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Effect of Rearing Systems and Shell Color on Some Egg Quality Parameters

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Abstract: This study was conducted to determine some quality parameters of retail brown and white-shelled grade A table eggs, which were produced by cage, free-range and organic systems.

For this, a total of 30 eggs, 10 from each rearing system, and 15 from each shell color were purchased, and egg weight, shape index, shell thickness, shell strength, and yolk color as outer and inner quality parameters were determined.

The heaviest eggs were from cage system (65.04 g), and shape index and shell strength were the highest in organic eggs (78.37% and 41.02 N/cm^2), while shell thickness was the lowest in free-range eggs (0.40 mm), and yolk color was the lightest in organic and free-range eggs (10 and 10.40). Additionally, brown eggs had higher values than white eggs in all of the parameters tested. Statistical analyses revealed that rearing systems have effect on shell thickness; while shell color has effect on both shell thickness and shape index ($p<0.05$).

In conclusion, contrary to the consumer prejudice, retail eggs from different rearing systems do not exhibit significant differences on some quality parameters tested.
Key Words: Rearing systems, layer hen, egg quality parameters.

Yetiştirme Sistemleri ve Kabuk Renginin Bazı Yumurta Kalite Parametrelerine Etkisi

Özet: Bu çalışma, perakende satış yerlerinde satışa sunulan kafes, serbest dolaşımlı ve organik yetiştirme sistemleri ile üretilmiş kahverengi ve beyaz kabuklu yumurtaların bazı yumurta kalite özelliklerinin belirlenmesi amacı ile yapıldı.

Bu amaçla, farklı firmalara ait her bir yetiştirme sisteminden 10'ar adet ve her bir kabuk renginden 15'er adet olmak üzere satın alınan toplam 30 adet yumurtanın, dış ve iç kalite özelliklerinden yumurta ağırlığı, şekil indeksi, kabuk kalınlığı, kabuk direnci ve yumurta sarı rengi belirlendi.

İncelenen özelliklerden yumurta ağırlığı kafes sistemindeki yumurtalarda en yüksek (65.04 g), şekil indeksi ve kabuk direnci organik yumurtalarda daha yüksek (% 78.37 ve 41.02 N/cm^2) bulunurken kabuk kalınlığı serbest dolaşımlı yumurtalarda en düşük (0.40 mm) sarı rengi organik ve serbest dolaşımlı yumurtalarda düşük değerlerde saptandı (10 ve 10.40). Ayrıca kahverengi yumurtaların beyaz yumurtalara göre incelenen tüm özellikler bakımından daha yüksek değerlerde olduğu tespit edildi. Yapılan istatistiksel analizler sonrasında, yetiştirme sistemlerinin kabuk kalınlığı üzerine, kabuk renginin ise hem kabuk kalınlığı hem de şekil indeksi üzerine olan etkisinin önemli olduğu saptandı ($p<0.05$).

Çalışmanın sonucunda, tüketicilerin önyargılarının aksine farklı yetiştirme sistemlerine ait perakende yumurtaların incelenen bazı kalite parametreleri yönünden önemli bir farklılık göstermediği belirlendi.

Anahtar Sözcükler: Yetiştirme sistemleri, yumurtacı tavuk, yumurta kalite özellikleri.

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Introduction

Animal-derived foods have an indispensible role in a sufficient and balanced diet. Egg is a cheap and easy to prepare animal-derived food with high digestibility (97%), and it is a good source of proteins, fats, vitamins and minerals for individuals of all ages. Primarily, it acquires essential amino acids in adequate and balanced amounts; therefore it is a protein with high biological value (95%). Additionally, it has a low calorie as 65-80 kcal, therefore can be used in healthy calorie-restriction diets: fat in eggs consist of 1.5 g saturated, 3 g unsaturated (linoleic acid - omega 6) fatty acids, in addition to phospholipids (lecithin, choline). Finally, eggs acquire significant amounts of vitamins A, D, E, and group B (thiamine, niacin, riboflavin, biotin), and adequate amounts of phosphorus, iron, zinc, sodium, chlorine, copper, magnesium, and manganese[2,15].

Turkey's annual 2015-egg production and consumption was reported as 17.206 million and 200 per capita[20]. In our country, egg is substantially produced by cage systems. However, in recent years due to enforcements of European Union and our National Regulations on animal welfare, and consumers tendency towards absence of chemical, antibiotic and hormone residues in foods, egg production by alternative systems (free-range and organic) other than cage are being used in our country[5,8].

