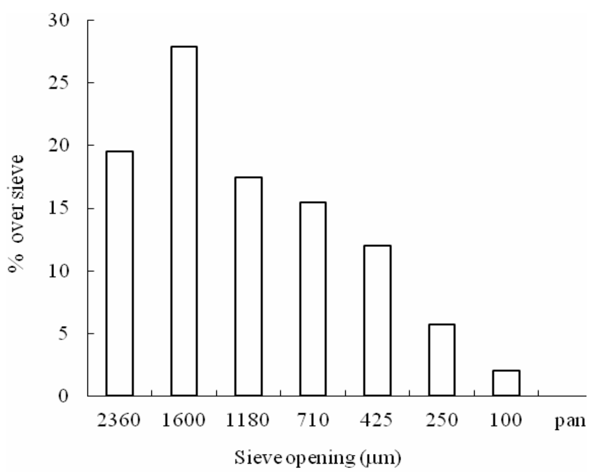

Fig. 3. Ground maize particle size in sample B.

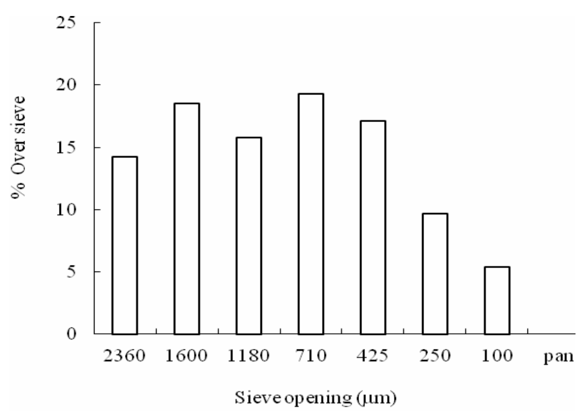

Fig. 4. Ground maize particle size in sample C.

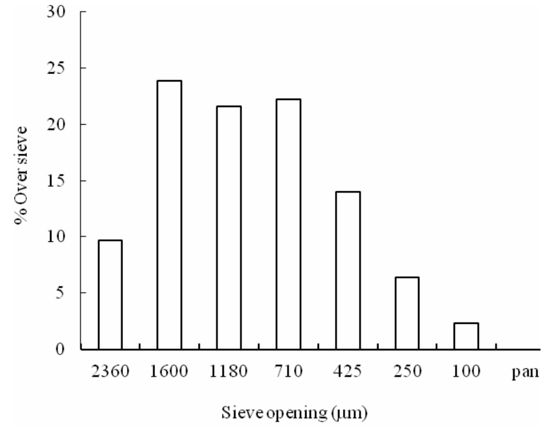

Fig. 5. Ground maize particle size in sample D.

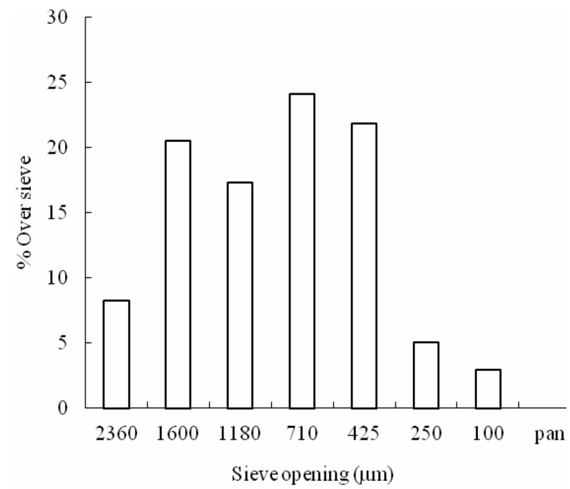

Fig. 6. Ground maize particle size in sample E.

