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RESEARCH PAPER

Effects of Different Viol Types on Egg Qualities in Table Eggs at Different Storage Temperatures

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Abstract

The purpose of this research was to examine the impact of storing table hen eggs in egg cardboard viol, plastic box viol, and cardboard box viols at various temperatures on the egg qualities. A total of 300 table chicken eggs were used in the study. The eggs were randomly distributed into three groups: standard cardboard viol, plastic box viol, and cardboard box viol. The eggs were stored at room temperature and in the refrigerator for 28 days. On the 0, 7, 14, 21, and 28 days of the experiment, ten eggs from each group were analyzed for egg weight loss, egg shell strength, Haugh unit, yolk index, and albumen pH. Viol type x storage temperature interaction effect was significant (P <0.05) only on egg weight loss, but its effect on other properties was insignificant. After 28 days of storage, egg weight loss was statistically insignificant between eggs stored in plastic box viols at 25℃ and eggs stored in cardboard viols at 4℃. The effect of viol types on egg shell strength, yolk index, Haugh unit, and albumen pH was insignificant. Egg weight loss was found to be better in plastic box viols than in other groups (P <0.05). Eggs stored in refrigerator conditions are better than egg stored room conditions in terms of egg quality criteria except eggshell strength (P <0.05). As a result, it would be more appropriate to store eggs in plastic box viols in order to preserve egg quality for a longer period of time.

Introduction

Although eggs are an animal protein source, their importance in human nutrition is high due to containing unsaturated fatty acids, vitamins, and minerals (Şenköylü 2001; Sarıca and Erensayın 2014; Puglisi and Fernandez 2022; Tian *et al.,* 2022). An egg obtained from a healthy animal has the highest quality value at the moment it is laid, but its quality may decrease depending on storage conditions, leading to marketing problems (Aygun 2017; Brasil *et al.,* 2019; Yenilmez and Bulancak 2020; Sariyel *et al.,* 2022).

Depending on the storage conditions, it is possible to observe a decrease in egg weight (Akyurek and Okur 2009; Sariyel *et al.,* 2022), a decrease in albumen height and Haugh unit (Aktan and Kampus 2011; Baylan *et al.,* 2011) , an increase in egg yolk index (Copur *et al.,* 2008), and an increase in albumen pH (Silversides and Budgell 2004). When eggs are collected from egg production companies, they need to be stored appropriately.

In the market, cardboard viols with a capacity of 30 eggs are used for storing or transporting eggs. However, in recent years, cardboard box viol and plastic box viol with a capacity of 6, 10, and 15 eggs have also started to be used. The use of cardboard box viol with a capacity of 6, 10, and 15 eggs during the sale of eggs makes it difficult for consumers to choose eggs based on their outer appearance, as the dirt on the surface of the eggshell cannot be seen. On the other hand, plastic viols provide convenience for consumers in terms of choice. However, foreign materials on the surface of eggs in plastic box viol can be seen more easily, making it easier to evaluate the eggs based on their appearance. Additionally, during storage or sales, there is a possibility of condensation on the egg surface or inside the viols, which can lead to the eggs becoming wet and causing the preference for viols more important.

In our literature review, it was observed that there are a limited number of studies on the effect of storing table chicken eggs in cardboard box viols or plastic box viols (with a capacity of 6, 10, and 15 eggs) on egg quality. Therefore, the main question of the research is which tray type can preserve egg quality for a longer period of time during storage under different storage conditions. Therefore, the aim of this study is to investigate the changes in egg quality by storing table chicken eggs in carton, cardboard box viol, and plastic box viols under room and refrigerator conditions.

Materials and Methods

Table eggs that were purchased daily from the Konya commercial egg producer were used in the study. A total of 300 table eggs were used. The research was carried out in the Egg Quality Laboratory of the Department of Animal Science, Faculty of Agriculture, Selcuk University. Eggs were randomly distributed into 3 groups: cardboard viol, plastic box viol, and cardboard box viol. For 28 days, eggs were stored at ambient temperature (25 ℃) and in the refrigerator (4 ℃) in viols. On days 0, 7, 14, 21, and 28 of the experiment, egg weight loss, eggshell strength, yolk index, Haugh unit, and albumen pH analyses were conducted on 10 eggs from each group. All eggs were weighed before the experiment and written on the egg. Egg weights were weighed with a precision digital balance (0.01 g). In the specified analysis periods, eggs (10 eggs from each group) were weighed again before the analysis, and egg weight loss was determined with the formula below.