Grade A table eggs are offered for sale as: produced by different rearing systems (free-range and organic), in different egg colors (white and brown), in different compositions (e.g. with omega-3 or DHA, with selenium). Specific requirements for these eggs are indicated in Turkish Food Codex Egg Notification (TFCEN) (2014/55)[13] and in Turkish Standard on Chicken Eggs in Shell (TS1068)[14]. Specifications such as egg weight, which is of importance and which should be within a specified range both for the producer and the consumer, constitute the quality criteria for eggs. Important parameters other than the ones indicated in TFCEN and TS1068 (shape index, shell thickness, shell resistance, yolk color) are specifications, which would affect shelf life of the egg, prevent problems during transfer and storage and provide preferability for the consumer[6,7,15]. Shell color, a parameter not used in determining egg quality, has top priority for consumer's preference while purchasing eggs. Some consumers have the tendency to buy white-shelled eggs, while some prefer brown-shelled eggs. Therefore, eggs are classified by their color as white-shelled and brown-shelled, and are packaged, priced, and sold separately. Both white-shelled and brown-shelled eggs have equal nutritional value. Shell color is a parameter based on chicken's breed (genotype), where brown hens lay brown-shelled, white hens lay white-shelled eggs[2,6,7,15].

Consumers have a belief that eggs from alternative systems compared to cage system eggs, and browns compared to whites are more nutritious, fresher, tastier, and has darker yolk color. This study in a sense was planned to test this bias, and the data obtained was evaluated within and with other prior related studies. Thus, the main aim was to determine some quality parameters (weight, shape index, shell thickness, shell resistance, yolk color) of brown and white eggs produced by cage, free-range and organic rearing systems.

Materials and Methods

Materials

Medium sized (M) grade A brown and white table eggs, belonging to different brands of 6 cage, 5 organic, and 5 free-range systems offered for retail sale in markets were used as materials in this study. One randomly sampled egg from a minimum viol (package) size of 10 eggs; of 10 cage, 10 organic and 10 free-range, totaling 30 eggs, where 15 and 15 were brown and white, respectively, were used.

Methods

Eggs were analyzed for some of their outer and inner quality parameters. As outer quality parameters; egg weight (Laboratory scale, Sartorius, BA2010S, Germany), shape index (Caliper, Mitutoyo Code No. 500-181-20, Model CD-15CPX, Japan), shell thickness (Caliper, Mitutoyo, Code No. 500-181-20, Model CD-15CPX, Japan), shell strength (Shell strength measurement apparatus - Push pull scale, Imada, Model No. SV-05, Japan), and as an inner quality parameter yolk color (Roche scale) were tested.

Egg Quality Parameters

Egg Weight. Eggs were placed on the measurement place of the laboratory scale with a sensitivity of 0.0001 g after tare, and the fixed number was read and recorded.

Shape Index. Width and length of each egg, which were measured by carefully placing the egg's widest and longest points to the digital caliper, was read and recorded. Width and length measurement values were used in the formula below to calculate shape index of each egg. Shape index = (Egg width / Egg length) x 100

Shell Thickness. For shell thickness measurement, shell parts from 3 points (sharp, equatorial and blunt points) of each egg were sampled, and their inner and outer membranes were peeled. These indicated shell pieces were placed and squeezed between the 2 ends of the caliper, and the values read on the digital display were recorded. Average shell thickness was determined by calculating the mean of the 3 readings from each egg.

Shell Strength. Each egg was placed vertically, and as blunt end facing upwards, under the shell strength measurement apparatus in a disposable plastic plate. Upper clamp of the apparatus was moved downwards until there is no distance between the clamp and the egg. Then, the clamp was moved further slowly up to the breakpoint of the egg, and the value at this point was read from the scale and recorded as Newton/cm^2 (N/cm^2).

Yolk Color. Each egg was broken into a white disposable plastic plate by paying attention not to disturb yolk. Corresponding number to the closest color determined by the Roche scale was recorded as score.

Statistical Analysis

Variables were expressed as means and standard deviation. Comparisons of groups based on rearing systems were performed by One Way Analysis of Variance (ANOVA). Subgroup analysis was performed by Bonferroni test. Comparisons of groups based on eggshell color were performed by t test for independent variables. Statistical analyses were performed by SPSS program (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp.), and level of significance was regarded as α=0.05 in the evaluation of the results.

Results

In this study, effect of different rearing systems on some quality parameters of eggs was examined and the results were presented in Table 1.

