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The Effect of Storage Periods on the Internal and External Quality Characteristics of White and Brown-Shell Table Eggs in Saudi Arabia

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ABSTRACT

Background: The eggs of hens are an essential source of protein, a food that meets human needs and provides the body with amino acids, metallic elements and vitamins that promote its health. The research aims to study the influence of storage period and strain and the interaction between them on components and internal and external quality traits of commercially produced brown and white-shell eggs.

Methods: A total of 180 eggs were randomly collected from both types. It was kept for 0, 15 and 30 days at temperatures ranging from 5±2°C to a humidity level of 60%. All eggs were broken to measure the egg coefficient, egg weight, egg weight loss and depth of the air chamber. shell thickness, shell density, shell cleanliness, shell surface area, shell weight relative to shell area unit, egg specific density, Haugh unit values, yolk color, presence of flesh and blood spots, white weight, shell weight, yolk weight, shell integrity, white weight percentage, percentage of shell weight, yolk weight ratio and yolk weight ratio.

Result: White eggs weighed more than brown eggs and storage periods had a significant ($P<0.05$) effect on the Haugh unit, specific density, air chamber depth and shell thickness. It has a positive effect on shell density and shell weight for both brown and white-shelled eggs. The storage period also led to a significant increase in weight loss, a significant decrease in white, yolk and shell and significant changes in all parts of the egg because the shell color changed.

Key words: External egg quality, Human consumption, Internal egg quality, Layers strain, Storage period.

INTRODUCTION

The products of laying hens play an important role in meeting human nutritional needs that help them stay healthy (Alshaikhi *et al*., 2021). Eggs are a vital food source for humans because they contain animal protein, fats, mineral salts, essential amino acids, saturated fats, yeasts and enzymes that are only found in a few foods (Sahar and Rahman, 2018). It is both preventive and therapeutic (Zaheer 2015). Egg storage characteristics play a significant role in their acceptability to consumer preferences (Sapkota *et al*., 2020). As a result, eggs are a low-cost, low-calorie source of high-quality protein and other nutrients (Ruxton 2013; Zaheer 2015). Egg quality traits have been shown to be influenced by genotype and storage period (Anderson *et al*., 2004; Alsobayel and Albadry, 2011). External and internal egg quality characteristics, as is well known, have a genetic basis. Environmental factors such as the bird's age, feeding, season, temperature, transportation, storage period and heat exposure influence the qualitative, chemical, functional and microbial characteristics of table eggs. Although farm-produced eggs are of high quality, inefficient farm handling, storage and marketing practices may result in dropped egg quality (Al-Obaidi *et al*., 2011). The most significant alterations in internal or external egg quality during storage duration or handling practices are caused by weight loss due to water evaporation (Samli *et al*., 2005; Calik 2013), increased hydrogen power of albumen and yolk, decreased Haugh unit values and carbonic acid dissociation (Mohiti-Asli *et al*., 2008; Monira *et al*., 2003). Because the vitelline membrane is weak (Jones, 2007; Kralik *et al*., 2014), water moves from the albumen to the yolk through the vitelline membrane. This causes the changes.

Fresh eggs have the highest quality characteristics and specifications, but they begin to deteriorate and become corrupted over time as a result of storage and exposure to heat, drought, odors, pollution and other factors in the surrounding environment. Due to the damage, it sustains

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during production and marketing, it becomes inedible. Eggs are often made faster than they can be sold, so they have to be stored for as long as possible to keep their quality (Johanning *et al*., 1996; Aygun, 2014).

In Saudi Arabia, commercial table eggs are primarily sold in supermarkets, poultry markets and grocery stores. Saudi families buy eggs in trays of 30 eggs, keep them in the refrigerator for two to three weeks and consume them within two to three weeks. Meanwhile, there is little information available on the quality characteristics of locally produced commercial eggs. The current study sought to evaluate egg quality by examining internal and external characteristics as well as the effect of the storage period on commercial table eggs sold in Riyadh during the summer. So, a study was done to compare and evaluate the effect of storage time on the outside and inside quality of brown and white-shell eggs raised by commercial farmers in the Riyadh area and sold in the area.

