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INFLUENCE OF THE STORAGE PERIOD ON THE QUALITY CHARACTERISTICS OF TABLE EGGS

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Summary: *The purpose of this study is to examine the effects of the storage period on the quality characteristics of Bovans Brown table eggs. Eggs from 47-week-old hens were sampled on the day of laying and stored in a refrigerator (4°C) for periods of 7, 14, 21, and 28 days. Measurements were performed for each storage period relative to the most important quality parameters of eggs. The following egg parameters were evaluated: weight, weight loss, shell breaking force, albumen height, Haugh units and yolk color. The results obtained show that the albumen height and Haugh unit (HU) were affected by the storage period and are of immense importance. The following parameters were found to be significantly influenced by different storage periods: weight loss (P<0.05), albumen height (P<0.05) and Haugh unit (P<0.01). Rapid reductions in the albumen height were recorded during 7, 14, 21 and 28 days of storage (ranging from 6.90 mm to 6.07mm). Moreover, the Haugh unit values also decreased during storage from 81.27 to 74.89 at 4°C. The present results suggest that the albumen height and the Haugh unit are the most important parameters of egg quality, obtained from commercial layers raised in battery cages, affected by a storage period of 4 weeks.*

Key words: *laying hens, table egg, quality, storage*

INTRODUCTION

Eggs are one of the most complex foods available to humans. They are rich in proteins and minerals, containing many essential amino acids with important biological values. Due to the high nutrient content and digestibility, eggs require special care as mishandling can render them a source of toxinfection (Figueiredo et al., 2013).

Both the internal and shell qualities of eggs are of major importance to the egg industry worldwide. The internal quality of eggs depends on several factors such as strain (Silversides and Scott, 2001; Samli et al., 2005), nutrition (Franchini et al., 2002), bird age, and storage temperatures (Roberts, 2004; Jin et al., 2011). The production and marketing of eggs in the EU is organized in keeping with the market rules and regulations stipulating the specific quality traits of eggs (Pavlovski et al., 2007).

According to the Council Regulation (EC) No 589/2008, market table eggs should remain fresh for no longer than 4 weeks after being laid. However, after a longer storage in the refrigerator, the table egg quality deteriorates, starting as soon as a hen lays an egg.

The albumen quality, yolk index, Haugh unit, and chemical composition are important indicators of the freshness of eggs. These parameters are also significant factors in the egg production industry as there is a constant increase in the demand for liquid and frozen eggs, as well as egg powder and yolk oil (Silversides and Scott, 2001, Hrnčár 2014).

According to Samli et al. (2005), the storage time and temperature are the most relevant factors affecting the albumen quality. However, during egg storage, some components of albumen and yolk may alter, and the quality of eggs tends to deteriorate. The lower the temperature of storage, the longer the shelf life of eggs will be. However, in

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some countries, refrigeration is optional during the distribution and commercialization processes. Santos et al. (2005) found that, at any age of laying hens, the internal quality of eggs is better when they are refrigerated.
The longer the storage time, the worse the egg internal quality will be as air temperature and humidity encourage the carbon dioxide transfer through the egg shell (Oliveira et al. 2009).
It has been established that the albumen quality, egg weight, and albumen height directly affect the Haugh unit (HU). Samli et al. (2005); Jin et al. (2011) and Chung and Lee (2014) evaluated the effect of age, temperature and storage period on the quality of eggs, arguing that an increase in the storage period caused a decrease in the Haugh unit and egg weight loss.
Although there are many studies dealing with the effect of storage on the egg quality traits, further research is necessary. Such research should always be relevant to the change in modern genotypes caused by an increasing number of laid eggs. The question is whether this increase affects the egg quality during storage, especially during the peak production of laying hens.
The purpose of this study is to determine the quality characteristics of eggs, obtained from Bovans Brown commercial layers raised in battery cages in the middle of the production cycle, during different storage periods (1, 2, 3, and 4weeks).