Table 1. Egg Quality Parameters Based on Rearing Type

Tablo 1. Yetiştirme Sistemlerine Göre Yumurta Kalite Parametreleri

Parameters	Rearing type						p-value
	Cage		Organic		Free-range		
	Mean ± SD		Mean ± SD		Mean ± SD		
Weight (g)	65.04	4.35	60.88	4.40	62.67	3.20	0.242
Shape index (%)	74.88	3.72	78.37	1.07	75.40	1.87	0.068
Shell thickness (mm)	0.47^{ab}	0.05	0.47^{a}	0.04	0.40^{b}	0.04	0.026
Shell strength (N/cm^2)	37.82	6.52	41.02	7.83	37.52	7.78	0.678
Yolk color (score)	12.00	0.00	10.00	3.79	10.40	1.95	0.371

SD: Standard Deviation
a, b: Values in the same row with different superscript are significantly different at p<0.05.
SD: Standart Sapma
a, b: Aynı satırdaki farklı üst harfli değerler arasındaki fark p<0.05 düzeyinde önemlidir.

Similarly, effect of different egg color on some quality parameters of eggs was examined and the results were presented in Table 2.

Table 2. Egg Quality Parameters Based on Shell Color

Tablo 2. Kabuk Rengine Göre Yumurta Kalite Parametreleri

Parameters	Shell Color				p-value
	Brown		White		
	Mean ± SD		Mean ± SD		
Weight (g)	63.20	4.07	62.40	4.70	0.714
Shape index (%)	77.70^{a}	1.48	74.21^{b}	3.19	0.008
Shell thickness (mm)	0.47^{a}	0.05	0.42^{b}	0.04	0.020
Shell strength (N/cm^2)	40.38	6.75	36.69	7.51	0.305
Yolk color (score)	10.90	3.07	10.71	1.60	0.886

SD: Standard Deviation
a, b: Values in the same row with different superscript are significantly different at p<0.05.
SD: Standart Sapma
a, b: Aynı satırdaki farklı üst harfli değerler arasındaki fark p<0.05 düzeyinde önemlidir.

Discussion

Egg Weight. In general, consumers prefer larger eggs based on 'the bigger the better' prejudice. In contrast to what is known, there is no difference in the nutritious value of eggs as they get larger, but as expected, more nutritional elements are taken when a larger egg is consumed. While egg weight is relatively low in the beginning of the rearing period, it increases to the end. Additionally, weight increases parallel to the increase in the amount of protein, amino acid and fat in the feed consumed. Brown eggs

are heavier and more expensive than white eggs. Eggs with double yolk are heavier[2]. In this study, the heaviest eggs were cage, then free-range and organic. Similarly, results were reported indicating free-range eggs lighter than cage eggs[1,17]. In our country, the weight range for M (Medium) size grade A table eggs in TFCEN was indicated as 53-63 g[13]. When evaluated from this aspect, free-range and organic egg samples examined in this study comply with the range indicated in TFCEN, whereas cage egg samples had results (65.04 g) above this range, therefore do not conform to TFCEN[13]. However, this discrepancy is not unfavorable for consumers: since eggs are priced based on weight, consumers, who buy these eggs, are actually buying misclassified L (Large) eggs in cheaper price. There was no statistical difference between groups on analysis of the effect of rearing systems on egg weight ($p>0.05$) (Table 1). There are several parallel studies to our study indicating that there was no effect of rearing system on egg weight[1,4,9,10,16,19], while other studies found significant differences in egg weights due to rearing systems[8,11,17]. There was no difference between groups on analysis of the effect of shell color on egg weight ($p>0.05$) (Table 2). Similarly, Barbosa Filho et al.[4] and Küçükyılmaz et al.[9] found no effect on egg weight due to shell color, whereas Vits et al.[18], and Singh et al.[11] did.

Shape Index. Abnormal shaped, abnormal-shell eggs in egg industry result low quality eggs. The ideal shape index value in eggs is 74%. If this value is lower than 72%, egg is considered long, and if it is higher than 76% it is spherical. Eggs out of this range is not preferred by the producer/retailer since they cannot fit properly into viols, therefore cause economical losses during storage and transfer. Although there is no indication of shape index range neither in the TFCEN[13] nor in TS1068[14], these values are commercially conventional/adopted[2]. Additionally, consumers also prefer oval eggs rather than long or spherical. In this study, cage and free-range eggs' shape indexes are within the standard range, whereas organic eggs had values above the range (78.37%) (were spherical). Shape index values in this study are similar to Van Den Brand et al.[16], and in contrast to Wang et al.[19]. Küçükyılmaz et al.[9] also indicated that organic eggs had higher shape index values than cage eggs. There was no statistical difference between groups on analysis of the effect of rearing systems on shape index ($p>0.05$) (Table 1). There is a similar study indicating the effect of rearing systems on shape index as insignificant[19], while there are other studies reporting significance of rearing systems on this parameter[9,16]. Additionally, there was a significant difference between groups on analysis of the effect of shell color on shape index ($p<0.05$) (Table 2). In parallel to our results, Küçükyılmaz et al.[9] and Şekeroğlu and Sarıca[12] determined that shell color significantly effected shape index.

