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INFLUENCES OF CALCIUM LEVELS WITH LIMESTONE PARTICLE SIZE ON LAYING PERFORMANCE , AND EGGSHELL QUALITY TRAITS OF LAYERS

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ABSTRACT: The current study estimated the influences of nutritive calcium levels besides limestone particle size upon performance , egg production and egg quality in first-cycle of Golden Montazah layers. Experimental scheme was completely randomized in 3x4 factorial arranging (three Ca levels – 2.8, 3.0 or 3.2%, in addition four particle size distributions – (100% fine" F" , 50% fine plus 50% coarse "C" , 25% "F" and 75% "C", or 100% " C") Totalizing 12 treatments including three replicates with eight birds each. Limestone size was ranged from fine (F < 0.6 mm) to coarse (1.9 <.C < 2.8 mm).

There was a significant influence of dietary calcium levels with particle sizes or the interaction between the two influences on feed intake (g/hen/day), egg production % , calcium intake and feed conversion.

Particles of limestone were significant effect on eggshell quality including density , shell breaking strength, thickness, eggshell (%) as well as EWSA . Eggshell breaking strength was enhanced when replacing fine limestone by 75% and 100% of coarser limestone substitutions . Shell thickness was significantly higher in 3 or 3.2% Ca groups compared with 2.8% Ca group. The main effect of Limestone particles size generally improved egg shell quality with increasing coarsity inclusion level. Limestone particle size significantly affected internal egg quality traits. Regardless of calcium levels , while limestone particle size is consider , best performance results of egg production, eggshell quality plus some of internal egg quality were obtained by replacing fine limestone by 75% and 100% of coarser limestone particle size .

In conclusion, the addition of calcium at level (3.0 - 3.2%) with supplying of coarse limestone (1.9mm< C <2.8mm) by 75 - 100% improves the performance of laying hen

Key words: Egg production, eggshell quality, limestone, particle sizes, hens.

INTRODUCTION

Calcium is an important constituents used for maintenance and egg production of laying chickens (William, *et al.*, 2006 ; Ahmed *et al*., 2013). Nutritionists were studied the calcium resources and its physical plus chemical characteristics to enhance the quality of the eggshell and bone system of modern layers.

This element has several acts in bird metabolism and eggshell formation. Nutritional calcium levels, particle size and solubility, according to source, influence eggshell quality. Therefore, quality of feedstuffs used in feeding is essential to enhance performance (An *et al*., 2016) .

Because of the particular chemical composition of eggshells (about 95% of the shell is calcium carbonate) and the dynamic process of shell calcification, the optimal supplying for hen's organism with Ca is the critical nutritional factor influencing eggshell quality. Nutritionists and poultry producers find a challenge in determine the needs of calcium in layers (Roland and Gordon, 1996).

Roberts , (2004) and Stringhini ,(2004) reported that Calcium absorption depending on some factors, involving the mineral availability, vitamin D_3, parathyroid hormone, gastrointestinal pH, calcium moreover phosphorus serum levels, fiber , fat contents and mineral granulomety of the diet

Some of researches stated a linear improving in eggshell quality was evident with increasing Ca levels.

Calcium under the nutritional requirements of fowls decline performance and egg quality (Keshavarz, 1986). Whereas, extreme dietary calcium decrease feed intake, feces, and increasing chalky deposits in the eggshell as reported by (Vicenzi, 1996).

Leeson *et al*. (1993) didn't obtain any influence of increasing levels of Ca on eggshell quality and concluding that , 3.4 g of daily Ca intake was enough for brown egg layers. Alterations in strains, environmental factors and some nutrients such as phosphorus, can affecting Ca requirement.

Calcium level above 3.6-3.9% haven't any effect on quality of eggshell this results was obtained by (Keshavarz, 2003; Pastore *et al*., 2012) comparing with the requirements in (NRC, 1994).

On the other hand, Jiang *et al*. (2013) stated that layers fed diets containing high Ca levels (4.4%) experienced decreasing eggshell quality (shell thickness) in comparison by control group (3.7% Ca).

Castillo *et al*. (2004), perceiving the valid NRC recommendations (1994) contradictory, carried out a research establishing the effect of 5 levels of Ca (from 2.93% to 4.82%) on production and quality of egg shell in a modern layer hybrid –white eggs, to determine the biologically optimal level to realize maximum production and egg shell quality. Based on research results, the authors reported that under given conditions, biologically optimal level of Ca necessary to realize the maximum production was 4.38%, for maximum egg shell quality 4.64%, and economically optimal level for maximum profit was 4.35% of Ca in diet.

Particle sizes of calcium sources in layers diets are essential reason influenced calcium bioavailability.

Various researchers have presented a positive effects of coarse particle size on quality of egg shell (Koreleski and Świątkiewicz, 2004; Lichovnikova, 2007; Skřivan *et al*., 2010), egg specific gravity and also bone strength (Ekmay and Coon, 2011).

On the other hand, (Skřivan *et al*., 2010) stated no influences of large particles limestone upon performance , egg quality, egg shell thickness, egg breaking strength and specific gravity**.**

Other findings informed the positive effect of substituting fine with coarse particles of limestone or oyster shell, both of which had longer retention times in the gizzard, and dissolved slowly which provide the hen's organism more evenly with Ca along maintaining sufficient calcium blood concentration during the night, observed by (Koreleski and Świątkiewicz, 2004 ; Lichovnikova, 2007).

Cufadar *et al*. (2011) examined the influences of nutritive Ca levels (3.0, 3.6, or 4.2%) and limestone particle sizes (< 2 mm, 2-5 mm, > 5 mm) in moulted hens (76 weeks of age). The achieved findings demonstrated that medium or large limestone particle sizes had a favorable effect on eggshell and tibia bone breaking strength when the diet was low in Ca, but this impact was not found in layers fed a normal or high Ca content.

