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Effect of hen age, egg weight and storage system on physical properties of egg from white-egg laying hens

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

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

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

Abstract

A total of 72 eggs from a group of 100 white laying hens housed in standard cages were analyzed. Thirty-six eggs were retired when the hens had 44 week of age and the other 36 eggs were retired eight weeks afterwards. 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 (25ºC) (storage system ET). The hen age, egg weight and storage system had not significant ($P>0.05$) effect on shell thickness. The specific gravity (SG) has a positive relation with shell quality. The egg class and storage system significantly ($P<0,05$) affected to SG, while no influence of bird age on this variable was observed. The yolk color increased with hen age but storage system had not effect on this variable. The increase of the hen age and the R and AT storage systems significantly ($P<0.05$)

reduced albumen height (H) and the interaction hen age x storage system was significant (P<0.025) for this variable. The reduction of the H due to R and ET storage systems was higher in the eggs from hens with 52 weeks of age than in those from hens with 44 weeks of age. The Haugh units (HU) was significantly (P<0.05) affected by hen age, egg class and storage system. The hen age increase reduced HU and the R and ET eggs had lower HU than C eggs. It is concluded that the bird age and storage system with high temperatures reduced the egg quality.

Keywords: bird age, storage system, egg quallity.

Efeito da idade, peso do ovo e sistema de armazenagem sobre as propriedades físicas de ovos de poedeiras leves

Resumo

Um total de 72 ovos de um grupo de 100 galinhas poedeiras leves alojadas em gaiolas-padrão foram analisados. Trinta e seis ovos foram coletados de galinhas tinham 44 semanas de idade e outros 36 ovos foram coletados oito semanas depois. Cada grupo de 36 ovos foi aleatoramente divididos em três grupos de 12 ovos. O primeiro grupo foi analisado logo após a coleta (sistema de armazenamento C); o segundo foi mantido durante uma semana na geladeira a 5º C(sistema de armazenamento R), e o terceiro foi mantido também durante uma semana, mas em temperatura ambiente, a 25 º C, sistema de armazenamento ET). O efeito da idade da galinha, o peso dos ovos e o sistema de armazenamento não foram significativos (P> 0,05) sobre a espessura da casca. Entretanto, a gravidade específica (SG) apresentou uma relação positiva com a qualidade da casca. A classe de ovo e o sistema de armazenamento afetaram de forma significativa (P <0,05) a SG, mas a influência da idade da ave sobre essa variável foi observada. A cor da gema aumentou com a idade da galinha, mas o sistema de armazenamento não teve efeito sobre essa variável. O aumento da idade da galinha e dos sitemas de armazenamento R e ET reduziram de forma significativa (P <0,05) a altura do albúmen (H). A interação entre a a idade da ave com o sistema de armazenamento foi significativa (P <0,025). A redução da H, devido aos sistemas de armazenamento R e ET foi maior nos ovos de galinhas com 52 semanas de idade do que naquelas com 44 semanas de idade. As unidades Haugh (UH) foram significativamente (P <0,05) afetada pela idade da galinha, classe de ovo e sistema de armazenamento. O aumento da idade da galinha reduziu HU e os ovos da clase C dos sistemas de armazenamento R e ET e a presentaram menor HU. Conclui-se que a idade da ave e o sistema de armazenamento com altas temperaturas reduzem a qualidade dos ovos.

Palavras-chave: idade das aves, sistema de armazenamento, qualidade de ovos.

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 egg.

MATERIALS AND METHODS

A total of 72 eggs from a group of 100 commercial strain (Hyline) Single Comb White Leghorn hens housed at our experimental henhouse were analyzed. The house is fully enclosed with ventilation and temperature control.

Laying hens were housed in standard cages that had a capacity of 4 hens per cage. The house is fully enclosed with ventilation and temperature control. The dimensions of the standard cage were: length 50.8cm, depth 45 cm, height at the front of the cage 40 cm. The area available per hen was 571.5 cm^2, with 12.7cm access to the food trough per hen. Diet (11.86 MJ, 165g CP, 35 g Ca 3 g available P/kg) and water were available *ad libitum*. Hens were exposed to 17 h daily photoperiod. Thirty-six eggs were retired when the hens had 44 week of age and the other 36 eggs were retired eight weeks afterwards. The two 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 54.00 to 62 .00 g, L from 62.01 to 70.00 and XL from 70.01 to 80.00). 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 ET).