MATERIAL AND METHODS

Eggs from Bovans Brown commercial layers raised in battery cages, in the middle of the production cycle, were used in this study. The laying hens were fed according to the nutrient requirements suggested in the Bovans Brown Management Guide. The photoperiods were 8 hours dark and 16 hours light. A total of 150 eggs were identified, weighed, and randomly distributed in trays immediately after arriving from the farm. A total of 120 eggs were stored in a refrigerator (4°C) for 7, 14, 21, and 28 days. The analysis of the remaining 30 eggs was performed on the first day. The egg quality analysis was performed at the Laboratory for Poultry Meat and Egg Quality, the Department of Animal Science, the Faculty of Agriculture in Novi Sad. After each storage period, the eggs were examined relative to the following egg quality parameters: egg weight (EW), egg weight loss (EWL), shell breaking force (SBF), albumen height (AH), Haugh units (HU), and yolk color (YC).
The EW and EWL losses were measured using a precision scale (0.01 g). SBF was determined using the Egg Force Reader instrument, which measures the weight required to break the egg shell. (Orka Food Technology Ltd, Israel). AH was measured using a tripod micrometer. YC was determined using the Roche yolk color fan. The Haugh unit score was calculated using egg weights and albumen heights (Haugh, *1937*). HUs were calculated using the following formula: $HU = 100*\log (H + 7.6 – 1.7W^{0.37})$, H = Height of the albumen (mm); W = Weight of eggs (g).
All the data were evaluated using the ANOVA, the GLM analysis and the STATISTICA 13 program (Stat Soft, 2016). The treatment means obtained for storage periods were tested relative to statistically significant differences using the Duncan's test. A value of $p<0.05$ was considered significant for all the analyses.

RESULTS

The results of the storage period effect on the quality characteristics of table eggs are presented in Table 1. The storage time significantly affected some parameters of internal and external eggs quality characteristics. The parameters such as egg weight loss (EWL), albumen height (AH), Haugh units (HU) significantly decreased ($P< 0.05$) with an increase in the storage period. Egg weight (EW) and yolk color (YC) were not significantly influenced by the storage period. On balance, EW did not significantly change during 28 days of cold storage.
EWL significantly increased during four weeks of cold storage (7 days and 14 days 0.72g; 21 days 1.07g; 28 days 1.00g). It was only 0.18g in the first week of cold storage, whereas it was 0.72g in the second week of cold storage. In the third and fourth week of cold storage, the weight loss was about 1 g.

Table 1. Effects of the storage period on the quality traits of eggs from 47-week-old of hens ($\bar{x}$ ± SD)

Storage length, days	EW (g)		EWL (g)		SBF, (kg)		AH, (mm)		HU		YC	
	$\bar{x}$	± SD	$\bar{x}$	± SD	$\bar{x}$	± SD	$\bar{x}$	± SD	$\bar{x}$	± SD	$\bar{x}$	± SD
0	65.45	4.99	-	-	4.48^{ab}	0.98	6.96^{a}	0.91	82.26^{a}	5.87	12.09	0.95
7	64.68	4.69	0.18^{a}	0.36	4.52^{ab}	0.91	6.90^{a}	0.89	81.27^{a}	7.12	12.17	0.91
14	65.31	5.39	0.72^{b}	0.36	4.95^{a}	1.05	6.68^{a}	0.79	79.55^{ab}	4.76	12.03	0.93
21	63.26	4.88	1.07 ^{c}	0.57	4.49^{ab}	1.10	6.13^{b}	1.01	75.72^{b}	8.52	11.80	0.61
28	63.83	5.91	1.00 ^{c}	0.26	4.36^{b}	1.19	6.07^{b}	0.89	74.89^{b}	7.40	12.20	1.06

($^{a, b, c}$) Different letters indicate significant differences between the means in each column ($p < 0.05$), ($\bar{x}$) - Mean, SD - Standard Deviation, Egg weight (EW), Egg weight loss (EWL), Shell breaking force (SBF), Albumen height (AH), Haugh units (HU), Yolk color (YC).

SBF was found to be the highest in the second week of cold storage (4.95 kg) and significantly lower in the fourth week of cold storage (4.36 kg). There was no statistically significant difference between SBF in the other weeks of cold storage. AH and HU significantly decreased ($P < 0.05$) throughout the cold storage, with the lowest value of 6.07 mm AH and HU 74.89, respectively. The highest value (AH 6.96 mm and HU 82.26. respectively) was recorded on day 0. YC was not reduced during a cold storage period of 4 weeks. The highest and lowest YC values were 12.20 and 11.80, respectively.

