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EFFECT OF DIFFERENT OF RATION OF COARSE AND FINE LIMESTONE PARTICLES ON PRODUCTION AND SHELL QUALITY OF LAYERS AT PEAK

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ORIGINAL ARTICLE

ABSTRACT: *A study was conducted to determine the influence of different particle sizes of limestone in layer diets on egg production and eggshell quality from 18 to 28 weeks of age. Limestone consisting of small (<1.0 mm) and coarse (2.0 - 3.8 mm) particles that is used in poultry diets was obtained from a South African company. The two particle sizes were mixed to produce five treatments viz. 100 fine (F): 0 coarse (C); 75 F: 25 C, 50 F: 50 C, 25 F: 75 C and 0 F: 100 C. Diets were isocaloric and isonitrogenous. A total of 167 point of lay pullets (18 weeks) were obtained from a commercial pullet farm and were individually caged. The pullets were randomly allocated to five treatments (n = 33) to determine egg production and eggshell quality characteristics. Egg production and eggshell quality data were recorded on individual bird basis and summarized at the end of the week. Dietary treatment did not influence (P>0.05) egg production and egg shell quality (shell thickness, egg weight, egg output, egg surface area, shell percentage and SWUSA) at 24 weeks of age. These results suggested that the influence of dietary limestone particle size distributions at a later stage of the laying period on egg production and egg quality needs further investigation.*

Keyword: *Calcium, Egg production, Egg weight, and Eggshell quality*

INTRODUCTION

In laying hens, calcium plays an important role in bone integrity and eggshell formation. Therefore, any deficiency in the supply or problem in calcium metabolism will lead to weaker bones and eggshells. This will have a deleterious effect on hatching egg quality, as well as, the production of table eggs. According to Roland (1986), the average calcium requirements for eggshell formation within a population of hens are greatest at approximately peak production.

There are several factors involved in egg shell formation of which calcium as a major constituent of the eggshell feature prominently. In this regard, not only the source and level of calcium is important but also the particle size of the calcium source. Roland (1986, 1988), and Guinotte and Nys (1990) reported that larger particles are superior to small or medium in improving egg shell strength and weight. In contrast, Keshavarz and Nakajima (1993) and Keshavarz (1998) found no influence of large particle size on egg shell thickness and egg weight.

The solubility of calcium carbonate depends on the particle size and source of calcium origin (Guinotte and Nys, 1990). Therefore, the ultimate aim should be to supply fine and coarse limestone particles in layer diets in a ratio that will ensure that calcium is available for egg shell formation. Small particle sources such as pulverized calcium carbonate ($CaCO_3$)) passed quickly through the digestive tract and the bird may not be able to sufficiently extract enough calcium to meet its needs. On the other hand, ground limestone could be absorbed by the hen during the day when it is eating, but

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during the hours of darkness metering of calcium occurs in the digestive tract from the gizzard because of the breakdown of the shell grit or limestone chips (Woolford, 1994). Larger particle sizes of $CaCO_3$ in the form of coarse limestone or oyster shell) will be retained in the gizzard for a longer period of time (Woolford, 1994; Korver, 1999). This situation allows for a gradual release of calcium from the gizzard to the small intestine for absorption, resulting in increased time over which the hen receives dietary calcium. According to Farmer et al. (1986), the aim is to offer the bird a constant supply of calcium to improve the shell characteristics and not an excess since it lowers production.

The aim of the study was therefore to investigate the effect of particle size distribution from a specific limestone source in a layer diet on egg production and egg quality at peak production (24 weeks of age).

MATERIAL AND METHODS

One hundred and sixty seven 17 weeks old pullets were obtained from a commercial pullet farm. All the pullets received the same layer diet except for the particle size distribution of the calcium supplement in the diets during lay. The pullets were randomly allocated to five groups of 33 pullets per diet. Pullets in each group received one of the five different ratios of fine (<1.0 mm) and coarse (2.0 - 3.8 mm) limestone particles namely 100, 75, 50, 25 and 0% fine or coarse particles. The two particle sizes of limestone grit were obtained from a commercial supplier of limestone to the poultry industry and these were classified as fine, (particle size <1.0 mm) and coarse (2.0 – 3.8 mm). The two types were mixed in the following ratios 100 F: 0 C, 75 F: 25 C, 50 F: 50 C, 25 F: 75 C and 0 F: 100 C. A medium particle size mixture (1-2 mm) was obtained by mixing equal amounts of fine and coarse particles. There were thus five dietary treatments with 33 individual hens in single cages serving as replicates for each treatment.