Shell Thickness. Shell thickness is an important quality parameter. This is due to the fact that cracked eggs can crash during transfer and marketing, which would lead to economical losses. Shell quality decreases, as the hen gets older. One of the parameters used to determine shell quality is by the measurement of shell thickness. Although there is no indication of shell thickness range neither in the TFCEN[13] nor in TS1068[14], values within 0.20-0.40 mm range in grade A table eggs are commercially conventional/adopted[2]. In this study, the lowest value for shell thickness was determined in free-range (0.40 mm), whereas cage and organic eggs (0.47 mm) had thicker shells. There was a statistical difference between organic and free-range groups on analysis of the effect of rearing systems on shell thickness ($p<0.05$) (Table 1). Studies on this subject, similarly found significant effect of rearing systems on shell thickness[1,3,9,17,18]. Contrarily, there are studies, which did not find a statistical difference between rearing systems and shell thickness[4,16,19]. There was a significant difference between groups on analysis of the effect of shell color on shell thickness ($p<0.05$) (Table 2). Brown eggs were determined to have thicker shells (0.47) than white eggs (0.42). In parallel to our results, Barbosa Filho et al.[4], Vits et al.[18], Küçükyılmaz et al.[9], and Şekeroğlu and Sarıca[12] determined that shell color significantly effected shell thickness.

Shell Strength. One other parameter for shell quality is the determination of shell strength. Having eggs with intact shells is important during transfer and marketing to prevent economical losses due to cracks and crashes. Although there is no indication of shell strength range neither in the TFCEN[13] nor in TS1068[14], values within 30-40 N/cm^2 range in grade A table eggs are expected[2]. In this study, the two groups with the lowest shell strength were free-range and cage, while although statistically insignificant ($p>0.05$), the organic group had stronger shells (41.02 N/cm^2). There are parallel

studies reporting no significant difference on the effect of rearing system on shell strength[18,19], while others[1,3] found difference on shell strengths from different rearing systems. There was no significant difference between groups on analysis of the effect of shell color on shell strength ($p>0.05$) (Table 2). In contrast to ours, Küçükyılmaz et al.[9] indicated that shell color significantly influenced shell strength.

Yolk Color. Although yolk color is not a parameter for determining the egg quality, it is an important criterion both for the consumer and for the food industry (pasta, cake, mayonnaise). Yolk color is affected by the coloring substances, and vitamins A and D in feeds. Consumers believe that eggs with darker yolk are tastier and more nutritious. However, there is no relationship between yolk color and egg's taste and nutritious value, as was in the shell color[2]. This was proved with blind studies. From childhood, consumers learn to correlate color and taste. Red tomato, bright orange colored carrot, yellow butter is perceived as tastier, and more natural and healthier products. A distinct change in the food's color, even if it does not change the taste and aroma of the product, would influence its acceptability. For instance, besides products as pink butter, green strawberries, which are uncommon to us, eggs with light colored yolks are not preferred. In our country, yolk color scor is preferred to be 12-13 in Roche scale[2]. In this study, yolk colors of organic and free-range eggs (score 10 and 10.40) are below this range, and within the range in cage eggs (score 12). As can be seen from this finding, contrary to the expectations of the consumers' organic and free-range eggs yolk color, eggs obtained from these systems had lighter yolks, but this difference was not statistically significant ($p>0.05$) (Table 1). Parallel to our results, some studies on this subject reported that there was no significant difference in the yolk color due to rearing systems[10,19], while some other studies reported vise versa[1,9,11,16,17]. There was no significant difference between groups on analysis of the effect of shell color on yolk color ($p>0.05$) (Table 2). In contrast to ours, Küçükyılmaz et al.[9], Singh et al.[11], and Şekeroğlu and Sarıca[12] indicated that shell color significantly influenced yolk color.

To conclude, contrary to the consumer prejudice, retail eggs from different rearing systems do not exhibit significant differences on some quality parameters tested.

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