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Effect of bird age and storage system on physical properties of eggs from brown laying hens

Antonio Callejo Ramos[1], William Cardoso Maciel[2], Argimiro Daza Andrada[1], Régis Siqueira de Castro Teixeira[2], Carlos Buxadé Carbó[1]

[1] Escuela Técnica Superior de Ingenieros Agrónomos, Madrid - Spain

[2] Laboratory of Ornithological Studies, Veterinary College of Ceara State University-Brazil.

Abstract

A total of 108 eggs from a group of 100 brown laying hens housed in standard cages were analyzed. Thirty-six eggs were retired when the hens had 30 week of age, other 36 eggs were retired when the hens had 35 week of age and the remaining 36 eggs were retired five weeks afterwards. Each group of 36 eggs was radomly divided in three groups of 12 eggs. First group was analyzed at once, second group one was kept during one week in the refrigerator (5ºC) and third group was kept also one week but on ambient temperature (25ºC). Shell color, shell thickness, specific gravity, albumen height and Haugh units wre obtained. The bird age had significant effect on shell color and shell thickness, but the storage system had not influence on such variables.The hen age had not effect on specific gravity, but the storage system affected to this variable. Hen age and storage system had significant influence ($P < 0.05$) on albumen height and Haugh units, and the interaction age x storage system was significant for these variables. The specific gravity had positive relations with shell thickness, yolk color, albumen height and Haugh units. It is concluded that bird age and storage system under high temperatures reduced the egg quality.

Key words: bird age, storage system, egg quality.

Efeito da idade da ave e do sistema de armazenamento sobre as propriedades físicas dos ovos de poedeiras semipesadas

Resumo

Um total de 108 ovos de um grupo de 100 poedeiras semipesadas alojadas em gaiolas-padrão com ambiente controlados e automatizados, foram analisados. Trinta e seis ovos foram coletados quando as galinhas tinham 30 semanas de idade, outros 36 foram coletados com as galinhas com 35 semanas de idade e mais 36 ovos foram retirados cinco semanas depois. Cada grupo de 36 ovos foi aleatoriamente divididos em três grupos de 12 ovos. O primeiro grupo foi analisado logo após a coleta, um segundo grupo foi mantido na geladeira (5 ºC) e o terceiro grupo foi mantido em temperatura ambiente (25 º C), ambos durante uma semana. Foram calculadas a cor e a espessura da casca, a gravidade específica, a altura de albumina e as unidades Haugh. A idade das aves teve efeito significativo sobre a cor e a espessura da casca, mas o sistema de armazenamento não teve influência sobre a idade da galinha como variáveis. A idade das galinhas não teve efeito sobre o peso específico, mas o sistema de armazenamento foi afetado para essa variável. A idade e o sistema de armazenagem teve influência significativa ($p<0,05$) na altura da albumina e unidades Haugh. O sistema de armazenamento com a interação idade foi significativa para essas variáveis. O peso específico teve relações positivas com a espessura da casca, cor da gema, altura da albumina e unidades Haugh. Conclui-se que a idade da ave e do sistema de armazenamento em temperaturas mais elevadas reduziram a qualidade dos ovos.

Palavras-chave: idade das galinhas, sitema de armazenamento e qualidade de ovos

1. Introduction

For the industry, the production of eggs which are good egg shell quality and good internal quality is critical to the economic viability of the industry. Problems with egg quality currently cost the industry important economic loss. Moreover, the physical quality of egg is interesting for consumers. Therefore, it is of great importance to understand the factors that affect egg physical quality. There are many experiments that have studied this aspect, specially the factors related with the hen feeding and diseases (Roberts, 2004). The effect of bird age on egg shell and internal quality have been studied by Silversides and Scott (2001) and Roberts and Ball (2004) and the effects of storage time and temperature on internal quality of egg are documented in Stadelman and Cotterill (1995) and Keener et al. (2000). However, to our knowledge, the influence of storage system on egg quality have been scarcely studied. Therefore, this research was mainly conducted to asses the effect of storage system on physical quality of eggs from brown laying hens.