Limestone was screened through sieves to obtain samples with appropriate diameters. An amorphous limestone (paste here) was used. The limestone source contained 90 % $CaCO_3$ and 36 % calcium.

Cages were fitted with feed troughs, water nipples and perches. The individual birds had free access to water and feed. Feed intake was recorded weekly. At arrival the pullets were subjected to a 16 hour light and an eight hour darkness regime, regulated by a timer.

Egg numbers were recorded daily and summarised on a weekly basis throughout the experimental period (*i.e.*, 18-28 weeks). Shell-less and those with defective shells were also recorded for production calculations. Individual egg weights were recorded for all the eggs produced by each hen on daily basis. Percent lay on a daily basis was calculated using the formula given by North (1984).

Five eggs of each hen were collected at week 24 to determine the shell quality. Following the measurement of egg weight, eggs were broken and shell thickness and shell weight (including membranes) determined. The shells were washed under slightly flowing water to remove adhering albumen (Kuhl and Seker, 2004; Strong, 1989) and wiped with a paper towel to remove excessive moisture. A meter sensitive to 0.001 mm was used to measure eggshell thickness. Three measurements were made on the sharp, blunt and equator of an egg and average thickness obtained for individual locations (Ehtesham and Chowdhury (2002).

The surface area (cm^2) of each egg calculated using the formula of Carter (1975), ($3.9782W^{.7056}$), where W is the egg weight in grams. Shell weight per unit surface area (SWUSA) expressed asmg/cm^2 and egg volume was calculated according to procedure described by Carter (1975) and Narushin (1997). Egg output (egg mass) was calculated by multiplying percent egg production x egg weight (North and Bell, 1990).

Statistical analysis

There effect of particle size and Data were subjected to ANOVA using the general linear model procedure (SAS Institute, 1999) to determine the effect of particle size distribution and age on response variables relating to egg production. The same procedure was followed to determine the effect of particle size distribution on response variables (shell thickness, shell weight, shell percentage, SWUSA, egg surface area, egg volume and egg contents).

RESULTS AND DISCUSION

Feed intake

Data on weekly feed intake of the hens fed diets with different particle sizes are shown in Table 1. Different particle size distributions of limestone in the diet did not significantly ($P>0.05$) influence feed intake of hens. In agreement with these results Watkins et al. (1977) observed that particle size distribution did not affect feed intake significantly. Guinotte and Nys (1990) who found significant increases in feed intake in Leghorns from 66 to 77 weeks, when hens were fed particulate limestone supplemented with coarse particles of limestone. Average daily feed intake was 119 g A highly significant ($P<0.001$) treatment x age interaction for feed intake occurred. Feed intake significantly ($P<0.001$) increased over time.

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Table 1 - Effect of limestone particle size distribution on weekly feed intake (g) of layers					
week	Particle size			Significance (P)	CV
	1 mm	1-2 mm	>2-3.8 mm		
18	716	665	769	0.1682	23.6
19	770	748	803	0.5618	18.0
20	740	729	749	0.9330	14.0
21	717	732	734	0.9583	12.5
22	740	747	751	0.1767	9.7
23	762	745	755	0.7155	9.4
24	775	741	749	0.3524	9.7
25	771	759	773	0.2956	10.1
26	777	772	802	0.1556	8.9
27	737	715	729	0.2923	8.0
28	748	734	734	0.8497	7.8

CV = coefficient of varianceFine <1.0 mm, Coarse >2.0-3.8 mm

Body weight

In accordance with feed intake, no significant (P>0.05) influence of particle size distribution on the body weight of the birds could be detected (Table 2). A statistically significant (P<0.001) increase in body weight of layers occurred from week 18 to 28. The average body weight of hens with the 100, 75, 50 25 and 0 fine limestone particles in the diet were 1.78 kg, 1.77 kg, 1.75 kg, 1.78 kg and 1.83 kg, respectively.

