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İ Ç İ N D E K İ L E R / C O N T E N T S

Effects of Storage Time And Temperature on Egg Quality Parameters and Electrical Conductivities of Eggs

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The aim of the present study was to examine the effects of storage time and storage temperature on the main quality parameters and electrical conductivities of eggs. Eggs from Bovans-White hens were subjected to various storage periods for 2, 7 and 14 days at 5 and 26°C temperatures. Haugh unit, albumen height, albumen pH and air cell size have been found to be the most important parameters which were greatly influenced by the storage time and temperature. In addition, electrical conductivity was found to be affected by storage temperature. The air cell size has reached to 4 mm 4 and albumen pH increased at two days storage.Storage temperature was also highly significant on electrical conductivity ($p < 0.01$). Interaction effect between the storage time and temperature were also significantly affectedthe egg weight loss, Haugh unit, albumen height, pH and air cell size. The results of the present study suggested that Haugh unit, pH of albumen, air cell size and electrical conductivity were the most important parameters greatly influenced by the storage period and storage temperature in eggs.

Keywords: Egg quality, storage time, temperature, conductivity

Depolama Süresi ve Sıcaklığının Yumurta Kalite Parametreleri ve Elektrik İletkenliği Üzerine Etkileri

Bu çalışmanın amacı, depolama süresi ve sıcaklığının yumurtaların kalite parametreleri ve elektrik iletkenlikleri üzerine olan etkilerini ortaya koymaktır. Bovans-White yumurtacı tavuklardan, toplanan yumurtalar farklı depolama sıcaklıklarında (5 ve 26°C) ve sürelerinde (2, 7 ve 14 gün) depolanmıştır. Çalışma sonucunda, depolama süresi ve sıcaklıklarından en yüksek düzeyde etkilenen yumurta kalite parametrelerinin Haugh birimi, albümin yüksekliği, albümin pH'sı ve hava kesesi yüksekliği olduğu saptanmıştır. İki günlük depolama sonucunda hava kesesi yüksekliği 4mm'ye çıkmış, albümin pH'sı da sıcaklığa bağlı olmaksızın hızla yükselmiştir. Depolama sıcaklığının ise elektrik iletkenliği üzerine etkisi önemli bulunmuştur ($p < 0.01$). Depolama süresi ve sıcaklıklarının interaksiyonu; yumurta ağırlık kaybı, Haugh birimi, hava kesesi yüksekliği, albümin yüksekliği ve pH'sı önemli derecede etkilenmiştir. Bu çalışma sonucunda, depolama süresi ve sıcaklıklarından en yüksek düzeyde etkilenen parametrelerin Haugh birimi, albümin pH'sı, hava kesesi yüksekliğive elektrik iletkenliği olduğu belirlenmiştir.

Anahtar Kelimeler: Yumurta kalitesi, depolama süresi, sıcaklık, iletkenlik

Introduction

Eggs provide a unique, well-balanced source of nutrients, including essential unsaturated fatty acids (linoleic acid,18:2n6), oleic acid, iron, phosphorus, trace minerals, and vitamins (A, D, E, K and B). However, egg quality is relatively unstable and begins to deteriorate immediately after it has been laid due to loss of moisture and carbon dioxide through the 7000–17 000 pores on the shell surface by diffusion (Balkan and Biricik, 2008; Jinangrat et al., 2010).

Major factors affecting egg quality are genetic and environmental factors (Washburn, 1990; Ahn et al., 1997), altough nutritional factors (Benabdeljelil and Jensen, 1990) have minor effects on egg quality parameters (Williams, 1992). However, dietary protein source and amino acid content might affect the albumen quality of eggs in laying hens (Roberts, 2004). Also, increase in egg yield has been reported to cause a decrease in egg shell quality andalbumen quality (Bougon et al., 1981).

