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Research article

EFFECT OF FEED PARTICLE SIZE ON GROWTH PERFORMANCE OF BROILER CHICKENS IN GHANA

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ABSTRACT: Maize supplies poultry with a major part of their energy requirement particularly in Ghana and some other parts of the world. However, most feed producers especially in Ghana do not examine feed particles size as a quality indicator in assessing feed preparation. Particle size of an ingredient is therefore very critical in achieving optimum utilization by animals. The manner in which ingredients are ground and the coarseness of that grind has a direct impact on the physiology of birds. The effect of feed particle size was investigated in a five-week study using 120 mixed-sex four week-old Cobb-500 broiler chickens. The birds were allocated randomly (completely randomized design) to three diets designated as T1 ,T2 and T3 each of which contained maize of varying particle sizes namely 'smooth,' 'coarse' and 'very coarse'. All diets had identical formulation and specifications with the only variable being the size of the ground maize. Birds had free access to feed and water. Parameters studied included feed intake, body weight gain, feed conversion efficiency, mortality, and carcass parameters. Feed cost per kg diet and feed cost per kg body weight gain were estimated. The results of the study indicated variations in the mean body weights at the end of the five-week experimental period. Birds fed on diet T1 consumed the least feed but were more efficient in converting feed to weight gain. Birds on diet T1 registered the highest dressing percentage while gizzard and liver weights were highest for birds on T3. Five mortalities were recorded, three from birds on dietary treatment T1 and one each from dietary treatments T2 and T3. Feed cost averaged GH¢0.30 per kg for all the treatments but cost of feed to produce a kg body weight was highest for birds on diet T3. Based on the fact that improvement in feed efficiency is more consistent for particle size reduction, a mean particle size of maize diet between 600 and 900µm is recommended for poultry farmers. Moreover, a routine particle size monitoring programme should include checking ground grain or one complete diet at least twice a year to assist feed millers produce feed of optimal particle size. Once these are made available to the poultry industry, production would be increased hence high income and better standard of living.

Keywords: Maize, smooth, coarse, very coarse, poultry performance

INTRODUCTION

Particle size of ingredients is critical in achieving optimum utilization by animals in as much as it is, in the overall process of handling and mixing (formulation) of ingredients to manufacture formulated feeds [4].

Many feed ingredients, especially cereal grains, are subjected to some form of particle size reduction before they are incorporated into poultry diets. Particle reduction begins by disrupting the outer protective layer of the seed (hull) exposing the interior. Continued reduction increases both the number of particles and the amount of surface area per unit of volume; this allows increased access to digestive enzymes. Particle size reduction is also used to modify the physical characteristics of ingredients, resulting in improved mixing, conditioning, pelleting, feed handling and transport, and, hopefully, in improved animal performance [3].

Feed particles are what a bird actually sees and touches in its diet. Broilers and layers eat using their own sensory perceptions of the food, ignoring in the short term all of the work done by the nutritionist [16]. The sensory perception of chickens is the crucial link between food technology and behavioral responses, a direct connection between the feed mill and the farm. [4]. The feed cues perceived by chickens take a number of forms. These include visual, tactile, olfactory stimuli and to a minor degree taste.

Young chickens tend to eat brightly coloured feed particles first and they will always show preference for larger feed particles, relatively independently of the composition of the particle. It is of interest that they will consume minimal quantities of a food at first, but there is a progressive switch of preferences according to sensory and nutritional testing of the food. [12].

The manner in which ingredients are ground and the coarseness of that grind has a direct impact on the physiology of birds. Nir *et al* [13]. asserted that digestibility of nutrients decreases when very small particles are used because they cause gizzard atrophy and discrete intestinal hypertrophy, caused by bacterial fermentation.

Particle size is established by the geometric mean diameter (GMD or d). However, the complete information on particle size must include a measure of dispersion. This measure is the geometric standard deviation (GSD) which establishes the range of variation among the different particle sizes [11].

These researchers noted that a small GSD represents higher uniformity. An improvement in feed efficiency of 7% and 9% for maize and sorghum respectively was observed as particle size reduced [8]. Based on these results and taking into account the milling costs and throughput characteristics, [6], recommended a size of between 600 to 800 μm for broilers.