Table 2 - Body weight (g) changes of layers					
week	Particle size			Significance (P)	CV
	1 mm	1-2 mm	>2-3.8 mm		
18	1784	1789	1828	0.8186	10.2
20	1844	1852	1867	0.9934	8.5
24	1873	1897	1860	0.8513	7.1
28	1929	1944	1900	0.8104	7.2

CV = coefficient of variance. Fine <1.0 mm, Coarse >2.0-3.8 mm

Egg production

From Table 3 and Figure 1 it seems that different ratios of limestone particle sizes did not influence (P = 0.3041) egg production. These results are in agreement with that of Watkins et al. (1977) and Guinotte and Nys (1990) who fed commercial laying hens fed ground and particulate sizes and found that egg production is not affected by particle size.

Table 3 - The influence of limestone particle size on egg characteristics at peak production					
Parameter	Particle size			Significance (P)	CV%
	< 1 mm	1-2 mm	>2-3.8 mm		
Egg. production (%/h/d)	79.82	74.87	79.73	0.1114	14.0
Egg weight (g/egg)	43.87	49.36	51.69	0.2159	12.9
Egg output (g)	56.72	51.97	56.00	0.2388	22.3
Egg volume (ml)	41.53	38.16	38.94	0.1114	17.0
Egg contents (g)	38.63	44.35	46.45	0.2317	13.3
Egg surface area (cm^2)	57.33	62.31	64.37	0.1011	16.4
Shell weight (g)	5.24	5.01	5.24	0.4710	17.1
SWUSA (mg/cm^2)	91.40	80.40	81.40	0.2099	18.0
Shell percentage (%)	10.42	10.15	10.14	0.2229	22.3
Shell thickness (mm):					
Sharp end	0.432	0.422	0.432	0.1335	4.1
Equator	0.442	0.432	0.422	0.7994	14.5
Blunt end	0.432	0.422	0.422	0.4613	4.5

Means within rows with different superscripts differ at P<0.05, SWUSA = Shell weight per unit surface area, CV = Coefficient of variation. Fine <1.0 mm, Coarse >2.0-3.8 mm

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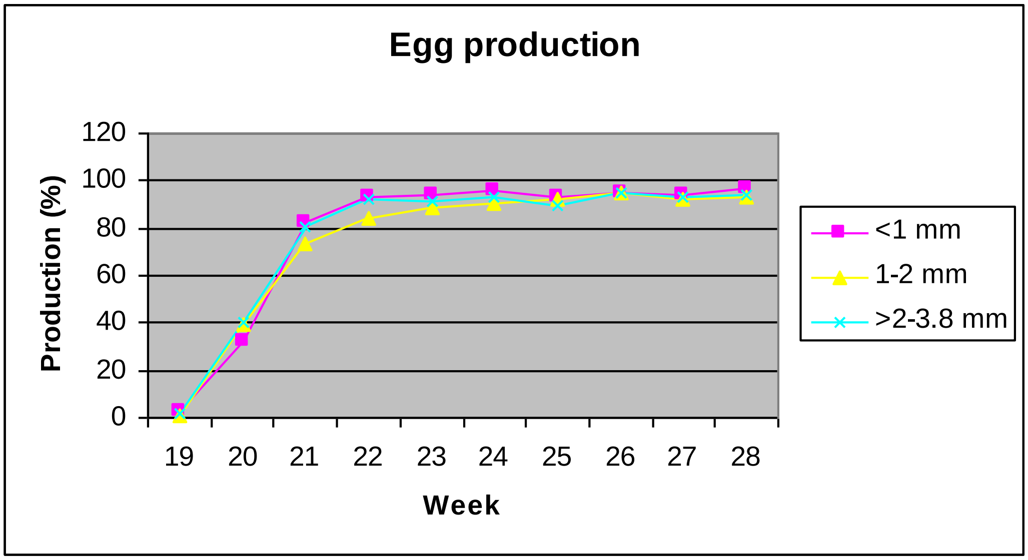

Fig. 1 - Effect of different ratios of limestone particles on egg production in layers

Figure 1 illustrates that there was a significant (P<0.05) increase in production from week 18 to 21 and thereafter egg production remained constant. Leeson and summers (1982) and McDaniel (1983) found a non-significant (P> 0.05) increase in egg production in hens fed oyster shells from 21 to 30 weeks of age.

Egg production increased (P<0.001) significantly over time (Figure 1). An average production percentage of 80% was observed up to week 28. This result is in agreement with Sreenivas (1997) who found that a constant egg production occurred at peak.

