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Effect of Age on Physio-Chemical Properties of Eggshell of Domestic Fowl

M. A. Oguike*

1 Introduction

Overall egg production is a major indication of the performance of commercial layers and contributes to a reasonable percentage of income in egg-producing farms (OLUYEMI AND ROBERTS, 1979). Apart from the overall total egg number, the farmer is equally interested in getting high quality eggs. Among the parameters used for assessing egg quality are eggshell, albumen and yolk qualities as well as egg size.

However, emphasis has been more on egg size, yolk, and albumen qualities but in actual fact, shell quality should rank higher than these (HAUVER et al, 1961), since shell-less eggs are not easily handled and are not called eggs at all.

Eggshell quality is assessed by such physical characteristics as shell strength (BAKER, 1960), shell weight, shell thickness and specific gravity of eggs.

It has been established that, among other factors, time of lay and position of the egg in the sequence (STURKIE, 1965), environment (SAUVEUR AND PICARD, 1989), disease (SPACKMAN, 1989), as well as age (SWENSON, 1970) influence shell quality. Ahvar et al (1983) reported that an increase in ambient temperature led to a decrease in eggshell thickness and average egg weight but that the intensity of the decrease depended on the age of the laying bird. Roland *et al.* (1975) reported that eggshell quality generally decreases with the age of the laying hen. Also Harms *et al.* (1990) found that shell thickness decreased as the hen aged, hence it is presumed that older birds produce thinner shells. Roland *et al.* (1975) tried to explain this phenomenon by relating the shell thickness to the amount of calcium deposited during shell formation. They noted that birds deposit constant amounts of calcium when eggshells are formed, and as the birds age, their eggs become larger. Since eggs get larger and the same quantity of calcium is deposited, the tendency is for the shell to be thinner. Then it is likely that greater incident of cracks and breakages are recorded with eggs of older birds since they are known to produce larger eggs with thinner shells. Therefore, age of the laying bird may be regarded as one of the important factors effecting egg production in relation to shell quality and number of eggs produced by a flock.

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* College of Animal Science and Animal Health, Federal University of Agriculture, Umudike, P. M. B. 7267, Umuahia, Abia State, Nigeria.

The objective of this study was to investigate the variations in the physical and chemical properties of eggshell of domestic fowl at different ages of their egg production.

2 Materials and Methods

The study was implemented in the poultry unit of the Department of Animal Science, University of Nigeria, Nsukka. A total of three hundred brown eggs laid by one hundred and thirty hybrid (Lohmann) pullets were used for the study. The birds came to lay at 22 weeks of age and egg collection began immediately. Thereafter, three-monthly intervals were allowed before subsequent collections, hence egg collection and treatments were done when the birds were 22 wks 34 wks, 46 wks, and 58 wks of age. Seventy-five eggs were randomly selected at the different ages of birds.

The laying birds were managed singly in battery cages in an open-sided battery cage tropical type poultry house. Feed samples fed to the birds throughout the period of production were analysed and contained about 16.90% C.P., 6.20% crude fibre, 4.58% ether extract, 10.45% moisture, 14.55% ash, 47.23% nitrogen free extract, 3.20% calcium and 0.56% phosphorus. They were given feed and water ad lib.

Shell and shell membrane weights of the eggs were determined using a sensitive weighing balance. Shell thickness was determined using a micrometer screw gauge. Shell porosity was determined using the methods outlined by Rahn *et al.* (1981). Shell specific gravity was obtained from the formula for specific gravity, i.e.:

$$S.G. = \frac{\text{mass}}{\text{volume}}$$

The mass of the shell was determined by weighing on a balance, while the volume was obtained based on Archimedes' principle of water displacement.

The calcium and magnesium content of the shell were determined using an atomic absorption spectrometer. Phosphorus was determined using Cecil Spectrophotometer while nitrogen was obtained with the use of improved Kjeldahl equipment. All are in accordance with A.O.A.C (1985).

Means and standard errors of the measurements were calculated. The Analysis of Variance (ANOVA) was computed using the model:

$$Xij = \mu + Ai + eij$$

Where:

Xij = Measurement of individual variables
μ = Overall mean
Ai = Effect of age
eij = Random error

Separation of means was done using Duncan's Multiple Range test at the 0.05 level of probability.

3 Results and Discussion

The results of the physical and chemical properties of the eggshell at the different ages of the birds are presented in Tables 1 and 2 respectively. Although Roland (1976) and Harms *et a.l* (1990) reported that, as egg weight increases with age of bird the shell weight remains fairly constant, the result of this investigation showed the contrary. There was progressive decrease in shell weight of the eggs as the birds aged (Table 1).

The mean shell weight of 4.92g when the birds were 58 weeks old was significantly lower ($P < 0.05$), than the shell weight at 22, 34 and 46 weeks. In the same way also, shell thickness decreased with age of the birds. This conforms with the findings of Harms et al (1990) who also noted decrease in shell thickness as the age of the laying birds increases. It was observed that eggs having shell weights of 3.5g or less have thin shells and were easily broken while shell weights of more than 6.0g seldom break. This therefore, suggests that shell weight could be used to assess eggshell quality.