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:

$HU = 100. \log [H – [G (30W^{0.37}-100)]^{0.5}/100] + 1.9]$ where:

HU = Haugh units

H = albumen height in mm which

G = 32.2

W = weight of whole egg in grams

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

The data were studied by means a variance analysis that included as main factors the hen age, egg class and storage system. The double interactions between such factors also were considered. Duncan test was used to compare the means. In addition, simple and multiple regressions equations were calculated to estimate the relationship between yolk color and egg weight (EW), and between Haugh units and albumen high (H) and EW. All analysis were carried out by means statistic packet SAS (1999).

RESULTS AND DISCUSSION

The eggs production during the week 44 and 52 was 82.99 and 71.63 percent respectively.

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

The bird age had a significant influence ($P<0.05$) on shell color. A color reduction with increasing the hen age was observed, which is in agreement with data from Walker and Hughes (1998) which detected a color reduction when eggs from hens of 60 and 72 weeks of age were compared. The color reduction seems that is related with stress factors (Hughes et al., 1986; Mills et al., 1991) which can generate an delayed oviposition and retention of eggs in the shell gland and this can lead an increased proportion of eggs with abnormal shell. The results of our experiment may indicate that the stress level would have been higher in hens older.

As expected the egg weight and storage system had not influence on shell color.

Table 1. Physical properties of egg according to hen age, egg class and storage system.

Variation factor	n	Shell color	Shell thickness	Egg weight	Albumen height	Yolk color	Specific gravity	Haugh units
Age (weeks)								
44	36	81.20[a]	0.42	67.27	6.66[a]	9.11[a]	1.07	84.67[a]
52	36	76.69[b]	0.43	67.91	5.42[b]	9.95[b]	1.07	75.00[b]
sem		0.44	0.0073	0.49	0.35	0.22	0.0012	2.40
Class								
M	25	78.68	0.42	59.62[a]	6.32	9.07	1.077[a]	85.07[a]
L	33	78.81	0.42	67.85[b]	6.54	9.77	1.076[a]	85.19[a]
XL	14	79.34	0.42	75.29[c]	5.26	9.74	1.069[b]	69.25[b]
sem		0.48	0.0070	0.53	0.38	0.24	0.0048	2.61
Storage system								
C	24	78.27	0.42	66.86	8.25[a]	9.88	1.084[a]	95.09[a]
R	24	78.42	0.43	67.94	6.40[b]	9.60	1.078[b]	84.81[b]
ET	24	80.14	0.42	66.86	3.48[c]	9.11	1.059[c]	59.60[c]
sem		0.85	0.0083	0.62	0.44	0.27	0.0015	3.00
P age		0.0001	0.81	0.37	0.016	0.01	0.75	0.0068
P class		0.75	0.99	0.0001	0.16	0.06	0.01	0.0022
P storage		0.15	0.43	0.28	0.0001	0.19	0.0001	0.0001
P age x class		0.50	0.28	0.24	0.76	0.65	0.76	0.65
P age x storage		0.45	0.24	0.16	0.025	0.10	0.009	0.081
P class x storage		0.98	0.80	0.84	0.081	0.60	0.065	0.045

M = 54.00-62.00 g L = 62.01-70.00 g HL =70.01-80.00 g C = eggs analyzed at once, R = eggs analyzed after one week of refrigeration (5º C)
ET = eggs analyzed after one week of storage at 25ªC.
sem = standard error of the means. According to variation factor means with different superscripts are significantly different P<0.05.

The hen age, egg weight and storage system had not significant (P>0.05) effect on shell thickness (ST). However, several experiments have found that shell quality decreases as birds grow older (Nys, 1986., Roberts & Ball, 2004). Egg weight (EW) increases with increasing hen age at the same time as shell weight increases or stays the same. Then the increase in egg weight is not accompanied by a proportional increase in shell weight the shell thicknes decreases. In our experiment an increase of egg weight did not lead to a reduction of shell thickness.

No significant correlation coefficient between ST and EW was observed (r = 0,12, P <0.92).