2. Materials and Methods

A total of 108 eggs from a group of 100 Brown Comb Leghorn laying hens housed at our experimental barn were analized. Layins hens were housed in standard cages that had a capacity of 4 hens. The dimensions of the standard cage were: length 50,8 cm, depth 45 cm, height at the front of the cage 40 cm. The area available per hen was 571,5 cm^2, with 12,7 cm access to the food trough per hen. Diet (11,86 MJ MJ, 165g CP, 35 g Ca 3 g available P/kg) and water were available *ad libitum*. Light was provided daily from 8 to 24 h. Thirty-six eggs were retired when the hens had 30 week of age, other 36 eggs were retired when the hens had 35 weeks of age and the remaining 36 eggs were retired five weeks afterwards. The three eggs collections were carried out at radom the same day of the week. Eggs from the layers were grading following UE commercial range (M from 53,0 to 62,9 g, L from 63,0 to 72,9 and XL from 73,0 to 80,0). Each group of 36 eggs was radomly divided in three groups of 12 eggs. First group was analyzed at once (storage system C); second one was kept during one week in the refrigerator (5ºC) (storage system R), and third group were kept also one week but on ambient temperature (25 ºC) (storage system AT).

All eggs were weighed with a precision weigher (0,01 g) both as conventional manner weight on air (WA) and sinked in water (WW). Such way, we obtain the specific gravity of egg (SG): SG = WA/(WA-WW).

For to measure albumen quality, eggs were cracked and dense albumen height (H) was measured by means an electronic height gauge (TSS -Technical Services and Supplies). Egg weight and albumen height permited to calculate the Haugh Units (HU) index by means expression:

$HU = 100. \log [AH – [G (30 EW^{0,37}-100)]^{0,5}/100] + 1,9]$ where:

HU = Haugh units

AH = albumen height in mm which

G = 32,2

EW = weight of whole egg in grams

Egg yolk color were settled using the former Roche® fan (actually DSM®), with a range from 1 to 15, and egg shell thickness were measured by means a digital micrometer EggAnalyzer - EggTester.com (www.**egg**tester.com/**egg analyzer**.html) (previously, eggshell membranes had been retired). Shell color was determined by means a reflect meter (EQReflectometer - Mitutoyo, Technical Services and Supplies Co. Ltd., Tokyo, Japan - http://japr.highwire.org/cgi/**co**ntent/full/16/4/605).

The data were studied by means a variance analysis that included as main factors the hen age and storage system. The double interactions between such factors were also considered. Duncan test was used to compare the means. In addition, correlation analysis was carried out in order to calculate the matrix of Pearson correlation coefficients of the egg physical properties and simple and multiple regressions equations were calculated to estimate the relationship between specific SG (dependent variable) and shell thickness, yolk color, albumen height and Haugh units (independent variables), and between Haugh units (dependent variable) and albumen height and egg weight (independent variables). The relations between egg weight and physical properties were also studied by means correlation analysis. All analysis were carried out by means statistic packet SAS (1999).

3. Results and Discussion

The egg physical properties according to hen age and storage system are presented in Table 1.

Table 1. Physical properties of egg according to hen age (HA) and storage system (SS).

HA(weeks)	n	Shell color	Shell thickness	Egg weight	Specific gravity	Yolk color	Albumen height	Haugh units
30	36	26,49[a]	0,39[a]	66,99	1,08	8,47	6,13[a]	83,37[a]
35	36	24,29[b]	0,37[ab]	67,12	1,08	12,61	5,91[a]	80,80[ab]
40	36	26,10[ab]	0,35[b]	66,33	1,08	10,14	5,13[b]	76,74[b]
SS								
C	36	25,37	0,38	67,16	1,09[a]	12,89	6,91[a]	89,47[a]
R	36	25,61	0,37	66,31	1,08[b]	9,11	7,00[a]	88,78[a]
ET	36	25,90	0,36	65,97	1,07[c]	9,22	3,26[b]	62,67[b]
sem		0,66	0,008	1,15	0,0016	1,65	0,25	1,74
P HA <		0,046	0,002	0,78	0,92	0,21	0,018	0,029
P SS <		0,85	0,23	0,75	0,0001	0,19	0,0001	0,0001

n = number of observations, C = eggs analyzed at once, R = eggs analyzed after one week of refrigeration (5º C), ET = eggs analyzed after one week of storage at 25º C. sem= standard error of mean. Means with different superscripts are significantly different (P <0.05).

