



Impact of maize particle size on egg production and egg quality of White Leghorns in early stage of production

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ABSTRACT

The aim of the present study was to determine the effect of the maize particle size on the performance of layers. Five maize-soybean based diets were formulated with maize particle size of 4.0, 6.0, 8.0, 10.0 and 12.0 mm sieve size with five treatments (T1: 4.0 mm mash diet; T2: 6.0 mm mash diet; T3: 8.0 mm mash diet; T4: 10.0 mm mash diet; T5: 12.0 mm mash diet) fed from 20 to 28 weeks of age. Each treatment was replicated three times, with 10 birds in each replicate. The results showed no significant difference in average daily feed intake, live weight, hen day egg production percentage, egg mass and egg indices except for haugh unit, which was highest for the 4 mm screen size and lowest for the 12 mm screen size in layers from 20 to 28 weeks of age. FCR (g/g egg mass) was highest for T3 as compared to the average of other treatments not affected by either of the feeds. In conclusion, the size of the screen used to mill the grain had no impact on hen production within the range of the study. Furthermore, the decision to grind grains more coarsely than is already customary would be favourable for the environment and the economy because it would reduce the amount of energy, labour, and time utilised in feed mills.

Keywords: Egg indices, Egg production, Maize, Particle size, Screen size

Poultry is one of the fastest growing agricultural industries in India today. While agricultural crop output has increased at a pace of 1.5 to 2% per year, egg production has increased at a rate of 6.7% per year (BAHFS 2020-21). Maize contributes around 50% of the total composition of the diet. So, the size of the screen used to grind it will ultimately affect the particle distribution and structure of the diet. Feed shape is important in regulating chicken development performance, digestion, nutrient digestion, intestinal health, and productive performance (Abdollahi *et al.* 2014, Guzman *et al.* 2015, Abadi *et al.* 2019). Compared to broilers, layer-strain poultry has undergone fewer experiments focussed on the feed form. This is likely since laying hens are often fed mash diets (Röhe *et al.* 2014). In laying hens (Safaa *et al.* 2009, Perez-Bonilla *et al.* 2014), mechanoreceptors in the beak detect changes in texture, which may alter feed intake (FI) and performance. Reduced particle size improves nutritional digestibility by increasing surface, allowing nutrients to interact with endogenous enzymes (Parsons *et al.* 2006). On the other hand, it often results in a less developed gizzard and GIT (Hetland *et al.* 2002), which may influence poultry performance (González-Alvarado *et al.* 2007). In contrast, increasing feed particle size will decrease feed passage rate, leading to more exposure time and influencing the

nutrients' digestibility. These opposing effects may cancel each other out, and the overall impact on hen production may be affected by variables like the characteristics and ingredient composition of the experimental diets. Performance indices, such as average daily feed intake (ADFI), weight gain (BWG), body weight (BW), feed conversion ratio (FCR), egg production rate, egg mass, and egg weight, are the primary measures for determining the extent of the response to changes in feed structure in the production of egg-laying chickens. In addition, relative albumen and yolk weights, haugh units, eggshell weight and breaking strength, and other metrics may be used to understand how feed structure affects the quality of table eggs (Koçer *et al.* 2016; Ege *et al.* 2019). In view of the above, the purpose of this study is to investigate the effect of varying feed particle size (by the addition of graded coarse maize) on production performance in layers.

MATERIALS AND METHODS

The procedures used in the experiment were approved by the Institutional Animal Ethics Committee (IAEC, registration no. GADVASU/2021/IAEC/62/13) and were conducted in a tropical, semi-arid, hot and subtropical monsoon type climatic condition at the Poultry Research Farm of the Department of Livestock Production Management, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana (Latitude: 30°54' North, Longitude: 75°48' East).