Hens has a strategy in reserve calcium to be used at the time when egg is being formed in shell gland, by that strategy we can find large particles of limestone retained longer in the gizzard and so dissolved slowly , this results were obtained by Leeson and Summers (1997).

Improve eggshell plus high number of marketable eggs obtained by Pelicia , *et al*., (2009) when using a high level of dietary Ca 50% substitution of fine-particle limestone via coarse limestone.

Enhancement the performance of commercial laying hens was reported by Araujo *et al*., (2011) by using of 4.12% of calcium simultaneously with the supplying of coarse limestone in (1.00 mm) without influencing the quality of eggs and bones.

The current experiment was done on the commercial Golden Montazah chicken at the peak production period during the first cycle to determine the influences calcium levels combined with limestone particle size upon performance, egg production plus egg quality.

MATERIALS AND METHODS

The current research was carried out at El-Fayoum Research Station , Animal Production Research Institute , Agricultural Research Center , Ministry of Agriculture , Egypt .

In this experiment, 288 Golden Montazah chickens , -32-week-old in their first production cycle were used- and lodged in cages individually up to 44 weeks of age. A photoperiod of 16:30 hours of light per day was used .

Particle size of limestone grits were obtained from a commercial provider of limestone used in poultry industry. Fine(F) and coarse(C). Particles were (F< 0.6 mm) and (1.9 < C < 2.8 mm), respectively.

Limestone was screened through sieves (0.6 mm, 1.9 mm and 2.8 mm) . Particle sizes of the limestone were measured manually to obtain samples with appropriate diameters. A completely randomized investigational scheme with a 3x4 factorial arrangement, consisting of three calcium levels (2.8, 3.0, or 3.2%) and four limestone particle size (mean geometric diameter - MGD) distributions (100% fine and 0% coarse) , (50% fine and 50% coarse) , (25% fine and 75% coarse) , and (0% fine and 100% coarse) , was applied . Totaling 12 treatments with three replicates of eight hens per experimental units.

Treatments were as follows:

T1= 3.2% calcium with 100% fine-particle ,

T2 = 3.2% calcium with 50% fine-particle limestone and 50% coarse-particle limestone**,**

T3 = 3.2% calcium with 25% fine-particle limestone and 75% coarse-particle limestone,

T4 = 3.2% calcium with 100% coarse-particle limestone,

T5 = 3.0% calcium with 100% fine-particle ,

T6 = 3.0% calcium with 50% fine-particle limestone and 50% coarse particle limestone,

T7 = 3.0% calcium with 25% fine-particle limestone and 75% coarse-particle limestone,

T8 = 3.0% calcium 100% coarse-particle limestone ,

T9 = 2.8% calcium with 100% fine-particle ,

T10=2.8% calcium with 50% fine-particle limestone plus 50%coarse-particle limestone,

T11=2.8% calcium with 25% fine-particle limestone and 75% coarse-particle limestone,

T12 = 2.8% calcium 100% coarse-particle limestone **.**

Hens were provided feed and water *ad libitum* during the whole experimental period (32 to 44 weeks) , and were fed diets based on corn, soybean meal, supplying the birds' nutritional requirements (according to NRC, 1994), except for the studied calcium level involving different forms of limestone , as shown in Table (1).

Experimental diets were balanced and composed to be isocaloric and iso-nitrogenous with only calcium levels and the sizes of limestone particle inside diets . The diets were analyzed according (AOAC, 1990).

The following laying traits were evaluated:

Egg production, individual feed intake, average egg weight, egg mass, feed conversion ratio per kg of eggs produced (gram feed/gram egg produced) .

Data for egg production were collected daily, egg weight and feed intake were determined weekly. During a total period of 12 weeks eggshell quality and internal egg quality were evaluated every 28 days

The obtained results were collected and presented as mean values for the 12-weeks period. All eggs produced during the experimental period were weighted to the nearest gram to calculate the mean egg weight. To determine egg mass from recording data of egg production and its weight at biweekly as the next form was used :

EM (egg mass) = EP (egg production) x EW (egg weight) .

The following egg quality parameters were determined:

Internal and external egg quality traits including density , eggshell percentage, eggshell weight per surface area, yolk color, yolk percentage, albumen percentage, albumen height, yolk height, egg weight, Haugh units, egg weight (g) , volume (ml) , egg length (mm) , egg diameter (mm), shell thickness (mm) and eggshell breaking strength.

The calculation of albumen was given by difference as following:

% albumen = 100 – (% yolk + % shell)

Eggshell weight per surface area (EWSA) was expressed in mg/cm², according to Abdallah *et al.* (1993), and obtained using the formula:

EWSA = {EsW/[3.9782 x (EW0.7056)]} x 1000 where: EsW = eggshell weight , EW = egg weight.

Haugh units were determined applying the formula:

HU = 100 log (H + 7.57 - 1.7 W0.37)

where: H = albumen height (mm) and W = egg weight (g).

Shell thickness of hen eggs was determined by a dial micrometer with a precision of 0.01 mm (Mitutoyo, 0.01 mm, Japan).

Eggshell breaking strength was determined using the digital force gauge (model: FGN-50) to measure shear strength and breaking force for eggshells .

Statistical Analysis :

The following statistical model was used :

$Yijk = \mu + Ca_i + LPS_j + CaPS_{ijk} + e_{ijkl}$

Where :

Yijk = observation of the kth experimental unit at Cai calcium level and LPSj limestone particle size distribution, μ = general mean, Cai = effect of i^{th} calcium level (3.2, 3.0, or 2.8%), LPSj = effect of j^{th} limestone particle size distribution (100% fine , 50% fine + 50% coarse , 25% fine + 75% coarse or 100% coarse), $CaLPS_{ijk}$ = effect of the interaction Ca × LPS, e_{ijkl} = random error associated to each observation.