The bird age had a significant influence (P<0,05) on shell color. A shell color (SC) reduction was observed in eggs from hens with 35 weeks of age. However, the eggs from hens with 40 weeks of age had the same color than those from hens with 30 or 35 weeks of age. Walker and Hughes (1998) found a color reduction when eggs from hens of 60 and 72 weeks of age were compared. The SC reduction with increasing hen age seems that is related with environmental stress factors (Hughes et al., 1986; Mills et al., 1991; Reynard and Savory, 1999), but in the present experiment we have not detected any stress factor during the experimental period. However, according to Sauver (1991) the eggs production percentage (EPP) and SC have a negative relation, and in the current experiment the EPP obtained for hens of 30, 35 and 40 weeks of age were 72,4; 93,0 and 85,7% respectively. As expected the storage system had not influence on SC.

Table 2. Matrix of Pearson correlation coefficients of the egg physical properties.

	Shell color	Shell thickness	Egg weight	Specific gravity	Yolk color	Albumen height	Haugh units
Shell color							
Shell thickness	-0.078 (0.42)						
Egg weight	-0.16 (0.09)	0.058 (0.55)					
Specific gravity	-0.14 (0.15)	0.35 (0.0002)	-0.15 (0.11)				
Yolk color	-0.042 (0.66)	-0.13 (0.19)	-0.037 (0.69)	0.36 (0.0002)			
Albumen height	-0.0071 (0.94)	0.11 (0.24)	0.11 (0.24)	0.50 (0.0001)	0.13 (0.17)		
Haugh units	0.0071 (0.94)	0.14 (0.15)	-0.064 (0.51)	0.55 (0.0001)	0.12 (0.20)	0.98 (0.0001)	

(   ) = P values

The hen age had significant (P < 0,05) effect on shell thickness (ST). In this experiment ST decreased as increased the hens age. Several experiments have found that shell quality decreases as birds grow older (Nys, 1986., Roberts and Ball, 2004), and Guesdon et al. (2006) observed that eggshell percentage and shell quality decreased as increased the bird age. Egg size increases with increasing hen age at the same time as shell weight increases or stays the same. Then the increase in egg weight (EW) is not accompanied by a proportional increase in shell weight the ST decreases. In the present experiment the hen age had not significant influence on EW and the correlation coefficient between EW and ST was not significant (P <0,55) (Table 2). The ST reduction with increasing hen age observed in this experiment may be explained because seems that there is some evidence of the reduction of the activity of 25-hydroxy-cholecalciferol-1-hydroxylase (an enzyme involved in calcium homeostasis) with increasing hen age (Joyner et al., 1987; Elaroussi et al., 1994). Moreover, the reduction of ST in hens with 40 weeks of age can be also explained because there is a negative relation between ST and EPP (Sauver, 1991). As expected no significant effect of storage system on ST was observed.

Table 3. Relationships between specific gravity (SG) anf shell thickness (ST), yolk color (YC), albumen height (AH) and Haugh units (HU).

Regression equation	n	R^2	RSD	P <
SG = 1.047 + 0.0842 ST	108	0.122	0.012	0.0002
SG = 1.07 + 0.00049 YC	108	0.130	0.013	0.0002
SG = 1.06 + 0.0028 AH	108	0.255	0.012	0.0001
SG = 1.04 + 0.00044 HU	108	0.302	0.012	0.0001
SG = 1.023 +0.0572 ST + 0.000456 YC +0.00036 HU	108	0.453	0.0098	0.0001

n = number of observations, R^2 = determination coefficient, RSD = residual standard deviation P = probability.

