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Effects of Shrink Film, Extended Storage and Temperature on External and Internal Table Egg Quality

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Abstract: This study was conducted to investigate effects of shrink film treatment as a covering material (*plastic shrink film or without*), extended storage (*5, 10, 15 or 20 d*) and temperature (*room or refrigerator*) and on internal and external table egg quality. Freshly laid eggs (n:480) were collected, randomized, weighed, pointed out numerically and divided into four groups of 120 eggs to test the length of egg storage treatments for 5, 10, 15 or 20 d. Eggs in each egg storage treatment group were randomized and allocated into two groups (with or without shrink film) of 60 eggs to test the effect of covering material. Then, eggs were stored at room (18-20 °C) or refrigeration (4-6 °C) temperature conditions. Significant differences were observed for all internal and external egg quality traits related with the length of storage time and temperature. The internal quality worsened by the prolonged storage particularly when the eggs were stored at room temperature. Shrink film treatment were significantly affected egg weight loss during storage and yolk index. As conclusion, table eggs should be storage in refrigeration temperatüre with shrink film and shorter time as soon as possible to improve food safety.

Key Words: Storage time, shrink film, storage temperature, egg quality.

Shrink film, Depolama Süresi ve Sıcaklığının Sofralık Yumurtalarda İç ve Dış Kalite Üzerine Etkileri

Özet: Bu çalışma polietilen shrink film, depolama süresi uzunluğu (5, 10, 15 ve 20 gün) ile depolama sıcaklığının, oda (18-20°C) veya buzdolabında (4-6°C), sofralık yumurtalarda iç ve dış kalite üzerine etkilerini incelemek amacı ile yapılmıştır. Günlük yaşta 480 adet yumurta numaralanıp tartılarak rastgele her birinde eşit sayıda yumurta yer alacak şekilde dört farklı depolama grubuna dağıtılmıştır. Her depolama grubundaki yumurtaların yarısı shrink film ile ambalajlanarak, yarısı ise ambalajlanmadan oda ve buzdolabı sıcaklığında depolanmışlardır. Çalışmada depolama süresi ve sıcaklığının incelenen tüm iç ve dış kalite özellikleri üzerine etkisi önemli bulunmuştur. Oda sıcaklığında depolanan yumurtalarda iç kalite özellikleri depolama süresinin uzaması ile giderek kötüleşmiştir. Shrink film uygulaması depolama süresince ağırlık kaybı ve sarı indeksi üzerine önemli düzeyde etkili bulunmuştur. Çalışmada gıda güvenliği açısından sofralık yumurtaların polietilen shrink film ile ambalajlanmış olarak buzdolabı sıcaklığında mümkün olduğu kadar kısa süreli depolanarak tüketime sunulması gerektiği sonucuna ulaşılmıştır.

Anahtar Sözcükler: Depolama süresi, shrink film, depolama sıcaklığı, yumurta kalitesi.

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Introduction

Packaging of the eggs is a critical point in the logistic chain of table eggs[1]. It protects the eggs from micro-organisms and natural predators; prevents loss of moisture; protects from temperatures that cause deterioration and possible crushing during handling storage and transportation. There are many different types of egg packages which vary both in design and packaging material used and many factors must be taken into consideration for packaging the eggs. Proper storage temperature and length are very critical factor for shelf life of eggs[2,3]. Interior egg quality was deteriorated by the length of storage[4,5]. The major factor in determining albumen height is egg storage time and conditions[6,7].

Carton egg trays are commonly used by the Turkish egg producers and covering these cases by a plastic shrink material before marketing became mandatory after the last avian flu epidemics. But, there are no clear findings about the effects of covering carton egg trays by shrink material on egg quality and shelf life at the marketing process. It was important; if packaging system consisted of cardboard (egg trays) with shrink wraps would improve the shelf life of eggs. Thus, the objectives of this study were conducted to investigate effects of shrink film treatment as a covering material, extended storage and temperature on internal and external table egg quality.

