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INFLUENCE OF LIMESTONE PARTICLE SIZE IN DIETS FOR HENS AND OVIPOSITION TIME ON EGGSHELL QUALITY

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Eggshell quality was studied in three groups of Issa brown hens, from 73 to 78 weeks of age. Group 1 (control) received a basal diet with 3,8 % Ca and 0,35 % available P, in which pulverized limestone (particle size 0,02 mm) was the main source of Ca. The other two groups of hens were fed diets of the same composition but differing in the supplemented limestone particle size. In group 2 and 3 60 % of the pulverized limestone was substituted with a granular form, of particle size 1,10-1,40 mm. and 1,42-2,80 mm respectively. Eggs for examination were collected at three periods of time: 7-9 hours, 11-13 hours and 15-17 hours. There were significant effects of particle size and oviposition time on eggshell quality. Egg mass and shell deformation decreased, while shell breaking force, shell thickness and shell mass increased with increasing oviposition time. At the afternoon period of laying, significantly higher ($p<0,05$) breaking force (5,0 kg) and lower shell deformation (21,9μ) were obtained in eggs of hens fed on the diet incorporating the granular form of limestone (particle size 1,10-1,40 mm) than eggs of hens fed only pulverized limestone. It was shown that there are possibilities for improving eggshell quality, in older hens, by a combination of pulverized and granular limestone in the diet, as a source of calcium.

Key words: eggshell, limestone, particle size, hens.

INTRODUCTION

Egg shell breakage produces significant economic losses in poultry farming and production. The ability of egg shells to withstand externally applied forces is a function of shell strength. Shell breakage is dependent on both shell strength and the magnitude of the insult (Hamilton, 1982). Numerous factors affect egg shell quality, including the age of the hens, strain of bird, nutrition, oviposition time, house temperature and diseases (Washburn, 1982; Woolford, 1994; Vitorović et al., 1995). Eggs had better shell quality if laid in the afternoon than in the morning (Pavlovski, and Masić, 1991; Pavlovski, and Vitorović, 1996; Škrbić et al., 1998).

The main source of calcium in hen diets is pulverized limestone. To improve shell quality suggestions for supplementation with a larger particle size of limestone or sea shells have been made(Proudfoot, and Hulan, 1987; Rao, and Roland, 1989; Kermanchoi, and Golion, 1991). Larger particles are retained in crop and gizzard for a prolonged period of time. This retention allows the Ca to dissolve slowly and enter the intestine at a slow rate and make calcium available during the period of shell formation through the night (Guinote and Nys, 1991). The retention of Ca in the gizzard of laying hens may be dependent upon particle size, porosity of the Ca source and overall in vivo solubility of the Ca source (Zhang and Coon, 1997). Calcium solubilization is important because hens have to release or solubilize Ca from the compound of origin before absorption can occur. Coarse particles of Ca led to an increase in gizzard and duodenal soluble Ca at the end of eggshell calcification in laying hens (Guinote et al., 1995). Roland (1986) suggested that shell quality may not be influenced by large Ca particle size if the level of Ca in the diet is adequate. Layers require a daily supply of about 3,7 g calcium for shell formation. Special problems are older hens which lay larger eggs with lower shell strength. Their ability to absorb and retain calcium decreases with the increase in age.

The present study was conducted to determine the effects of different sized of granular limestone in the diet on the eggshell quality in hens at the end of egg production.

MATERIALS AND METHODS

A total of 90 Issa Brown hens were divided into three groups (30 birds per group) and housed in cages (4 birds per cage) from 73 to 78 weeks of age (without moulting). Hens were provided with feed and water *ad libidum*. All groups received a basal diet (Table 1) of the same composition. The differences between groups were in the supplied particle sizes of calcium sources (limestone) in the diet. Group 1 (control) received pulverized limestone of particle size 0,02 mm. In the diet of group 2.40 % limestone was pulverized and 60 % in granular form (particle size 1.10-1.40 mm) and in group 3.40 % limestone was pulverized and 60 % in granular form (particle size 1.42-2.80 mm). Limestone was obtained from the Venčac mine, Aranđelovac and ground and sieved in the Institute for Technology of Nuclear and other Raw Materials, Belgrade. The calcium content of the limestone was 36 %.