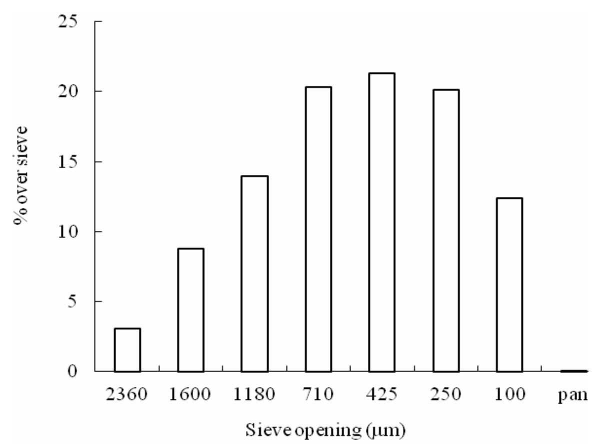

Fig. 7. Ground maize particle size in sample F.

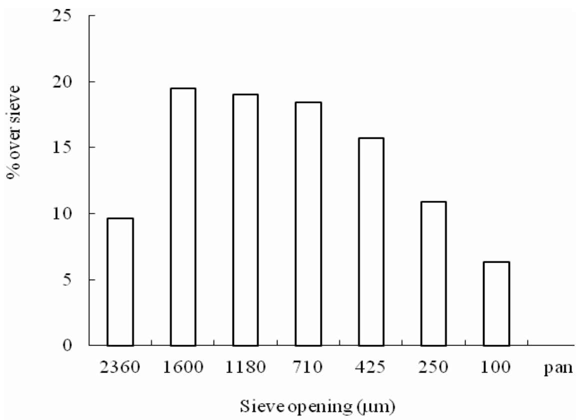

Fig. 8. Ground maize particle size in sample G.

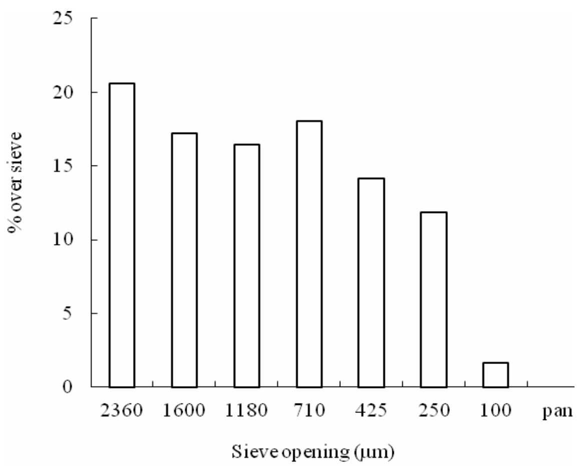

Fig. 9. Ground maize particle size in sample H.

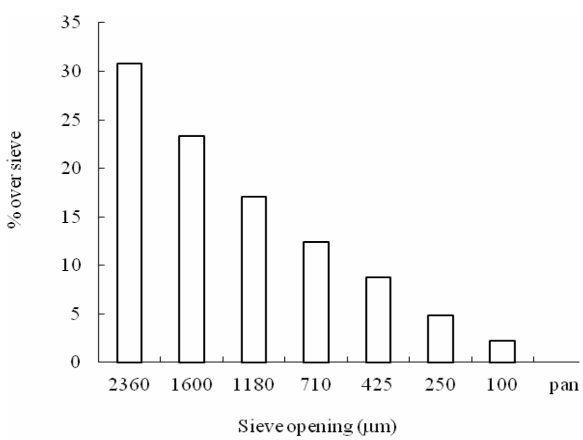

Fig. 10. Gound maize particle size in sample I.

Goodband *et al*. (2002) suggested that a routine particle size monitoring programme should include checking ground grain or one complete diet at least twice a year and up to every 60 to 90 days for large operations. When this is adopted in the metropolis, it would assist the feed millers to grind maize to optimal particle size for feed formulation. Furthermore, feed conversion efficiency will improve with optimum particle size (Dritz and Hancock, 1999).

CONCLUSIONS

The following conclusions can be drawn from this study:

- Particle size of ground maize produced by the feed mills in the Kumasi Metropolis ranged from 628±1.93 to 1450±2.25 µm;
- Only one mill (Mill G) ground maize to a particle size of 628±1.93 µm which was within the recommended range for poultry; and
- The weight of ground maize retained on screens above and below 710 µm ranged 26-72% and 16-48%, respectively.

Recommendation

- It is recommended that particle size analysis should become a routine quality control measure during poultry feed manufacturing.

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