Materials and Methods

In the experiment; freshly laid day old white 480 table eggs produced by hens at 40 week of age in Research and Experimental Farm at the Faculty of Veterinary Medicine, in Bursa, in Turkey were collected, randomized, weighed, pointed out numerically and divided into four groups of 120 eggs to test the length of egg storage treatments for 5, 10, 15 or 20 d. Eggs in each egg storage treatment group were allocated into two groups of 60 eggs to test the effect of cover with polyethylene shrink film or without. A manual shrink wrap machine was used to wrapped the eggs under 250 C^o temperatures for 4 second (exposure time). Then, eggs were stored at room (18-20 C^o) or refrigeration (4-6 C^o) temperature conditions with 60 % RH until the sampling time. Thus, 16 experimental groups with 30 eggs each were constituted of this study. Eggs in each experimental group were divided three replicates with ten eggs each.

Eggs were weighed at the beginning of experiment and end of the storage. Each egg was measured with a tripod micrometer, and the shape index (SI) was calculated according to the formula: SI = (height/width) × 100 (Quintana-Lo´pez, 1999). Shell strength was measured using a cantilever system by applying increased pressure to the broad pole of the shell[8] and recorded in Newton (N) force required to crack the shell surface. After all eggs were broken on to a flat surface, the height and width of both albumen and yolk was measured with a tripod micrometer. The height of the albumen midway between the yolk and the edge of the thick albumen was measured to the nearest 0.1 mm with a tripod micrometer. The shell with the shell membranes was washed in warm water and allowed to dry at room temperature overnight; eggshell thickness was then determined using a micrometer. Haugh units were calculated using the formula. The color of the yolk was determined using the DSM color fan[9]. Shell thickness (without inner and outer shell membranes; membranes were removed manually) was measured at three areas (broad end, middle portion and narrow end of the shell), by using a micrometer (mitutoyo®, 0.01-20 mm, Japan). The albumen and yolk index was determined as the ratio of the yolk and albumen height to the yolk and albumen width, respectively. Haugh unit was calculated from the records of albumen height and egg weight using following formula[10,11]:

$$HU = 100.\text{Log}\,(H - 1.7W^{0.37} + 7.6)$$

Where,

HU= Haugh unit H=Albumen height (mm)

W =Egg weight (g)

All data were analyzed using ANOVA test procedure of SPSS version 13.00[12]. Mean separation was performed using the Duncan test[13]. Length of storage duration, storage temperature and covering treatment were the main effect.

Results

External egg quality traits in the groups are presented in Table 1. There were significant differences for the egg weight losses due to main effects of storage time, temperature and packaging treatment ($P < 0.05$, $P < 0.05$, $P < 0.044$). Shell thickness was affected significantly by main effect of storage time ($P < 0.001$).

There was a significant difference for the egg-shell destruction strength between the storage temperature groups ($P < 0.047$). Internal egg quality traits in the main groups are shown in Table 2. Storage time and temperature affected Haugh unit, yolk color, yolk and albumen index of eggs ($P < 0.001$). It was found that significant effect of packaging treatment (shrink film) on yolk index ($P < 0.010$). In this study, storage time x packaging and storage time x storage temperature x packaging interactions for shell thickness were found significant ($P < 0.001$, $P < 0.015$). There were a significant storage time x temperature interactions for Haugh unit, yolk colour and yolk index ($P < 0.040$, $P < 0.003$, $P < 0.001$) and a significant storage time x packaging treatment for yolk index ($P < 0.039$).

Table 1: Effect of shrink film, storage time and temperature on external egg quality traits.

Tablo 1: Shrink film, depolama süresi ve sıcaklığın yumurta dış kalite özellikleri üzerine etkisi.

