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Feeding behaviour of layer hens supplemented with snail or oyster shells in the last laying phase: effects on egg quality

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Abstract

The experiment aimed to evaluate the effects of additional biological sources of calcium to hens between 60 to 72 weeks-old, on egg production and egg quality. A total of 72 ISA Brown hens having an average laying rate of 86.6 ± 4.14 % were divided into 4 dietary treatments groups in which oyster shells (O and O_+) and snail shells (S and S_+) were used. In dietary treatments O_+ and S_+, hens were fed with a balanced diet and supplemented with oyster and snail shells, respectively, through free choice-feeding system. Completely Randomized Design was used. Hens were housed in Californian cages and each diet was delivered to nine cages (replications) of two hens each.

The supplementation of shells significantly increased the daily intake of calcium per hen and per egg. Compared to the control diets S and O, the intake of balanced feed significantly decreased in S_+ and O_+, respectively. The intake of crude protein and metabolisable energy significantly decreased in oyster shell dietary treatments; but not in snail shell ones. Irrespective of the type of shell, no significant effect of shell supplementation was recorded on feed conversion ratio and laying rate. The laying rate improved significantly in O_+ compared to S_+. Snail shell supplementation, significantly improved the egg weight (60.8 g *versus* 63.4 g in S and S_+, respectively); but, that of oyster shell did not. No significant effect of shell supplementation was noticed on thickness, weight, percentage and index of eggshell. The Haugh unit and albumen height of egg were similar. Economically, the supplementation of snail shell significantly, reduced the efficiency of diet. It can be concluded that, despite the increase of calcium intake, the supplementation of snail or oyster shells to ISA brown aged layer hens did not significantly improve eggshell characteristics; but, that practice increase the egg weight in hens fed with snail shell.

Key words: Benin, calcium, minerals, layer hens, snail shell, oyster shell, egg quality

Introduction

Physiologically, when layer hens are getting old, weight of eggshell decreases while the egg weight increases resulting in a decrease of eggshell thickness and its weakness (Larbier and Leclercq 1992).Thus, eggs produced at the end of the production cycle are the most affected by the poor shell quality (Safaa et al 2008).These statements indicate that aged hens are not enough efficient in calcium absorption as the younger ones. Egg quality and its composition also change with the level of production and age of layer. Thus, proportion of yolk increases, whereas the proportion of albumen decreases when hens' age advances (Sauveur 1988).

In the brown egg-laying hens, the percentage of eggshell decreased from 9.8 to 8.9% and eggshell thickness also decreased from 0.403 to 0.373 mm from 22 to 57 weeks of age (Al-Batshan et al 1994). Thus, the percentage of broken eggs increases from 0.43% at 22 weeks to 1.81% at 74 weeks of age (Grobas et al 1999). The frequency of defective eggs may increase from 7 to 11% during laying, collecting and packaging phases of egg (Yörük et al 2004).Consequently, eggs with inferior shell quality are a major economic loss in poultry industry (Sharma et al, 2009). It is estimated that due to poor shell quality, about 6-8% of eggs are lost in different phase of egg handling system from point of production to point of consumption (Camarius et al 1996).

Apart from the consideration of the nature of calcium source, the increase of the level of calcium in the balanced diet or the delivery of additional amount of calcium separately are some potential strategies to improve hens' eggshell quality at the end of the laying period (Yöruk et al 2004, Sharma et al 2009 and Çath et al 2012); this without a significant increase of the feeding cost.

This experimentation was carried out to investigate specifically the effects of the supplementation of different biological calcium sources, by using the free choice feeding system, on egg production and egg quality in brown hens during the late laying period.

Material and Methods

The experiment was carried out in Benin at the Laboratory of Poultry Research and Zoo-Economy, University of Abomey-Calavi. The snail shell used was especially from *Achatina* species. They were cleaned with water, sundried and ground. The snail and oyster shells cost 47 FCFA/kg and 110 FCFA/kg, respectively.

A total of seventy two Isa Brown laying hens of 60 weeks-old, weighting on average 1662.5 ± 33.17 g, were housed in Californian cages. Their average laying rate was 86.57 ± 4.14%.