The results were submitted to analysis of variance, and means with statistical difference were compared using SPSS (2007) statistical package. Duncan's multiple range tests (Duncan , 1955) were used to separate means . Statements of statistical significance are based on a probability of $P < 0.05$.

RESULTS AND DISCUSSION

Influences of nutritive calcium levels and limestone particle sizes on performance, and egg quality of layers through the experimental period are shown in Tables (2–5) and Figures (1-6) .

Laying performance :

Table (2) and Figures (1-3) show the performance results. There were significant main effect of calcium levels, limestone particle sizes plus the interaction among these factors on all parameters measured except egg weight and egg production variables.

When dietary calcium levels, was 2.8% birds had the highest feed intake (g). However, at 3.2%Ca levels hens recorded the highest calcium intake (g). On the other hand, 3.2% Ca of the diet exceeded other Ca levels in terms of improved FCR. Concerning limestone particle size response, it is generally accepted that coarse particles were better than fine counterparts. Also, a fluctuation in the response to particle size is deduced. The 50% coarse recorded the highest egg weight. Also 75 or 100% coarse particles recorded the best egg production and FCR, while, while 100% fine or 50% coarse particles showed the highest feed intake and calcium intake. All studied variables were significantly affected by the studied factors.

Regardless of calcium levels the best findings of egg production were noticed with 75% and 100% distributions of fine limestone by coarse particles . Feed intake, was decreased with increasing the percent of coarse limestone , the best results observed in diet containing 100% coarse limestone

The results obtained in our study agreed with Faria (2002) who didn't obtained effect of limestone particle size distributions on egg production when using (0.15 - 0.60mm) , (0.60 - 1.20 mm) , or (1.18 to 2.0mm) . Also, the author found no influence of these factors on the egg weight .

Also , Geraldo *et al*. (2006), demonstrated that calcium level and particle size of limestone used didn't affect the egg weight and egg's quality among studied groups.

Current findings partially match those described by Pelicia *et al*., (2009) who obtained a tendency of decreasing feed intake as dietary Ca levels increased.

Contrary to the present study , when Ito *et al*. (2006), substituted fine limestone (0.5 mm) via coarse limestone (3.0 mm) up to 30% feed intake didn't influenced by limestone particles . As well as , Faria (2002) , determined the increasing of feed intake by using particle sizes of limestone between 0.6 to 1.2mm .

In different study by , Geraldo *et al*., (2006 a) discovered enhancement of layers feed intake by feeding fine limestone (0.135mm) as compared with coarse-particle (0.899mm).

Reently , Aliasghar *et al*., (2019) used 50% of calcium substituting by medium or coarse particle size combinations (1-2 mm) and (2- 4mm) of oyster shell , and compared with control diet (100% ground , < 1 mm) . Results showed that layers feed diets with coarse Ca had significantly better feed intake compared to control .

Findings indicated that Ca consumption raised when Ca level increased in the diet . As well as there was a semi constant trend of Ca intake with different particle size distributions . Data from the current study were consistent with the outcomes of Pelicia et al ., (2009) .

The best conversion per eggs mass detected with 3.2% calcium level , and with diets replaced fine limestone by 75% of coarse limestone (1.9mm < C< 2.8 mm) followed by the diet containing 100% coarse particles . The results are in accordance with the findings of Faria (2002) who obtained improving feed conversion when using limestone particle size among 0.15 and 0.6mm. Conversely , FRC/dz or per kg eggs (FCR/kg) didn't affected by dietary Ca levels Rodrigues *et al*. (2005) .

Similarly , findings of Ito *et al.* (2006), and Pelicia *et al.,(*2009) when feeding hens with different limestone particle sizes didn't detect any differences in feed conversion ratio per dozen eggs or per kg eggs .

External egg quality :

Table (3) and Figures (4-6) show the main effect of feeding different calcium levels and limestone particle sizes plus their interaction on egg shell quality.

Egg shell quality including density, shell weight and percentage, breaking strength and EWSA was not significantly affected by dietary Ca level. Shell thickness was significantly higher in 3 or 3.2% Ca groups compared to 2.8% Ca group. Concerning the effect of limestone particle size, density was not affected. The 75% coarse particles showed significantly the highest shell weight and percentage, and EWSA. Meanwhile, 50% coarse particles significantly had the highest thickness and 100% coarse particles gave the highest value of breaking strength. Only shell thickness was significantly affected by the interaction.

Findings showed no significant effect of calcium levels on eggshell weight , eggshell percentage , breaking strength and (EWSA) , whereas , different distributions of coarser limestone were significantly influenced ($P<0.05$) all analyzed parameters except the density . Shell thickness was significantly affected by Ca levels , limestone particle size and theirs interaction .

EWSA was significantly affected by substituting fine limestone by coarser particles particularly with 75% coarse limestone . On the other hand , Oliveira *et al*. (2002) detected no influence of Ca levels on EWSA.

Ito *et al*. (2006) showed an improvement in egg specific gravity by using coarser limestone when compared to finer particles. Conversely, Geraldo *et al*. (2006 b) and Pelicia *et al*., (2009) observed no effect of limestone particle size distribution upon egg specific gravity.

Regardless of calcium levels the best results of eggshell quality obtained by replacing fine limestone by 75% and 100% of coarser limestone particle size .

The results obtained in our study agreed with Pavloviski *et al*., (2003) and Araujo *et al*., (2011) who assessed the replacing of pulverized limestone by coarser granulometery at 60 or 80% levels , and noticed an enhancement in eggshell quality (better thickness , shell weight, higher breaking strength and lower shell deformation) .

