Revista Brasileira de Zootecnia
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ISSN 1806-9290
www.sbz.org.br

R. Bras. Zootec., v.41, n.9, p.2064-2069, 2012

Egg quality of laying hens in different conditions of storage, ages and housing densities

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ABSTRACT - The objective of this research was to evaluate the quality of eggs from Dekalb White hens under different temperatures (room temperature, 25 ºC; and refrigeration, 8 ºC), storage times (7, 14 and 21 days), age of birds (35, 40, 45 and 50 weeks) and housing densities (625, 500, 416.6 and 357.14 cm^2/birds). Haugh unit (HU) values and albumen height of 1,120 eggs from 528 laying hens, randomly allocated to four groups with different population densities were evaluated. The results showed a significant effect on Haugh units, between the time and storage conditions and between the ages of laying hens and storage condition. Eggs stored in refrigeration showed less weight loss and better Haugh unit indices when compared with eggs stored at room temperature. The increased time of storage, regardless of the temperature, caused loss in their quality. According to the results of this study, based on the evaluation of the albumen height, temperature, storage time, density and age of the layers influence the values of Haugh unit.

Key Words: egg storage, Haugh unit, hen, laying, population density

Introduction

The chicken egg is one of the finest foods, offering men an almost complete balance of essential nutrients with proteins, vitamins, minerals and fatty acids of great biological value (Brugalli et al., 1998). In addition to being one of the foods of lowest cost, it increases the consumption of food of high nutritional value for the low-income population (Pascoal et al., 2008; Menezes, 2009).

In Brazil, because refrigeration is not mandatory, commercial eggs are packed from the moment they are laid and stay until the final distribution at room temperature, and in some cases, refrigerated only in the homes of consumers. Although the Brazilian law determines minimum internal traits, only the weight and characteristics of the shell have been considered (Brasil, 1997).

The use of Haugh units has been accepted as a measure of the quality of the albumen in various studies on egg quality (Eisen et al., 1962). The Haugh unit value of fresh eggs decreases with increasing age of the hen (Cunningham et al., 1960; Fletcher et al., 1981, 1983; Silversides et al., 1993; Ramos et al., 2008), and the albumen height decreases as birds age, as well (Carvalho et al., 2003; Ramos et al., 2008). According to Campos & Baião (1975), Sauveur (1993) and Santos (2005), temperature and storage time negatively influence the quality of eggs and significantly reduce the Haugh unit, because of the continuous loss of CO_2. Davis & Stephenson (1991), Morais et al. (1997) Leandro et al. (2005) and Menezes et al. (2009) report that the temperature and relative humidity are the most important factors that affect egg quality during storage. Barbosa et al. (2004), evaluating the effect of temperature (ambient and refrigerated) and storage time (0, 7, 14, 21, 28 and 35) on egg quality, verified that the increase of storage time caused reduction in Haugh unit and egg weight. They also reported that the storage time affects the quality of eggs, exerting a negative influence on the Haugh unit.

The objective of this research was to evaluate the quality of eggs from Dekalb White hens under different temperatures (room temperature, 25 ºC; and refrigeration, 8 ºC), storage time (7, 14 and 21 days), age of birds (35, 40, 45 and 50 weeks) and population density (625, 500, 416.6 and 357.14 cm^2/bird).

Material and Methods

This research was conducted at Agricultural Company Inga LTDA, located in the city of Belo Jardim, state of Pernambuco, Brazil, 180 km from the west of the capital, Recife, during the period from March to July 2010. A total of 528 Dekalb White layers were used, standardized according to physical characteristics, weight and health

Received June 29, 2011 and accepted June 6, 2012.
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aspects, raised in a single nutrition program in the starter, growth, and production phases. Hens were housed in cages measuring 100 × 50 × 40 cm and randomly allocated in four groups (cages) of different densities: 8 birds at 625 cm²/bird; 10 birds at 500 cm²/bird; 12 birds 416.6 cm²/bird; and 14 birds at 357.14 cm²/bird.

All groups received the same treatment according to the requirements of the strain for each week of age. The specifications provided by the producer and by the manual of raising of the DeKalb White hen were followed without alterations.

