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Effects of Egg Storage Conditions on Eggshell Resonant Frequency and Albumen Characteristics

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Abstract: Increasing egg storage duration affects egg internal quality, especially albumen quality by increasing pH and decreasing Haugh Unit (HU). But, in most of African contexts, egg producers, sellers and consumers store the eggs in different conditions regardless of quality deterioration. In this study, 1920 eggs produced by Lohmann layer flocks of 48 weeks and 58 weeks of age were investigated. The eggs were divided randomly and equally in 4 groups and stored at 3 different conditions for 21 days at: 1) Room Conditions (RoC); 2) Super Market Conditions (SmC) and 3) Refrigerator Conditions (RfC). During storage, all the eggs were weighed and Resonant Frequency (RF) were measured at day 3, 6, 9, 12, 15, 18 and 21 according to flock age and storage condition. Then at the same days, sample of 30 eggs per flock and per storage condition were used to measure albumen pH and HU. The results indicate that eggs weight decreased significantly with storage duration ($P<0.001$). But, egg relative weight loss was lower ($P<0.01$) for eggs of RfC group than that of SmC and RoC groups. There was a positive linear relationship between RF and storage duration. But, daily increase in RF was affected by layer flock age. The highest daily increase was obtained in RoC group or SmC group, respectively for flock of 48 weeks of age or flock of 58 weeks of age. Eggs of RfC groups had the highest albumen HU and the lowest albumen pH ($P<0.001$). It is concluded that detrimental effects of storage duration are more or less pronounced depending on storage conditions especially storage environmental temperature. It is recommended that, in African countries, consumption eggs can be stored at room or super market conditions not longer than 6 days but in the refrigerator up to 21 days.

Key words: Egg storage, egg quality, albumen, yolk

INTRODUCTION

Several methods have been used to assess egg quality. These include measurements of volume, shape, pH or thickness of the albumen and the water, protein or total solids content of the yolk and albumen (Wesley and Stadelman, 1959 and Hunton, 1987), pulse nuclear magnetic resonance or ultrasonic echo (Mirsa *et al*., 1980 and Povey and Wilkinson, 1980) and candling (Montgomery and Stewart, 1973). However, the use of albumen Haugh Unit (HU) is the most widely used and accepted assessment of egg internal quality (Davami *et al*., 1987; Sahin *et al*., 2002; Ledur *et al*., 2002). Among albumen proteins (ovalbumin, ovotransferin, ovomucoid, ovomucin, lysozyme and globulines), the ovomucin is reported to be the most important in determining the height of thick albumen (Johnson and Zabik, 1981). Thus, changes in the viscosity or pH of the albumen may play a role in determining the nutritional quality of egg. With regard to external quality, since eggshell is the natural packaging material for the egg contents, its integrity and strength are important parameters in determining its quality. Besides genotype and nutritional factors, the most important factors that affect egg quality are flock age and egg storage conditions (Kidwell *et al*., 1964 and Tona *et al*., 2004). Increasing egg storage duration affects egg internal quality, especially albumen quality by increasing pH and decreasing HU (Benton and Brake, 1996; Reis *et al*., 1997; Suarez *et al*., 1997; Lapao *et al*., 1999; Silversides and Scott, 2001 and Tona *et al*., 2004). But, in most of African contexts, egg producers, sellers and consumers store the eggs in different conditions regardless of quality deterioration. To our knowledge, there is no information about the effects of egg storage conditions and duration in African countries. Therefore, this study aim to put emphasis on 3 different egg storage conditions for at least three weeks on egg albumen pH, Haugh Unit (HU), egg weight and Resonant Frequency (RF).

MATERIALS AND METHODS

A total of 1920 eggs produced by Lohmann layer flocks of 48 weeks and 58 weeks of age (960 eggs per flock)

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were studied. The eggs were collected between 10.00 and 12.00 AM at layer farm after the collection of eggs of previous day. Prior to storage, all the eggs were weighed and resonant frequency were determined according to the flock. Also, a sample of 30 eggs was used to measure albumen pH and HU. Then for each flock, eggs were divided randomly and equally in 4 groups and stored at 3 different conditions.