Aliasghar *et al*., (2019) showed that coarse particle size of oyster shell significantly increased the calcium content of eggshell , thickness , density and shell weight per surface area (SWSA) . They concluded that substituting of fine oyster shell with 50% coarse particles (2-4mm) have superior effects on egg shell quality .

Table (4) shows no effect of dietary calcium level on external egg quality: egg weight, volume, length and diameter .

Replacing of fine limestone by (50% fine+50% coarse) significantly improved both egg weight and diameter compared to other forms, while neither egg volume nor egg length was significantly influenced. The interaction among calcium level and limestone particle size significantly affected egg weight but not other variables.

Interior egg quality :

Table (5) displays the internal egg quality results. Nutritive Ca level hadn't effect on internal traits of egg including yolk percentage and color, albumen percentage and height, yolk height and Haugh unit. Limestone particle size significantly affected internal egg quality traits. 100% coarse particle size showed the highest yolk percent. 75% coarse particle size showed the highest yolk colour, albumen percent, and Haugh unit. 50% coarse particle size showed the highest albumen height , also with 75% coarse particles had the highest yolk height. The interaction significantly affected albumen percent.

The results showed the best internal egg quality obtained by replacing fine limestone by 75% and 100% of coarser limestone particle size , respectively. The findings of present study are in agreement with Oliveira (2002) and Ito *et al*., (2006) who obtained no impacts of calcium levels on yolk percentage, albumen percentage , yolk color and Haugh units . Moreover, Geraldo *et al.*, (2006b) and Pelicia *et al*., (2009) reported that Haugh units didn't influenced by using different levels of calcium .

Results of egg quality in the current study showed that , increasing calcium levels and using the coarser particles of limestone primarily influences shell quality while interior egg traits less sensitive to calcium levels or coarse , which agreement with many other studies .

Our findings confirms the positive effect of substituting fine with coarse particles of limestone which had longer retention times in the gizzard, and dissolved slowly which provide the hen's organism more evenly with Ca along maintaining sufficient calcium blood concentration during the night .

CONCLUSION

Current experiment indicated that , increasing dietary calcium levels leading to increase the quality of eggshell as explained by improving eggshell percentage , thickness , breaking strength and " EWSA" .

Eggshell breaking strength enhanced when replacing fine limestone by 75% and 100% of coarser limestone substitutions . There was a slight enhancement on layer performance such as egg production % , feed conversion, furthermore decreased feed intake with increasing calcium levels .

Regardless of calcium levels, while limestone particle size is treated , best performance results , egg production, eggshell quality plus some of internal egg traits were obtained when replacing fine limestone by 75% and 100% of coarser limestone particle size . So, the addition of 3.0 - 3.2% calcium with supplying of coarse limestone (1.9mm < C < 2.8mm) by 75 - 100% improves the performance of laying hen.

Table (1) : Percentage and calculated compositions of the experimental diets .

Calcium level %	**Ca %**		
Ingredients (%)	**3.2%**	**3.0%**	**2.8%**
Yellow Corn	63.56	63.56	63.56
Soybean meal 44%	24.85	24.65	24.4
Wheat bran	1.85	2.55	3.42
Limestone	7.47	6.97	6.38
NaCl	0.3	0.3	0.3
Vit. &Min. premix	0.4	0.4	0.4
Di calcium phosphate	1.51	1.51	1.48
Dl- Methionine	0.06	0.06	0.06
Calculated analysis :			
Protein	16.13	16.15	16.17
ME, kcal / kg	2709	2714	2720
Calcium %	3.2	3.0	2.8
Av. Phosphorus	0.407	0.409	0.400
Lysine %	0.897	0.895	0.853
Methionine	0.350	0.351	0.351

Vitamin and mineral premix supplied the following : Vit. A 14000000 IU , Vit. D_3 3000000 IU , Vit. E 8000 IU , Vit K 4000 mg , Vit B_1 3500 mg , Vit B_3 10000 mg , Vit. B_6 3500 mg , Vit. B_{12} 30 mg , Biotin 300mg , Pantothenic acid 20000 mg , Nicotinic acid 5000 mg , Folic acid 2000 mg , & Colene 500000 mg , Mn 100000 mg , Zn 80000 mg , Fe 50000 mg , Cu 12000 mg , I 1000 mg , Se 300 mg , Co 300 mg

Table (2) : Laying performance of layers fed different Ca levels and limestone particle size distributions.

Ca level (%)	Egg wt. (g)	Egg Prod. (%)	Feed intake (g/bird/day)	Ca intake (g/bird/day)	FCR/kg
3.2	51.69	70.031	119.13 c	3.81 a	3.59 a
3.0	50.60	69.141	122.91 b	3.69 b	3.75 b
2.8	51.36	68.858	124.06 a	3.47 c	3.77 b
Particle size					
100% fine	51.03 b	67.748 b	123.91 a	3.71 a	3.82 b
50% coarse	51.53 a	66.081 b	123.88 a	3.68 a	3.87 b
75% coarse	51.17 b	71.463 a	122.94 b	3.64 b	3.58 a
100% coarse	50.95 b	70.486 a	121.28 c	3.65 b	3.66 a
Probability					
Ca level	ns	ns	*	*	*
Particle size	*	*	*	*	*
Ca level*particle size	*	*	*	*	*

Means in columns followed by different letters are different (P<0.05) .

Table (3): Eggshell quality of layers fed different Ca levels and limestone particle size distribution.

