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Effect of the Delivery Mode of Snail and Oyster Shells on Laying Hens' Performance and Eggs Quality

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ABSTRACT

The effects of free choice-feeding of snail and oyster shells on eggs production and egg quality were assessed by using 72 ISA Brown hens of 60 weeks-old with an average laying rate of 83.3±3.59% at the beginning of the experiment. The hens were housed in Californian cages. They were divided into 4 dietary treatments based on oyster shell (O_b and O_s) and snail shell (S_b and S_s). Hens in O_b and S_b treatments were fed with balanced diets containing oyster and snail shells, respectively. In O_s and S_s dietary treatments, oyster and snail shells were delivered separately from the rest of the feed. Each diet was delivered to nine replicates cages of two hens each. The hens consumed significantly ($P<0.05$) more snail shell than oyster shell in the free choice-feeding. That feeding strategy significantly, decreased the eggshell thickness in hens fed oyster based-diets, but not in hens fed snail shell based-diets. It significantly reduced the efficiency (unit/egg) of metabolisable energy, crude protein and phosphorus. The free choice-feeding of both types of shells did not affect significantly the physical aspects of the internal and edible parts of eggs. In snail shell based-diets, the free choice-feeding appeared more convenient than balanced diet feeding to improve egg weight and to keep the laying rate and eggshell thickness.

Key words: Benin; free choice-feeding; egg; aged hens

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INTRODUCTION

Dietary calcium (Ca) has an important effect on birds' eggshell formation and quality. In poultry diet, calcium is often provides by shell and limestone. By improving the productivity of commercial layers these last years, potentially, less dietary Ca is available for eggshell calcification (Roberts, 2004). Thus, higher levels of dietary calcium levels (4% or more) have been suggested by breeders of modern layer breeds during the older age phases in order to compensate for higher Ca requirements (Çatlı *et al*., 2012). During the eggshell formation, the calcium requirement of laying hens is higher; this results in a specific appetite for calcium (Larbier and Leclercq, 1992). Thus, the use of a balanced diet with an invariable level of calcium in laying hens does not take into account the fact that shell formation is a cyclical phenomenon (Sauveur, 1992).

It is therefore suitable to allow free access to Ca sources separately from the diet. That feeding strategy was defined as separate calcium feeding (Mongin and Sauveur, 1975). In fact, when the dietary Ca is presented separately, the hen is able to regulate its dietary Ca intake (Mongin and Sauveur, 1974), and this can improve the efficiency of energy and other nutrients. Moreover, at high ambient temperature, separate Ca feeding improves eggshell quality and egg production of laying hen (Picard *et al*., 1986).

The objective of this study was to investigate in warm and wet region of Benin, the effects of the free choice-feeding of different biological calcium sources (oyster and snail shells), on egg production and egg quality in brown hens during the late laying period.

MATERIALS AND METHODS

The snail shells were from *Achatina* species. They were cleaned with water, sundried and ground. The snail shell and oyster shell cost 47 FCFA/kg and 110 FCFA/kg, respectively.

A total of 72 ISA Brown laying hens having an average live weight of 1684.9±24.3 g were housed in Californian cages used as repetitions. They were 60 weeks-old with an average laying rate of 83.3±3.59%. The birds were distributed into four equal groups of 18 hens in 9 cages (replicates) of 2 hens each. During 12 weeks, two groups of hens were fed with two balanced diets (O_b and S_b) containing oyster and snail shells respectively as main sources of Ca (Table 1). The two other groups of hens were fed with two low-calcium-diets (O_s and S_s), and oyster and snail shells were respectively provided *ad-libitum* and separately from the other mixed feedstuffs. Water was also given *ad-libitum*. In the poultry house, the ambient temperature and the relative humidity varied from 27.5 to 28.7°C and 74.0 to 81.9%, respectively.

Table 1: Composition and price of the experimental diets

Ingredients/Nutrients	Oyster shell based-diets		Snail shell based-diets	
	O_b	O_s	S_b	S_s
Ingredients (in 100 kg diet)				
Maize	55.4	55.4	55.4	55.4
Soybean cake	24	24	24	24
Cotton cake	9	9	9	9
Oyster shell	10	0	0	0
Snail shell	0	0	10	0
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
Total	100	90	100	90
Price (F.CFA[2]/kg)	207.6	217.8	201.3	217.8
Nutrition Composition				
Dry Matter, %	88.6	78.6	88.6	78.6
Metabolisable Energy, MJ/kg	10,85	10,85	10,85	10,85
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	0.25	3.47	0.25
Phosphorus, %	0.57	0.57	0.57	0.57
Sodium, %	0.16	0.13	0.13	0.13
Ca/P	7.1	0.45	6.1	0.45

[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.

