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Performance of Japanese Quails Fed Feeds Containing Different Corn and Limestone Particle Sizes*

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ABSTRACT

This study aimed at evaluating performance and egg quality of Japanese quails fed feeds containing different corn and limestone particle sizes. A total number of 648 birds in the peak of production was distributed in a random complete block experimental design, using a 2x3 factorial arrangement (2 corn particle sizes and 3 limestone particle sizes). Birds were designated to one of two blocks, with six replicates of 18 birds each. Mean geometric diameter (MGD) values used were 0.617mm and 0.723mm (corn fine and coarse particle sizes, respectively), and 0.361mm, 0.721mm, and 0.947mm (limestone fine, intermediate and coarse particle sizes, respectively). The following treatments were applied: T1: fine corn feed, with 100% fine limestone; T2: fine corn feed, with 50% fine limestone and 50% intermediate limestone; T3: fine corn feed, with 50% fine limestone and 50% coarse limestone; T4: coarse corn feed, with 100% fine limestone; T5: coarse corn feed, with 50% fine limestone and 50% intermediate limestone; T6: coarse corn feed, with 50% fine limestone and 50% coarse limestone. The experiment lasted 112 days, consisting of 4 cycles of 28 days. No significant interaction was observed among corn and limestone particle sizes for any of the analyzed parameters. There were no significant effects ($p>0.05$) of the tested corn particle sizes on quail performance or egg quality. There were significant ($p<0.05$) isolated effects of limestone particle size only on the percentage of cracked eggs, which was reduced when birds fed 50% coarse limestone (0.947mm) and 50% fine limestone (0.361mm) as compared to those fed 100% fine limestone. Therefore, the inclusion of 50% coarse limestone (0.947mm) is recommended for quail egg production.

INTRODUCTION

The optimization of egg production and quality potential of poultry is associated to several factors, such as proper environmental conditions, health, genetic improvement, and supply of adequate feeds.

Feed ingredient particle size assessment is included in this context, as, regardless the rearing phase, diets can be fed in mesh, crumbled, or pelleted form. This requires ingredient grinding, and particle size determination. Mill screen diameter is related to ground particle size, which may cause performance variation (De Brum *et al.,* 1998). The most precise parameter to evaluate particle size is MGD (mean geometric diameter) of the particles, which can be determined in the laboratory.

Many research studies were carried out aiming at determining ideal particle size of feed ingredients, such as corn and limestone (Freitas *et al.*, 2002; Leandro *et al.*, 2001; Magro *et al.*, 1999). The correct determination of corn particle size is important, because it implies in the possibility of increasing animal productivity, obtained through better feed intake, weight gain, egg production, egg weight, and feed conversion ratio.

Calcium, due to its relevance in eggshell formation, has been extensively studied (Ito, 2002; Scheideler, 1998; Guinotte and Nys, 1991; Roland, 1986). In layer production, significant direct economic losses are caused by low eggshell quality and cracked eggs rates.

Most research studies on calcium investigate the most appropriate levels to be fed to poultry, as well as optimal limestone particle size. Variations in these factors may influence egg production and quality.

When limestone presents a very fine particle size, its transit through the gizzard is very fast and therefore present low availability at the time of eggshell formation (Zhang & Coon, 1997). According to Coon (2002), 1/3 or 1/2 of the supplied limestone supplied to commercial layers should be coarse, with a diameter higher than 1.0mm (2.5mm average diameter).

In layers, eggshell formation usually occurs during the night, when there birds present low feed intake. The use of coarse particles of calcium ensure a longer retention of these particles in the gizzard, and their longer permanence in the intestinal tract, thereby increasing calcium availability at the time of egg formation. This reduces the mobilization of bone calcium by the birds, which also benefits eggshell quality, as eggshells containing high bone calcium usually present quality problems, according to Famer *et al*. (1986).

However, in Japanese quails, due to body size differences, it may not be valid to extrapolate results obtained in corn and limestone particle sizes performed with layer chickens or broilers. In addition, the small amount of information in literature on this subject demand further studies.

This study aimed at investigating the influence of different dietary corn and limestone particle sizes on the performance and egg quality of Japanese quails, aiming at obtaining the best MGD values to optimize Japanese quail egg production and quality.