Groups/Parameter	Fresh egg weight	Egg weight loss (%)	Shape index	Shell thickness (mm x 10^{-2})	Eggshell destruction strength (N)
0 (control)	68.54 ± 1.13	-	72.33±0.60	33.15±0.56	32.36±1.85
Storage time, day					
5	69.72 ± 0.61	0.68	72.66 ± 0.44	32.90 ± 0.24 ^{b}	32.80 ± 0.96
10	69.25 ± 0.59	1.11	73.00 ± 0.43	34.34 ± 0.21 ^{a}	32.84 ± 0.97
15	69.91 ± 0.62	1.82	72.06 ± 0.39	32.93 ± 0.21 ^{b}	33.90 ± 0.97
20	69.18 ± 0.60	1.89	71.50 ± 0.40	33.48 ± 0.19 ^{b}	35.76 ± 0.96
Storage temperature					
Refrigeration	69.74 ± 0.43	0.93	72.08 ± 0.32	33.35 ± 0.17	32.91 ± 0.69
Room	69.28 ± 0.44	1.82	72.41 ± 0.30	33.48 ± 0.18	34.74 ± 0.66
Shrink film					
Egg tray with wrapped shrink film	69.44 ± 0.46	1.02	72.33 ± 0.32	33.27 ± 0.17	33.93 ± 0.66
Egg tray without wrapped shrink film	69.58 ± 0.45	1.73	72.18 ± 0.30	33.57 ± 0.20	33.73 ± 0.70
ANOVA					
Storage Time	0.787	0.050	0.798	0.001	0.077
Storage Temperature	0.439	0.050	0.450	0.579	0.047
Shrink Film	0.814	0.044	0.256	0.191	0.823
Time x Temperature	0.383	0.546	0.275	0.804	0.174
Time x Shrink Film	0.296	0.351	0.604	0.001	0.770
Temperature x Shrink Film	0.821	0.968	0.321	0.587	0.332
Time x Temperature x Shrink Film	0.680	0.840	0.315	0.015	0.908
SEM	0.300	0.298	0.222	0.117	0.457

a-b: within columns, values with different superscript letters differ significantly.
*Mean ± S.E.

Table 2: Internal egg quality traits in the main groups.

Tablo 2: Denemede yer alan ana gruplarda yumurta iç kalite özellikleri

Groups/Parameter	Haugh Unit	Yolk color	Yolk index (%)	Albumen index (%)
0 (control)	84.89±1.56	11.06±0.22	42.40±0.80	9.94±0.44
Storage time, day				
5	75.75 ± 1.32^{a}	11.42 ± 0.16^{a}	42.43 ± 0.44^{a}	7.57 ± 0.19 ^{a}
10	67.94 ± 1.32^{b}	10.77 ± 0.15^{bc}	41.88 ± 0.45^{ab}	6.03 ± 0.17^{b}
15	66.67 ± 1.33 ^{b}	10.90 ± 0.14^{b}	40.70 ± 0.44$^{b\,c}$	5.70 ± 0.19^{b}
20	59.47 ± 1.30 ^{c}	10.75 ± 0.14^{c}	38.73 ± 0.46^{c}	4.90 ± 0.41^{c}
Storage temperature				
Refrigeration	62.38 ± 0.99	11.10 ± 0.12	44.82 ± 0.31	6.96 ± 0.14
Room	60.89 ± 0.98	10.82 ± 0.13	37.05 ± 0.32	5.09 ± 0.22
Shrink Film				
Egg tray with wrapped shrink film	67.50 ± 0.93	10.99 ± 0.10	41.51 ± 0.33	6.10 ± 0.14
Egg tray without wrapped shrink film	67.62 ± 0.99	10.93 ± 0.13	40.36 ± 0.32	6.06 ± 0.23
ANOVA				
Storage Time	0.001	0.001	0.001	0.001
Storage Temperature	0.001	0.001	0.001	0.001
Shrink Film	0.430	0.428	0.010	0.114
Time x Temperature	0.040	0.003	0.001	0.135
Time x Shrink Film	0.566	0.091	0.039	0.845
Temperature x Shrink Film	0.087	0.428	0.780	0.124
Time x Temperature x Shrink Film	0.743	0.246	0.148	0.622
SEM	0.682	0.042	0.222	0.095

a-c: within columns, values with different superscript letters differ significantly.
*Mean ± S.E.M

Discussion

In this study; shrink film treatment, length of storage time and storage temperature for the table eggs were significantly affected weight loss during storage. Compare to fresh egg, egg weight losses in groups of longer storage time, room temperature and without shrink film were found to be significantly greater ($P < 0.05$). Especially, clear differences were determined in 20 day storage in room temperature without shrink film treatment (Table 3). Shape index of eggs no significantly affected by all the main factors investigated in this experiment and all interactions between the main factors for the shape index were found to be not significant. Although egg shape index was not a good estimator of shell thickness it could be used as a criterion for determining the stiffness of eggshell[14]. Also, there was a significant negative correlation between shape index and albumen height[15]. Shape index and shell thickness affect the proportion of damaged eggs during handling and transport[16]. In this experiment, shell thickness of the eggs only affected by the storage time and storage time x shrink film interaction was found significant ($P < 0.001$). The significant storage time x shrink film interaction for shell thickness of eggs revealed that shrink film improved quality of eggs in 5 and 10 d storage and no longer storage (Table 3). In this study, eggshell destruction strength was found superior in eggs storage in room temperature conditions ($P < 0.047$). As reported previously by Jones and Musgrove[17] no differences were detected for shell strength with extended storage. This finding is similar for packaging treatment and shrink film treatment. Shell strength might play in affecting external *Salmonella Enteritidis* contamination of egg contents[18] and it is correlated with shape index. Concurrent with the findings of Carter[19] and Altuntas and Sekeroglu[20], the greatest force needed to rupture eggs was found in eggs with high shape index values.