- Room conditions (RoC)
- Super market conditions (SmC) and
- Refrigerator conditions (RfC)

The eggs were stored on paper trays for 21 days. During storage period, environment temperatures were recorded and average temperatures were 29±1°C, 26±1°C and 4±0.25°C, respectively for RoC, SmC and RfC groups. Also, all the eggs were weighed and resonant frequency were measured at 3, 6, 9, 12, 15, 18 and 21 days according to flock age and treatment. Then at the same days, sample of 30 eggs per flock and per storage condition were used to measure albumen pH and HU.

Albumen characteristic measurements: Each sampled egg was weighed and broken out to measure albumen for HU and pH. For each broken egg, the Egg Quality Measurement System (Futura®, Lohne, D-49393) was used to record egg weight and thick albumen height, by connecting a transmission box and a balance to a personal computer. After calibration of the albumen height gauge, for each weighed and broken egg, the height of albumen was measured (±0.25 mm) with a vertically mounted micrometer with an electronic path. Between eggs, the micrometer was cleaned with distilled water and then dried with absorbent paper. The standard software program version $2A^2$ calculated albumen HU with egg weight and albumen height. After HU measurement of each egg, the albumen was separated from the yolk and was used immediately for pH measurement. The pH of the thick albumen was measured with a pH meter (Schott®CG840, Hofheim, D-6238) after calibration of the electrode with buffered solutions of pH 7 and 10. Between eggs, the probe was cleaned with distilled water.

Acoustic resonance analysis: Egg RF was used as assessment parameter of eggshell strength. The RF measurement was performed using the technique described by Coucke *et al.* (1997), involving mechanical excitation of the egg by a mechanical impactor. The impactor hit the egg at its equator, and noise of the vibrating egg was recorded by a microphone, situated at the equator at 90° to the impactor. The recorded signal was sent to a data acquisition card and transformed by fast Fourier transformation to obtain the resonant frequency for the first spherical mode of the vibrating egg.

Statistical analysis: The data were processed with a statistical software package of SYSTAT 11. The effects of flock, storage condition and storage duration on egg weights, egg RF, and albumen pH and HU were analyzed using a 3-way, fixed effects ANOVA model (Neter *et al.*, 1996).

RESULTS

Effects of storage conditions and flock age on egg weight: Egg weight decreased linearly with increasing storage time. Figure 1 shows changes in egg relative weight loss during storage period according to flock age and storage conditions. With regard to flock age, fresh egg weights of layers of 58 weeks of age were heavier than those of layers of 48 weeks of age ($P<0.001$). Irrespective of flock age and storage duration, eggs weight decreased significantly with storage condition ($P<0.001$). But in both flock age groups, egg relative weight loss was lower ($P<0.01$) for eggs of RfC group than that of eggs stored at room or supermarket conditions.

Effects of storage conditions and flock age on resonant frequency: There was a positive linear relationship between RF and storage duration. Daily RF increases according to flock age and storage conditions are shown in Fig. 2. Overall, daily RF increases of eggs from layers of 48 weeks of age were lower than those of layers of 58 weeks of age ($P<0.05$). Flock age x storage conditions also affected RF. Indeed for layers of 48 wk of age, daily RF increase of eggs of RoC group was higher ($P<0.05$) than that of eggs of SmC and RfC groups which were similar. While for layers of 58 wk of age, daily RF increases were in following order: SmC>RoC>RfC ($P<0.05$).

Effects of storage conditions and flock age on albumen characteristics: Figure 3 shows albumen HU in relation to storage duration according to flock age and storage conditions. Overall, albumen HU decreased with increasing storage duration. Albumen HU of fresh eggs from layers of 48 weeks of age were higher than those of layers of 58 weeks of age. During storage and from d 3 onward, albumen HU of both groups of RfC were significantly higher that those of all the other groups ($P<0.001$). But, difference between flock ages at collection day was maintained and was even more pronounced as storage duration increased. From d 3 of storage until the end of storage duration, albumen HU of SmC and Roc groups were comparable within each flock age.