The hen age had not significant influence on specific gravity (SG), but the storage system affected significantly (P< 0,05) to this variable. According to Table 2 results the SG had a positive relation with ST, yolk color (YC), albumen height (AH) and Haugh units (HU). The relationships found between SP and ST,YC, AH and HU are presented in Table 3. These results are interesting because suggest that can have a positive relation between specific gravity and egg internal quality. The independent variables ST, YC and UH, jointly, accounted for 45,3% of the variation in SP. Hempe et al. (1988) also found a positive relation between SG and ST and Abdallah et al. (1993) observed that broken egg percentage decreased as increased SG.

Table 4. Interaction hen age (HA) x storage system (SS) for the variables albumen height and Haugh units.

HA	SS	n	Albumen height	Haugh units
30	C	12	6.64[a]	88.38[a]
30	R	12	8.07[a]	95.88[a]
30	ET	12	3.67[b]	65.85[b]
35	C	12	6.51[a]	86.40[a]
35	R	12	8.20[a]	95.03[a]
35	AT	12	3.05[b]	60.98[b]
40	C	12	7.59[a]	93.62[a]
40	R	12	4.75[c]	75.42[c]
40	ET	12	3.06[b]	61.17[b]
sem			0.45	3.02
P <			0.0001	0.0001

n = number of observations, C = eggs analyzed at once, R = eggs analyzed after one week of refrigeration (5º C), ET = eggs analyzed after one week of storage at 25º C. sem= estandard error of mean. Means with different superscripts are significantly different (P <0.05).

Hen age and storage system had significant influence on AH and HU but had not effect on YC (Table 1). Eggs from hens with 40 weeks of age had lower AH than those from hens with 30 or 35 weeks of age. The HU value was lower in eggs from hens with 40 weeks of age than in eggs from hens with 30 weeks of age. The AH and HU values were lower in eggs conserved under ET storage system than under C or R storage system. The interaction hen age x storage system was significant (P <0,05) for the variables AH and HU (Table 4). In the eggs from hens with 40 weeks of age AH and HU values were significantly (P <0,05) lower under R than under C storage system, whereas this did not occur in the eggs from hens with 30 or 35 weeks of age. In order to quantify, in this experiment, the relationship between HU and AH and EW equation of multiple regression was calculated. The following equation was obtained: HU = 56,59 + 6,69 AH – 0,21 EW (R^2 = 0,97, RSD = 2,87, P <0,0001). The variables AH and EW, as a whole, explained the 97% of the variability of HU.

AH and HU measure the viscosity of the thick albumen. Low values of AH and HU indicate low viscosity of the thin albumen, which means a poor albumen quality. The changes that occur when albumen becomes less viscous are little known (Roberts, 2004), although according to Li-Chan and Nakai (1989) two albumen proteins (ovomucin and ovoalbumin) appear to play a major role. A study from Leeson and Caston (1997) has indicate that low viscosity thin albumen may be due to eggs spending longer tha normal in the shell gland and therefore taking up more water. The changes occurring in albume quality during egg storage appear to be related to changes occurring in ovomucin particularly the thick albumen (Toussant and Latshaw, 1999).

AH and HU decrease with storage time and this decrease occurs more quickly at higher temperatures (Roberts, 2004) whereas the cooling of eggs leads to an improvement of HU of stored eggs (Keener et al., 2000). On the other hand, the pH of albumen increases during the storage and this is thought to be related to the reduction of albumen quality (Roberts, 2004). According to several studies (Silversides and Scott, 2001; Roberts and Ball, 2004) the increase of hens age declines the albumen quality, which is in agreement with the results observed in our experiment.

According to the correlation analysis results (Table 2) the EW had not significant effect on SC (P <0,09), ST (P <0,55), SG ((P <0,11), YC (P <0,69), AH (P <0,24) and HU (P <0,51).

It is concluded that the bird age and egg storage system under high temperatures reduced the egg quality.

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