The birds were distributed into four equal groups of eighteen hens housed in nine cages of two hens each. During 12 weeks, each of the four dietary treatments (Table 1) was delivered to each group of hens (in nine cages). Hens were fed with four balanced diets containing oyster shell (O and O_+) and snail shell (S and S_+) as calcium sources. A supplementary calcium source was delivered *ad libitum* in separate feeder to hens fed with O_+ and S_+. Water was given *ad libitum*. In the poultry house, the ambient temperature was between 27.5 and 28.7°C, whereas the relative humidity varied from 74.0 to 81.9%.

Feeding and laying performances (feed, minerals, protein and energy intakes, feed conversion ratio, and laying rate), eggs quality (weight, shape index, Haugh units, shell thickness at equator, shell weight and albumen height, egg content percentage, shell index and egg shape index) and economics of feeding (Feeding cost and Economic Feed Efficiency) were assessed. Haugh units and Economic Feed Efficiency (EFE) were calculated according to Haugh (1937) and Houndonougbo et al (2009), respectively.

The data were analysed by using the mixed procedure in SAS 9.2. Analyses were performed according to the following model:

$Y_{ij} = \mu + T_i + S_j + TS_{ij} + \varepsilon_{ij}$

Y_{ij}= Observation for dependent variables;

μ = Overall mean;

T_i = Fixed effect of the type of shell;

S_j= Fixed effect of shell supplementation;

TS_{ij} = Interaction effect between type of shell and its supplementation;

ε_{ij} = Residual error.

While, the effect of type of shell and the interaction between shell and the supplementation are in the statistic model, it is mainly the effect of shell supplementation that was focused in this paper. The mean values and the pool standard error of mean (SEM) are presented in tables. The significant differences were reported when $P < 0.05$.

Table 1. Composition in ingredients and nutrients and price of the experimental balanced diets

Ingredients/Nutrients	Dietary Treatments*			
	Oyster shell		Snail shell	
	O	**O_+**	**S**	**S_+**
Ingredients, %				
Maize	55.4	55.4	55.4	55.4
Soybean cake	24	24	24	24
Cotton cake	9	9	9	9
Oyster shell	10	10	0	0
Snail shell	0	0	10	10
Lysine	0.05	0.05	0.05	0.05
Methionine	0.15	0.15	0. 15	0. 15
Dicalcium Phosphate	0.8	0.8	0.8	0.8
Iron Sulfate	0.025	0.025	0.025	0.025
Salt (NaCl)	0.3	0.3	0.3	0.3
Prémix[1]	0.25	0.25	0.25	0.25
Price/kg (F.CFA[2])	207.6	207.6	201.3	201.3
Nutrition Composition				
Dry Matter, %	88.6	88.6	88.6	88.6
Metabolisable Energy, MJ/kg	10,8	10,8	10,8	10,8
Crude Protein, %	18.9	18.9	18.9	18.9
Crude Fibre, %	4.16	4.16	4.16	4.16
Crude Fat, %	3.54	3.54	3.54	3.54
Methionine + Cystine, %	0.78	0.78	0.78	0.78
Lysine, %	0.97	0.97	0.97	0.97
Methionine, %	0.46	0.46	0.46	0.46
Calcium, %	4.05	4.05	3.47	3.47
Phosphorus, %	0.57	0.57	0.57	0.57
Sodium, %	0.16	0.16	0.13	0.13
Ca/P	7.1	7.1	6.1	6.1

** O+ and S+ dietary treatments were obtained by supplementing hens fed O and S balanced diets with respectively, oyster and snail shells.*
[1]Premix contained per kg: Vitamins: A 4000000 UI; D3 800000 UI; E 2000 mg; K 800 mg; BI 600 mg; B2 2000 mg; niacin 3600 mg; B6 1200 mg; B12 4 mg; Choline Chloride 80000 mg; Minerals: Cu 8000 mg; Mn 64000 mg; Zn 40 000 mg; Fe 32000 mg; Se 160 mg.
[2]1 € = 655.9 F.CFA

Results

Balanced feed and shell intakes

The intake of balanced feed, significantly decreased with the supplementation of oyster or snail shells to old layer hens (Table 2).That behaviour is more important in case of snail shell supplementation than that of oyster shell. On the other hand, the intake of supplementary shell was irrespective of the type of shell. Consequently, the total feed intake was similar in O and O_+, but not in S and S_+ dietary treatments. Hens supplemented with oyster shell were therefore able to regulate their total feed intake more than those supplemented with snail shell.