Egg shell and yolk colour has always received more attention from the consumer than the other components of the eggs. Yolk and albumen of the eggs having different commercial values are used for different markets, and the proportion of yolk and albumen is largely determined by the age and strain of layer[21]. The percentage of albumen and yolk is important to the egg breaking industry, with the yolk being more valuable. Egg yolk from a newly laid egg is round and firm. As the egg gets older, the yolk absorbs water from the egg white, increasing its size. This produces an enlargement and weakness of the vitelline membrane; the yolk

Table 3: External and internal egg quality traits in the interactive groups.

Tablo 3: Denemede yer alan interaktif gruplarda yumurta iç ve dış kalite özellikleri

Groups/Parameter	Pre-storage Egg Weight	Egg weight loss (%)	Shape index	Shell thickness (mm x 10^{-2})	Eggshell destruction strength (N)	Haugh Unit	Yolk color	Yolk index (%)	Albumen index (%)
5d – RT – SF	69.6 ± 1.20	0.17	73.2 ± 0.89	32.5 ± 0.47	31.3 ± 1.83	82.6 ± 2.64	11.6 ± 0.17	46.1 ± 0.89	8.7 ± 0.37
5d – RT - without SF	70.9 ± 1.19	0.97	72.3 ± 0.89	33.6 ± 0.46	30.8 ± 1.80	82.4 ± 2.56	11.3 ± 0.16	42.9 ± 0/91	8.6 ± 0.41
5d - room T - SF	69.6 ± 1.21	0.50	72.3 ± 0.90	33.3 ± 0.46	33.6 ± 1.81	72.8 ± 2.61	11.7 ± 0.18	41.9 ± 0/88	7.1 ± 0.38
5d - room T - without SF	68.9 ± 1.20	1.09	72.9 ± 0.85	32.3 ± 0.48	35.6 ± 1.82	65.2 ± 2.63	11.1 ± 0.19	38.8 ± 0/88	6.0 ± 0.39
10d – RT – SF	70.7 ± 1.20	0.51	71.7 ± 0.91	35.0 ± 0.44	32.1 ± 1.79	71.4 ± 2.59	11.0 ± 0.17	45.6 ± 0.91	6.6 ± 0/38
10d – RT - without SF	69.5 ± 1.19	1.25	72.6 ± 0.88	33.4 ± 0.45	29.4 ± 1.89	73.8 ± 2.60	11.0 ± 0.19	44.8 ± 0.87	6.9 ± 0.36
10d - room T - SF	68.5 ± 1.22	0.87	73.7 ± 0.87	34.5 ± 0.49	35.3 ± 1.86	65.3 ± 2.62	10.5 ± 0.18	39.4 ± 0.88	5.6 ± 0.39
10d - room T - without SF	68.3 ± 1.19	1.81	73.0 ± 0.81	34.4 ± 0.44	34.5 ± 1.84	61.3 ± 2.64	10.6 ± 0.19	37.7 ± 0.89	5.1 ± 0.40
15d – RT – SF	70.5 ± 1.20	0.59	72.0 ± 0.89	32.4 ± 0.48	34.2 ± 1.87	68.9 ± 2.66	11.2 ± 0.20	45.9 ± 0.90	6.5 ± 0.38
15d – RT - without SF	69.5 ± 1.20	1.38	71.5 ± 0.90	33.3 ± 0.46	34.2 ± 1.88	71.2 ± 2.59	11.5 ± 0.21	45.5 ± 0/91	6.3 ± 0.39
15d - room T - SF	70.3 ± 1.19	2.54	73.0 ± 0.85	31.7 ± 0/49	33.9 ± 1.89	60.7 ± 2.61	10.6 ± 0.19	36.9 ± 0.86	4.4 ± 0.39
15d - room T - without SF	69.3 ± 1.20	2.76	71.8 ± 0.87	34.3 ± 0.48	33.3 ± 1.90	65.9 ± 2.63	10.3 ± 0.18	35.3 ± 0.91	5.5 ± 0.40
20d – RT – SF	68.2 ± 1.21	1.33	72.2 ± 0.88	33.2 ± 0.49	36.2 ± 1.88	68.1 ± 2.64	11.3 ± 0.19	44.9 ± 0.88	6.1 ± 0.41
20d – RT - without SF	69.1 ± 1.19	1.26	71.3 ± 0.87	33.5 ± 0.45	35.1 ± 1.89	68.8 ± 2.65	11.3 ± 0.18	43.5 ± 0.89	6.1 ± 0.39
20d - room T - SF	68.3 ± 1.21	1.61	70.6 ± 0.90	33.5 ± 0.47	34.9 ± 1.90	50,3 ± 2.66	10.8 ± 0.19	32.2 ± 0.86	3.9 ± 0.40
20d - room T- without SF	71.2 ± 1.21	3.37	72.0 ± 0.91	33.7 ± 0.46	36.9 ± 1.91	50.7 ± 2.63	11.0 ± 0.21	34.4 ± 0.87	3.6 ± 0.41