Ca level (%)	Density (g/cm^3)	Eggshell Wt. (g)	Thickness (mm)	Eggshell (%)	Breaking strength(N)	EWSA (mg/cm^2)
3.2	1.07	5.39	0.41 a	10.22	29.77	82.24
3.0	1.06	5.36	0.41 a	10.19	29.92	82.18
2.8	1.06	5.33	0.38 b	10.08	28.52	81.73
Particle size						
100% fine	1.06	5.13 c	0.37 ab	9.53 c	28.13 b	77.02 c
50% coarse	1.06	5.08 c	0.42 a	9.46 c	27.47 b	76.81 c
75% coarse	1.06	5.74 a	0.38 b	10.86 a	29.69 ab	87.73 a
100% coarse	1.07	5.26 b	0.41 ab	10.17 b	31.06 a	81.62 b
Probability						
Ca level	ns	ns	*	ns	ns	ns
Particle size	ns	*	*	*	*	*
Ca level*particle size	ns	ns	*	ns	ns	ns

Means in columns followed by different letters are different (P<0.05) .

Table (4) : Egg quality of layers fed different Ca levels and limestone particle size distribution**.**

Ca level (%)	Egg Weight (g)	Egg Volume (ml)	Egg Length (mm)	Egg Diameter (mm)
3.2	53.67	49.89	53.99	41.87
3.0	52.73	49.56	54.01	41.52
2.8	52.47	49.91	53.89	41.64
Particle size				
100% fine	53.28 [ab]	49.82	53.65	41.23 [b]
50% coarse	53.88 [a]	50.38	53.89	42.18 [a]
75% coarse	53.15 [ab]	49.76	54.42	41.54 [b]
100% coarse	51.84 [b]	49.22	53.59	41.31 [b]
Probability				
Ca level	ns	ns	ns	ns
Particle size	*	ns	ns	*
Ca level*particle size	*	ns	ns	ns

Means in columns followed by different letters are different ($P<0.05$) .

Table (5) : Internal egg quality of layers fed different Ca levels and limestone particle size distribution.

Ca level (%)	Yolk (%)	Yolk Color *	Albumen (%)	Albumen Height	Yolk Height	Haugh unit
3.2	30.27	6.72	59.65	5.70	17.36	72.98
3.0	30.49	6.72	59.32	5.43	17.23	72.65
2.8	30.92	6.11	58.85	5.99	17.59	72.56
Particle size						
100% fine	30.51 [ab]	5.62 [b]	58.91 [b]	5.63 [ab]	17.02 [b]	71.53 [b]
50% coarse	29.99 [b]	5.89 [b]	59.14 [b]	6.18 [a]	17.52 [a]	70.50 [b]
75% coarse	30.48 [ab]	7.17 [a]	60.05 [a]	5.66 [ab]	17.60 [a]	75.75 [a]
100% coarse	31.21 [a]	6.50 [ab]	58.63 [b]	5.27 [b]	17.06 [b]	71.93 [b]
Probability						
Ca level	ns	ns	ns	ns	ns	ns
Particle size	*	*	*	*	*	*
Ca level*particle size	ns	ns	*	ns	ns	ns

Means in columns followed by different letters are different ($P <0.05$) .

Egg production, eggshell quality, limestone, particle sizes, hens.

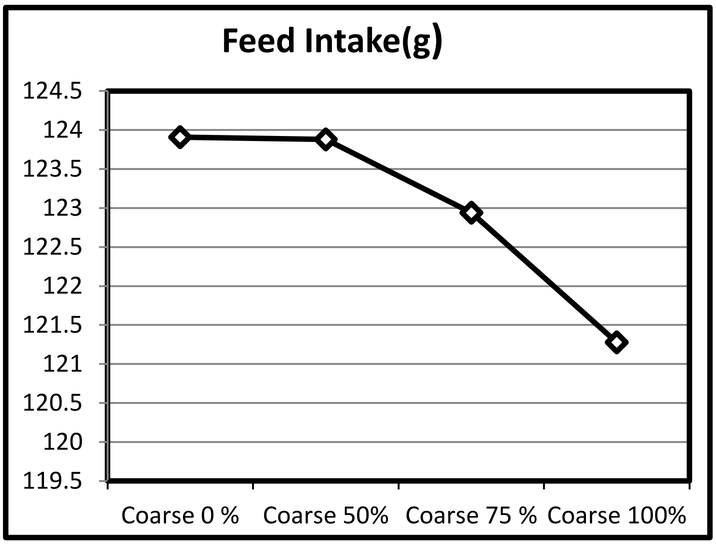

Fig.(1): The effect of coarse limestone ratios on Feed Intake (g)