Table 2. Feed, energy, protein and minerals intakes of laying hens supplemented with oyster or snail shells

Parameters	O	O_+	S	S_+	SEM[1]	P-value
Balanced feed + shell intake, g/hen/day	117.9^a	118.0^a	111.2^b	114.3^c	0.842	< 0.0001
Balanced feed intake, g/hen/day	117.9^a	103.0^b	111.2^c	99.0^d	0.620	< 0.0001
Supplemented shell intake, g/hen/day	-	14.9^a	-	15.3^a	0.182	< 0.561
ME intake, MJ/hen/day	$1,28^a$	$1,24^b$	$1,21^c$	$1,19^c$	0,0090	< 0.0001
ME intake, MJ/egg	1,56	1,47	1,52	1,51	0,0249	0.0744
Crude Protein Intake, g/hen/day	22.3^a	21.6^b	21.2^c	20.8^c	0.157	< 0.0001
Crude Protein Intake, g/egg	27.2	25.6	26.6	26.3	0.434	0.0744
Calcium Intake, g/hen/day	4.77^a	5.94^b	3.88^c	5.20^d	0.734	< 0.0001
Calcium Intake, g/egg	5.83^a	7.02^b	4.88^c	6.56^d	0.116	< 0.0001
Phosphorus intake, g/hen/day	0.672^a	0.653^b	0.638^c	0.629^c	0.0047	< 0.0001
Phosphorus intake, g/egg	0.821	0.774	0.802	0.793	0.0131	0.0873

[a,b,c,d] *Means in the same row without common letter are different at P<0.05*

[1] *SEM: Standard error of the mean*

[2] *ME: Metabolisable energy*

The free choice-feeding of supplementary oyster or snail shells (O_+ and S_+) decreased hens' daily intake of metabolisable energy (ME) by 3.10 and 1.58 %, crude protein (CP) by 3.24 and 1.92 % and phosphorus by 2.91 and 1.43 %. Thus, in case of oyster shell supplementation there was a decrease of ME and CP intakes. That feeding practice, improved the daily intake of calcium per hen by 24.5 and 34.0%, in O_+ and S_+ treatments compared to O and S, respectively. A decrease of the daily phosphorus intake is noticed in supplemented diets, this in relation with the decrease of the balanced feed intake.

However, per produced egg, the decrease of balanced feed intake in supplemented dietary treatments (O_+ and S_+) did not affect the intakes of ME, CP and phosphorus; but it increased the intake of calcium by 20.4 and 34.4%, compared to O and S, respectively. The decreases of ME and CP per egg were in the range of 5.9% and 1.2%, respectively in O_+, versus 5.9% and 1.1% in S_+.

Laying performances and feed conversion ration

The supplementation of both shells had no significant (P > 0.05) effect on laying rate and feed conversion ratio (Table 3). However, the supplementation of oyster shell specifically improved the laying rate by about 3.2%, indicating an effect of the type of shell.

Table 3. Laying rate and feed conversion ration of laying hens supplemented with oyster or snail shell

Parameters	O	O_+	S	S_+	SEM[1]	P-value
Laying rate, %	82.1^{ab}	85.3^b	80.6^a	80.0^a	1.41	0.044
Feed conversion ratio, kg feed/kg egg	2.25	2.25	2.30	2.27	0.037	0.743

[a,b] *Means with the same superscripts along the same row are not significantly different (P > 0.05).*

[1] *SEM: Standard error of the mean*

Egg quality

The providing of supplementary calcium sources to layer hens through the free choice-feeding decreased the egg weight by 3.06% in O_+, whereas in S_+, it improved the egg weight by 4.28 % (Table 4). However, the improvement of egg weight in hens supplemented with snail shell has to be confirmed in subsequent experiment, on a larger scale for example.

The practice of oyster or snail shell supplementation did not improve the shell index, shell thickness, shell weight and shell percentage of eggs; but, there was a significant effect of the calcium source on the eggshell weight and the shape index of eggs. The albumen and yolk percentage, albumen height and Haugh unit, were similar between diets (Table 4), indicating no effect of the shell supplementation on the internal characteristics of eggs.