The aviary is built with precast material in its structure and covered with wood and with shingles of asbestos cement, with the floor cemented and the open sides. The cages were the same used in industries (commercial type), without any enrichment. Nipple-type drinkers and metal trough feeders were placed in front of and outside the cage. The distribution of the feed was changed every day, in an amount according to age and recommendation of the bird supplier. The diet given to birds was produced at the feed mill of the poultry company where the experiment was conducted, under the guidance of the supplier of vitamin-mineral premix, as to its formulation.

During the research, the temperature inside the shed ranged between 19 and 32 ºC and the relative humidity ranged between 75 and 90%.

The collection of eggs occurred at intervals of five weeks. Two hundred and eighty eggs were used for each shipment, totaling 1120 eggs. After packaging in cardboard trays with up to 30 eggs each, they were stored at room temperature (average 25 °C) and refrigeration (average 8 ºC). Eggs were collected in the morning, identified and analyzed for the following variables: egg weight, albumen height and Haugh unit. Laboratory tests were performed at the Departamento de Morfologia e Fisiologia Animal of Universidade Federal Rural de Pernambuco, Brazil.

The eggs were individually weighed on an analytical balance, accurate to 0.01 g each time after storage (7, 14 and 21 days). They were then broken and weighed without the shell on a flat glass measuring 20 × 20 cm. Albumen height measurement was performed with a digital caliper. The egg yolk was removed and the weight of the albumen was recorded, obtaining the egg yolk weight difference between the weights. The shell thickness was measured at three points of the equatorial region of the egg, using a digital caliper. The shell weight was recorded after a previous treatment for at least four hours in an oven at 60 °C.

To calculate the Haugh unit, the following formula was used (Cotta, 1997):

$HU = 100 \text{ Log } (h - 1.7\ w + 7.6)$, in which HU = Haugh unit, h = albumen height (mm) and w = egg weight (g).

The effect of the interaction of factors type of storage (temperature and refrigeration), storage time (7, 14 and 21 days), age of birds (35, 40, 45 and 50 weeks) and population density (625, 500, 416.6 and 357.14 cm²/bird) were studied. The experimental design was completely randomized and the analysis of variance was conducted using program ASSISTAT (Silva, 2009) and the comparison between pairs of means was done by the Tukey test at 5% probability.

Results and Discussion

The higher the value of the Haugh unit (Table 1), the better the quality of eggs, which are classified according to the United States Department of Agriculture (USDA) as AA (100 to 72), A (71 to 60), B (59 to 30) and C (below 29) (USDA, 2000), in which the refrigerated eggs are classified as AA.

The age of the hens (35, 40, 45 and 50 weeks) and storage temperature (8 and 25 °C) had an influence on albumen height, with higher values ($P<0.05$) in eggs from younger hens of up to 35 weeks of age (5.836 mm), compared with the hens of 40 (5.455 mm), 45 (5.153 mm) and 50 (4.487 mm) weeks of age. The results from this study are in line with those reported by Carvalho et al. (2003) and Ramos et al. (2008), who found that the albumen height is negatively affected as the age of the laying hens increases. Silversides & Scott (2001), evaluating different strains of laying hens, showed that the percentage of albumen was lower in older birds in any of the tested strains.

Concerning the eggs in refrigeration for 7 days of storage, there were significant differences ($P<0.05$) in birds of 50 weeks of age housed in groups with different densities (625, 416.6 and 357.14 cm²/bird) and between

Table 1 - Mean albumen height, Haugh unit and shell percentage according to age and storage temperature of the eggs from Dekalb White hens

Hen age (weeks)	Albumen height (mm)	Haugh unit	Shell (%)
35	5.836a	83.218a	11.075a
40	5.455ab	80.667ab	10.042b
45	5.153b	78.551b	10.198b
50	4.487c	74.487c	9.997b
CV (%)	10.89	4.65	4.88
Storage temperature			
Room temperature (25 ºC)	3.497b	67.608b	10.496a
Refrigeration (8 ºC)	6.968a	90.854a	10.159a
CV (%)	46.89	20.74	2.30

Means followed by same letter in columns do not differ statistically from one another by the Tukey test at 5% probability.
CV - coefficient of variation.

age groups (625, 500, 416.6 cm²/bird) (Table 2). The laying hens housed at a density of 500 cm²/bird) had higher mean value of Haugh unit (93.98).

