

The effects of maize meal particle size distribution on broiler performance

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Abstract

Feed constitutes 60 to 80% of the total broiler production costs and there is a need to improve on feed characteristics to increase efficiency of nutrient utilisation and reduce costs. Two hundred Cobb day old chicks were fed maize-soya bean-based diets. The maize in the diets was ground by hammer mill and passed through five screens which had 3, 4, 5, 6 and 8 mm perforations that produced maize particle sizes of 400, 450, 535, 750, and 930 microns respectively. The trial had five treatments with each treatment having two replications. Forty birds were allocated for each replicate. Data collected on weekly basis include feed intake, total mass per replication, mean mass per replication, treatment mean mass, feed conversion ratio per replication, treatment mean feed conversion ratio, and mortality. The findings indicate that there were no significant differences ($p > 0.05$) on the Average Daily Feed Intake, average daily gain and consequently the Feed Conversion Ratio amongst the birds fed maize with particle sizes ranging from 400 to 930 microns.

Key words: Particle size, maize, performance

Introduction

Feed particle size is an area of interest and concern in the livestock feed industries and many feed ingredients are ground before they are incorporated into poultry diets (Lott *et al.*, 1992). Cereal grains are the primary energy source in monogastric nutrition (maize in particular, constitutes more than 50% of most broiler diets), therefore, not only producers must be concerned about the composition of the grain, but also how it is processed so that the bird may fully utilise the nutrients. Particle size encompasses both the sizes of the various ingredients used in poultry diets

as well the consistency of the particle. Continued reduction of particle size increases both the number of particles and the surface area per unit volume allowing for greater access to the digestive enzymes. In addition, particle size is used to modify the physical characteristics of the ingredients (Goodband *et al.*, 2002). Particle size impacts in the manner in which ingredients are handled and processed in the mill. Continued reduction of particle size, however, is not without a cost. Keratinization, an indication of stomach irritation that may lead to

ulcers and stomach ulcers are always a concern with finely ground diets. Feeding finely ground feeds may increase the potential of bird mortality.

Poultry serves as a rich source of animal protein which is crucial in human nutrition. Animal protein intake has been on the decline and more so in the rural areas which make up 85% of the extreme poor in Zimbabwe (FOS, 1995). Zimbabwe produces about 6500 metric tonnes of poultry meat per month (WATT AgNet 2011) which translate to a per capita consumption of about 6.5kg. This is below the needs expressed by local consumers and it pales into insignificance when compared to neighbouring countries whose annual per capita consumption ranges between 28kg and 32kg of poultry meat respectively. This deficit has led to increased imports of poultry meat from developed countries (FAO, 2008) and importation of genetically modified meats and meat products that are banned in Zimbabwe. Therefore any measures, such as improving the efficiency of feed intake in poultry, which improve broiler performance, are worth investigating.

There has been a general use of one screen size (of 5mm) in the feed industry to grind maize for broiler starter, grower and finisher diets. Studies focusing on optimal grain size, specifically maize particle size and performance are limited, and somewhat have presented conflicting results when roller mills were used to grind maize (Goodband *et al*, 2002). There was need, therefore, to investigate the screen size combinations

to use in grinding maize for broiler feeds when using hammer mills for optimal nutrient utilisation efficiency. Maize particle sizes that allow proper acceptance by the birds promote best nutrient digestibility and performance, maintain bird health and are economically viable should be identified. The objective of the study was to determine the effect of screen size combinations of ground maize on broiler performance

Materials and methods

Study Area

The study was carried out at Henderson Research Institute which is located about 30km North of Harare, with coordinates 17° 33' S and 30° 58' E. The Institute is located in Natural Region IIa in Mashonaland Central province. The area receives an average rainfall of 800mm per annum. Daily temperature ranges from 18-28°C. The institute is bounded on the north by an Iron Mask Range of hills and on the south by granite hills. The area lies on an altitude of about 1300m above sea level.