During the 5 week experimental period eggs were collected every day at three periods of time (time of oviposition): 7-9 hours, 11-13 hours and 15-17 hours The following eggshell quality characteristics were determined: egg mass (g); shell deformation on a Marius Instrument loaded with 500 g ; shell breaking force on an "IS-96" instrument with 100 mm/min rate of force applied at the equator (kg);

shell thickness with membrane (0.01 mm); shell mass (g). Data were subjected to analysis of variance. Differences between means were tested by the t-test.

Table 1. Composition of the basal diet

Ingredients	Composition (%)
Maize	64.3
Soybean meal (44%)	15.0
Yiest (50 %)	5.0
Fish meal (44 %)	4.0
Dicalcium phosphate	1.3
Limestone pulverised*	9.0
Salt	0.2
Mikozel	0.2
Vitamin.-mineral mixture	1.0
Calculated composition	
ME, Kcal/kg	2682
Crude proteins, %	16.84
Calcium, %	3.80
Available phosphorus, %	0.35
Lysine, %	0.909
Methionine, %	0.44
Methionine and cystine, %	0.70*

Group 2- granular limestone (1.10-1.40 mm) 5.4 % and pulverized limestone 3.6 %;
Group 3- granular limestone (1.42-2.80 mm) 5.4 % and pulverized limestone 3.6 %.

RESULTS AND DISCUSSION

The results obtained are shown in table 2.

The average masses of morning eggs in group 1 (pulverized limestone) and in group 2 (60 % limestone particle size 1,10-1,40 mm) were significantly higher ($p<0,01$, $p<0,05$, respectively) than in group 3 (60 % limestone particle size 1,42-2.80 mm). With increasing oviposition time egg mass showed a significant ($p<0,01$) downward tendency, which is in agreement with the results of Pavlovski and Mašić (1991).

Deformation, as an indirect measurement of shell strength, in morning eggs was significantly lower ($p<0,05$) in group 1 and group 3 than in group 2. Larger Ca particle size (group 2 and 3) gave a significant ($p<0,05$) improvement in shell strength of eggs laid during the afternoon (15-17 hours). Hens supplemented with pulverized limestone had the highest shell deformation which indicated that those shells were softer. With increasing oviposition time shell deformation decreased, which means that shell strength increased. These results are in agreement with observed values for shell breaking force, which increased with oviposition time in all experimental groups of layers. Similar conclusions were made by Pavlovski and Vitorović (1996) and Škrbić et al., (1998).

Table 2. Eggshell characteristics influenced by Ca particle size in hen diets and oviposition time

Group (Ca particle size)	Oviposition time (hours)		
	7-9	11-13	15-17
	Egg mass (g)		
1	63.8 ± 4.42 ^{a,A}	61.4 ± 4.38 ^{a}	60.8 ± 4.70 ^{a}
2	62.1 ± 5.10 ^{b,A}	59.8 ± 5.34 ^{B}	56.1 ± 4.13
3	60.8 ± 5.44 ^{A}	59.9 ± 5.23 ^{B}	57.2 ± 4.67
	Deformation (μ)		
1	25.5 ± 7.07	25.0 ± 6.27	23.2 ± 7.05 ^{b}
2	26.9 ± 8.18 ^{b,A}	24.4 ± 7.90	21.9 ± 9.24
3	25.8 ± 6.02 ^{A,B}	23.3 ± 5.20	19.9 ± 7.10
	Breaking force (kg)		
1	3.7 ± 1.06 ^{a}	4.1 ± 1.28 ^{B}	4.3 ± 1.37 ^{B}
2	3.6 ± 1.23 ^{a}	4.0 ± 1.52 ^{B}	5.0 ± 1.96 ^{b,A}
3	3.2 ± 1.11	4.0 ± 1.51 ^{A}	4.6 ± 1.53 ^{A}
	Shell thickness without membrane (0.01 mm)		
1	37.7 ± 3.92 ^{b}	37.6 ± 3.68	39.3 ± 4.82
2	36.1 ± 3.90	37.6 ± 4.40 ^{B}	39.3 ± 5.36 ^{A}
3	37.5 ± 4.10	38.1 ± 3.77	40.6 ± 4.26 ^{B}
	Shell mass (g)		
1	8.5 ± 0.96 ^{b}	8.3 ± 0.94	8.7 ± 0.68
2	8.2 ± 1.13	8.2 ± 1.24	8.5 ± 1.14
3	8.2 ± 1.01	8.4 ± 1.02	8.4 ± 1.12

Means standard deviation
Significant differences:
- Small letters: a - p<0.01; b - p<0.05; differences between groups (columns), dependent on Ca particle size.
- Capital letters: A - p<0.01; B - p<0.05; differences within groups (rows) dependent on oviposition time.