The Haugh unit of eggs stored at room temperature showed significant difference (P<0.05) in the birds of 45 weeks in the groups with densities of 416.67 and 357.14 cm²/bird. The highest mean value was recorded in the group of density of 625 cm²/bird at all ages tested. The coefficient of variation showed low values, ranging from 0.27 to 6.07%, which shows that it is a stable variable.

Regarding eggs in refrigeration at 14 days of storage, there were significant differences (P<0.05) in the groups housed at densities of 500, 416.67 and 357.14 cm²/bird (Table 3). The highest values occurred at a density of 625 cm²/bird. In eggs stored at room temperature, the difference was statistically significant (P<0.05) at the density of 416.67 cm²/bird. The highest mean value was observed at the density of 625 cm²/bird (69.47). Therefore, the birds housed at this density showed better results in terms of egg quality.

Concerning the eggs in refrigeration at 21 days of storage, there were significant differences (P<0.05) in groups housed at densities of 416.67 cm²/bird with 45 weeks (Table 4). In eggs stored at room temperature, the difference was statistically significant (P<0.05) at the density of 500 cm²/bird. The higher mean values for eggs under refrigeration (89.74 HU) and for eggs stored at room temperature (62.60 HU) was at the density of 625 cm²/bird.

Analyzing the temperatures of storage according to the age of the laying hens, it was found that at ambient temperature, the eggs of the birds at 35 weeks of age reached higher values for albumen height (Table 1) and Haugh unit (Tables 2, 3, 4) in relation to the other groups. The eggs in refrigeration showed lower values of this variable in older birds, indicating that regardless of the storage temperature, there is decrease of the albumen height (Table 1) and Haugh unit (Tables 2, 3, 4) with advancing age of the laying hens. These results reinforce the findings of Cunningham et al. (1960), Fletcher et al. (1983), Silversides et al. (1993) and Ramos et al. (2008), who found results similar to those found in this study. The albumen height and Haugh unit are important for assessing the quality of eggs. Among the densities evaluated in our study (625, 500, 416.6, 357.14 cm²/bird), the density of 625 cm²/bird showed the best mean values for albumen height and Haugh unit, and therefore presented better egg quality.

There was a statistically significant difference (P<0.05) of the Haugh unit of eggs from hens between the ages (35, 40, 45 and 50 weeks) and between the storage temperatures (8 and 25 ºC) (Table 5). Mean values were decreasing with age in both storage conditions: with and without refrigeration. All mean values of Haugh unit of the eggs in refrigeration were higher than those stored at room temperature. The birds at 35 weeks of age had higher quality for the eggs in refrigeration (94.166), and birds at 50 weeks of age had the lowest egg quality, both at room temperature (63.092) and

Table 2 - Mean Haugh units (HU) of eggs from Dekalb White hens at 7 days of storage according to age, storage temperature and population density (cm²/bird)

Hen age (weeks)	7 days of storage				CV (%)
	625 cm²/bird	500 cm²/bird	416.67 cm²/bird	357.14 cm²/bird	
	Eggs in refrigeration				
35	96.02aA	96.24aA	95.94aA	96.53aA	0.27
40	93.91aA	94.59aA	94.37aA	93.54abA	0.49
45	92.97aA	96.76aA	94.06aA	94.70aA	1.68
50	86.06bB	88.35bAB	89.66bA	90.67aA	2.24
Mean	92.24±3.73	93.98±3.35	93.51±2.33	93.86±2.12	
CV (%)	4.68	4.12	2.88	2.62	
	Eggs at room temperature				
35	79.22cA	77.11cA	75.66cA	75.64bA	2.19
40	80.31cA	75.27cdA	74.91cA	77.29bA	3.22
45	77.34cA	74.03cdAB	70.17cBC	67.33cC	6.07
50	77.91cC	70.06dB	72.21cAB	70.58bcB	4.95
Mean	78.70±1.15	74.12±2.25	73.24±2.18	72.71±3.96	
CV (%)	1.69	4.03	3.45	6.30	

Means followed by the same lowercase letter in the columns and uppercase letter in the rows do not differ statistically from one another by the Tukey test at 5% probability.
CV - coefficient of variation.