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Experimental birds and housing management: In total, 150 White Leghorn pullets of uniform weight were chosen at 19 weeks of age and allocated into five treatment groups, each with three replicates, and each replication comprising ten birds, and they were kept in separate two-tier California cages for studies with a one-week adaptation period for acclimatisation. The birds were provided a weighed amount of meal and *ad lib.* water. The exposure of the birds was a continuous photoperiod of 16 h of light and 8 hours of darkness (16L: 8D) in a day with a light intensity of 50 lux. An open trough feeder and a waterer were placed outside the cages. Daily records of the room's temperature were kept throughout the experiment 20 ± 4 °C (March 2020, first period of experiment) and 31 ± 4 °C (April 2020, second period of experiment).

Feed preparation: Five iso-caloric (2600 ME kcal/kg feed) and iso nitrogenous (18% CP) treatment diets were formulated, with each having a different maize particle size (4 mm, 6 mm, 8 mm, 10 mm, and 12 mm) (Table 1). The BIS-recommended nutritional needs for laying hens were fulfilled or surpassed by the diets (2007). The maize was ground in a horizontal hammer mill equipped with a 4, 6, 8, 10 and 12 mm screen and added to the appropriate experimental diet. Five diets were utilised in a factorial configuration with five different screen sizes (4, 6, 8, 10, or 12 mm) to mill the maize in the experiment, which was carried out using a completely randomised design.

Table 1. Ingredient composition of the experimental diet

Ingredient	Layer (g/kg)
Maize	405.25
Soyabean DOC	220.00
Rice polish	88.00
DoRB	102.83
Dicalcium phosphate	125.00
Limestone powder	25.00
Trace mineral	1.00
Vit AD ₃ EK	0.200
Vitamin B complex	0.200
Vitamin C	0.500
Neftin	0.300
Choline chloride	0.100
Vitamin B ₁₂	0.300
Toxin binder	1.00
Marble chips	25.00
DL-Methionine	0.620
Salt	4.700

Laboratory analysis: The representative samples from each diet were collected and ground using a laboratory grinder and then the proximate analysis of the experimental diet was carried out as per AOAC (2012) (Table 2).

For the particle size estimation, GMD (geometric mean deviation) and GSD (geometric standard deviation) were calculated using the amount of per cent particle size distribution. Feed particle size is commonly assessed by the sieve analysis of a 100 g representative sample passing

Table 2. Nutrient composition (%) of different treatment diets (On dry matter basis)

Proximate parameter	Treatment				
	T1	T2	T3	T4	T5
Moisture (%)	7.80	8.00	9.40	9.20	8.80
Dry matter (%)	92.20	92.00	90.60	90.80	91.20
Crude protein (%)	18.25	18.22	17.89	17.98	18.06
Ether extract (%)	3.67	3.615	3.625	3.69	3.515
Crude fibre (%)	5.60	6.10	5.80	5.80	5.90
Ca (%)	3.06	3.12	3.04	3.00	3.08
P (%)	0.415	0.421	0.413	0.418	0.415

through a SANCO testing shaker containing a series of sieves of various sizes and diameters ranging from 0.075 mm to 2.0 mm, which were used to separate the particles into different sized fractions as detailed by Baker and Herrman (2002).

Feed intake, body weight and FCR: The average daily feed intake (ADFI) and body weight (g) of birds were recorded at biweekly intervals. The feed conversion ratio (FCR) per gram of egg mass was calculated.

Egg production and egg indices: Hen productivity in terms of HDEP (hen day egg production) were measured at a biweekly interval. The two eggs from each replicate were weighed at a biweekly interval and the average value was used for the calculation of the egg weight for that replicate. The number of under-graded, dirty, broken, and shell-less eggs was recorded daily by replicate in all eggs produced. An egg was considered dirty when a spot of any kind or size was detected on the shell. Egg indices were measured at a fortnightly interval. A minimum of 2 eggs per replicate were chosen at random to test egg quality characteristics. A total of 30 eggs (2 eggs $\times$ 3 replicates $\times$ 5 treatment diets) were used for exterior and interior egg quality measures, which included egg weight (gram), specific gravity (varying salt solution with the help of a hygrometer), shape index (ratio of egg length to diameter), yolk colour (Roche Color Fan), yolk index (ratio of yolk length to yolk diameter), albumen height (Spherometer in mm), Haugh unit ($100 \log (H + 7.57 - 1.7W^{0.37})$) and shell thickness (vernier clipper in mm).