MATERIALS AND METHODS

The location and experimental design

The research was conducted at King Saud University's Animal Production Department's experimental poultry research unit in Riyadh, Saudi Arabia. The trial ran during the spring months of "March-April 2019," with average temperatures ranging between 20.4°C and 33.4°C and average relative humidity of 28% in Riyadh in April. 320 brown and white shell eggs were purchased from the shops. The collected six fresh egg dishes, made up of two trays with 30 eggs each, were chosen three times at random intervals. 180 of the eggs had brown shells and 180 had white shells. Each species' eggs were divided into four groups, each containing 30 eggs and were stored for 0, 15 and 30 days at 3-5°C with an average humidity level of 60%. Each collection's eggs were separated into four groups, each with 20 eggs and each group served as a replicate. Each group of eggs was weighed separately to the nearest 0.01 g. Using a candling light and a thin plastic ruler, egg groups that had been stored for 15 and 30 days were reweighed. The depth of the egg air cell (AC) was then measured in millimeters for each replicate.

Evaluation of external egg quality characteristics

The different egg weight (EW)groups were individually weighed before storage to the nearest 0.01 g. Egg groups stored for 15 and 30 days to calculate the percentage of egg weight loss (WL), were reweighed and the depth of the air chamber (ACD) was measured in millimeters using a candling light and a thin plastic ruler and the egg test device for all of the eggs in each replicate. The shell cleanliness (CL) and whether it was free of any cracks or fractures were examined. The depth of the air chamber was measured using the inserted ruler and an egg test device, where the egg was placed with the device from its wide end and the air chamber appeared to be measured. Shell thickness (ST), shell density (SD), shell surface area (SA) and shell weight relative to shell area unit (SW USA). The specific density (SG) was calculated by immersing an egg in water to find out the amount of displaced water and finding the specific density from the following equation:

$$\text{Specific density (SG)} = \frac{\text{Egg weight in air}}{\text{Egg weight in air-weight in water}}$$

Calculating the egg's coefficient (EI) by measuring the length and width of the egg > (width/length) * 100.

Egg surface area (SA) in cm^2 was calculated for each egg using the following equation suggested by Nordstrom and Qusterhout (1982): SA = ¼ 3:9782 × egg weight $^{0:7056}$

$$\text{SD (g.cm-3)} = \frac{\text{Shell weight (g)}}{\text{Surface area, cm}^2} \times \text{Shell thickness, cm}$$

According to the following equation:

$$\text{SG} = \frac{\text{Weight of air}}{\text{Difference between the weight of air and water}}$$

(North and Bell, 1990).

Evaluation of internal egg quality characteristics

After each replicate of each eggshell color is broken out, the eggs are placed on a special glass table with a mirror on the bottom that allows us to see the contents of the egg inside from above and below. The contents of the inner egg were examined for the following: the presence or absence of meat (MS) and blood (BS) spots optically. Measuring was done by the degree of yolk color (YC) using the Roch Color Scale (Hoover Man La Roche), which is graded to the degrees of yellow of 1-15 color gradations from very pale to deep yellow (North and Bell, 1990). measured the Haugh unit (HU) by using the Haw device (Haugh, 1937), where we measure the height of the heavy whites at a distance of half a centimeter from the yolks. were directly determined using a micrometer that is adjustable to egg weight and gives the Haugh unit value (USDA, 2000). The yolk has been isolated from the white with a special funnel and then weighed on the scale after completely stripping it of any traces of whiteness, giving the yolk weight (g). The shell was carefully cleaned to get rid of the albumen, dried for 24 hours at 21–24°C and then weighed (SW) to the nearest gram, 0.1 g. Three measurements of shell thickness (ST) in mm 10 were taken in the middle and on both sides of each egg with membrane using a dial touch micrometer. The qualitative characteristics of eggs were estimated using the following formulas:

Weight of the egg = Weight of the egg after storage - (Yolk weight + Shell weight).

$$\text{Yolk indicator} = \frac{\text{Yolk height (mm)}}{\text{Yolk diameter (mm)}}$$

$$\text{Yolk percentage} = \frac{\text{Yolk weight (g)}}{\text{Egg weight}} * 100$$

$$\text{Albumin ratio} = \frac{\text{Weight of albumen (gm)}}{\text{Weight of eggs}} * 100$$

$$\text{Yolk/albumin} = \frac{\text{Yolk weight (g)}}{\text{Weight of albums (g)}} * 100$$

Haugh unit = 100 leu (e + 7.57-1.7 f-37).

