Effects of Corn Particle Size in Layer Diet on Laying Performance and Uniformity of Egg Quality under High Stocking Density

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A total of 600 international commercial strain layers (Roma Brown, 30 week old) raised under tropical environment were used to determine effects of corn particle size on growth performance and uniformity of egg quality. Hens were randomly allocated to meal diets with three different corn particle size of 638, 870 µm hammer milled corn and 1,079 µm rolled corn. There were 5 pens per diet. Each pen comprised of 10 cages with 4 hens per cage. Feeding finer corn particle size resulted in decreased ($P < 0.04$) average daily feed intake. There was no difference in body weight gain, egg production, egg weight and mortality rate. Egg quality; weight, specific gravity, yolk color, Haugh units and egg shell thickness, was not affected with the corn particle size. However, hens fed completed diets with corn particle size of 638 and 870 µm resulted in lower coefficient of variation of egg weight ($P < 0.02$), egg yolk color ($P < 0.02$) and egg white weight ($P < 0.05$) compared to those fed diet with corn particle size of 1,079 µm. Our results suggested feeding hens raised under high stocking density of 4 hens per cage with the corn particle size approximately of 638 and 870 µm or the completed diet particle size of 556 and 735 µm resulted in lower feed intake and lower coefficient of variation or higher uniformity of egg weight, egg yolk color and egg white weight.

Keywords: layers; corn; particle size; egg quality; uniformity

Introduction

Many attentions have been given to the coarse grinding of corn or even an inclusion ration of 20% whole grains such as wheat in laying hen diets for economic and nutritional purposes (Reece et al., 1985; Lott et al., 1992; Wild, 1992; Cabrera, 1994; Nir et al., 1994). Results of feeding coarse ground corn or whole grain showed heavier and more muscular gizzards than those fed conventional layer diets. However, stocking density of layers, raising under commercial layer farms in Thailand, is usually 4-5 birds per cage and only 3 birds are able to reach feed at a time. Consequently, birds which move faster would reach the feed and have better chance to select coarse particles such as coarse ground corn. On the other hand, birds which move slower would have only the fine particles such as rice bran, soybean meal, oyster shell or vitamin-mineral premix left to be eaten. These would result in an individual bird of the same cage receiving unequal amount of diets. Nutrient variation of birds within the cages might result in flock non-uniformity. Our assumption on eating behavior of layers under high stocking density and unequal chance of getting feed of different particle sizes would affect layer performance. The purpose of the study was to determine the effects of corn particle size in layer diets on growth performance and egg quality raising under high stocking density.

Materials and method

Three different corn particle sizes were ground through a hammer mill to achieve the corn particle size of 600 and 900 μm and rolled through a roller mill to achieve the corn particle of 1,200 μm. Corn were milled in a hammer mill equipped with a 3-mm and a 10-mm hammer mill screen and rolled in a roller mill with a gap clearance of 1.8 mm and passed through a 10-mm sieve opening. Geometric mean particle size, geometric standard deviation of particle size, surface area and number of particles corn were determined with a sieving analysis according to ASAE (1983). Meal diets were formulated to provide 0.95% lysine, 3.5% calcium, 0.4% available phosphorus and 2,750 kcal/kg (*Table 1*). Corn and other ingredients were mixed and manufactured in a meal diet. A total of 600 international commercial strain layers layers (Roma Brown, 30 week old) were used to determine the effect of three different corn particle sizes on growth performance and uniformity of egg quality. Hens were randomly allocated to three different meal diets based on three particle sized corn. There were 5 replicates per diet. Each replicate comprised of 10 18×36×36 in^3 cages with 4 hens per cage placed under the 16 hours a day lighting program. Feeding program was 2 times a day and water was fed *ad libitum*. The duration of experiment was five 28-day periods. Hen weight, feed intake and egg production were weighted and recorded at the end of each period. On the last three day of each period, three eggs were randomly selected in each replication for egg quality analysis consisting of egg weight, egg yolk color, egg white height for Haugh units calculation and egg shell thickness.