According to Beyer [4], particle size is another manufacturing parameter that has received little attention in previous researches. It must be noted that maize is the major ingredient in most complete feeds for poultry and that particle size of ground maize has a large impact on average particle sizes in the complete feed. Maize supplies poultry with a major part of their energy requirement particularly in Ghana and some other parts of the world; however, most feed producers (in Ghana) do not examine feed particles size as a quality indicator in assessing feed preparation.

This study aimed, therefore to determine the effect of variations of ground maize (as a major ingredient) in most complete feeds on broiler performance and subsequently suggest the best feed particle size to be used by farmers for broiler feed formulation.

MATERIALS AND METHODS

The study was conducted at the Department of Animal science, Faculty of Agriculture, KNUST, Kumasi, Ghana covering a total period of 5 weeks.

One hundred and twenty day-old mixed-sex Cobb-500 commercial broiler chickens obtained from Foani Farms, Cote D'ivoire were used in the study. Initial weights of the birds were taken and birds were allocated to three dietary treatments T_1, T_2 and T_3 containing maize of different particle sizes with four replications per treatment in a completely randomized design. Maize for the 3 treatments were grinded (with a roller mill) at Agricare Ltd, Ghana to obtain varying particle sizes, namely 'smooth' (GMD = 713.82μ m), 'coarse' (GMD = 1462 μm) and 'very coarse' (GMD = 1506.8 μm).

Procedure for Particle Size Determination

100g of each sample of ground maize for treatments T_1 ,T_2 and T_3 was screened through six (6) sieves with a sieve shaker (Retch GmbH and Co. KG, Germany) and the weight of the ground maize particles not filtering through each screen was determined using the procedure of ASAE (2003). The feed particles that filtered through all screens were collected in the pan and weighed. The size of screen openings used were 2500, 1600, 710, 250, 180, and 160 microns. The weight values of particles collected on each screen were entered in the appropriate columns of spreadsheet to determine the diameter of ith sieve in stack (ith= individual measurements), average particle size GMD and GSD using equations (1), (2) and (3).

1. $$di = (d_u x\ d_o)^{0.5}$$

Where di = diameter of the ith sieve in stack

du = nominal sieve aperture size next larger than ith sieve (just above in a set) mm

do = normal sieve aperture size of the ith sieve, mm

Because it is not practical to count each particle individually and calculate an average, the average particle size was calculated on a weight basis, using the equation.

2. $d_{gw} = \log^{-1} \left[\frac{\sum (w_t \log d_t)}{\sum w_t} \right]$

The standard deviation was calculated from equation (3)

3. $S_{gw} = \log^{-1} \left[\frac{\sum w_t \log d_t}{\sum w_t} \right]$

Where W_t = mass on ith sieve, g.

The composition of the experimental diet was the same for all 3 treatments with the only variation being in the particle size of ground maize used for the formulation of the diets namely, 'smooth', 'coarse' and 'very coarse'.

The finisher diet (Table 1) was formulated to contain 212 g CP/kg and metabolisable energy value of 11.72 MJ/kg.

Table 1: Composition and Calculated Analysis of Finisher Diets for Broilers.

INGREDIENT	T_1
Maize	55kg
Fishmeal	15kg
Soya bean mal	6kg
Wheat bran	18kg
Oyster shell	5.5kg
Vitamin Premix	0.25kg
Salt	0.25kg
Total	100kg

TOTAL OR AVAILABLE AMINO ACIDS	%
Protein	21.20
Fat	4.00
Crude fibre	3.90
Lysine	1.15
Methionine	0.49
Cysteine	0.22
Calcium	1.00
Total Phosphorus	0.68
ME (Kcal/kg)	2800

Management

Each group of 10 birds was kept in coops with a floor space of $0.72m^2$ per bird. Two plastic water troughs and two small sized rectangular wooden feedings troughs were placed in each coop. Birds had free access to feed and water during the feeding period of 5 weeks.

The normal vaccination programme of the farm was followed. Birds were vaccinated against Gumboro and Newcastle diseases. A coccidiostat, Narcox (Radar NV, Dienze, Belgium) was administered via the drinking water three times a week up to the 4th week.

Parameters measured included initial body weight, final body weight, body weight gain, feed consumption, feed conversion efficiency, carcass parameters, dressing percentage and economics of gain.

Body weights were taken at the beginning of the experiment and at weekly intervals. Total body weight for a replicate was obtained by summing up all the individual weights per replicate and the average weight was determined by dividing the total body weight by the number of birds in a replicate. Moreover, the average body weight gain was determined by subtracting the previous week's body weight from the current week's value and dividing the figure by the number of birds in a replicate.