The specific gravity (SG) has a positive relation with shell quality (Hempe et al., 1988). Abdallah et al. (1993) observed that broken egg percentage decreased as increased SG. In the present experiment a significant linear relation between SG and ST was detected:

SG = 0.963 (± 0.201) + 0.321 (±0.055) ST (R^2 = 0.27, RSD = 0.016, P <0.0001)

The egg class and storage system significantly (P<0,05) affected to SG, while no influence of hen age on this variable was observed. XL eggs had lower SG than L and M eggs, and eggs under storage conditions ET and R also had lower SG than C eggs.

The interaction hen age x storage system was significant (P<0.009) for the SG (Table 2). In hens with 44 week of age the storage system ET lead to a reduction higher of SG than in hens with 52 week of age.

Table 2. Interaction hen age x storage system for specific gravity

Hen age	Storage system	n	Specific gravity
44	C	12	1.085^{a}
44	R	12	1.081^{ac}
44	ET	12	1.056^{b}
52	C	12	1.082^{ac}
52	R	12	1.076^{c}
52	ET	12	1.063^{d}
sem			0.0021

sem = standar error of the mean. Means with different superscripts are significantly different P<0.05.

The yolk color increased with hen age and the L and XL eggs tended (P<0.06) to have higher values of this variable. Nevertheless, the storage system had not significant influence on yolk color A significant linear relation between the variables yolk color (YC) and EW was found according to the following equation:

YC = 5.51 (±1.56) + 0.060 (±0.023) EW (R^2 = 0.09, RSD = 1.19, P<0.012)

The increase of the hen age and the R and AT storage systems significantly ($P<0.05$) reduced albumen height (H) and the interaction hen age x storage system was significant ($P<0.025$) for this variable (Table 3). The reduction of the H due to R and ET storage systems was higher in the eggs from hens with 52 weeks of age than in those from hens with 44 weeks of age.

Table 3. Interaction hen age x storage system for albumen height

Hen age	Storage system	n	Albumen height
44	C	12	8.05[a]
44	R	12	7.68[a]
44	ET	12	4.26[b]
52	C	12	8.45[a]
52	R	12	5.11[b]
52	ET	12	2.70[c]
sem			0.59

sem = standar error of the mean. Means with different superscripts are significantly different $P<0.05$.

The albumen quality is usually measured from the H, although this variable is usually converted into Haugh Units by means the equation mentioned above.

The Haugh units (HU) was significantly ($P<0.05$) affected by hen age, egg class and storage system. The hen age increase reduced HU and the R and ET eggs had lower HU than C eggs. The XL eggs had lower HU than L and M eggs. The interaction between egg class and storage system was significant ($P<0.045$) for Haugh values (Table 4). In all the egg class the ET storage system significantly reduced the HU, but the R storage system only decreased the HU in the eggs XL. Moreover the HU reduction produced by ET storage system was higher in XL eggs than in M and L eggs.

In order to quantify, in this experiment, the relationship between HU and H and EW equation of multiple regression was calculated. The following equation was obtained:

$HU = 64.89\ (\pm 4.92) + 6.19\ (\pm 0.17)\ H - 0.30\ (\pm 0.072)\ EW \quad (R^2 = 0.97,$ $RSD = 3.34,\ P < 0.0001)$

The variables H and EW, as a whole, explained the 96% of the variability of HU.

Table 4. Interaction egg class x storage system for Haugh values.

Egg class	Storage system	n	Haugh values
M	C	8	96.63^{a}
M	R	9	87.95^{a}
M	ET	8	70.62^{b}
L	C	9	93.53^{a}
L	R	10	94.29^{a}
L	ET	14	67.74^{b}
XL	C	7	95.12^{a}
XL	R	5	72.19^{b}
XL	ET	2	40.44^{c}
sem			4.32

sem = standar error of the mean. Means with different superscripts are significantly different P<0.05.

H and HU measure the viscosity of the thick albumen. Low values of H 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 & Latshaw, 1999).

H 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 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 & Scott, 2001; Roberts & Ball; 2004) the increase of hens age declines the albumen quality, whih is in agreement with the results observed in our experiment.

It is concluded that the bird age and storage system with high temperetures reduced the egg quality.

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