Figure 4 indicates that albumen pH, during storage, followed different trend according to storage conditions

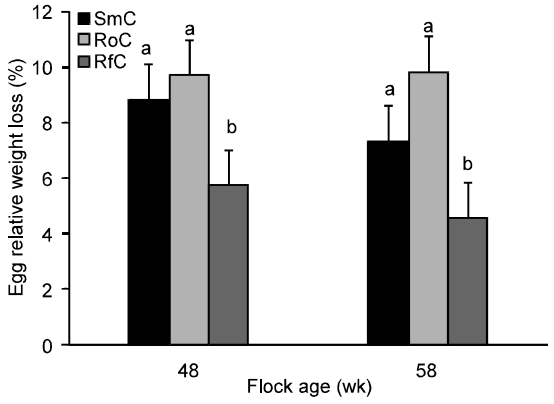

Fig. 1: Relative egg weight loss during storage according to flock age and storage conditions. Within each flock age, data sharing no common letter were different (P<0.05)

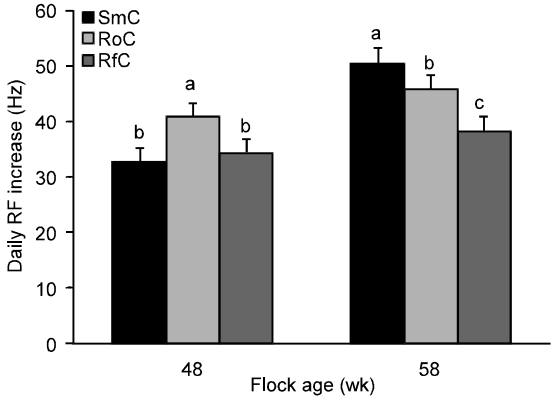

Fig. 2: Daily increase in Resonant Frequency (RF) during storage according to flock age and storage conditions. Within each flock age, data sharing no common letter were different (P<0.05)

regardless of flock age. Overall, albumen pH increased with storage duration. Flock age did not affect albumen pH for fresh or stored eggs. With regard to storage condition, eggs of RfC groups had significantly lower albumen pH (P<0.001) than those of all other storage conditions for which pH were comparable throughout the storage duration. Moreover, there was a positive quadratic relationship between albumen pH of SmC and RoC groups and storage duration while albumen pH of RfC group and storage duration were positively and linearly related up to 21 days of storage.

DISCUSSION

This study focuses on the effects of flock age and egg storage condition and duration on some consumption egg qualitative parameters such as egg weight, eggshell strength (RF) and albumen pH and HU. The study shows clearly that changes in egg quality

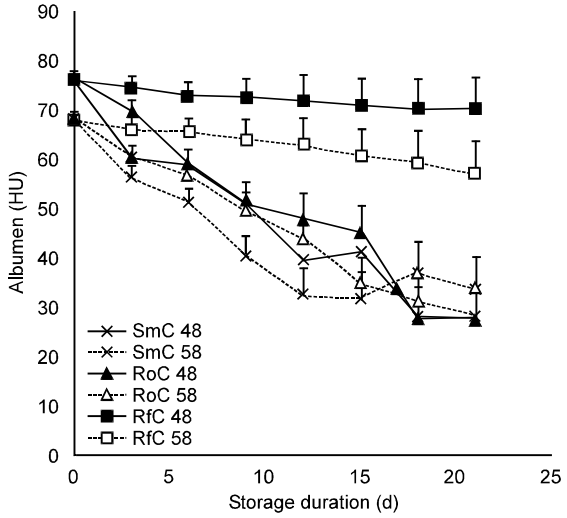

Fig. 3: Relationship between albumen Haugh unit (HU) and storage duration in function of flock age and storage condition. For each storage day, data sharing no common letter were different (P<0.05)

parameters did not follow the same trend during storage. Also during storage flock age, storage condition and their interaction affected egg quality parameters differently.