Statistical analysis: For the statistical examination of performance attributes, replication means were used as the experimental unit. To determine if responses to increasing levels of 12 mm feed particle size were linear or quadratic in character, all data was submitted to orthogonal polynomial contrasts using SAS general linear model technique (2009). Means were separated by the least significant difference (LSD) when the F-test indicated a significant result. At $p < 0.05$, differences were deemed significant.

RESULTS AND DISCUSSION

Particle size: The maize feed particle size was compared in the 4, 6, 8, 10 and 12 mm sieve sizes, maize ground using the 12 mm sieve size was observed to have a larger percentage of coarse particles (above 1.0 mm size). In a diet of 4, 6, 8, 10, and 12 mm, the percentage of coarse

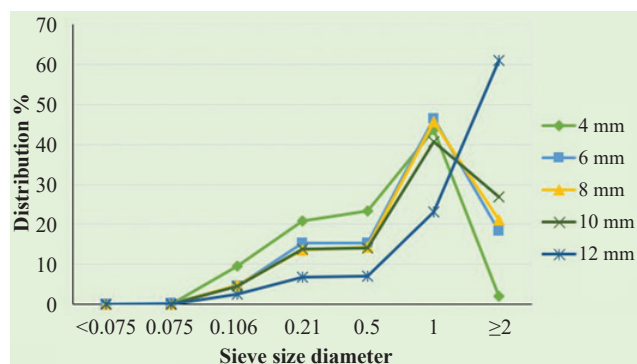


Fig. 1. Particle size distribution of maize grounded using sieve size of 4, 6, 8, 10 and 12 mm.

particles above 1 mm and 2 mm increased with increasing sieve size (Fig. 1). The GMD (Geometric mean deviation) of the cereal and the diet increased with changing sieve size from 732.17 μm to 1506.8 μm and 681.63 μm to 866.47 μm (Table 3). Herrera *et al.* (2017) found that increasing the size of the screen from 4 to 12 mm increased the GMD of the diet (average of the maize and barley diet) by 42.3% (1,003 μm to 1,427 μm). With larger screens, the GSD has a tendency to rise.

Table 3. Geometric mean diameter and Geometric standard deviation (GMD $\pm$ GSD, μm) of the maize¹ and experimental diets²

Screen size (μm)	GMD $\pm$ GSD ¹ (μm)	GMD $\pm$ GSD ² (μm)
4	732.17 $\pm$ 3.103	681.63 $\pm$ 2.671
6	999.23 $\pm$ 2.062	685.32 $\pm$ 2.781
8	1041.1 $\pm$ 2.049	789.40 $\pm$ 2.586
10	1075.4 $\pm$ 2.071	806.43 $\pm$ 2.654
12	1506.8 $\pm$ 1.878	866.47 $\pm$ 2.698

¹ and ² superscripts represent GMD $\pm$ GSD (μm) of the maize and experimental diets respectively

Average daily feed intake, body weight and feed conversion ratio: ADFI(g) (Fig. 3), body weight, and FCR were not affected by changing screen size from 20 to 28 weeks of age. In agreement with the current study, ADFI was not influenced by the increased screen size used to crush the grain, as reported by Kocer *et al.* (2016) and Herrera *et al.* (2017). Conversely, most published studies found that hens exhibited a preference for bigger grain particles and also that fine grinding decreased voluntary FI in laying hens (Safaa *et al.* 2009). In this regard, Safaa *et al.* (2009) discovered that birds fed maize or wheat ground with a 10 mm screen had a 2.5% higher FI than hens fed the same grains ground with a 6 mm screen. In this connection, Nir *et al.* (1994) suggested that coarse particles are more matched to the size of the beak than small particles. Similarly, Amerah *et al.* (2007) showed greater feed consumption in laying hens given coarsely ground grains as seen by Hamilton and Proudfoot (1994). Similar findings to those of our research have been observed by MacIsaac and Anderson (2007) and Safaa *et al.* (2009). According to MacIsaac and Anderson (2007), the FCR (g/g eggs) of laying hens between the ages of 22 and 28 weeks was