Table 4. Mean values for quality traits of eggs from laying hens supplemented with oyster or snail shell

Parameters	O	O_+	S	S_+	SEM	P-value
Egg weight, g	63.9^a	62.0^b	60.8^c	63.4^a	0.236	< 0.0001
Shell Index, g/cm^2	8.61	8.34	8.19	8.34	0.167	0.328
Eggshell thickness, mm	0.376	0.362	0.359	0.367	0.006	0.182
Eggshell percentage, %	9.98	9.72	9.63	9.78	0.201	0.652
Eggshell weight, g	6.58^a	6.31^{ab}	6.04^b	6.22^b	0.167	0.0282
Egg shape index, %	77.8^a	76.7^{ab}	76.2^{ab}	75.6^b	0.555	0.044
Haugh unit	88.4	86.6	88.7	88.6	1.190	0.549
Albumen height, mm	8.19	7.84	8.09	8.15	0.207	0.647
Albumen and yolk percentage, %	90.0	90.3	90.4	90.2	0.201	0.652

[a,b,c] Means with the same superscripts along the same row are not significantly different (P > 0.05)

Economics of feeding

The cost of feeding and the ratio between the eggs' revenue and the feeding charges through the Economic Feed Efficiency (EFE) demonstrated that the supplementation of oyster or snail shell was not economically beneficial (Table 5). There was a tendency (P = 0.071) for shell supplementation to increase the feeding cost. Specifically, the supplemented snail shell diet (S_+) reduced the EFE compared to the control diet S.

Table 5. Feeding cost and Economic Feed Efficiency (EFE) in old laying hens supplemented with oyster or snail shells

Parameters	O	O_+	S	S_+	SEM[1]	P-value
Feeding Cost, FCFA[2]/egg	29.9	29.2	28.1	29.3	0.468	0.071
EFE, FCFA Egg/ F.CFA Feed	2.12^a	2.19^a	2.28^b	2.18^a	0.0360	0.024

[a,b]Means with the same superscripts along the same row are not significantly different (P > 0.05)
[1]SEM: Standard error of the mean
[2]Euro (€) = 655.9 FCFA

Discussion

Feed and shell intakes

The balanced feed intake of hens was affected by the free choice-feeding of supplementary oyster and snail shell. However, the total feed intake significantly increased only in case of snail shell supplementation. At 32 °C, choice feeding system, significant increase the shell-grit intake (P < 0.05), but not on the total feed intake of 34 weeks-old laying hens (Henuk et al 2000).The results confirm the non significant effect on total feed intake of layer hens supplemented with oyster shell, but not with snail shell. The aged hens are able to regulate their total feed intake in case of oyster shell supplementation. In the hot and humid climatic conditions of Benin, that ability reduces the daily intake of ME, CP and phosphorus. Thus, oyster shell supplementation improved more the nutritional efficiency of hens through a reduction of ME and CP ingested per egg than the supplementation of snail shell.

The supplementation of both types of shell increases the daily calcium intake of hens and consequently the mass of calcium per egg. Thus, the daily calcium intakes in supplemented diets are higher than 4 g/hen suggested by Van Eekeren et al (2006). Consequently, on the basis of the daily feed intake per hen, the Ca/P ratios in O_+(9.10) and S_+(8.27) were higher than 6.67 (INRA 1989) and 7.38 (NRC 1994). These results are in agreement with the significant difference of daily feed intake, ME, CP, calcium intakes reported by Olver and Malan (2000) in free choice-feeding of hens fed with limestone powder between 16 to 80 weeks-old. However, in younger laying hens (20 to 44weeks-old), Iskandar (2011) did not found any significant effect of the intake of protein concentrate, corn and oyster shell on calcium and phosphorus intake. The regulation process of mineral intake by laying hens depends therefore on their age.

Hens fed with snail shell based diets (S and S_+) ingested the lowest amounts of feed, ME and nutrients. The result demonstrate that the total feed intake of hens fed snail shell based diet can be increased by supplementing that shell to hens. However, in case of expensive shell such practice can increase the cost of feed and reduce its efficiency, mainly if the egg production is not improved consequently.