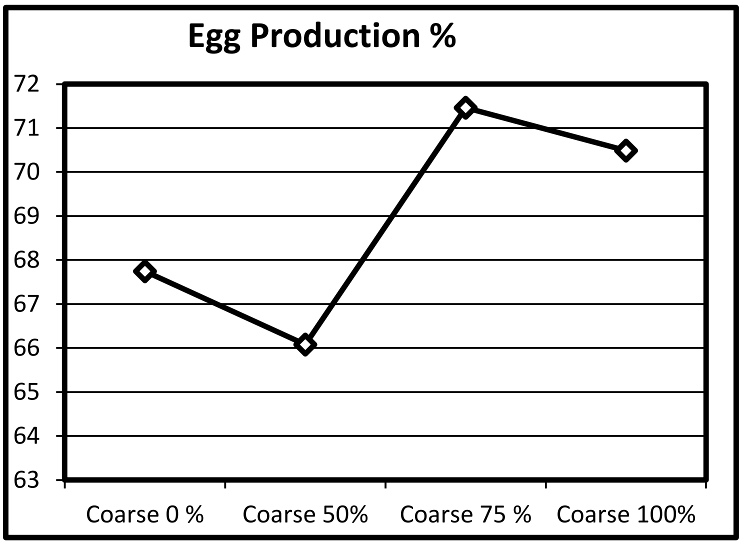

Fig.(2): The effect of coarse limestone ratios on egg production%

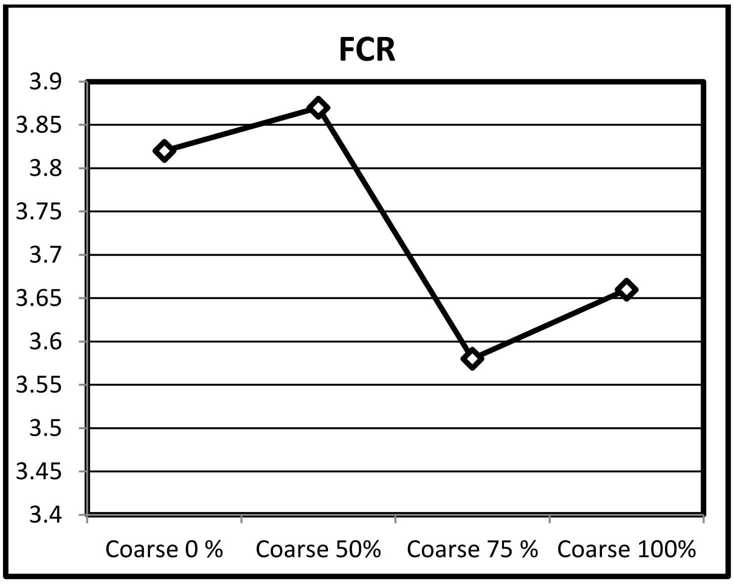

Fig.(3): The effect of coarse limestone ratios on Feed Conversion Ratio .

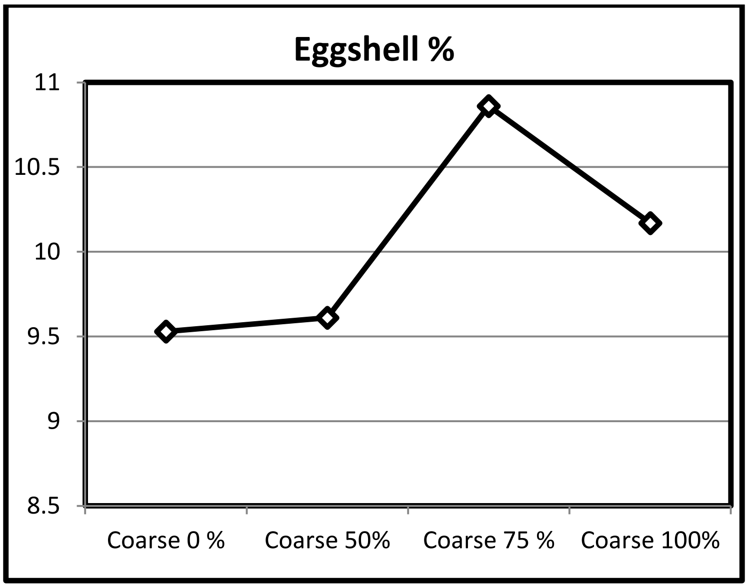

Fig.(4): The effect of coarse limestone ratios on Eggshell (%)

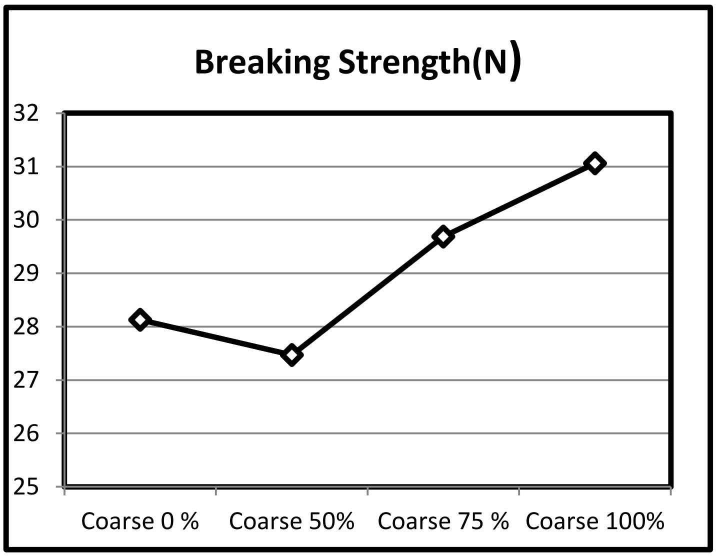

Fig.(5): The effect of coarse limestone ratios on Breaking Strength (N)

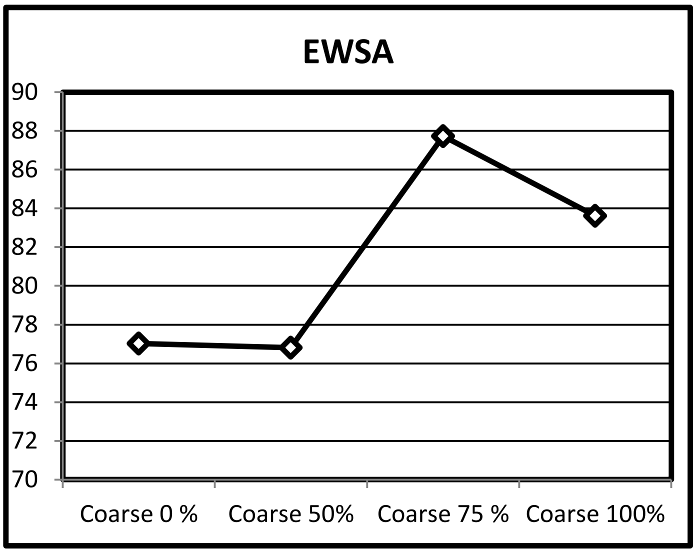

Fig.(6): The effect of coarse limestone ratios on Eggshell Weight Per Surface Area.