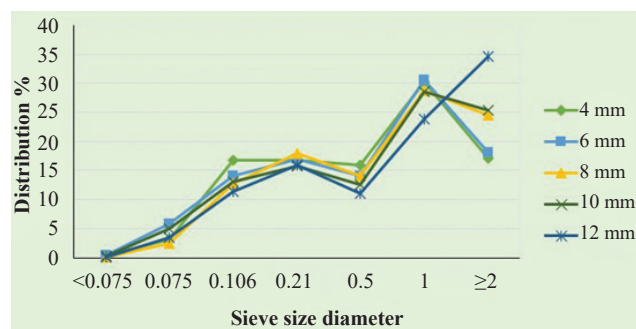


Fig. 2. Particle size distribution of diets containing maize grounded using 4, 6, 8, 10 and 12 mm sieves.

unaffected by corn and wheat processed with either a 5 mm or a 7 mm screen. Safaa *et al.* (2009) observed that cereal particle size did not alter FCR even when the primary cereal was ground to pass through 6, 8, and 10 mm screens. In contrast, Herrera *et al.* (2017) found that, on average, FCR from 17 to 49 weeks of age tended to be lower in birds given the 4 mm sieved ground meals than in birds fed the other diets (6, 8, 10, and 12 mm). Interestingly, there was a continuous decrease in ADFI and FCR with time. This might be due to a continuing increase in temperature from March to April. However, there was no significant difference in ADFI among different treatment groups, but T2 showed a relatively higher decrease in ADFI compared to other screen sizes (Fig. 3).

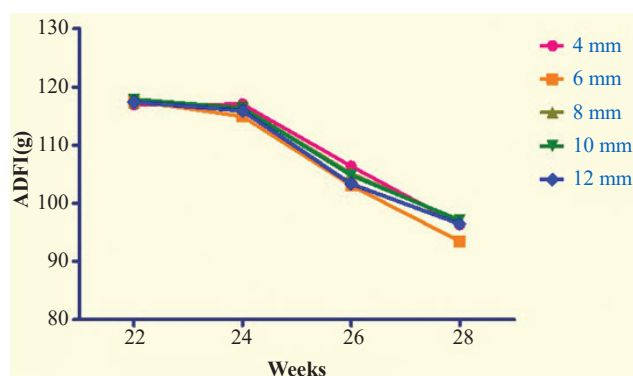


Fig. 3. Impact of feeding of coarsely ground maize diet using sieve size of 4, 6, 8, 10 and 12 mm on ADFI (g) at fortnightly duration.

Bird performance: The production traits like HDEP, % crack egg, % dirty egg, % shell less and egg mass (g) were also not affected by screen size during the experimental period (Table 4). Safaa *et al.* (2009) found no changes in egg production. Similar to this, Kocer *et al.* (2016) and Ruhnke *et al.* (2015) showed that specific changes to feed shape and screen size had no impact on the rate of egg production and egg weight. In contrast to our results, Herrera *et al.* (2017) showed a tendency for improvements in egg production and egg weight in birds fed the 10 mm ground diets compared to hens given the 6 mm ground diets.