Egg weight loss (%) = [initial egg weight (g) – end of storage egg weight (g)] / initial egg weight (g) x 100

Shell breaking strength was measured with the Egg Force Reader device (Orka Food Tech.i China) and its unit was expressed as kg (Sariyel *et al.,* 2022). After the albumen height was determined with the Egg Analyzer (Orka Food Tech.i China) device, the Haugh unit was determined according to Haugh (1937).

The egg yolk was separated on a flat surface and the height of the egg yolk was determined with a digital height gauge. Egg yolk diameter was determined with a digital micrometer and calculated according to Funk (1948). After separating the egg albumen from the yolk, it was measured with a pH meter (Mettler Toledo, Switzerland).

The experiment was carried out in 2x3 randomized plots according to a factorial design in order to compare the qualities of eggs packed in plastic, cardboard, and standard viols to be stored at room temperature and in the refrigerator (Düzgüneş *et al.,* 1987). The MINITAB 16 statistic software was used in the analysis, and the Tukey multiple range test was used to determine the different groups. The significance level of 0.05 was used for statistical evaluation.

Results and Discussion

Table 1 summarizes the effects of storage temperature, viol types, and the storage temperature x viol type interaction on egg weight loss (%). During storage, storage temperature, viol types, and storage temperature x viol types interaction had a significant effect on egg weight loss. At the end of storage, the lowest weight loss was found in the C group (6.94%) stored at 25 ℃, and the lowest egg weight loss was found in the CB group (2.20%) at 4 ℃. After 28 days of storage, egg weight loss was statistically insignificant between eggs stored in plastic box viols at 25°C and eggs stored in cardboard viols at 4℃. When the effect of the viol type on the egg weight loss was examined, the lowest egg weight loss was detected in the PL group during the storage period.

When the effect of storage temperature on egg weight loss was examined, the weight loss of eggs stored at 4 ℃ during storage was found to be lower than that of those stored at 25 ℃. Egg weight loss during storage occurs as a result of the evaporation of water from the egg (Drabik *et al.,* 2021; Eroglu *et al.,* 2021). Egg weight loss is desired to be minimal during storage. The most important criterion around the classification of eggs is egg weight. In general, the market shelf life of eggs around the world is 28 days. Egg weight loss gains even more importance as eggs are sold in markets in room conditions in Turkey. According to the result obtained from our study, it would be more appropriate to store eggs in plastic viols when it is necessary to store eggs in room conditions in terms of egg weight loss. Table 2 summarizes the effects of storage temperature, viol types, and the storage temperature x viol type interaction on egg shell strength (kg).

Viol type, storage temperature, and the storage temperature x viol type interaction effect were not significant in any period of storage. It is consistent with the research indicating that the eggshell strength during storage is not significantly impacted by the storage temperature (Jo *et al.,* 2011; Sert *et al.,* 2011; Sariyel *et al.,* 2022). For egg producers, the strength of a table egg's shell is a crucial economic factor. The greater the breaking strength, the less breakage will occur during egg collection, transport, and storage, resulting in reduced economic losses.

Table 1. The effect of storage temperature, viol types and storage x viol type interaction on egg weight loss (%)

Treatment		Initial Egg Weight	Egg Weight Loss (%)			
			7 days	14 days	21 days	28 days
Storage Temperature (℃)	25	63.46	1.44	2.66	3.97	5.86
	4	61.75	0.64	1.28	1.84	2.62
	SEM	0.93	0.33	0.07	0.12	0.14
	P value	> 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Viol type[1]	C	61.98	1.31[a]	2.39[a]	3.66[a]	4.99[a]
	CB	62.84	1.16[b]	2.08[b]	3.01[b]	4.51[a]
	PL	63.01	0.65[c]	1.45[c]	2.04[c]	3.23[b]
	SEM	1.14	0.04	0.08	0.14	0.17
	P value	> 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Storage Temperature (℃) x Viol Type	25 x C	62.11	1.66[a]	3.02[a]	4.92[a]	6.94[a]
	25 x CB	63.05	1.74[a]	3.15[a]	4.28[a]	6.83[a]
	25 x PL	65.24	0.93[b]	1.80[b]	2.70[b]	3.81[b]
	4 x C	61.83	0.95[b]	1.75[b]	2.39[bc]	3.03[bc]
	4 x CB	62.61	0.58[c]	1.00[c]	1.74[cd]	2.20[c]
	4 x PL	60.77	0.37[c]	1.09[c]	1.37[d]	2.65[c]
	SEM	1.61	0.05	0.12	0.21	0.24
	P value	> 0.05	< 0.05	< 0.05	< 0.05	< 0.05