Environmental factors such as storage time, temperature, humidity and the presence of CO_2 have major effects on the egg quality. Albumen quality is an important indicator for the egg freshness (Proudfoot, 1962; Akbar et al., 1983; Ahn et al., 1997, Lapão et al., 1999; Bozkurt and Tekerli, 2009). Fresh albumen is gelatinous and possesses ovomucin, a special kind of structural protein. Scott and Silversides (2001) reported that the mucin is diminished with increasing storage ever more, which causes thinning in the egg

albumen and the albumen height decreases. Haugh unit (HU) is calculated from the inner thick albumen height and the egg weight (Haugh, 1937). Relatively high Haugh unit (>75) and small air space are a good evidence for fresh eggs (Schwaegele, 2001). Shenga et al. (2010) reported that Haugh unit, albumen and yolk indices of both raw and pasteurized eggs progressively declined with storage time.

Shell life and quality of shell egg is a function of CO_2 content (Keener et al., 2001). Silversides and Villeneuve (1994)reported that albumen pH is a useful tool for describing the changes in albumen quality during the storage but its measurement is time consuming.Albumen pH increases with the loss of CO_2 from the egg. The increase in pH and dry matter has been reported by extending the storage time from 2 to 30 days.

The electrical conductivity of foods is linearly dependent on the temperature and water - ion content (Jha et al., 2011). Electrical conductivity is increased when big molecules are broken into small ones. Furthermore, electrical conductivity is a sign of the microbial infection degree (Kofoth, 1999).

The problem in determining egg quality is to find a factor that is rapidly measured and associated with the difference in quality (Hunton, 1987). There are a number of studies, concerning the effects of storage time on egg quality. However, the interaction of time and temperature is not fully known. The aim of the present study was to examine the effects of storage time and temperature, and the interaction between them on egg quality in aged laying hens.

Materials and Methods

Eggs were obtained from Bovans-White hens that were included in a laying trial at experimental unit of Department of Animal Science of Namik Kemal University. Eggs were collected from65 wkold-hens. At once 140 eggs were collected for the present experiment. Fresh eggs were collected and measured within 2 h after being laid. The eggs (with 20 replicates) were stored for 2, 7 and 14 days at the refrigerator (5°C) and room (26°C) temperatures. Humidity was 55 to 60% for all treatments. For sampling, each egg was weighed and broken and the height of the thick albumen was measured within a tripod micrometer. The albumen was separated by using an egg separator and then pH levels were measured, using a pH meter (Inolab level 1). Haugh unit were calculated using the following formula; $HU=100 \log (H-1.7W^{0.37}+7.57)$ (Haugh, 1937). Air cell (mm) and the egg shells (micron) were measured with a micrometer (Mauser, Germany). The electrical conductivity of the albumen was measured using a conduktometer (WTW, Germany).

The data were subjected to ANOVA using a general linear model included with the main effect of storage time and storage temperature by a statistical package program (Statistica, 1999).

Results and Discussion

Storage time and temperature significantly affected almost all the internal and external quality parameters investigated in the present study. The effects of storage time and temperature on egg quality and albumen quality were presented in Table 1 and Table 2, respectively.

Egg weight loss increased by storage time and temperature, except for 2 d storage time, likely due to water loss through the shell. Besides, air cell size exceeded to 4.37 mm by only two day storage at 5°C temperature. The air cell size drastically increased from 2.96 (in fresh eggs) to 7.84 mm for 14 d of storage at 26°C temperature (Table 1). These findings are in accordance with the results of Walsh et al. (1995) who reported significant ($p < 0.001$) increases in egg weight loss by 0.360 and 0.570 g at 7 and 14 days storage, respectively. Similar results for egg weight losses were also reported by some researchers (Silversides and Villeneue,1994; Bozkurt and Tekerli, 2009).

In addition to these results, shell weights were adversely affected by storage temperature. However, storage time and temperature did not have an effect on shell thickness.