Statistical analysis

The data were statistically analyzed using the SAS software (2005) to verify the presence of significant differences between the average levels of each factor and the capacity to overlap between the researched features for each strain, using the following statistical model:

$$Y_{ijk} = \mu + B_i + S_j + BS_{ij} + e_{ijk}$$

Where,

Y_{ijk} is the individual observation,

u is the general mean,

B_i is the main effect of the i^{th} breed,

S_j is the main effect of the th storage period,

BS_{ij} is the Interaction effect between breed and storage period,

e_{ijk} is a random error.

RESULTS AND DISCUSSION

The findings also indicated that longer storage periods resulted in a faster rate of change in trait scores. The study showed that ten, twenty and thirty days of storage duration resulted in a significant ($p \leq 0.05$) decrease in Haugh unit values, yolk weight ratio, specific density, shell thickness and shell weight per unit of surface area, as well as an increase in yolk color grade, yolk albumin ratio and air cell depth; however, shape index and shell density were unaffected by storage length (Alsobayel and Albadry, 2011; Alshaikhi *et al*., 2021). Similar storage length effects were reported by several researchers for Haugh unit values and the yolk index. The specific density and air cell depth (Samli *et al*., 2005; Alsobayel and Albadry, 2011) and shell thickness (Khatun *et al*., 2016; Monira *et al*., 2003). Contrary to our findings, other researchers claimed that the storage time had no bearing on the yolk color grade, yolk albumin ratio, shell thickness, or shell surface area (Alsobayel and Albadry, 2011; Khatun *et al*., 2016; Yildirim, 2017; Stoji and Peri, 2018). In addition, according to some researchers, increasing the storage duration resulted in a significant increase in shell density, shell thickness and shell weight per unit of surface area (Lee *et al*., 2016; Alsobayel and Albadry, 2011), as well as a decrease in yolk color grade (Kralik *et al*., 2014; Drabik *et al*., 2018).

In Table 1, there are significant differences in weight between brown eggs and white-shell eggs, as well as between yolk weight and white weight and shell weight. We did not notice significant differences between the ratio of yolk (0.43) to whiteness (0.42) and the amount of loss in egg weight (0.57), (1.11), brown and white. Storage had an effect on the weight of the yolk and white and the ratio of yolk and albumin between brown eggs and white-shell with an increase in the storage period, while there was no effect on the weight of eggs, the amount of loss and the weight of the shell, as we note that the interaction had no effect on the previously mentioned traits except for the weight of the egg. (Cunningham *et al*., 1960; Attia *et al*., 2014) noted that the proportion of albumin in large eggs was higher than that in small eggs. Previous research discovered statistically significant differences in these parameters between breeds and strains (Silverides and Scott, 2001; Zeta *et al*., 2009). As it turned out, increasing the storage period significantly reduces the percentage of albumen while increasing the percentage of yolk (Akyurek and Okur, 2009; Aygun, 2014). Although there are statistically significant differences between eggs of all breeds that were stored for different periods in the above-mentioned percentages, there is no interaction between strain and storage period. This was not revealed at a significant level in all percentages mentioned in the study. This result is confirmed by Scott and Silversides (2000), who reported that there was no significant effect of the interaction between strains and storage period on the studied traits.

The average egg weight was 61.41 g in brown-shelled eggs and 56.63 in white-shelled eggs as in (Table 1) and it was heavier than that found in a previous study in Iraq (Al-Nedawi, 2006). The eggs produced by Brown outperformed significantly ($p<0.01$) those produced by White Lohmann. This confirmed result was found earlier by Hassanin (1990). local Iraqi chickens and compared with some imported breeds, as well as those studied using several breeds (Monira *et al*., 2003; Zita *et al*., 2009).