Table 2. The effect of storage temperature, viol types and storage x viol type interaction on egg shell strength (kg)

		Initial Egg Shell Strength (kg)	Egg Shell Strength (kg)			
			7 days	14 days	21 days	28 days
Storage Temperature (℃)	25	4.45	4.39	4.27	4.48	4.61
	4	4.42	4.60	4.46	4.56	4.58
	SEM	0.106	0.09	0.09	0.11	0.08
	P value	0.866	> 0.05	> 0.05	> 0.05	> 0.05
Viol type[1]	C	4.45	4.41	4.48	4.32	4.69
	CB	4.37	4.47	4.37	4.67	4.62
	PL	4.48	4.61	4.25	4.56	4.48
	SEM	0.130	0.11	0.11	0.13	0.11
	P value	0.822	> 0.05	> 0.05	> 0.05	> 0.05
Storage Temperature (℃) x Viol Type	25 x C	4.56	4.45	4.48	4.26	4.67
	25 x CB	4.41	4.38	4.18	4.38	4.63
	25 x PL	4.37	4.34	4.16	4.79	4.53
	4 x C	4.35	4.38	4.47	4.38	4.72
	4 x CB	4.33	4.56	4.54	4.95	4.61
	4 x PL	4.59	4.88	4.34	4.32	4.42
	SEM	0.18	0.16	0.16	0.19	0.15
	P value	0.481	> 0.05	> 0.05	> 0.05	> 0.05

[1]C: Cardboard viol; CB: Cardboard box viol; PL: Plastic box viol; SEM: Mean of standard errors

Table 3 summarizes the effects of storage temperature, viol types, and the storage temperature x viol type interaction on the Haugh unit. The storage temperature x viol type interaction effect did not have a significant effect on the Haugh unit during storage. The effect of viol type on the Haugh unit was only significant on day 21 of storage (P<0.05). On the 21st day of storage, the Haugh unit of the eggs in the PL group (74.12) was higher than the Haugh unit of the eggs in the C group (67.24) (P<0.05), but the difference between the Haugh unit of the eggs in the PL group (74.12) and the Haugh unit of the eggs in the CB group (70.96) was statistically insignificant.

The effect of storage temperature on the Haugh unit in all periods was found to be statistically significant. The effect of storage temperature on the Haugh unit in all periods was found to be statistically significant.

It was determined that the Haugh unit value of eggs stored at 4 ℃ during storage was higher than that of those stored at 25 ℃. In the egg industry, the Haugh unit is the main criterion for quality, and the greater the Haugh unit, the higher the albumen quality of the egg. During storage, the Haugh unit decreases due to the increase in clusterin and ovoinhibitory concentrations in albumen and the disordering of ovalbumin structure (Sheng *et al.,* 2018).

Table 4 summarizes the effects of storage temperature, viol types, and the storage temperature x viol type interaction on the yolk index. The effect of storage temperature x viol type interaction on the yolk index of eggs was significant only on day 28 of the storage period (P<0.05). On the 28th day of storage, the lowest yolk index value was found in group C eggs stored at 25℃, and the highest yolk index value in group C eggs stored at 4°C (P<0.05).

Viol type did not have a significant effect on the yolk index value in all periods of storage. The effect of storage temperature on the yolk index in all periods was found to be statistically significant. It was determined that the yolk index value of eggs stored at 4 ℃ during storage was higher than those stored at 25 ℃. This finding appears to be consistent with research that demonstrates that as storage temperatures increase, the yolk index dramatically declines (Samli *et al.,* 2005; Akarca *et al.,* 2021; Güler *et al.,* 2022; Sariyel *et al.,* 2022). The egg yolk index, which assesses the resistance to stretching of the vitelline membrane in the yolk, can be used to determine how fresh an egg is. The quality of the egg yolks improves as the egg yolk index increases (Stadelman 1995). The egg yolk index drops as a result of the water in the egg white diffusing into the egg yolk as the vitelline membrane of the egg yolk deteriorates (Didar 2019). Table 5 summarizes the effects of storage temperature, viol types, and the storage temperature x viol type interaction on albumen pH. Storage temperature x viol type interaction and viol type did not have a significant effect on the albumen pH in all periods of storage. The effect of storage temperature on the albumen pH in all periods was found to be statistically significant. It was determined that the albumen pH of eggs stored at 4 ℃ during storage was lower than that of those stored at 25 ℃. This result is consistent with the studies stating that the pH value of egg whites also increased due to the increase in storage temperature (Sariyel *et al.,* 2022; Tan *et al.,* 2022). Albumen's pH increases as a result of a shift in the carbonic acid-bicarbonate buffer system caused by the release of carbon dioxide from the eggshell's pores during storage (Shin *et al.,* 2012; Mathew *et al.,* 2016).