From 19 to 28 weeks, cracks and shell-less eggs accounted for 9% of the total egg production. Previous study of Guinotte and Nys (1990) reported 13-20% for cracks and shell eggs from 20 to 30 weeks of age. Most of the cracks and shell-less eggs were from birds fed a calcium source with fine particles. Watkins et al. (1977) is of the opinion that ground limestone produce poor egg shells compared to coarse ones.

Egg weight

Egg weight (P = 0.4558) and egg output (P= 0.5066) were not significantly influenced by limestone particle size in the diet (Table 3). These findings are consistent with Cheng and Coon (1987) who concluded that switching from ground limestone to coarse oyster shell resulted in no significant differences in egg weight. It is evident from Figure 2 that egg weight increased (P<0.05) from week 19 to 28. Egg weights of all the rations increased from ±40 g and to ±50 g by the 24th week and maintained the trend up to the 28th week. These findings confirmed the previous observations (Leeson and Summers, 1982; McDaniel, 1983) that egg weight is lowest at the beginning of the production cycle and increases throughout the laying period.

Egg quality

Data on the influence of limestone particle size distribution on egg volume, egg contents and egg surface area are given in Table 3. No significant differences occurred in egg volume (P=0.1310) and egg surface area (P=0.1393). The highest (P<0.001) values of egg contents were recorded when 100 and 75 % fine limestone particles were included in the diet. Although significant differences for shell weight (P<0.0017) and shell percentage (P<0.0001) occurred, no clear influence of particle size distribution on these characteristics could be detected.

From Table 3, it seems that SWUSA was significantly (P<0.0142) different amongst treatments but this was not confirmed by Tukey's test. In accordance with SWUSA no significant (P> 0.05) difference in eggshell thickness occurred. The findings of this study are in disagreement with the findings of Watkins et al. (1977) who observed that replacement of two-thirds of fine calcium particles with hen size particles of improved egg-shell strength. Dekalb (1998) states that one third of the layer dietary calcium should be supplied in large particle form (2-5 mm). The source of calcium and the time of laying period could probably explain these contradictory results. According to Zhang and Coon (1997), the limestone retention of calcium in the gizzard of laying hens for improving shell quality may be dependent upon particle size, porosity of the calcium source and overall *in vitro* solubility of the calcium source.

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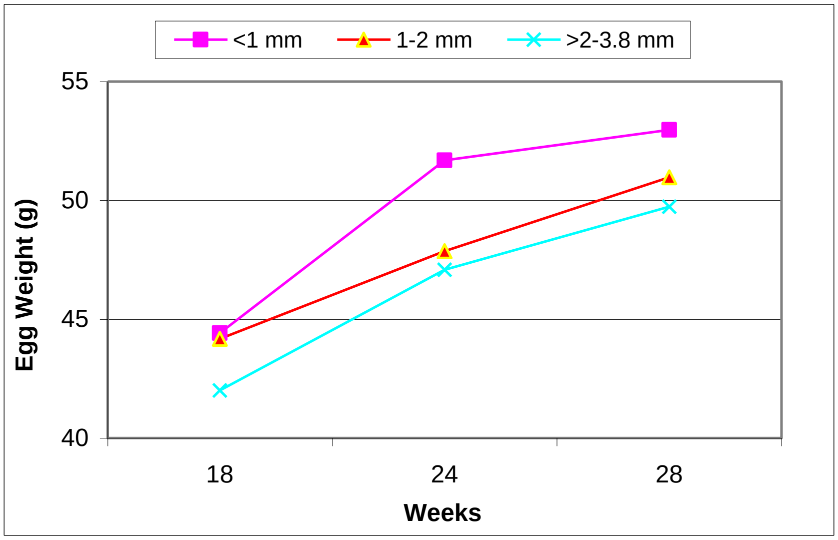

Fig. 2 - Effect of dietary particle size distribution on egg weight

CONCLUSION

From these results it seems that the ratio of fine (<1.0 mm) and coarse (>2.0-3.8 mm) limestone particles in a layer diet does not influence egg production and egg shell quality (shell thickness, egg weight, egg output, egg surface area, shell percentage and SWUSA) at 24 weeks of age. However, the results apply only for the specific limestone used in this study and for peak production. These results suggest that the influence of dietary limestone particle size distributions at a later stage of the laying period on egg production and egg quality needs further research.

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