REFERENCES

Abdallah, A.G., Harms, R.H. and El-Husseiny, O. 1993 . Various methods of measuring shell quality in relation to percentage of cracked eggs. Poultry Sci. : 72(11):2038-2043.

Ahmed, N. M., Abdel Atti, K. A., Elamin,K. M., Dafalla,K. Y., Malik,H. E. E. and Dousa, B. M. 2013. Effect of dietary calcium sources on laying hens performance and egg quality. J. Anim.Prod. Adv. 3:226-231.

Aliasghar ,Saki ; Abbas R. and Azam , Y. 2019. Calcium particle size feeding time influence egg shell quality in laying hens .Acta Scientiarum Animal Sci. v.41 ,e 42926 .

An, S.H. , Kim, D.W. and An, B.K.2016. Effects of dietary calcium levels on productive performance , eggshell quality and overall calcium status in aged laying hens . Asian Australas. J. Anim. Sci., 29 : 1477-1482 .

AOAC ,1990. Official Metgods of Analysis . 15 th ed. Association of Official Analytical Chemists , Arlington , VA.

Araujo, J. A., Silva, J. H. V., Costa, F. G. P., Sousa, J. M. B., Givisiez, P. E. N., and Sakomura, N. K. 2011. Effect of the levels of calcium and particle size of limestone on laying hens. *Revista* Brasileira de Zootecnia, *40*(5), 997-1005. doi: /10.1590/S1516-35982011000500009.

Castillo, C., Cuca, M., Pro, A., Gonzalez, M., and Morales, E. 2004. Biological and economic optimum level of calcium in White Leghorn laying hens. Poultry Science, 83, 868-872.

Cufadar, Y., Olgun, O. and Yildiz, A.O. 2011. The effect of dietary calcium concentration and particle size on performance, eggshell quality, bone mechanical properties and tibia mineral contents in moulted laying hens. British Poultry Science 52: 761-768.

Duncan ,D.B.,1955. Multiple Range and Multiple F test . Biometric , 11:1-42.

Ekmay, R. D., and Coon, C. N. 2011. An examination of the P requirements of broiler breeders for performance, progeny quality and P balance 2. Ca particle size. *International Journal of Poultry Science*,*10*(10), 760-765.

Faria, LV.2002. Granulometria do calcلrio calcيtico and nيveis de cلlciopara poedeiras comerciais em segundo ciclo de produçمo [dissertaçمo]. Lavras (MG):Universidade Federal de Lavras;. 61p.

Geraldo, A.2006a. Niveis de calcio e granulometrias do calcario para frangas de reposiçao no periodo de 3 a 12 semanas de idade. Revista Brasileira de Zootecnia 35(1):113-118.

Geraldo, A. 2006b. Niveis de calcio e granulometrias do calcario para frangas e seus efeitos sobre a produçdo e qualidade de ovos. Revista Brasileira de Zootecnia 35(4 Suppl):1720-1727.

Ito, D.T., Faria, D.E., and Kuwano, E.A. 2006 . Efeitos do fracionamento do colcio dietario e granulometria do calcorio sobre o desempenho e qualidade dos ovos de poedeiras comerciais. Acta Scientiarum Animal Sciences ,28(2):187-195.

JiaNGg, S., Cui, L., Shi, C., Ke, X., Luo, J. and Hou, J. 2013 . Effects of dietary energy and calcium levels on performance, egg shell quality and bone metabolism in hens. The Veterinary Journal 198: 252-258.

José Anchieta de Araujo, José Humberto Vilar da Silva, FernandGuilherme Perazzo Costa,Janaína Maria Batista de Sousa, Patrícia Emília Naves Givisiez, Nilva Kazue Sakomura .2011. Effect of the levels of calcium and particle size of limestone on laying hens. R. Bras. Zootec., v.40, n.5, p.997-1005.

Keshavarz , K. 1986. The effect of variation of calcium intake on production performance and shell quality. Poultry Science 65(11):2120-2125.

Keshavarz , K. 2003. A comparison between cholecalciferol and 25-OH-cholecalciferol on performance and eggshell quality of hens fed different levels of calcium and phosphorus. Poultry Science 82: 1415-1422.

Koreleski, J. and Światkiewicz, S.2004. Calcium from limestone meal and grit in laying hen diets - effect on performance, eggshell and bone quality. Journal of Animal and Feed Sciences 13: 635-645.

Koreleski, J., and Świątkiewicz, S. 2004. Calcium from limestone meal and grit in laying hen diets-effect on performance, eggshell and bone. *Journal of Animal and Feed Sciences*, *13*(4), 635-645.

Leeson, S., Summers, S, J.D.1997. Commercial poultry nutrition **.** 2.ed. Guelph: Univ. Books. 350p.

Leeson, S., Summers,J. D. and Caston,L.1993. Response of brown-egg strain layers to dietary calcium or phosphorus. Poult. Sci. 72:1510-1514.

Lichovnikovak , M. 2007. The effect of dietary calcium source, concentration and particle size on calcium retention, eggshell quality and overall calcium requirement in laying hens. British Poultry Science 48: 71-75.

Oliveira, JR. de. 2002. Naveis de calcio em dietas para poedeiras leves and semipesadas no segundo ciclo de produçڡo. Ciência Agrotecnica 26(5):1060-1067.

Pastore, S.M., Gomes, P.C., Rostagno, H.S., Albino, L.F.T., Calderaon, A.A.,Vellasco, C.R., Dasilva Vlana, G. and Almeida, R.L.D. 2012. Calcium levels and calcium: available phosphorus ratios in diets for white egg layers from 42 to 58 weeks of age. Revista Brasileira de Zootecnia 41: 2424-2432.