Table 3. The effect of storage temperature, viol types and the storage temperature x viol type interaction on Haugh unit

Treatment		Initial Haugh Unit	Haugh Unit			
			7 days	14 days	21 days	28 days
Storage Temperature (℃)	25	83.06	71.29	63.84	62.02	55.94
	4	83.35	81.87	84.24	79.53	77.00
	SEM	1.07	1.005	0.991	1.263	1.067
	P value	0.849	< 0.05	< 0.05	< 0.05	< 0.05
Viol type[1]	C	81.80	76.07	71.9	67.24[b]	65.27
	CB	83.20	76.55	75.37	70.96[ab]	67.28
	PL	84.60	77.10	74.78	74.11[a]	66.84
	SEM	1.31	1.22	1.21	1.54	1.31
	P value	0.334	> 0.05	> 0.05	< 0.05	> 0.05
Storage Temperature (℃) x Viol Type	25 x C	82.49	72.39	61.03	58.30	53.91
	25 x CB	81.91	69.82	64.77	63.84	57.92
	25 x PL	84.79	71.66	65.72	63.91	56.00
	4 x C	81.13	79.77	82.91	76.19	76.63
	4 x CB	84.51	83.31	85.96	78.06	76.68
	4 x PL	84.43	82.54	83.84	84.31	77.72
	SEM	1.85	1.74	1.72	2.19	1.85
	P value	0.543	> 0.05	> 0.05	> 0.05	> 0.05

Table 4. The effect of storage temperature, viol types and storage x viol type interaction on yolk index

Treatment		Initial Yolk Index	Yolk Index			
			7 days	14 days	21 days	28 days
Storage Temperature (℃)	25	0.44	0.38	0.33	0.27	0.20
	4	0.42	0.45	0.45	0.43	0.41
	SEM	0.01	0.010	0.010	0.010	0.010
	P value	0.068	< 0.05	< 0.05	< 0.05	< 0.05
Viol type[1]	C	0.42	0.41	0.40	0.34	0.32
	CB	0.44	0.41	0.39	0.35	0.30
	PL	0.43	0.42	0.39	0.36	0.29
	SEM	0.01	0.01	0.01	0.01	0.01
	P value	0.365	> 0.05	> 0.05	> 0.05	> 0.05
Storage Temperature (℃) x Viol Type	25 x C	0.43	0.37	0.34	0.26	0.19[c]
	25 x CB	0.44	0.37	0.32	0.26	0.20[c]
	25 x PL	0.45	0.39	0.33	0.27	0.21[c]
	4 x C	0.41	0.46	0.46	0.41	0.46[a]
	4 x CB	0.44	0.46	0.46	0.43	0.40[ab]
	4 x PL	0.41	0.45	0.44	0.44	0.37[b]
	SEM	0.01	0.02	0.01	0.01	0.02
	P value	0.442	> 0.05	> 0.05	> 0.05	< 0.05

[a-c] Significant differences exist between the means of a column using different superscripts (P<0.05); [1]C: Cardboard viol; CB: Cardboard box viol; PL: Plastic box viol; SEM: Mean of standard errors

Table 5. The effect of storage temperature, viol types and storage x viol type interaction on albumen pH

Treatment		Initial Albumen pH	Albumen pH			
			7 days	14 days	21 days	28 days
Storage Temperature (℃)	25	9.08	9.59	9.75	9.63	9.77
	4	9.10	9.16	9.21	9.12	9.35
	SEM	0.04	0.01	0.01	0.02	0.01
	P value	0.731	< 0.05	< 0.05	< 0.05	< 0.05
Viol type[1]	C	9.07	9.37	9.47	9.40	9.57
	CB	9.14	9.41	9.47	9.36	9.57
	PL	9.06	9.34	9.48	9.36	9.55
	SEM	0.05	0.02	0.01	0.02	0.01
	P value	0.538	> 0.05	> 0.05	> 0.05	> 0.05
Storage Temperature (℃) x Viol Type	25 x C	9.09	9.56 [a]	9.74	9.64	9.77
	25 x CB	9.07	9.63 [a]	9.75	9.64	9.78
	25 x PL	9.08	9.59 [a]	9.76	9.60	9.74
	4 x C	9.04	9.19 [b]	9.21	9.16	9.36
	4 x CB	9.20	9.18 [b]	9.19	9.09	9.35
	4 x PL	9.06	9.10 [b]	9.23	9.10	9.33
	SEM	0.07	0.03	0.02	0.03	0.02
	P value	0.399	< 0.05	> 0.05	> 0.05	> 0.05