A set of data was analyzed as a complete block design. Analysis of variance was performed using the GLM procedure of SAS and treatment comparison was compared with the Duncan's multiple range test (SAS, 2003).

Table 1 Composition of the basal diet[a]

Ingredients (as fed basis)	%
Corn	53.68
Soybeam meal (44% crude protein)	21.15
Fish meal (58% crude protein)	5.00
Extracted rice bran	10.00
Palm oil	1.00
Oystershell meal	7.65
Dicalciumphosphate	0.75
Salt	0.40
DL-methionine	0.12
Vitamin mineral premix[b]	0.25

[a]The basal diet was formulated to 0.95% lysine, 3.5% calcium, 0.4% available phosphorus and 2,750 kcal/kg.
[b]Premix supplied per kg of diet was composed of 4,000,000 IU of vitamin A; 1,200,000 IU of vitamin D; 4,000 mg of vitamin E; 600 mg of vitamin K;. 800 mg of vitamin B1; 2,000 mg of vitamin B2; 1,200 mg of vitamin B6; 2.5 mg of vitamin B12; 5,000 mg of nicothenic acid; 3,000 mg of d-calciumpantothenic acid; 200 mg of folic acid; 4 biotin; 100,000 mg of choline choride; 24 mg of Mn; 20 g of Zn; 16 g of Fe; 4 g of Cu; 0.8 g of I; 0.08 g of Co and 0.04 g of Se.

Results and discussion

Particle sizes of complete diets were smaller than those of ground corn because of the smaller particle sizes of other ingredients such as soybean meal, fish meal and rice bran. Log normal standard deviation representing the uniformity of corn particles increased as the mean particle size was increased. However, the value of log normal standard deviation was slightly different in the complete diet than those of ground corn. Complete diets with corn particle size of 870 μm had the highest uniformity of particles compared to those diets with the corn particle size of 638 μm and 1,079 μm. Density of diets increased from 0.49 to 0.57 g/cm^3 as the mean particle size of the diet increased *(Table 2)*.

Table 2 Physical characteristic of ground corn and meal diets

Items[a]	Particle size,µm		
	600	900	1,200
Ground corn characteristics			
Geometric mean particle size,µm	638	870	1,079
Log normal standard deviation of particle size	2.03	2.25	2.42
Bulk density, g/cm^3	0.54	0.56	0.58
Diet characteristics			
Geometric mean particle size,µm	556	735	810
Log normal standard deviation of particle size	2.11	2.03	2.40
Bulk density, g/cm^3	0.49	0.53	0.57

There was no difference in body weight gain, egg production, egg weight and mortality rate in laying hens fed experimental diets (P > 0.05). However, hens fed diets with corn particle size of 638 and 870 µm consumed 2% less feed (P< 0.04) than those fed diet with corn particle size of 1,079 µm. These resulted in 4% less feed per a-dozen egg in hens fed diets with finer corn particle size. Davis *et al*. (1951) and Nir et al., (1994) suggested that average daily feed consumption in hens was related to the diet particle size. Coarse particle size with denser feed bulk density promoted more feed consumption. On the other hand, finer particle size decreased feed consumption due to dustiness problem (Patrick and Schaible, 1980 and Cheeke, 1999). In the present experiment, layers fed more fine particles were able to maintain egg production with less consumed compared with coarse particles. For egg quality, Haugh units, egg shell thickness, specific gravity, egg yolk weight, egg white height and egg white weight were not affected (P> 0.19) by the geometric mean particle size of completed diets (*Table 3*).