Table 1: Effect of breed and egg storage period on egg parameter, egg weight (EW), egg weight loss (EWL), Albumen weight (AW), Yellow weight (YW), Shell weight (SW) and (YW/AW) of brown (B) and white (W) shelled eggs marketed in Riyadh region.

	EW (gm)	EWL (gm)	WY (gm)	AW (gm)	SW (gm)	YW/AW (gm)
B	61.41a	0.57	16.59	38.42a	5.87a	0.43
w	56.63a	1.10	15.31b	34.72a	5.48b	0.42
G	**	NS	**	**	**	NS
S.P.d (s)	NS	**	**	**	NS	**
00	58.99	0.00	14.76c	38.66a	5.62	0.38
15	58.86	0.26	16.23b	35.53B	5.59	0.43
30	59.21	0.87	16.86a	35.51B	5.72	0.48
G*S	NS	NS	NS	**	NS	NS
SEM	±0.126	±0.318	±0.092	±0.333	±0.037	±0.007

(S.P.D); Storage period in days, (W); White, (B); Brown, (G); Genotype.

NS: Non-significant. Means in the same column with different superscripts differ significantly (P<.05). ** Highly significant (P<.01).

In Table 2, egg weight decreased significantly as storage time increased from 0, 15 and 30 days (Table 2). Also, according to Meijerhof (1994), no appreciable effect of the storage period on egg weight was found. Therefore, we note that storage has a significant effect on white eggs and brown shells in the percentage of egg weight loss, the percentage of the yolk weight, the percentage of the weight of the white and the percentage of the weight of the shell. It was also found that the storage period had an effect on all the above-mentioned traits except for the percentage of egg weight loss. The interaction did not have any effect on all traits.

In Table 3, it shows that there are significant differences between white and brown eggshells in HU units, yolk color (YC), shell integrity (BR), presence of flesh and blood spots (MS, BS) and cleanliness of the shell. As we note that storage has an effect on Howe units, as it was found to decrease as the storage period increased, as well as the presence of blood spots in the color of the yolk, which increases with the length of the storage period and the storage period did not have any effect or significant differences for the rest of the characteristics, as it turned out that the interaction model predicted that the significant effects of haw unit and yolk color had no effect on shell cleanliness (CL), shell integrity (BR) and the presence of flesh and blood spots (MS, BS). This result was inconsistent with that found before (Samil *et al*., 2005), who claimed that the interaction between strain and storage period did not affect egg weight significantly. The mean HUF is 0.173, as claimed by many researchers (Stadelman and Cotterill, 1995; Siyar and Ashori, 2007). The HOF measurement unit in this study had a significant effect (P<0.01) for the strains (71,40) (75,30) brown and white, respectively. HU, measurement of Issa Brown (83) and it was similar to its value measured in White Livorno, University of Baghdad (Al-Nedawi, 2006). While the value of white leghorn is close to that found before (Monira *et al*., 2003) and (Scott and Silversides, 2000). HU severity decreased significantly (P<0.01) from 79.40 in zero days of storage to 75.30 and 28.47 in 15 and 30 days of storage (Table 3). Earlier, the study reported that increasing the storage period significantly decreased the Hof unit in different breeds (Akyurek and Okur, 2009). The interaction between the strain and storage period affected the Hof unit significantly (P<0.01). The Hof unit gradually decreased in storage temperature. The longer the storage period (P<0.05) (Alsobayel and Albadry, 2011; Aygun, 2014).

In Table 4, it shows that there are no significant differences between brown eggs and white-shell eggs in the percentage of egg weight, egg weight loss, egg weight

Table 2: Effect of strain genotype and storage period on egg weight (EW), shell thickness (ST), egg surface area (SA), shell density (SD), shell weight per unit of surface area (SWUSA), specific gravity (SG), air cell depth (AC) and shape index (SI) of brown (B) and white (W) shelled eggs marketed in Riyadh region.