This study confirms the positive relationship between egg weight and hen age (Peebles and Brake, 1987; Tona *et al.* 2001). Moreover, it is well known that flock age has a major impact on internal egg quality (Lapao *et al.*, 1999 and Tona *et al.*, 2004). However, the lack of difference between flock age with regard to RF and albumen pH suggests that RF and albumen pH are not the relevant parameters for egg external or internal quality assessment.

There was a negative or positive relationship between storage duration and albumen HU or pH respectively. This finding is in the line with previous reports on hatching eggs (Benton and Brake, 1996; Suarez *et al.*, 1997; Silversides and Scott, 2001; Tona *et al.*, 2004). Indeed, at oviposition, egg contains a high level of CO_2 which starts to escape during storage. Egg albumen contains bicarbonates and CO_2 and the loss of dissolved CO_2 results in an increase in the pH of the albumen. This catalytic activity continues to break down albumen proteins, leading to increasing thin albumen and therefore decreasing albumen HU. There was also a positive and linear relationship between storage duration and RF. To our knowledge, this is the first report on relationship between egg storage duration and RF. This relationship may be partly explained by linear decrease of egg weight during storage. Indeed, Perianu *et al.* (in press) reported a negative correlation between egg weight and RF. Because there was a lack of relationship between flock and RF, it can be

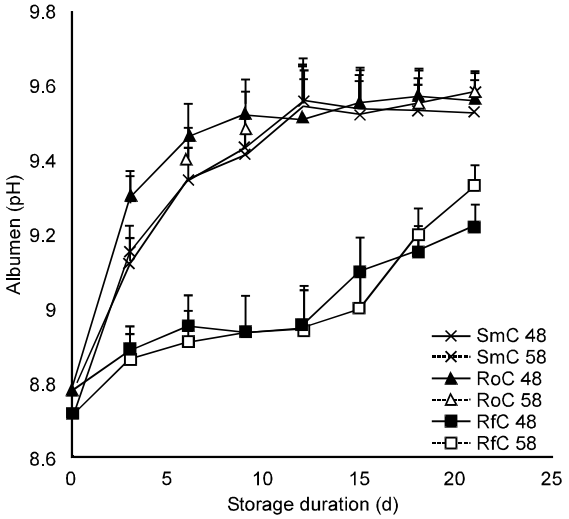

Fig. 4: Relationship between albumen pH and storage duration in function of flock age and storage condition. For each storage day, data sharing no common letter were different (P<0.05)

hypothesized that changes in RF with storage duration may be partly related to changes in attachment of eggshell and its membranes. In addition, it was assumed that increasing in egg air chamber volume or height leads to an increase in RF (Perianu *et al*., in press). Moreover, it is well known that egg air chamber volume increase with increasing storage time. The relationship between egg storage duration and RF, albumen HU and pH suggests that RF, albumen HU and, for short storage duration, albumen pH are relevant parameters for egg external and internal quality assessment with regard to storage duration.

Storage conditions affected significantly egg weight, RF, and albumen HU and pH differently and logically because of differences in average temperatures recorded during storage. With regard to albumen characteristics, eggs lost as much quality in 3 d at room or super market conditions as in 21 d in refrigerator. Eggs stored at refrigerator condition had the highest egg weight and albumen HU but the lower albumen pH and lower increase in RF compared to eggs stored at room or super market conditions. These detrimental effects of RoC and SmC groups on egg quality may be due to slow catalytic activity of proteins on one hand, and on the other hand to very little escape of CO_2 at low temperature.

In conclusion, this study shows that consumption egg storage duration result in deterioration of egg qualitative parameters such as eggshell strength, egg weight and albumen characteristics. Detrimental effects of storage duration are more or less pronounced depending on storage conditions especially storage environmental temperature. It is recommended, in African countries, that consumption eggs can be stored at room or super market conditions not longer than 6 d but in the refrigerator up to 21 d.

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