Table 3 Effects of corn particle size on laying performance, egg production and egg quality

Items	Particle size,µm			P-Value
	600	900	1,200	
Laying performance and egg production[a]				
Daily feed intake, g/day	115.9±2.1[b]	116.4±1.5[b]	118.5±0.4[a]	0.0404
Feed per a dozen egg, kg	1.75±0.02[ab]	1.71±0.03[b]	1.80±0.06[a]	0.0577
Weight gain, g	85.8±3.64	86.4±3.57	88.4±4.42	0.8062
Egg production, %	81.2±3.82	82.8±2.60	80.9±3.23	0.6315
Egg weight, g	63.9±0.76	63.8±0.83	63.9±1.21	0.9712
Mortality rate, %	2.0±2.09	5.00±4.68	2.50±2.50	0.3371
Egg quality[b]				
Haugh units	77.4±1.5	77.5±1.5	75.8±1.5	0.1897
Egg shell thickness, mm	0.37±0.01	0.38±0.01	0.38±0.01	0.6624
Specific gravity	1.089±0.001	1.089±0.001	1.088±0.001	0.8054
Egg yolk color, scores	8.59±0.17[c]	9.44±0.16[a]	9.12±0.19[b]	0.0001
Egg yolk weight, g	17.0±0.2	17.0±0.3	16.9±0.3	0.8229
Egg white weight, g	40.14±0.54	40.11±0.69	39.91±0.60	0.8022
Egg white height, mm	5.26±0.16	5.25±0.17	5.08±0.13	0.1630

[a]A total of 600 layers (Roma Brown, 30 week-old) with 5 replicates per diet; each replicate comprised of 10 cages with 4 hens per cage; were used to the experiment.

[b]A total of 1,350 eggs with 10 replicates per treatment × 3 eggs × 3 days × 5 periods × 3 treatments were measured for egg quality.

In addition, the uniformity of egg quality was the major interest for layer producers in Thailand. High uniformity, represented with low coefficient of variation, of egg production and production was favored for all producers. Our results showed that the coefficient of variation of egg quality was significantly affected by the experimental diets. Hens fed completed diets with corn particle size of 638 and 870 µm resulted in the lower coefficient of variation or higher uniformity of egg weight, egg yolk color and egg white weight, compared to those fed the diet with corn particle size of 1,079 µm *(Table 4).* Lesson and Summers (1991) suggested that individual hen received unequal amount of energy and protein would result in different egg production. One factor that might be the cause of receiving unequal amount of nutrients is raising birds under high stocking density with 4 birds per cage as show in our experiment, only 3 birds were managed to reach feed at a time. Consequently, birds which move faster would reach the feed and have better chance to select coarse particles such as coarse ground corn. On the other hand, birds which move slower would have only the fine particles such as rice bran soybean meal oyster shell or vitamin-mineral premix left to be eaten. These might result in individual birds in the same cage receiving unequal amount of nutrient. Therefore lower uniformity of egg quality occurred. In conclusion, feeding layers raised under high stocking density of 4 hens per cage with the corn particle size approximately of 638 and 870 µm or the completed diet particle size of 556 and 735 µm resulted in lower feed intake and lower coefficient of variation or higher uniformity of egg weight, egg yolk color and egg white weight.

Table 4 Effects of corn particle size on the coefficient of variation (CV) of egg production and quality[a,b]

Items	Particle size,µm			P-Value
	600	900	1,200	
CV of egg production, %	2.86±1.25	2.44±0.58	3.31±1.37	0.4892
CV of egg quality,%				
Egg weight	7.91±0.49[b]	7.92±0.60[b]	8.74±0.61[a]	0.0232
Haugh units	16.49±2.76	14.95±1.42	17.08±2.40	0.3414
Egg yolk color	12.27±2.24[b]	11.79±1.07[b]	13.55±0.44[a]	0.0225
Egg yolk weight	10.09±1.24	9.77±0.69	10.04±0.35	0.8175
Egg white weight	7.70±0.32[b]	7.61±0.39[b]	8.27±0.48[a]	0.0488
Egg white height	21.96±2.21	20.14±1.44	22.43±2.58	0.2381

[a] A total of 1,350 eggs with 10 replicates per treatment × 3 eggs × 3 days × 5 periods × 3 treatments were measured for egg quality.

[b]The coefficient of variation (CV) of egg quality was calculated by: CV = standard deviation/mean × 100. For the CV of egg production, standard deviation and mean was calculated from the total number of eggs from each replicate per treatment in each period. For the CV of egg quality, standard deviation and mean was calculated from individual egg that received from three eggs in each replicate per treatment form each day within each period.

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