MATERIALS AND METHODS

The experiment was carried out in the Poultry Production Sector of the School of Animal and Veterinary Sciences – UNESP/Botucatu. The experimental period lasted 112 days, consisting of 4 cycles of 28 days each. A random complete block experimental design, with a 2x3 factorial arrangement (2 corn particle sizes and 3 limestone particle sizes), was applied. A total number of 648 birds in the peak of production was distributed in two blocks, with six replicates of 18 birds each.

Birds were housed in a 15m long x 7m wide poultry house, containing 96cm long x 33cm wide x 16 cm high metal cages, specific for egg production. Cages, with a capacity of 18 birds each, were divided in three compartments. Each compartment was equipped with 1 nipple drinker and 1 trough feeder located in front of the cage. Birds were acquired with one day of age, and raised under the same management and feeding conditions until the onset of lay. Light was provided 17 hours per day. Birds were offered feed and water ad libitum during the entire experimental period, and feed was supplied twice daily to each experimental unit.

Feed residues were weekly weighed in an electronic scale to calculate feed intake and feed conversion ratio per dozen eggs and per kg eggs. The number of eggs of each experimental unit was daily recorded in a dedicated form, and eggs were weekly weighed to obtain average egg weight. For egg quality analyses, 2 eggs per replicate were collected during 3 consecutive days every 28 days. These eggs were transported to the lab, and weighed in precision scale (0.01 g); their eggshell specific gravity was evaluated, and then broken to measure yolk and albumen percentages. Eggshells were dried in an oven at 60ºC for three days, weighed and then eggshell percentage was calculated. Eggshell thickness was measured using a pachymeter in three different eggshell locations, and values were recorded in a dedicated form for subsequent calculation the final average. Haugh units were determined by measuring albumen height, using a micrometer, and calculation was based in the formula suggested by Stadelman & Cotterill (1986):

$$\mathbf{UH = 100 \log (H + 7.57 - 1.7\, W^{0.37})}$$

Where H = albumen height (mm); W = egg weight (g); 7.57 = correction factor for albumen height; and 1.7 = correction factor for egg weight.

During rearing, development, and production stages, birds were fed diets based on corn and soybean meal, formulated according to NRC (1994) recommendation. Feed used during the production period is presented in Table 1. Experimental treatments, described in Table 2, consisted of different corn particle sizes (coarse and fine – 0.723mm and 0.617mm, respectively) and limestone particle sizes (coarse, intermediate, and fine – 0.947mm, 0.721mm, and 0.361mm, respectively), which were calculated according to Technical Communication 215 Embrapa – CNPSA (1996). The following performance parameters were analyzed: feed intake (FI), egg production (lay percentage), average egg weight, and feed conversion ratio per dozen eggs and per kg eggs. Analyzed egg quality parameters were: specific gravity, yolk and albumen percentages, and Haugh units.

Table 1 - Calculated percentage and chemical composition of the experimental diet.

Ingredients	Quantity
Corn	56.32
Soybean meal	33.32
Soybean oil	2.86
Salt	0.35
Limestone	5.35
Dicalcium phosphate	1.31
Vitamin and mineral premix[1]	0.30
DL-methionine	0.14
Choline (70%)	0.05
Total	**100.00**
Nutrients	
Crude protein (%)	20.00
Metabolizable energy (kcal/kg)	2900
Calcium (%)	2.50
Available phosphorus (%)	0.35
Methionine (%)	0.45
Methionine + Cystine (%)	0.76
Lysine (%)	1.07
Choline (mg/kg)	1564

*1 - Composition per kg experimental feed: Cu: 8 mg; Fe: 50 mg; Mn: 70 mg; Zn: 50 mg; I: 1.2 mg; Se: 0.2 mg; 2 - Vit. A: 14,000 IU; vit. D3: 4,000 IU; vit. E: 10 mg; vit. K3: 3.2 mg; vit. B2: 6mg; vit. B12: 16 mcg; Niacin: 40 mg; Pantothenic acid: 10 mg; Antioxidant: 30 mg.

Statistical analysis was performed using SISVAR statistical software, according to Ferreira (1998). Performance and egg quality parameters were submitted to analysis of variance and means were compared by the test of Tukey at 5% significance.

RESULTS AND DISCUSSION

Performance results are presented in Table 3. There was no significant interaction between the studied factors (corn particle size *vs.* limestone particle size) relative to performance parameters.