Egg quality: From 20 to 28 weeks of age, the screen size used to grind the main cereal did not affect any of the egg quality traits studied, except for haugh unit that tended

Table 4. Influence of the screen size used to grind the main cereal on hen productivity and egg quality from 20 to 28 weeks of age¹

Parameter	4	6	8	10	12	SEM ¹	Overall treatment effect ¹	Linear effect ²	Quadratic effect ³
HDEP (%)	93.83	95.28	94.61	95.5	94.44	1.14	0.844	0.689	0.421
Egg mass (g)	54.12	54.57	56.21	53.24	54.92	1.03	0.351	0.934	0.581
FCR(g/g egg mass)	2.02	1.98	1.96	2.06	1.98	0.078	0.907	0.942	0.835
Body weight (g)	1385.9	1383.6	1381.8	1352.5	1372.1	10.5	0.149	0.078	0.682
ADFI (g)	109.2	107.3	108.9	109.1	108.2	2.71	0.987	0.998	0.946
Crack egg (%)	1.06	1.29	1.60	1.45	1.63	0.298	0.657	0.201	0.62
Dirty egg (%)	2.25	1.98	1.76	1.80	1.80	0.283	0.724	0.258	0.466
Shell less egg (%)	1.36	1.17	1.47	0.816	1.23	0.186	0.206	0.304	0.729
Egg quality traits									
Egg weight (g)	57.7	57.26	59.38	55.72	58.15	1.01	0.147	0.842	0.989
Shape index	78.52	77.65	78.06	77.15	77.69	0.626	0.625	0.284	0.525
Specific gravity	1.09	1.10	1.09	1.09	1.09	0.001	0.459	0.142	0.64
Shell thickness(mm)	0.377	0.390	0.389	0.401	0.398	0.011	0.633	0.152	0.642
Yolk index	0.455	0.454	0.45	0.465	0.472	0.007	0.324	0.042	0.453
Haugh unit	95.64 ^a	94.43 ^a	94.66 ^a	90.09 ^{ab}	93.84 ^b	1.350	0.046	0.066	0.313
Yolk colour	4.208	3.833	4.208	4.583	4.33	0.193	0.102	0.103	0.729

^{a,b} Within a row, means without a common superscript differ significantly. ⁸ Pooled standard error mean. ^{2,3,4} The interactions between main effects, the linear and the quadratic effect of the screen size were significant for all variables ($P < 0.05$).

($P = 0.046$) to be higher in hens fed the 8 mm screen ground diet, followed by 4 mm and 6 mm, as compared with the average of hens fed the 10 mm and 12 mm screen ground diets (Table 4). In support with our findings, Ege *et al.* (2019) studied the effects of two feed particle sizes (4 and 8 mm sieves). With the exception of the yolk colour score, which decreased with the crumbling of the feed, feed shape and screen size had no effect on egg mass, egg weight, and quality attributes of the eggs.

In contrast to our finding, Hamilton and Proudfoot (1995) found that Haugh units were similar when birds aged 20 to 70 weeks were fed either fine-or coarse-ground wheat and supported by Hafeez *et al.* (2015) and Kocer *et al.* (2016) who reported that changes in albumen weight by particle size were not very important in terms of application. Similar to our findings, Amornthawaphat *et al.* (2014) reported maize particle size (638 μm , 870 μm , and 1,079 μm) had no impact on yolk colour. In contrast to our findings, Kitto (2017) observed that between 35 and 43 weeks of age, hens fed the 600 μm meals had considerably lighter yolk colour than 900 μm , 1200 μm , and 1500 μm treatment-fed hens.

In brief overview, our results are consistent with recent studies by Hafeez *et al.* (2015); Kocer *et al.* (2016) and Herrera *et al.* (2017), which found that most of the egg quality traits of a layer strain (Lohmann LSL) were unchanged by particle diameter and feed form.

The adjustment of feed particle size (GMD 681.63 vs. 866.47 μm) barely had any effect on the overall feed intake, FCR, laying rate, egg external and internal quality of this current layer strain. As a result, the size of the screen used to crush the grains and the type of diet may be changed to suit particular needs without compromising the well-being or productivity of egg-laying birds. Additionally, choosing

to grind grains more coarsely than is currently customary would be favourable for the environment and the economy because it would reduce the amount of energy, labour, and time consumed in feed mills.

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