Feeding and laying performance (intakes of feed, energy, protein and minerals; feed conversion ratio and laying rate), economics of feeding (feeding cost and economic feed efficiency) and eggs' quality (weight, shape index, Haugh units, shell thickness, shell weight and albumen height, albumen + yolk weight, shell and shape indexes) were evaluated.

Haugh units and economic feed efficiency were calculated according to Haugh (1937) and Houndonougbo *et al.* (2009), respectively. Data were analyzed by using the mixed procedure in SAS 9.2. Thus, the following model was performed:

$$Y_{ij} = \mu + T_i + D_j + TD_{ij} + \varepsilon_{ij}$$

Y_{ij} = Observation for dependent variables;

μ = Overall mean;

T_i = Fixed effect of the type of shell;

D_j = Fixed effect of the delivery mode of shell;

TD_{ij} = Interaction effect between type of shell and its delivery mode;

ε_{ij} = Residual error.

The mean values and the pool standard error of mean (SEM) are presented in tables. The significant differences were set at $P<0.05$. Mainly, the effect of the delivery mode of shells was focused in this paper.

RESULTS

Feeding efficiency and laying performance

The intakes of the low-calcium-diets by hens were similar in O_s and S_s; but the hens significantly consumed more snail shell than oyster shell. Consequently, the total feed intake recorded in dietary treatment O_s was significantly lower than that in S_s (Table 2).

The hens fed with both low-calcium-diets, significantly ($P<0.05$) increased their daily metabolisable energy (ME) and crude protein intakes (CP). The increase of ME and CP intakes was lower between oyster diets (respectively, 2.34 and 2.47%) than between snail shell diets (respectively, 9.09 and 9.61%). Also, the intake of EM and CP per egg was significantly ($P<0.05$) higher in hens fed unbalanced snail shell diet, but not in those fed unbalanced oyster shell based diets (Table 2). These results demonstrate an effect of the delivery mode and of the type of shell on the intake and the efficiency of ME and CP in aged brown layer hens.

The intake of calcium decreased significantly ($P<0.05$) in hens fed unbalanced oyster based-diet (Table 2). Thus, hens did not balance their Ca intake in free-choice oyster diet (O_s). Compare to the respective balanced diets, the daily phosphorus intake of hens increased respectively, by 10.4 and 20.2% in oyster and snail shells unbalanced diets. Thus, the hens fulfilled their Ca requirement in snail shell based-diets, but not in oyster shell based-diets; while, irrespective of the type of shell, hens improved their phosphorus intake.

The separation of the oyster and snail shells from the mixed feed had no significant effect ($P>0.05$) on laying rate and feed conversion ratio (Table 3). However, that practice improved more the laying rate in snail shells based-diets than oyster based-diets.

The free choice-feeding of oyster and snail shells increased ($P<0.05$) respectively, the feeding cost by 5.7 and 16% and decreased ($P<0.05$) the economic feed

Table 2: Feed, energy, protein and minerals intakes of laying hens in free choice-feeding of oyster and snail shells

Parameters	O_b	O_s	S_b	S_s	SEM[1]	P-value
Total feed intake, g/hen/day	117.9^a	117.4^a	111.2^b	120.8^c	0.875	< 0.0001
Low-calcium-diet intake, g/hen/day	-	108.7	-	109.7	0.985	0.4878
Shell intake, g/hen/day	-	8.67^a	-	11.1^b	0.361	< 0.0001
Metabolisable Energy intake, MJ/hen/day	1.28^a	1.31^b	1.21^c	1.32^b	0.009	< 0.0001
Metabolisable Energy intake, MJ/egg	1.56^{ab}	1.60^a	1.52^b	1.61^a	0.024	0.0393
Crude Protein intake, g/hen/day	22.3^a	22.8^b	21.0^c	23.0^b	0.163	< 0.0001
Crude Protein intake, g/egg	27.2^{ab}	27.8^a	26.4^b	28.0^a	0.416	0.0414
Calcium intake, g/hen/day	4.77^a	3.55^b	3.86^c	3.88^c	0.087	< 0.0001
Calcium intake, g/egg	5.83^a	4.33^b	4.85^c	4.72^c	0.129	< 0.0001
Phosphorus intake, g/hen/day	0.672^a	0.742^b	0.634^c	0.762^d	0.005	< 0.0001
Phosphorus intake, g/egg	0.821^a	0.903^b	0.797^a	0.926^b	0.014	< 0.0001