The tested factors did not influence lay percentage, and 84.06% average lay percentage was obtained for the entire experimental period. These results are consistent with those of Leandro *et al.* (2001), who did not find significant effects of corn particle size on egg production of Japanese quails. Ito (2002) also did not observe any influence of limestone particle size on the egg production of 40-week-old light commercial layers.

Corn particle size did not affect (p>0.05) cracked egg percentage, but limestone particle size had a significant effect (p<0.05) on this characteristic. Fine limestone (0.361mm MGD) resulted in a higher percentage of cracked eggs, and was statistically different from coarse limestone (0.947mm MGD), which determined the lowest percentage of cracked eggs during the experimental period. Intermediate limestone particle size (0.721mm MGD) did not result in statistical differences as compared to the other particle sizes.

Egg weight was not significantly (p>0.05) affected by corn or limestone particle sizes. These results are consistent with those observed by Deaton (1989), who

Table 2 - Experimental treatments.

Treatments	N. replicates	Birds/Repl.	Birds/Treat.
1- Fine corn feed with 100% fine limestone (T1)	6	18	108
2- Fine corn feed with 50% fine limestone and 50% intermediate limestone (T2)	6	18	108
3- Fine corn feed with 50% fine limestone and 50% coarse limestone (T3)	6	18	108
4- Coarse corn feed with 100% fine limestone (T4)	6	18	108
5- Coarse corn feed with 50% fine limestone and 50% intermediate limestone (T5)	6	18	108
6- Coarse corn feed with 50% fine limestone and 50% coarse limestone (T6)	6	18	108
Total	648		

Table 3 - Performance of Japanese quail layers fed different corn and limestone particle sizes.

Parameter	Corn (mm)		Limestone (mm)			CV (%)	Mean
	0.617	**0.723**	**0.361***	**0.721****	**0.947*****		
Lay (%)	83.52	84.59	82.22	85.37	84.58	4.95	84.06
Cracked (%)	1.28	1.24	1.40[b]	1.24[ab]	1.14[a]	19.68	1.26
Egg weight (g)	10.71	10.75	10.80	10.70	10.69	2.01	10.73
Egg mass (g/bird/day)	8.96	9.10	8.89	9.15	9.05	5.08	9.03
Feed intake (g/bird/day)	27.25	26.81	27.35	26.50	27.25	5.99	27.03
FCR/dz	0.40	0.39	0.41	0.38	0.39	10.66	0.39
FCR/kg	3.10	3.04	3.19	2.96	3.06	10.21	3.07

* Diet with 100% fine limestone (0.361mm) ** Diet with 50% fine limestone (0.361mm) and 50% intermediate limestone (0.721mm) *** Diet with 50% fine limestone (0.361mm) and 50% coarse limestone (0.947mm). Means followed by different letters in the same row and within each factor are different by the test of Tukey (P<0.05).

fed layer chickens with feeds containing different corn particle sizes, and did not find any changes in egg size or quality. As to limestone particle size, Ito (2002) found that the use of coarse limestone (3.0 – 5.0 mm MGD) in layer chicken feeds decreased egg weight as compared to feeds with fine limestone (MGD lower than 0.5mm) during the second experimental period. The contradiction with Ito's data is probably due to the different species used, to the limestone particle size range, or even to the lack of uniformity standardization (geometric standard diameter – GSD) in the analyzed particle sizes.

Average egg mass was 9.03g/bird/day. No significant effects of corn and limestone particle sizes on this parameter were verified.

Feed intake was stable during the entire experimental period, with an average of 27.03g/bird/day. No individual effects of different corn or limestone particle sizes were observed, which is consistent with data obtained by Deaton *et al*. (1989). However, the results of the present experiment are different from those of Magro *et al*. (1999), who observed that 21-2-day-old broilers presented higher feed intake when fed corn particle sizes measuring 1.175mm MGD.

No significant treatment effects (p>0.05) were verified on feed conversion ratio by dozen eggs or by kg eggs. Average feed conversion ratio/dz was 0.39kg/dz, and average feed conversion ratio/kg eggs was 3.07kg/kg. This lack of significant effects were also observed by Leandro *et al*. (2001) and Zanotto *et al*. (1999).

Data relative do internal and external egg quality parameters during the experimental period are presented in Table 4.