Management of birds

In the study, 200 Cobb day old chicks were fed maize-soya bean based diets. The diets were iso-energetic and iso-nitrogenous with the same range and spectrum of vitamins, minerals and amino acids. The feeds varied only in the maize particle size, which had a dry matter content of 94%. Five screens which had (3mm, 4mm, 5mm, 6mm, and 8mm) perforations were used to grind the maize using a Hippo 5 Hammer Grinding Mill. They produced

maize particles with Geometrical mean diameters (GMD) of 400, 450, 535, 750, and 930 microns. The trial had 5 treatments with each treatment having two replications. 20 birds were allocated for each replicate. The day old chicks were individually weighed and the birth weights were recorded in order to measure the weight gain during feeding. Water and feed was given on *ad-libitum* basis. Light was provided continuously throughout the experiment in the form of daylight and infrared lamps at night with an average light intensity of 25lux. The relative humidity ranged between 50-60%.

Experimental Design

A completely randomised design was used for the trial. All treatments were randomly allocated in the pens. The birds were fed *ad-libitum*. From day one to seven, the birds were given water with a vitamin stress pack (RX 184) to minimise the stress of settling down. The birds were also vaccinated against Infectious Bursal Disease (IBD) on day 10 and on day 20. Standard broiler bird management systems were affected throughout the experiment.

Data collection

The following data was collected and tabulated on weekly basis. Feed intake / grams /bird/ day, Mean grams /bird/ day, Total feed intake (grams) per replication, Mean Feed intake, Total mass per replication (mass of all birds in each replication), Mean mass per replication, Treatment Mean mass, Feed Conversion Ratio per replication which was calculated by dividing total feed consumed by the live weight gain of the broilers.

Statistical analysis

The effects of screen size combinations on Daily Feed Intake, Average Daily Gain and Feed Conversion Ratio were analysed using Generalised Linear Models (GLM) of Statistical Analysis System (SAS) (2003). The model used was:

$$Y_{ij} = \mu + T_i + E_{ij} \text{ where;}$$

Y_{ij} = Daily Feed Intake, Average Daily Gain and Feed Conversion Ratio;

μ = overall mean;

T_i = effect of the i^{th} screen size combination on Daily Feed Intake, Average Daily Gain and Feed Conversion Ratio;

E_{ij} = random error assumed to be normally distributed with mean zero and variance, σ^2

Results and discussion

There were no significant differences ($p > 0.05$) on the average Daily Feed Intake, average daily gain and consequently the Feed Conversion Ratio at 42 days of age (Table 1). Cabrera (1994) found no effect of diet particle size (1000 to 400 microns) on growth performance of broiler chicks fed a complex (added tallow, meat and bone meal, and feather meal) diet fed in a crumbled form. Benedetti *et al.* (2011) also found out that the performance of broilers at 42 days of age was not affected by maize texture or particle size.

Table 1: Nutritional composition of the feed

	Starter	Grower	Finisher
Crude Protein (%)	22	20	19
Fat (%)	5	5	6
Crude Fiber (%)	4	5	5
Calcium (%)	1.1	1.2	1.2
Phosphorus (%)	0.8	0.8	0.8

There was an improvement in the Average Daily Feed Intake in broiler chicks which were fed a broiler starter ground with a 5mm screen compared to those on an 8mm starter diet (Table 2). It appears that these effects of feed particle size may be influenced by age of birds. There is some evidence that very coarse particles may adversely influence the performance in young birds. Douglas (1990) reported that mash feeding of coarser particle diets of either sorghum or maize that were ground (GMD, 1470-1800 μm) depressed weight gain and feed efficiency in broiler starters compared with those diets with finely hammer milled grains (GMD, 833-947 μm). Particle sizes larger than 1000 μm (GMD) are thought to be too large for chicks to utilise efficiently, as their passage through the gizzard is slower (Lott *et al.*, 1992), possibly because the undeveloped gizzard is physically unable to break down large grains. This may explain the poor performance observed when chicks are fed mash diets based on cracked maize (Davis *et al.*, 1951) and very coarse particles (Douglas *et al.*,

1990) from day one post hatch. A parallel situation occurs when whole grains were fed, and it has been observed by Ravindra *et al.* (2006) that young chicks have difficulties in swallowing whole wheat during the first few days of life. These researchers found that, when chicks are fed diets with whole wheat from day one, the birds grow slower and eat less feed compared to those fed ground wheat diets.