[ab]Means with the same superscripts along the same row are not significantly different (P > 0.05); [1]SEM: Standard error of the mean

Table 3: Feed conversion ratio and laying rate of laying hens in free choice-feeding of oyster and snail shells

Parameters	O_b	Os	S_b	Ss	SEM[1]	P-value
Feed Conversion Ratio, kg feed/kg egg	2.25	2.24	2.30	2.30	0.037	0.545
Laying Rate, %	82.1	83.1	80.6	82.9	1.44	0.612

[ab]Means with the same superscripts along the same row are not significantly different (P > 0.05); [1]SEM: Standard error of the mean

efficiency by 5 and 16% in O_s and S_s, compare to the respective values in balanced diets O_b and S_b (Table 5).

Egg Quality

The separate delivery of oyster shell as the main calcium sources to aged layer hens had no significant effect (P>0.05) on egg weight (Table 4); but that practice, significantly increased (P<0.05) egg weight by about 5.1% when using snail shell. Moreover, the shell weight decreased (6.99%) significantly with the free choice-feeding of oyster shell, whereas that of snail shell increased it (5.12%) significantly (P<0.05).

The shell index and shell thickness of eggs decreased significantly (P<0.05) with the free choice-feeding of oyster, while in snail shell based diets, they were similar (P>0.05). The free-choice Ca feeding practice had no significant effect on eggs' shell percentage. Thus, compare to oyster shell, the delivery mode of snail shell had more significant effect on eggshell quality.

Regarding the internal characteristics of eggs, albumen and yolk percentage, albumen height and Haugh units, were similar (P>0.05) between all the dietary treatments (Table 4), indicating a no significant effect of the type of shell and its delivery mode on these variables.

DISCUSSION

Feeding efficiency and laying performance

The type of shell use in free choice-feeding of aged ISA brown hens did not affect the intake of both low-calcium-diets (O_s and S_s). Nevertheless, the total feed intake increased significantly in separate snail shell based diet, confirming the earlier findings of Mongin and Sauveur (1974) according to which, feed intake increases when the calcium content of the diet decreases, even though oyster shell is given ad libitum. Using limestone powder, Olver and Malan (2000) reported that, free choice-feeding system increased significantly (P<0.05) its intake, but not the total feed intake in laying hens from 16 to 80 weeks of age, as demonstrated in this study. The free access of aged laying hens to oyster and snail shells reduces their nutritional efficiency by increasing ME, CP and phosphorus ingested per egg, whereas it improves the efficiency in calcium which is the main mineral in shell. These results are in agreement with the significant increase of energy intake found by Picard *et al.* (1986) when studying the effects of separate calcium feeding on laying hens performances at 20 and 33 °C; but the results do not confirm the significant increase of calcium intake they had reported. In young layer hens (20 to 44 weeks of age), Iskandar (2011) did not find any significant effect (P>0.05) of the voluntary intake of protein concentrate, corn and oyster shell on intake of Ca and phosphorus. At young age, hens have therefore more regulation ability in Ca intake than when they become old. In this study, hens fed with snail shell balanced more their Ca intake than those fed with oyster shell.

In the semi-wet conditions of Benin, the free choice-feeding of both shells did not affect significantly the laying rate and feed conversion ratio of the aged laying hens. In younger laying hens (20 to 44 weeks-old), Iskandar (2011) did not find any significant effect (P>0.05) of protein concentrate, corn and oyster shell intakes on hens' egg production and feed conversion ratio. However, Henuk *et al.* (2000) reported that, at 32°C, choice feeding system, increase significantly (P<0.05) the laying rate but not the feed conversion ratio in 34 weeks-old laying hens. Nevertheless, Picard *et al.* (1986) found in the warm conditions (33°C) significant increase in the laying rate of hens submitted to separate calcium feeding. In this study, the effect of that mineral feeding strategy on laying rate was more important in snail shell based-diets than oyster shell based-diets.

The negative effect (P<0.05) of free choice-feeding of both shells on the feeding cost and economic feed efficiency (EFE) demonstrate that in the commercial and environmental conditions in Benin, that feeding practice is not interesting economically in the rearing of aged brown layers hens.