Table 3 - Mean Haugh units of eggs from Dekalb White hens at 14 days of storage according to age, storage temperature and population density (cm²/bird)

Hen age (weeks)	14 days of storage				CV (%)
	625 cm²/bird	500 cm²/bird	625 cm²/bird	500 cm²/bird	
	Eggs in refrigeration				
35	96.22aA	95.47aB	95.23aBC	93.57aC	1.18
40	90.90bA	89.57abA	90.84abA	88.36bA	1.35
45	91.97abA	88.04bB	87.92bB	89.69abAB	2.11
50	89.12bA	89.67abA	87.95bA	87.47bA	1.15
Mean	92.05±2.61	90.67±2.83	90.49±2.98	89.77±2.33	
CV (%)	3.28	3.61	3.81	2.99	
	Eggs at room temperature				
35	76.34cA	72.16cAB	69.60cB	71.23cAB	3.97
40	64.93eA	66.14cdA	67.69cA	66.20cA	1.71
45	70.99dA	66.21cdB	67.10cAB	66.83cAB	3.20
50	65.62eA	63.01dAB	59.44dB	65.63cA	4.62
Mean	69.47±4.60	66.88±3.31	65.96±3.87	67.47±2.21	
CV (%)	7.65	5.72	6.78	3.78	

Means followed by the same lowercase letter in the columns and uppercase letter in the rows do not differ statistically from one another by the Tukey test at 5% probability.
CV - coefficient of variation.

in refrigerated environment (85.882). These results can be attributed to physical and chemical reactions that occur, leading to protein degradation.

Ramos et al. (2008), analyzing the Haugh unit of the eggs stored at room temperatures and in different types of containers for 21 days, indicated that the room temperature and storage time adversely affect the average of Haugh unit, reducing the average of Haugh units with increasing storage time, corroborating the results found in this study.

In eggs in refrigeration, there was a decrease in internal quality, but this reduction was greater in eggs that were stored at room temperature. Similar results were observed by Frazier (1976) and Pombo (2003), who report that water loss in eggs takes place by evaporation and varies as a function of storage time, temperature, relative humidity and porosity of the shell. These authors also report that all eggs stored under refrigeration (8 °C), were classified as AA, or excellent quality, according to the quality control recommended by the USDA (2000).

There were no statistically significant differences ($P<0.05$) between the densities studied at 14 and 21 days of storage (Table 6). However, there was a significant effect ($P<0.05$) between storage periods. After 21 days storage, the lowest mean values of Haugh units were found, in contrast to the values found at 7 and 14 days. All mean values of Haugh units decreased with increasing storage time, demonstrating that storage time and population density influence this variable. The coefficient of variation showed low values for storage time (1.03 to 1.64) and density (5.75 to 6.74); this indicates that the variable studied is very stable, with better results for the density of 625 cm²/bird at 7 days of storage.

Morais et al. (1997) observed reduction in the mean values of Haugh unit of eggs at 21 days of storage. According to Stephenson et al. (1991) and Cherian et al. (1996), when the eggs are stored for long periods,the egg weight can also decrease due to water loss and centralization of the yolk.

Campos & Baião (1975), Sauveur (1993) and Santos (2005) mentioned that the temperature and storage time negatively influenced the quality of table eggs and verified that these parameters exert a significant reduction in Haugh unit, mainly by continuing losses of CO_2. In this experiment, when evaluating the effect of storage temperature within each age group, it was found that, at any age, there is better preservation of the internal quality of the eggs when they are kept under refrigeration.