Average albumen percentage was 62.27%. There was no interaction (p>0.05) among the studied factors, nor significant effect of treatments on this parameter. These data are consistent with those reported by Deaton (1989) and Ito (2002), who showed that albumen percentage was not influenced by limestone particle size; however, they did not observe any interaction between corn and limestone particle sizes, which is different from the present study, where no interaction was found between analyzed factors (corn and limestone particle sizes) relative to albumen percentage.

When yolk percentage was analyzed, the results showed no significant interactions (p>0.05) among the studied factors, nor significant treatment effects on this parameter. Average yolk percentage was 29.48%. These results are different from those obtained by Ito (2002), who observed that the effects of limestone particle size combined with corn particle sizes adversely influenced yolk percentage in all studied cycles.

No significant interaction (pP>0.05) was found between corn and limestone particle sizes, nor any treatment effect on eggshell percentage, eggshell thickness, or egg specific gravity. Average eggshell percentage, eggshell thickness, and egg specific gravity obtained during the experimental period were 8.25%, 0.197mm, and 1.075g/ml H_2O, respectively. The results of limestone particle size on eggshell quality parameters obtained in the present study are different from those of Guinotte & Nys (1991b), who studied different combinations of calcium sources and particle sizes, and observed that calcium sources with particle sizes lower than 1.0mm resulted in lower eggshell strength in commercial layer chickens. Roland's (1986) literature review on commercial layers also shows that calcium sources with particle sizes higher than 3.0mm resulted in similar eggshell quality, independent of source (oyster meal or limestone). When only fine calcium sources are used, eggshell quality traits are worse. For instance, when commercial layers were fed calcium sources with particle sizes higher than 3.0mm, Scheideler (1998) obtained higher apparent eggshell density as compared with the use of calcium sources with particle sizes lower than 0.50mm.

The literature information mentioned above partially disagrees with the findings of the present study. Despite not detecting significant differences in specific gravity, eggshell percentage, or eggshell thickness

Table 4 - Egg quality of Japanese quail layers fed different corn and limestone particle sizes.

Parameter	Corn (mm)		Limestone (mm)			CV (%)	Mean
	0.617	**0.723**	**0.361***	**0.721****	**0.947*****		
Albumen (%)	62.24	62.30	62.12	62.22	62.48	1.04	62.27
Yolk (%)	29.52	29.43	29.64	29.57	29.23	2.14	29.48
Eggshell (%)	8.24	8.26	8.24	8.21	8.29	2.38	8.25
Eggs. thickn. (mm)	0.196	0.198	0.197	0.196	0.197	2.86	0.197
Sp. gravity (g/ml H_2O)	1.075	1.075	1.074	1.075	1.075	0.15	1.075
Haugh units	87.45	87.66	87.46	87.44	87.77	1.37	87.56

* Diet with 100% fine limestone (0.361mm) ** Diet with 50% fine limestone (0.361mm) and 50% intermediate limestone (0.721mm) *** Diet with 50% fine limestone (0.361mm) and 50% coarse limestone (0.947mm). [1] (P>0.05).

among treatments as a function of limestone particle size, there was a numerical trend (not statistically significant) of specific gravity improvement when 50% intermediate or coarse limestone particle size was used, as compared to 100% fine limestone. On the other hand, a significant reduction in the percentage of cracked eggs was observed in birds fed 50% coarse limestone as compared to those fed only fine limestone. These results suggest that, although eggshell improvement, as measure by specific gravity, was not sufficient to be statistically detected ($p<0.05$), it did improve eggshell quality, as demonstrated by the reduction of cracked egg percentage.

There was no treatment interaction, nor significant treatment effects ($p>0.05$) on Haugh units, which average was 87.56 in the present experiment. These results are different from those observed by Ito (2002), who observed interaction between limestone particle sizes and their ratios in the diet, as well as an isolated effect of limestone particle size on Haugh unit averages in light commercial egg layer eggs.

CONCLUSIONS

The use of different corn particle sizes (0.617 and 0.723mm MGD) and limestone particle sizes (100% 0.361mm MGD; 50% 0.721 MGD and 50% 0.361 MGD; 50% 0.947mm MGD and 50% 0.361mm MGD) in the diet did not influence performance and egg quality parameters in the studied Japanese quails.

Considering the reduction of the percentage of cracked eggs with the use of 50% coarse limestone particle size (0.947mm) as compared to birds fed only fine limestone particle size (0.361mm), the use of 50% coarse limestone particle size (0.947mm) can be recommended in the feed of Japanese quails for egg production.

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