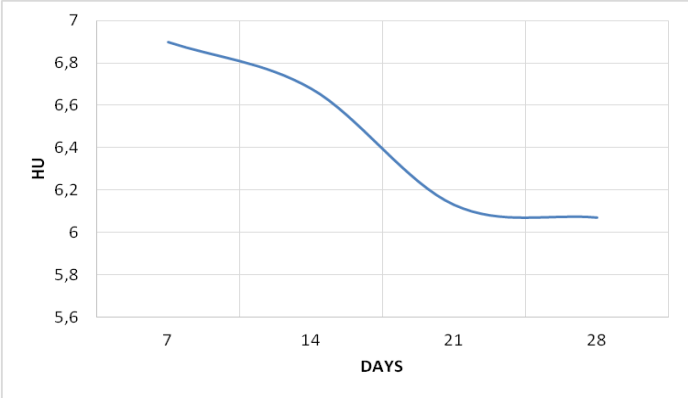

Figure 1. **Effect of the storage period on Haugh units**

DISCUSSION

In our study, EW was not significantly influenced by the storage period. Jones et al. (2014) and Samli et al. (2005) found no statistically significant differences in EW during 5 weeks of cold storage, which is consistent with our results. The results of Jones and Musgrove (2005) were also fairly uniform for EW during 10 weeks of cold storage. The results obtained in this study show that EWL significantly increased during four weeks of cold storage.

Other authors such as Samli et al. (2005) and Jin et al. (2011) have also argued that the duration of cold storage significantly affects EWL.

In addition to the storage period and conditions, the strain and age of laying hens exert a major effect on the albumen height of eggs. Silversides and Scott (2001) reported that the albumen height depends on strains, and that eggs from Brown hens had lower albumen heights than those from White hens. Moreover, the albumen height of all eggs is the highest when the egg is laid and decreases with an increase in the storage period (Silversides et al. 2006).

In the present study, AH and HU significantly decreased throughout the storage period. Samli et al. (2005), Jin et al. (2011), Chung and Lee (2014) and Đukić Stojčić et al. (2017) obtained the same results, arguing that an increase in the storage period caused a decrease in HU and EWL attributable primarily to the loss of water and carbon-dioxide from the egg white.

SBF was found not to be drastically reduced during 28 days of cold storage. Furthermore, Jones and Musgrove (2005) reported that the shell strength did not significantly change during the storage period. Significant changes in YC did not occur after 28 days of cold storage. This is congruent with the results of Jin et al. (2011), Maria Elena et al. (2006) and Barbosa et al. (2011), who concluded that the YC of eggs kept under refrigeration did not change during the storage period at 4 °C. Santos et al. (2009) reported that the eggs kept at room temperature, regardless of the storage period, had a slightly brighter YC compared to the eggs storied in a refrigerator.

CONCLUSION

The results obtained in this study indicate that eggs from commercial laying hens raised in battery cages exhibited a minor deterioration in the internal egg quality parameters during four weeks of cold storage after the day of laying. The present results suggest that the AH and HU of eggs were greatly affected by the storage period. It can be concluded that higher egg quality is associated with higher EW, AH and HU values. In conclusion, eggs from commercial laying hens (raised in battery cages in the middle of the production cycle) kept under refrigeration were found to exhibit a minor deterioration in the internal quality of eggs.

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UTICAJ SKLADIŠTENJA NA KVALITET KONZUMNIH JAJA

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Izvod: Cilj ovog istraživanja je bio da se ispita efekat vremena skladištenja na kvalitet konzumnih jaja od kokošaka nosilja hibrida Bovans Brown. Jaja od 47-nedeljih kokošaka su uzorkovana istog dana nakon što su snešena, doneta sa farme i smeštena u frižider (4 ° C) tokom perioda od 7, 14, 21 i 28 dana. Nakon toga, za svaki period skladištenja jednom nedeljno, vršena su merenja najvažnijih parametara kvaliteta jaja. Određivani su sledeći parametri: težina jaja (EW), gubitak težine jaja (EWL), sila loma ljuske (EBF), visina belanca (AH), Hogove jedinice (HU) i boja žumanca (YC). Rezultati istraživanja pokazuju da su visina belanca i Hogove jedinica veoma važni parametri na čiji kvalitet utiče vreme skladištenja jaja. Statistički značajan efekat skladištenja tokom različitih vremenskih perioda je pronađen na sledećim parametrima: gubitak težine jaja ($P < 0.05$), visina belanca ($P < 0.05$) i Hogove jedinice ($P < 0.01$). Zapaženo je smanjenje visine belanca (od 6.90 mm do 6.07 mm) sa dužinom skladištenja od 7, 14, 21, 28 dana skladištenja. Isto tako, tokom perioda skladištenja, vrednost Hogovih jedinica se smanjuje sa 81.27 na 74.89 kod jaja skladištenih na 4° C. Prikazani rezultati istraživanja pokazuju da su visina belanca i Hogove jedinice najvažniji parametri kvaliteta jajeta, koji se menjaju pod uticajem skladištenja kod jaja od komercijalnih nosilja.

Ključne reči: *kokoši nosilje, kvalitet, konzumna jaja, skladištenje*

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