Table 1. Effects of storage time and temperature on egg quality

Storage time day	Temperature °C	Egg weight		Shell		Air cell size mm
		Fresh g	Loss* g	Weight g	Thickness µ	
Fresh eggs		64.5	-	7.2 **b**	269	2.96 **a**
2	5	64.3	0.19 **a**	7.1 **ab**	286	4.37 **b**
	26	64.7	0.32 **ac**	6.5 **ab**	274	4.30 **b**
7	5	64.4	0.41 **c**	6.8 **ab**	284	4.86 **b**
	26	64.8	0.99 **d**	6.4 **a**	273	5.78 **c**
14	5	64.0	0.86 **d**	6.6 **ab**	271	5.69 **c**
	26	64.1	2.04 **e**	6.4 **a**	283	7.84 **d**
SEM		0.389	0.060	0.060	2.225	0.128
Source of variation				P		
Storage time		0.883	<0.001	0.373	0.500	<0.001
Storage temperature		0.517	<0.001	0.056	0.366	<0.001
Time x temperature		0.790	<0.001	0.289	0.724	<0.001

a-e: Different letters indicate significant differences between the means in each column.
* Loss (g) = (Fresh egg weight-Stored egg weight)

Dramatic decreases were observed in Haugh unit and albumen height by increasing storage time and temperature ($p < 0.001$). Haugh unit dropped from 81.5 to 68.2 at 5ºC temperature in 14 days storage, whereas at 26ºC storage temperature this drop has further extended from 74.6 to 24.0 (Table 2). These results are in agreement with those of Scott and Silversides (2000), who reported significant ($p < 0.05$) decreases from 9.16 to 4.75 mm in albumen height in 10 d of storage. Similar results were also demonstrated by other researchers (Walsh et al., 1995; Lapão et al., 1999; Samli et al., 2005; Bozkurt and Tekerli, 2009; Shin et al., 2012). Decrease in albumen height might be attributed to proteolysis of ovomucin, cleavage of disulfide bonds, interactions with lysozyme and changes in the interaction between α and β ovomucins(Silversides and Budgell, 2004).

Table 2. Effects of storage time and temperature on albumen quality

Storage time Day	Temperature °C	Haugh Unit	Height mm	pH	Electrical conductivity mS/cm
Fresh eggs		82.9 e	7.2 e	7.98 a	8.68 a
2	5	81.5 de	7.0 de	8.24 b	8.56 a
	26	74.6 d	6.0 d	8.50 c	8.64 a
7	5	78.7 de	6.5 de	8.64 cd	8.64 a
	26	54.5 b	3.9 b	9.18 d	8.73 a
14	5	68.2 c	5.2 c	8.62 cd	8.65 a
	26	24.0 a	2.0 a	9.31 d	9.00 b
SEM		0.142	0.165	0.044	0.019
Source of variation				P	
Storage time		<0.001	<0.001	<0.001	0.242
Storage temperature		<0.001	<0.001	<0.001	<0.001
Time x temperature		<0.001	<0.001	<0.001	0.058

a-e: Different letters indicate significant difference s between the means in each column

In this study results that, increases in albumen pH were observed with increased storage time and temperature ($p < 0.001$). pH values were extended from 7.98 in fresh eggs to 9.31 at 26°C in 14 days of storage.These findings are in agreement with the results reported by other researchers (Silversides and Villeneue, 1994; Lapão et al., 1999; Scott and Silversides, 2000; Samli et al., 2005; Shin et al., 2012). However, Walsh et al. (1995) reported that neither temperature nor storage time influenced in albumen pH. The increase in albumen pH during the storage might be related to the deterioration of albumen quality (Roberts, 2004).

In addition to these findings, significant ($p < 0.01$) changes occurred in electrical conductivity, depending on the increased temperature. Electrical conductivity was 8.68 in the fresh eggs, but it increased to 9.00 by increased storage temperature. This might be a proof of albumen deterioration due to being broken into small molecules by increasing storage temperature. The storage time x temperature interaction also affected egg weight loss, air cell size, Haugh unit, albumen height and pH ($p < 0.001$).

The decrease in albumen quality was clearly pronounced at 5 and 26ºC storage temperatures as the eggs from 2 to 14 days of storage time. Most of these changes in egg quality might be originated from water loss by evaporation through the pores in the shell and the escape of CO_2 from albumen (Hinton, 1968; Shenstone, 1968; Robinson, 1987; Keener et al., 2001).

In conclusion, the results of the present study suggested that Haugh unit, albumen pH and air cell size were the most important parameters greatly influenced by the storage period and storage temperature. However, parameters such as shell weight and electrical conductivity were only affected by storage temperature.

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