Laying performance and feed efficiency

The significant improvement of the laying rate in O_+ compared to S_+ is linked to the type of shell and not to the supplementation practice. Thus, in case of oyster or snail shells supplementation, the significant decrease of the daily intake of energy, protein and phosphorus is without a significant effect on egg production and feed conversion ratio. That practice can be therefore used to improve the nutritional efficiency of feed in old layer hens. Compared to oyster shell based diets, the significant decrease of feed intake in snail shell based diets (S, S_+) resulted in a reduction of egg production. This demonstrates, an effect of the nature of the biological calcium source, but not that of supplementation which improved significantly the laying rate in a second laying cycle (85 - 105 weeks-old) of Brown Nick hens supplemented with oyster shell instead of limestone (Çath et al 2012). The laying rates recorded are higher than 79.8% reported in limestone based diets (Saunders-Blades et al 2009) and than 72.7%, when the limestone and oyster shell were combined at 60:40 in Lohmann Brown hens' diet (Safaa et al 2008). They are also higher than 63.7 to 69.4% (Yörük et al 2004) reported in Hisex brown layer hens supplemented with different levels of sodium bicarbonate during the late laying period (54^{th} to 65^{th}weeks-old).

The feed conversion ratios are close to 2.32 - 2.52 (Olver and Malan 2000), but lower than 2.75 - 2.97 (Yörük et al 2004). Considering the current price of snail shell (47 FCFA/kg) and oyster shell (110 FCFA/kg) in Benin, their supplementation to brown hens through the free-choice feeding in the last three months of the laying did not affect the feed cost, but that practice decreased the economic feed efficiency in snail shell based diets. Economically, the supplementation of oyster shell is more profitable than that of snail shell.

Egg quality

The egg weight was influenced negatively by the supplementation oyster shell and positively by that of snail shell. Thus, the supplementation of snail shell increased the egg weight by 4.28%, whereas the supplementation oyster shell decreased it by 3.06%.These results are different from the no significant effect of free choice-feeding of oyster shell grit on egg weight at 20 and 32 °C (Henuk et al 2000). The egg weight increases with hens age, hence the weight of collected eggs are lower than 67.4 to 68.2 g reported in 85 weeks-old hens (Çath et al 2012), but higher than 56.4 to 58.0 g recorded in layer hens supplemented calcium and phosphorus between 55 and 62 weeks-old (Sharma et al 2009). They are close to the weight of eggs (63.9 to 66.1 g) laid by Lohmann Selected Leghorn hens from 46 to 62 weeks of age (Narváez-Solarteet al 2006).

A supplementation of sodium bicarbonate to layer hens did not affect significantly the shape index, shell thickness, yolk colour and Haugh units (Yörük et al 2004). These results are in agreement with the similar values recorded between dietary treatments for these variables in this experiment. The shell thickness (0.359 to 0.376 mm) are in the range of 0.351- 0.376 mm (Yörük et al 2004), but slightly higher than 0.345 to 0.353 mm (Çath et al 2012) and 0.342 to 0.351 mm (Safaa et al 2008). The calcium efficiency decreases with the age of layer hens (Al-

Batshan et al 1994, De Ketelaere et al 2002); hence, the feeding behaviour of the supplemented hens did not change significantly the eggshell quality. The supplemented hens might excrete more calcium than the non supplemented ones due to the low calcium absorption capacity of aged hens (Sharma et al 2009) and to the limited ability of hens to store calcium for future shell formation (Lennards and Roland 1981). The hens kept in the hot and humid environment of Benin might reach the optimum level of egg shell qualities, or they did not consume enough additional calcium in order to improve significantly the egg shell qualities, while *ad libitum* oyster or snail shells were supplemented to them.

Conclusion

The supplementation of oyster shell to hens fed balanced diets during the last three month of laying period, increased calcium intake and significantly decreased metabolisable energy, crude protein and phosphorus intake of hens. The supplementation of snail shell increased only calcium intake. These feeding behaviours of hens did not improve the laying rate, feeding cost and eggshell quality. Oyster shell supplementation decreased the egg weight, whereas that of snail shell significantly improved it. This indicates an effect of the type of shell in such feeding strategy.

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