Shell membrane weight increased with the age of the laying birds as shown in Table 1. This contrasts the findings of Britton and Hale (1977) that eggs of older hens have less shell membrane than those of pullets. From the results of this study, it is evident that shell membrane has an inverse relationship with shell thickness hence thicker shells have thin shell membranes and vice versa. There were significant differences in the shell porosity ($P < 0.05$). Eggs laid when the birds were 58 weeks were significantly higher in shell porosity those of the other ages ($P < 0.05$). This coincides with the period when the shell thickness was thinner implying that thinner shells are more porous than thicker ones.

Table 1: Physical properties of eggshell at different production age

Eggshell Characteristics	**Age (Weeks)**			
	22	34	46	58
Weight (g)	5.43^{c}	5.33^{b}	5.30^{b}	4.92^{a}
Membrane weight (g)	0.19^{c}	0.21^{b}	0.23^{c}	0.23^{c}
Thickness (mm)	0.36^{c}	0.35^{c}	0.33^{b}	0.31^{a}
Porosity (mg cm^{-2} day^{-1})	3.47^{b}	3.44^{b}	3.35^{a}	4.80^{c}
Shell Specific gravity (g cm^{-3})	1.00^{b}	1.09^{c}	0.99^{b}	0.89^{a}

1. Values followed by the same letters in the same row are not significantly different (P^{3} 0.05) using Duncans New Multiple Range Test (DNMRT).
2. Each value is a mean of 75 records.

Shell specific gravity was significantly higher at the age of 34 weeks then the others, and lowest at the age of 58 weeks. The shell specific gravity recorded in this study at the various ages of the birds does not agree with the 2.028g C^{-3} reported by Harms *et al.* (1990) for avian species. The variations in the specific gravity of this study and that of the other authors could be due to age differences, environment or other unknown factors.

The eggshell of the birds recorded the highest calcium content at 22 weeks and lowest at the age of 46 weeks. It was expected that the calcium content of the shell would be at a minimum at the age of 52 weeks of the birds when shell thickness was thinnest since it has been established that shell thickness is directly proportional to the amount of calcium carbonate deposited during shell formation (Washburn and Potts 1975). However, factors other than calcium deposition during shell formation or age may have contributed to these variations, example efficiency of feed conversion as well as the prevailing season.

There were significant variations ($P < 0.05$) in the magnesium content of the eggshell at the different ages of the birds (Table 2). Shells produced when the birds were 22 and 58 weeks had a significantly lower and higher, respectively, magnesium content in their eggshell than the others.

This does not agree with the reports of Brooks and Hale (1955) that harder (thicker) shells have higher magnesium proportions. It was observed that eggs with higher phosphorus contents in the shells were larger in size and exhibit thinner shell thickness. This is particularly true of eggshells of eggs laid when the birds were 58 weeks old. The eggshell of eggs laid when the birds were 34 and 46 weeks old did not show significant differences ($P < 0.05$) in their nitrogen content. However, they were significantly different ($P<0.05$) from that of 22 and 58 weeks. The eggshells of 22 and 52 weeks old birds have significantly higher nitrogen contents although they were significantly different from each other. Other factors above the scope of this study may have contributed to their high nitrogen contents since there is a large gap in their age.

Generally, it was observed that the performance of the birds was at peak at the age of 34 weeks. The number of eggs produced throughout the period of study was greatest at this age. The physical characteristics of the shell as well as their chemical contents were within the range recommended for good shell quality during this period. Thereafter egg production and shell quality gradually decreased.

It is therefore recommended that the commercial poultry farmer should pay particular attention to management practices at this period of peak production. It is expected that it is at this period that the farmer makes highest profit in egg producing farms.

Table 2: Major Minerals elements of the egg shell at different age of Production

Eggshell	Age (Weeks)			
	22	34	46	58
Calcium	92.52^{b}	90.23^{b}	89.47^{a}	90.98^{c}
Magnesium	0.87^{a}	0.96^{b}	0.98^{b}	1.31^{c}
Phosphorus	0.08^{ab}	0.10^{b}	0.12^{c}	0.14^{d}
Nitrogen	4.24^{c}	3.96^{b}	3.17^{a}	4.04^{b}

4 Summary

Investigations were conducted on the effect of age of laying birds on the physical and chemical properties of eggshell when the birds were 22, 34, 46 and 58 weeks old. The birds were housed in battery cages and given water and layer's diet (17% C.P. and 3.20% Ca) ad lib.

The result of the study showed mean eggshell weight of 5.43, 5.33, 5.30 and 4.92 g at 22, 34, 46 and 58 weeks respectively. The shell membrane weights at 22 and 34 weeks were significantly lower than those of 46 and 58 weeks. There were also significant differences ($P < 0.05$) between shell thickness, shell porosity and specific gravity at the different ages of laying.

The magnesium and phosphorus content of the shells showed a significant increase with the advancing age of the birds. The calcium content of the shell at 46 weeks was significantly lower ($P < 0.05$) than those of 22 and 58 weeks. Significant differences ($P < 0.05$) were observed both in the physical and chemical properties of the eggshell at the different ages of the birds.

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