Egg quality

The free choice-feeding of aged layer hens with oyster shell had no significant influence on egg weight. This result is in agreement with the non significant effect of the free choice-feeding of oyster shell on egg weight at 20 and 32°C (Henuk *et al*., 2000) and at 20 and 33°C (Picard *et al*., 1986). However, the free choice-feeding of snail shell had significantly increased the egg weight. That feeding practice is therefore more indicated with snail shell than oyster shell to improve the egg weight.

The separate feeding of oyster shell had negative effect on eggshell weight whereas, that of snail shells influenced it positively. These results are in agreement with the significant effect of the separate Ca feeding on eggshell weight reported by Banga-Mboko *et al*. (2001). However, Iskandar (2011) did not find any significant effect of the free choice-feeding of protein concentrate, corn and oyster shell on eggshell weight.

The decrease of shape index (5.42%), shell index (6.29%) and shell thickness (5.62%) of egg linked to the practice of separate feeding in only oyster shell based-diets, demonstrate a significantly effect of the type of shell when using that feeding strategy. Moreover, the separate calcium feeding had no significant effect (P>0.05) shell percentage of egg. Sauveur and Mongin (1974) found significant influences of low calcium-diets plus oyster shell on shell index. In free choice-feeding system, Banga-Mboko *et al*. (2001) reported significant increase of eggshell thickness and eggshell percentage, whereas Iskandar (2011) did not find any significant effect of that feeding system on eggshell thickness. The eggshell thickness (0.356 to 0.376 mm) recorded in this study, are in the range of 0.351 to 0.376 mm (Yörük *et al*., 2004), but slightly higher than 0.342 to 0.351 mm (Safaa *et al*., 2008) and 0.345 to 0.353 mm (Çath *et al*., 2012).

Table 4: Quality of eggs from laying hens in free choice-feeding of oyster and snail shells

Parameters	O_b	O_s	S_b	S_s	SEM[1]	P-value
Egg Weight, g	63.9[a]	63.8[a]	60.8[b]	63.9[a]	0.300	< 0.0001
Shape Index, %	77.8[a]	73.8[b]	76.2[a]	75.3[a]	0.972	0.035
Shell weight, g	6.58[a]	6.15[bc]	6.05[b]	6.36[ac]	0.107	0.003
Shell Index, g/cm^2	8.61[a]	8.10[b]	8.18[b]	8.36[ab]	0.128	0.026
Eggshell thickness, mm	0.376[a]	0.356[b]	0.359[b]	0.366[ab]	0.005	0.038
Eggshell percentage, %	9.98	9.41	9.63	9.71	0.153	0.075
Albumen height, mm	8.18	8.01	8.09	7.86	0.221	0.763
Albumen + Yolk percentage, %	90.2	90.6	90.4	90.3	0.153	0.075
Haugh Units	88.4	87.3	88.7	86.5	1.244	0.576

[ab]Means with the same superscripts along the same row are not significantly different (P > 0.05); [1]SEM: Standard error of the mean

Table 5: Feeding cost and Economic Feed Efficiency (EFE) of laying hens in free choice-feeding of oyster and snail shells

Parameters	O_b	O_s	S_b	S_s	SEM[1]	P-value
Feeding Cost, F.CFA[1]/egg	29.9[a]	31.6[b]	28.1[c]	32.6[b]	0.477	< 0.0001
EFE, F.CFA Egg/F.CFA Feed	2.12[a]	2.02[b]	2.28[c]	1.96[b]	0.034	< 0.0001

[ab]Means with the same superscripts along the same row are not significantly different (P > 0.05); [1]SEM: Standard error of the mean; [1] Euro (€) = 655.9 F.CFA

Albumen and yolk percentage, Albumen height and Haugh units, were similar (P>0.05) between the dietary treatments (Table 4), indicating a no significant effect of the delivered mode of shell on the physical characteristics of the internal and edible part of eggs. The Haugh units (86.5 to 88.7) are in the range of 87.43 to 90.12 (Iskandar, 2011), but there are lower than 100.31 to 100.98 (Olver and Malan, 2000).

Conclusion

In warm and wet climate of Benin, the free choice-feeding of oyster and snail shell during the last three month of laying period, significantly reduces the efficiency of dietary energy and nutrients. That feeding strategy did not improve eggshell thickness, but decreased it significantly in hens fed oyster based-diets due to a low intake of that shell offered *ad-libitum*. However, in hens fed snail shell based-diets the eggshell thickness was not affected and egg weight increase significantly. In snail, shell based-diets, the free choice-feeding is therefore more convenient than balanced diet feeding. Snail shells can be mainly used in that feeding strategy as long as its availability and price are not limits factors.

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