	EW (gm)	ST (mm × 10)	SA (sm)^2	SD (gm/cm)^3	SWUSA (mg/cm)^3	SG AC (mm)		EI (gm)
G	NS	NS	**	**	**	**	**	**
B	61.41	3.39	72.20a	2.07 a	81.32a	1.07 b	3.62 b	78.41 a
W	56.63	3.95	67.47 b	2.04 b	80.25 b	1.08 a	3.10 a	76.05 b
S.P.d (s)	NS	NS	NS	NS	NS	**	**	**
00	58.99	3.90	70.63	2.01	79.60	1.09 b	2.63 a	78.08 a
15	58.86	3.96	68.98	2.02	80.49	1.08 B	2.20 B	76.51 b
30	59.21	3.95	68.88	2.10	81.82	1.07 C	4.25c	77.10 ab
G*S	NS	NS	NS	NS	NS	NS	NS	NS
SEM	±0.007	±0.002	±0.002	±0.393	±0.081	±0.487	±0.001	0.035

(S.P.D); Storage period in days, (W); White, (B); Brown, (G); Genotype.

NS: Non-significant. Means in the same column with different superscripts differ significantly (P<.05). ** Highly significant (P<.01).

Table 3: Effect of genotype and storage period on Haugh unit values (HU), blood (BS) and meat (MS) spots percent, shell cleanliness (CL), Broken and yolk color grades (YC) of brown (B) and white (W) shell eggs marketed in Riyadh region.

	HU	BS	MS	YC	CL	Broken
G	**	**	**	**	NS	**
B	71.40b	0.34 a	0.21 a	6.91 a	0.01	0.02
W	75.30 a	0.01	0.08 b	5.07 b	0.05	0.11
S.P.d (s)	**	**	NS	**	NS	NS
00	79.83 a	0.27 a	0.20	5.77 c	0.07	0.05
15	71.75 b	0.15 ab	0.06	5.98 b	0.03	0.08
30	68.47 c	0.12 b	0.17	6.22 a	0.00	0.07
G*S	**	NS	NS	**	NS	NS
SEM	±0.173	±0.025	±0.026	±0.026	±0.013	±0.019

(S.P.D); Storage period in days, (W); White, (B); Brown, (G); Genotype.

NS: Non-significant. Means in the same column with different superscripts differ significantly (P<0.05). ** Highly significant (P<0.01).

Table 4: Effect of breed and egg storage period on egg weight percentage, egg weight loss, egg weight percentage and shell weight percentage. Egg weight ratio (EWL), egg weight loss (YW), egg weight ratio (AW) and shell weight ratio (SW).

	EWL (%)	YW (%)	AW (%)	SW (%)
G	NS	NS	NS	G
B	9.63	27.27	63.09	9.65
w	1.94	27.31	62.94	9.75
SPDs	**	**	**	**
00	0.00	25.00	65.41	9.54
15	0.43	27.83	62.44	9.73
30	1.45	29.04	61.11	9.84
G*S	NS	NS	NS	NS
SEM	±0.552	±0.150	±0.152	±0.058

SPDs- Storage period in days, W- White, B- Brown, G- Genotype. NS: Non-significant. Means in the same column with different superscripts differ significantly ($P<0.05$). **Highly significant ($P<0.01$).

percentage and shell weight percentage. And it has a significant effect on the storage period, with an increase in the storage period of 0, 15 and 30 days. There is no effect of interference (G*S) on the studied traits in the table. Several studies (Scott and Silversides, 2000; Silversides and Scott, 2001; Hermiz *et al*., 2012) found a statistically significant relationship between egg weight and its components. These variations may result from genetic variables such as a distinct breed, environmental modifications made while the herd was being raised, the age of the chickens, dietary disparities, egg size and heat stress. Also, poor handling of eggs on the farm, poor marketing channels while transporting them to the market and poor storage methods play an important role in maintaining the characteristics of eggs.

CONCLUSION

We conclude from the study that storage duration, strain and temperature significantly affect the quality characteristics of marketed table eggs. Furthermore, brown and white eggs stored for 30 days at 52°C and 50-75% relative humidity retain internal quality characteristics and are relatively safe for human consumption. We recommend storing eggs in their original carton, which will protect their fragile shell, counteract the drying effects of refrigeration and prevent odors. Do not exceed 35 days. Also, cook eggs to 160 degrees Fahrenheit to kill salmonella or other bacteria. Using pasteurized eggs eliminates the risk of disease transmission.

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