Pelicia ,K., Garcia, E., Mori, C., Faitarone, ABG., Silva, AP., Molino, AB., Vercese, F., and Berto , DA. 2009. Calcium levels and limestone particle size in the diet of commercial layers at the end of the first production cycle . Braz. J. of Poult. Sci. v.11 / n.2 / 87 – 94.

Roberts, J. R. 2004. Factors affecting egg internal quality and eggshell quality in laying hens. J. Poult. Sci. 41:161-177.

Rodrigues EA.2005. Naveis de cلlcio em raçoes de poedeiras comerciais no segundo ciclo de postura. Acta Scientiarum Animal Sciences; 27(1):49-54.

Roland, D.A. and Gordon, R.W. 1996 . Metabolism and role of phosphorus, calcium and vitamin D3 in layer nutrition. In: COELHO, M.B.; KORNEGAY, E.T. (Eds.) Phytase in animal nutrition and waste management, a BASF reference manual. Mt. Olive: BASF, p.125-136.

Skřivan, M., Marounek, M., Bubancova, I., & Podsedníček, M. 2010. Influence of limestone particle size on performance and egg quality in laying hens aged 24–36 weeks and 56–68 weeks. *Animal Feed Science and Technology, 158*(1-2), 110-114. doi: 10.1016/j.anifeedsci.2010.03.018.

SPSS, 2007.SPSS User's Guide Statistics Version 16.0 . Copyright SPSS Inc. USA.

Stringhini, J.H. 2004. Influência da granulometria do calcário calcítico sobre a composição de minerais em tíbias de poedeiras comerciais com diferentes idades. In: CONFERÊNCIA APINCO DE CIÊNCIA E TECNOLOGIA AVÍCOLA, 2004, Santos. Anais... Santos: Conferência Apinco,. p.105.

Vicenzi, E. 1996. Fadiga de gaiola e qualidade da casca do ovo: aspectos nutricionais. Anais do 6؛ Simposio Técnico de Produçao de Ovos**;** Sao Paulo, SP. Brasil: APA; p.77-91.

William, N. S., Horacio, S. R., Paulo, R. S., Luis, F. U., and Marcelo, A. S. 2006. Nutritional requirement of calcium in White laying hens from 46 to 62 Wk of age. International Journal of Poultry Science, 5(2), 181-184.

Egg production, eggshell quality, limestone, particle sizes, hens.

الملخص العربي

تأثير مستويات الكالسيوم المختلفة والحجم الجزيئي للحجر الجيري علي كفاءة الاداء الانتاجي وصفات جودة القشرة في الدجاج البياض

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أجريت هذه الدراسة بمحطة بحوث الدواجن بالفيوم لمعرفة تأثير المستويات المختلفة لعنصر الكالسيوم وكذلك نسب استبدال الحجر الجيري الناعم بالحجر الجيري الخشن بحجم جزيئي يتراوح ما بين (أكبر من 1.9مم وأقل من 2.8 مم) علي كفاءة الاداء وانتاج البيض وكذلك صفات جودة قشرة البيض للدجاج المنتزة الذهبي .
تم استخدام نسب كالسيوم (2.8 ،3.0، 3.2 %) بالاضافة إلي استبدال الحجر الجيري الناعم بالاخر الخشن عند مستويات (100% ناعم) ،(50% ناعم + 50% خشن) ،(25% ناعم +75% خشن) (100% حجر جيري خشن) في صورة 12 معاملة (3 مكرر لكل معاملة) وكل مكرر يحتوي علي 8 دجاجات لكل منهم.
ولقد أظهرت النتائج المتحصل عليها وجود تأثير معنوي لكل من مستوي الكالسيوم وحجم جزيئات الحجر الجيري والتداخل بينهم علي كل من صفات الغذاء المأكول(بالجم / دجاجة /يوم) ، نسبة انتاج البيض ، الكالسيوم اليومي المأكول بالاضافة إلي معدل التحويل الغذائي في صورة كتلة البيض .
أثر الحجم الجزيئي للحجر الجيري بصورة معنوية في صفات جودة قشرة البيض حيث تضمن الوزن النوعي (الكثافة) ، قوة تحمل القشرة (الصلابة) ، سمك القشرة ونسبتها بالاضافة الي صفة وزن القشرة بالنسبة لمساحة السطح EWSA .
عند الاخذ بعين الاعتبار نسب استبدال الحجر الخشن بالناعم وجد تحسن معنوي في صلابة القشرة (القدرة علي التحمل) عند مستوي استبدال 75% و 100% وكان التحسن المعنوي لسمك القشرة عند استخدام مستوي للكالسيوم 3.0% و3.2% مقارنة بالمجموعة المستخدم فيها 2.8% كالسيوم .
بصفة عامة أدى استخدام الحجر الجيري الخشن الي احداث تحسن في صفات جودة القشرة خاصة مع زيادة نسبة الاستبدال .
عند الاخذ في الاعتبار الحجم الجزيئي للحجر الجيري وجد أن أفضل النتائج المتحصل عليها لكل من الكفاءة الانتاجية وصفات جودة القشرة بالاضافة لبعض الصفات الداخلية للبيض كان عند استبدال الحجر الجيري الناعم بالاخر الخشن عند مستوياتاستبدال (75% إلي 100%) وعند مستوي كالسيوم (3.0- 3.2%) داخل علائق الدجاج البياض لتحسين كفاءة الانتاج .

الكلمات الدالة : إنتاج البيض ،جودة القشرة ، الحجر الجيري ، دجاج ، حجم الجزيئات.