- Feed conversion efficiency was determined as the amount of feed consumed per unit body weight gain

Four birds (2 males and 2 females) were randomly selected from each replicate at the end of the 5-week feeding period for carcass evaluation. The birds were withheld of feed for about 12 hours to empty their crops. The weight of each selected bird was approximately equal to the weight of the birds in that particular replicate. Birds were slaughtered by cutting the jugular vein (carotids 1 and 2) using a sharp knife and allowed to bleed and then weighed. Each bird was then de-feathered, eviscerated and the dressing percentage was obtained by expressing the eviscerated weight as a proportion of the live body weight.

Cost of a kg feed was estimated based on price of the ingredients at the time of the study. Cost of feed to gain a kg weight for each replicate was also determined.

A group of ten birds each were allocated to three dietary treatments T_1, T_2 and T_3 containing maize of different particle sizes defined as 'smooth' (GMD = 713.82µm), 'coarse' (GMD = 1462 µm) and 'very coarse' (GMD = 1506.8 µm), in a completely randomized design, with four replications per treatment.

All data collected were subjected to analysis of variance using statistical package for social scientists (SPSS) version 11.0.

RESULTS

Tables 2, 3 and 4 indicate the particle analysis results obtained from the 3 dietary treatments with the frequency distribution for the various particle sizes shown in Figures 1, 2 and 3, respectively.

Table 2: Treatment 1 –smooth particle sizes

Over screen (Sieve size)(microns)	Initial wt of sieve (g)	Wt of sample sieved (g)	Wt of sample (g)	% wt of sample (%)
2500	490.32	489.49	0.83	0.86
1600	533.60	550.98	39.29	17.94
710	660.25	499.54	39.29	40.56
250	428.60	459.43	30.83	31.82
180	394.88	402.72	7.84	8.09
160	397.41	398.12	0.71	0.73
			Total = 96.88	

Table 3: Treatment 2- coarse particle sizes.

Over screen (Sieve Size) (microns)	Initial Wt. Of Sieve(g)	Wt of sample sieved (g)	Wt Of Sample (g)	% Wt. Of Sample (g)
2500	490.32	516.50	26.18	16.09
1600	533.60	566.07	33.07	32.96
710	400.25	486.72	26.47	26.38
250	428.60	440.74	12.14	2.10
180	394.88	39.18	2.30	2.92
160.	397.41	397.58	0.17	0.17
			Total 100.33	

Table 4: Treatment 3-very coarse particle sizes.

Over screen (sieve size) (microns)	Initial wt of sieve(g)	Wt of sample + sieve(g)	Wt of sample (g)	% wt of sample (%)
2500	40.32	516.25	25.93	27.26
1600	533.60	563.57	29.97	31.51
710	460.25	847.78	27.53	28.95
250	428.60	438.78	10.18	10.70
180	394.88	396.38	1.50	1.58
160	397.41	397.41	0.00	0.00
			Total = 95.11	

The performance of birds fed on the three diets; T_1, T_2, and T_3 with different ground maize particle sizes are shown in Table 5:

Table 5: The effect of feed particle size on performance of broiler chicken

Parameters	T_1	T_2	T_3	SEM
Initial body weight (kg)- 4 weeks old birds	1.49	1.48	1.50	
Final body weight (kg)- after 5 weeks	2.74^a	2.59^b	2.73^a	0.02065
Body weight gain (kg)	1.25^a	1.11^b	1.23^a	0.01864
Feed Intake (kg)	3.82^a	3.87^a	4.24^b	0.05645
Feed conversion efficiency	3.26^a	3.59^b	3.63^c	0.04999
Mortality	3^a	1^a	1^a	0.25990
Dressing percentage (%)	76.47^a	74.86^b	74.22^c	0.28936
cost / kg feed (GH¢)	2963.65	2963.65	2963.65	
Feed cost /kg body weight gain (GH¢)	6697.85	7675.85	7794.40	

SEM-Standard Error of Means a, b, c = Means in the same row with different superscript are significantly different ($p < 0.05$)

T_1-Diet with smooth texture T_2-Diet with coarse texture T_3-Diet with very coarse texture

DISCUSSION

From the results obtained in the present study (Tables 2, 3 and 4), a Geometric Mean Diameter (GMD) of 713. 82 mm which forms about 40 % of the weight of the samples of ground maize used in the treatment T1 seems to be in agreement with a proposal by [7], who recommended a mean particle size of between 600 and 800µm for poultry.