Barbosa et al. (2004) studied the effect of temperature and storage time on the internal quality of commercial eggs, and observed linear increase in the percentage of egg yolk as a function of storage time. In a place where the room temperature is high and the eggs are not refrigerated, they should be consumed within one week after laying. Studies on the effects of tropical climate showed that the two most important factors affecting egg quality during storage are

Table 4 - Mean Haugh units of eggs from Dekalb White hens at 21 days of storage according to age, storage temperature and population density (cm²/bird)

Hen age (weeks)	21 days of storage				CV (%)
	625 cm²/ bird	500 cm²/ bird	625 cm²/ bird	500 cm²/ bird	
	Eggs in refrigeration				
35	92.03aA	91.2aA	90.33aA	91.11abA	0.76
40	94.16aA	94.62 aA	93.31aA	93.72aA	0.59
45	92.86aA	88.73aAB	86.85aB	85.36bdB	3.67
50	79.89bA	79.73bA	79.05bA	82.91dA	2.14
Mean	89.74±5.73	88.59±5.52	87.39±5.32	88.28±4.32	
CV (%)	7.38	7.20	7.04	5.66	
	Eggs at room temperature				
35	64.59cdA	64.35cA	67.17cA	61.96eA	3.30
40	65.53cA	60.66cdB	62.56cdAB	62.51eAB	3.21
45	58.45dA	58.20dA	60.32dA	58.73eA	1.62
50	61.83cdA	49.82eB	53.43eAB	47.52fB	11.81
Mean	62.60±2.79	58.26±5.34	60.87±4.95	57.68±6.04	
CV (%)	5.08	10.59	9.40	12.09	

Means followed by the same lowercase letter in the columns and uppercase letter in the rows do not differ statistically from one another by the Tukey test at 5% probability.
CV - coefficient of variation.

Table 5 - Mean Haugh units of eggs from Dekalb White hens according to bird age and condition of storage

Hen age (weeks)	Storage temperature		CV (%)
	Room temperature	In refrigeration	
35	71.263aB	94.166aA	19.58
40	68.672bB	92.661aA	21.03
45	66.311cB	90.830bA	22.07
50	63.092dB	85.882cA	21.64
CV (%)	4.47	3.43	

Means followed by the same lowercase letter in the columns and uppercase letter in the rows do not differ statistically from one another by the Tukey test at 5% probability.
CV - coefficient of variation.

Table 6 - Mean Haugh units (HU) of eggs from Dekalb White hens according to population density and storage time

Population density (cm²/bird)	Storage time			CV (%)
	7 days	14 days	21 days	
625	85.471aA	80.764aB	76.171abC	5.75
500	84.055aA	78.789abB	73.428cC	6.74
416.67	83.376aA	78.232cB	74.131bcC	5.89
357.14	83.290aA	78.627bcB	72.982cC	6.59
CV (%)	1.03	1.23	1.64	

Means followed by the same lowercase letter in the columns and uppercase letter in the rows do not differ statistically from one another by the Tukey test at 5% probability.
CV - coefficient of variation.

temperature and relative humidity (Davis & Stephenson, 1991; Morais et al., 1997; Leandro et al., 2005).

The Haugh unit is considered a standard measure of quality (Williams, 1992; Eisen et al., 1962). According Silversides et al. (1993, 1994), the Haugh unit of eggs obtained from hens at 26 weeks of age was 88.48±0.44, and at 65 weeks, the value was 77.40±0.44. Pope et al. (1960), Cunningham et al. (1960), Fletcher et al. (1981, 1983) and Belyavin (1988) are unanimous on Haugh unit and age of the hen, and stated the Haugh unit decreases with increasing age. Romanoff & Romanoff (1963), Campos et al. (1973) and Fennema (1993) stated that in eggs stored at room temperature or higher temperature, the quality can be preserved provided that the shell is impermeable to carbon dioxide loss.

Conclusions

According to the results obtained and the conditions in which this experiment was carried out, density, temperature and time of storage and age of the birds have an influence on the values of Haugh unit. Thus, it is recommended that eggs be stored in refrigeration in order to maintain the internal quality for a longer period. The recommended density population for Dekalb White hens is 625 cm²/birds.

Acknowledgments

The authors thank CNPq for the financial support given for this research.

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