Table 2: Comparative performance of seven day old birds fed starter diets where the maize

Particle size (microns)	Feed Intake	Feed conversion ratio
400	139 ^a	1.17 ^a
460	139 ^a	1.18 ^a
535	140 ^a	1.19 ^a
780	138 ^a	1.18 ^a
940	133 ^b	1.14 ^b

^{a,b}Mean values with the same superscripts were not significantly different at day 42 ($P > 0.05$)

Optimum particle size intake probably varies with the rate of development of the digestive system, the beak dimensions and the gape (Portella *et al.*, 1988). Once proper gizzard development is attained, improvements in performance associated with the feeding of coarser, more uniform particles may be partly explained by the lower energy input required by birds

when they ingest coarser particles. It is known that the number of pecks to consume a given amount of feed is reduced when particle size increases (Jensen *et al.*, 1962).

In the growing and finishing phases, the results showed that there was no significant differences in ADG as the screen sizes were varied from 3mm to 8mm. These findings are in line with Reece (1986)'s studies that reported no significant effect on weight gains and feed efficiency. Parson (2006) reported positive effects on broiler performance when coarse maize particles were fed compared to finer particles. Early findings indicated that the larger the feed particle size of grain the greater the flow rate of digesta in the digestive tract (Svihus *et al.*, 2002). Almost as a rule of thumb, it would appear that older data indicates that with each additional 10% fines, a loss of 1 conversion point will result (Waibel, 1992).

Subsequent studies, however, have confirmed the beneficial effects of course grinding in mash diets (Reece *et al.*, 1986; Hamilton and Proudfoot, 1995; Nir *et al.*, 1995). Reece *et al.* (1985) fed mash diets based on maize ground by hammer mill (GMD, 814 µm) and roller mill (GMD, 1343 µm) to broiler starters, and observed better performance in birds fed coarse particle size in terms of weight gain and feed efficiency. Although it is generally believed that finer grinding will increase the substrate surface area for enzymatic digestion, and coarse grinding will decrease the substrate surface area for enzymatic digestion, data reviewed herein suggests that there is no significant difference on feeding broilers with either a fine or a coarse diet in the growing and finishing phases. However, it is recommended that broilers be fed with fine ground maize during the starter phase as this will give them a good frame to build up carcass.

Table 3: Effect of particle size of maize on broiler performance at 42 days of age

Mean particle size Diameter (microns)	Av. Daily Gain (grams)	Daily Feed Intake (grams)	Feed conversion ratio
400	29.1 ^a	49.9 ^a	1.71
460	30.2 ^a	50.2 ^a	1.66
535	30.4 ^a	51.4 ^a	1.69
780	31.7 ^a	52.6 ^a	1.66
940	30.3 ^a	51.6 ^a	1.70

^{a,b}Mean values with the same superscripts were not significantly different at day 42 (P > 0.05)

Particle size and on-farm feed processing

When considering the cost-benefit analyses of grinding, it was found that it takes 18 minutes more to grind one tonne of fine maize (3mm) than the time needed to grind the same quantity of maize using an 8mm screen. This translates to a saving of about US\$1.08 per tonne. This means that using smaller screen sizes to grind maize may also increase labour costs and reduce production rates as demonstrated by Dritz and Hancock (2001). The reduction of feed particle size is the second largest energy cost after that of pelleting in the broiler industry (Reece *et al.*, 1985). Dozier (2002) estimated that the utility usage comprised 25 to 30% of the manufacturing cost of broiler feed. Any reduction in energy consumption from grinding could significantly lower feed cost. Reece *et al.* (1986) reported that energy savings of 27% could be achieved by increasing the screen size of a hammer mill from 4.76 to 6.35 mm hence, any gain in productivity of birds from the reduction of particle size may be sufficient to offset the higher cost of fine grinding. Zanotto *et al.* (1994) also reported that coarse grinding will reduce energy consumption by 61%, with no effect on nutrient digestibility and broiler performance. Overall, grinding maize with a large screen size 8mm might have greater savings in terms of energy costs for grinding maize for inclusion in grower and finisher diets.

Table 4: Economic analysis of the ground maize

Screen size (mm)	Time taken to grind 1 tonne of maize (minutes)	ZESA billing Kw/hr/kvA = \$0.08
3	33	\$1.98
5	19	\$1.14
8	15	\$0.90

Hippo 5 grinding mill Motor rating - 45kw

Conclusion

The findings indicate that there were no significant differences on the average daily feed intake, average daily gain and consequently the feed conversion ratio amongst the birds fed maize with particle sizes ranging from 400 to 930 microns.

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