Hens from group 2., supplemented with granular limestone of particle size 1.10-1.40 mm in the diet, laid eggs, during the morning, with shells of significantly

($p<0,01$) higher breaking force (3.6 kg) than (3.2 kg) hens in group 3. At the afternoon period (15-17 hours) of egg collection, significantly ($p<0,05$) higher shell breaking force (5.0 kg) was observed in eggs of group 2 hens than in hens (4.3 kg) from group 1 (pulverized limestone). Guinote and Nys (1991) have observed that eggs from hens given a pulverized limestone diet had lower breaking strength than those from hens supplied with a particulate limestone diet.

Shell thickness and shell mass were not influenced by calcium particle size but showed a significant increase with time of laying.

In summary, the results showed that a diet with 60 % of total limestone in granular form, (particle size of 1.10-1.40 mm) had positive effects on eggshell quality.

CONCLUSIONS

Egg mass and shell deformation decreased with increasing oviposition time. The shell breaking force, shell thickness and shell mass increased with increasing oviposition time. Eggs had better shell quality if laid in the afternoon than in the morning. Hens supplemented with granular limestone of particle size 1.10-1.40 mm in the diet, laid eggs with higher shell strength, especially during the afternoon period of oviposition, than those supplemented with pulverized limestone. The obtained results showed that it may be possible to improve eggshell strength in older hen by partially using a larger particle size of limestone in the diet.

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UTICAJ VELIČINE ČESTICA MERMERA U HRANI NOSILJA I VREMENA OVIPOZICIJE NA KVALITET LJUSKE JAJA

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SADRŽAJ

Ispitivanje je obavljeno na 90 nosilja Issa Brown, u uzrastu od 73-78 nedelja, podeljenih u tri grupe. Sve grupe su za ishranu dobijale smeše istog sastava, u kojima je glavni izvor kalcijuma bio mleveni mermer. Razlike između grupa su bile u veličini čestica mermera dodatog u hranu. Grupa 1, (kontrola), je dobijala smešu sa praškasto mlevenim mermerom (kreda), veličine čestica 0,02 mm. U smeši za grupu 2 oko 60 % mermera je bilo sa krupnijim česticama (1,10-1,40 mm), a 40 % u obliku krede. U smeši za grupu 3 oko 60 % mermera je bilo sa još krupnijim česticama (1,42-2,80 mm), a 40 % u obliku krede. Za ispitivanje kvaliteta ljuske jaja su sakupljana svakodnevno u tri vremenska intervala (vreme ovipozicije): 7-9 sati, 11-13 sati i 15-17 sati. Ustanovljeno je da sa vremenom ovipozicije opada masa jaja i deformacija ljuske, dok se vrednosti sile loma, debljine i mase ljuske povećavaju. Veličina čestica mermera dodatog u hranu, ispoljila je značajan uticaj na kvalitet ljuske jaja, izražen kroz deformaciju i silu loma. Jaja nosilja iz 2. i 3. grupe (krupnije čestice mermera), snesena popodne, imala su značajno ($p<0,05$) manje vrednosti deformacije (21,9 μ; 19,9 μ) i veće vrednosti sile loma ljuske (5,0 kg; 4,6 kg) u odnosu na jaja nosilja iz 1. grupe. U toku prepodnevnog perioda nošenja, jaja nosilja 1. i 2. grupe su ispoljila veću silu loma u odnosu na jaja nosilja 3. grupe. Generalno, može se zaključiti da je 2. grupa nosilja (veličina čestica mermera 1,10-1,40 mm) pokazala najbolje rezultate i da je moguće poboljšati čvrstoću ljuske jaja, kod starijih nosilja, dodatkom u hranu izvesne količine mermera krupnijih čestica.