Similarly a recommendation by [11], of GMD between 700 and 900µm for broilers does not deviate from the results of the present study. From the above therefore, particle size for dietary treatment 1 is in tune with the particle size uniformity required. However, particle sizes from treatments 2 and 3 are found to be over and above the recommended figure. The frequency distribution for treatment 1 shows a NORMAL curve (distribution) while those from treatments 2 and 3 are skewed towards one direction, that is, to the left.

The average feed consumption for the entire experimental period of 5 weeks ranged from 3.82 kg for birds on the diet with the 'smooth' particle size to 4.24 kg for those on the 'very coarse' diet (Table 5). There was a consistent increase in feed intake generally for all the dietary treatments as the birds aged.

The significant variation in feed intake between birds on dietary treatment 1 and those on dietary treatment 3 could be due to the difference in particle size of the maize component of the diet and partly due to the inherent genetic differences of the individual birds with regard to digestibility.

Particle size of feed has been reported to be of great importance in regulating intake in broiler chickens with preference for diets containing smooth particles instead of those finely ground or coarser particles [13]. Birds have difficulty in consuming particles that are bigger or much smaller than the size of the beak [10, 5].

Initial body weights for all three dietary treatments (four weeks at start of the experiment) were not much different from each other, ranging from 1.49 kg for treatment 1 to 1.50 kg for treatment 3. Final body weights and body weight gains (at five weeks termination of the experiment) were highest for birds fed the 'smooth' particle size diet, but no significant differences were found between birds on treatments 1 and 3. However, birds fed diets containing the 'smooth' particle sizes were more efficient in converting feed into meat. The decline in efficiency of birds on the treatment with the 'very coarse' particle size (Treatment 3) was due to the larger particle sizes which resulted in inefficient digestion. The results obtained are in agreement with those of [8] who reported improvement in feed efficiency of 7% and 9% for maize and sorghum respectively for poultry as particle size was reduced.

It has been suggested that particle digestion within the proximal small intestine is slower when particles are uniform resulting in more peristaltic movements and may result in a better utilization of the nutrients [12]. Any alteration in the structure of the feed might have a significant effect on performance by restricting or making some nutrients unavailable [9], as cited by [5]. Conclusively, improvements in feed efficiency are more consistent for particle size reduction with the greatest reductions noted in younger birds [8].

A total of 5 mortalities were recorded throughout the 5-week experimental period, three from birds on dietary treatment T_1 and one each from T_2 and T_3. Post-mortem autopsies indicated that mortalities recorded in the present study were not due to the particle size of the grain component of broiler diets. Stress from growing and having to adapt to a 'new' environment could be an attributable factor [16].

Particle size of the grain component of the broiler diets had an influence on carcass yield with birds on dietary treatment 1 registering the highest carcass dressing percentage. The higher carcass yield of birds fed diets containing the 'smooth' particle size was mainly a reflection of the higher performance by those birds. Necropsy examination performed on birds at the end of the study however revealed no gross abnormalities in the major internal organs (liver, gizzard, heart, lungs, and kidney).

The cost of a kg feed averaged GH¢0.30 for all three treatments. The cost of feed to produce a kg body weight was highest for birds on diet with larger grain particle sizes, i.e., treatment 3 (GH¢7794.40). Thus, it is more economical to feed broilers on diets with smooth grain particle sizes.

This is contrary to [15], who reported that the use of larger particle size for the grain component of a diet would result in a significant saving in the energy cost of grinding.

Conclusively, the following observations were made:

1. There were improvements in body weight gain and feed utilization for diets containing the particle size with the 'smooth' (GMD = 713.82µm) texture, with subsequent improvement in carcass dressing percentage.
2. It was more economical to produce birds on diets with smooth particle sizes. This is because the cost of feed to produce a kg body weight gain was more expensive for diet with the 'very coarse' (GMD = 1506.8 µm) particle size.

Based on the fact that improvement in feed efficiency is more consistent for particle size reduction, a mean particle size of maize diet between 600 and 900µm is recommended for poultry farmers.

Moreover, a routine particle size monitoring programme should include checking ground grain or one complete diet at least twice a year to assist feed millers produce feed of optimal particle size.

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