RT: refrigeration temperature, **SF**: Shrink Film, Room **T**: Room Temperature

looks flat and shows spots. However, the chemical composition of the egg's yolk and white do not change much. The major factor in determining albumen quality is egg storage time and conditions[7].

In this study, as reported previously[3,22-24] extended storage led to decreases in Haugh unit, albumen and yolk index. The decrease in internal egg quality is due to the loss of water and CO_2.[25]. The shrink film treatment reduced water loss. Albumen height is often used as a quality parameter to indicate that the egg is old or has been stored wrongly. But, the characteristics of albumen are not the only measure of egg quality. A newly laid egg has an albumen height of 5-8 mm and this variation is highly heritable. Eggs stored for 7 days or more reduces part of the albumen's stability to form a gel and therefore the height will be lowered to 50 to 75% of its original height even the storage temperature has been correct[26]. In concurrent with findings of Miles and Henry[27] eggs stored in room conditions had poorer albumen quality than those stored refrigeration temperature. As reported previously2 yolk and albumen index was decreased in room temperature conditions. Average yolk index value of eggs wrapped shrink film was found to be greater than eggs without shrink film. In this study, the Haugh Unit measurements averaged 75.75 at 5 d storage time group and 59.47 at 20 d storage time group. Haugh Unit values significantly decreased 1.49 units with increased storage temperature. This is consistent with the findings of Keener et al.[28]. Wrapping with plastic shrink film of eggs do not affect Haugh Unit values. The results of a previous study suggested that Haugh unit of albumen, influenced by the storage period and storage temperature in laying hens and extension of the storage time up to 10 d and temperature up to 29°C resulted in significant deterioration of egg quality[29]. Kirunda and McKee[30] found that aged eggs had lower Haugh units and yolk index compared to fresh eggs. Although previously reported[31] that packaging eggs with shrink film reduced the internal quality losses resulted from prolonged storage, all traits measured in the experiment, except for egg weight loss and yolk index were not affected by shrink film treatment. In this study, interactive effects between storage time and temperature were also significant for egg weight loss, Haugh unit and albumen height. In general, egg quality declined more rapidly in eggs stored at room temperature than in the refrigeration temperature. Kamel et al.[32] reported that shelf-life of egg stored at or below 25°C can be extended significantly. Chen et al.[33] reported that low-temperature storage had a significant impact on the safety and overall quality of the eggs. El-Sheikh and Younis[25] reported that the shelf life continued through 21 or 28 days of storage for older and younger hen's eggs according to microbial contents of egg, respectively.

As a conclusion; table eggs should be storage in refrigeration temperature with shrink film and shorter time as soon as possible. Shrink film help prevent extensive moisture loss from the eggs and it could be contribute to long term shelf-life. As suggesting by The US Food and Drug Administration[34] it should be buying only eggs if they are sold from a refrigerator or refrigerated case for improves egg safety.

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