[1]C: Cardboard viol; CB: Cardboard box viol; PL: Plastic box viol; SEM: Mean of standard errors

Conclusions

According to the results obtained from our study, it was determined that the type of viol affects only egg weight loss. In terms of egg weight, it was observed that storage in plastic box viol preserves egg weight better than other viol types. It is seen that storing eggs in plastic box viols will preserve their shelf life longer.

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References

Akarca, G., Istek, Ö., Tomar, O. 2021. The Effect of Resin Coating on the Quality Characteristics of Chicken Eggs During Storage. Journal of Food Science, *86*(4): 1243-1257.

Aktan, S., Kampus, D. 2011. Effects of Age and Storage Duration on Relationships among Albumen Quality Traits and Egg Weight in Japanese Quails. Journal of Animal and Veterinary Advances, *10 (Supplement)*: 3340 - 3344.

Akyurek, H., Okur, A. A. 2009. Effect of Storage Time, Temperature and Hen Age on Egg Quality in Free-Range Layer Hens. Journal of Animal and Veterinary Advances, *8*(10): 1953-1958.

Aygun, A. (2017). The Eggshell Microbial Activity. In P. Hester (Ed.), *Egg Innovation and Strategies for Improvement* (pp. 135-144). Academic Press, Elsevier.

Baylan, M., Canogullari, S., Ayasan, T., Copur, G. 2011. Effects of Dietary Selenium Source, Storage Time, and Temperature on the Quality of Quail Eggs. Biological Trace Element Research, *143*(2): 957-964.

Brasil, R., Cruz, F., Rufino, J., Oliveira, P., Freitas, B., Viana, G. 2019. Physical-Chemical and Sensorial Quality of Eggs Coated with Copaiba Oil Biofilm and Stored at Room Temperature for Different Periods. Brazilian Journal of Poultry Science, *21*.

Copur, G., Camcil, O., Sahinler, N., Gul, A. 2008. The Effect of Propolis Egg Shell Coatings on Interior Egg Quality. Archiv Fur Geflugelkunde, *72*(1): 35-40.

Didar, Z. 2019. Effects of Coatings with Pectin and Cinnamomum Verum hydrosol included Pectin on Physical Characteristics and Shelf Life of Chicken Eggs Stored at 30°C. Nutrition and Food Sciences Research, *6*(4): 39-45.

Drabik, K., Próchniak, T., Kasperek, K., Batkowska, J. 2021. The Use of the Dynamics of Changes in Table Eggs During Storage to Predict the Age of Eggs Based on Selected Quality Traits. Animals, *11*(11): 3192.

Düzgüneş, O., Kesici, T., Kavuncu, O. 1987. Ve Gürbüz, F. 1987. Araştırma ve Deneme Metodları.

Eroglu, M., Baykalir, Y., Erisir, Z. 2021. The Effect of Different Storage Period on Some Egg Quality Characteristics and Ovalbumin Levels in Goose Eggs. Emirates Journal of Food and Agriculture, *33*(8): 699-703.

Funk, E. 1948. The Relation of the Yolk Index Determined in Natural Position to the Yolk Index as Determined after Separating the Yolk from the Albumen. Poultry science, *27*(3): 367-367.

Güler, G., Ayşe, Ş., Turgud, F. K., Tahtabiçen, E., Aylin, A., Samli, H. E. 2022. Effects of Propolis Extract Coating on Shelf Life and Quality Parameters of Eggs Obtained from Free-Range Hens. Journal of Tekirdag Agricultural Faculty, *19*(1): 89-100.

Haugh, R. R. 1937. The Haugh Unit for Measuring Egg Quality. The US Egg Poultry Magazine, *43*: 522-573.

Jo, C., Ahn, D., Liu, X., Kim, K., Nam, K.-C. 2011. Effects of Chitosan Coating and Storage with Dry Ice on the Freshness and Quality of Eggs. Poultry science, *90*(2): 467-472.

Mathew, A. O., Olufemi, A. M., Foluke, A., Abel, O. 2016. Relationship of Temperature and Length of Storage on Ph of Internal Contents of Chicken Table Egg in Humid Tropics. Biotechnology in Animal Husbandry, *32*(3): 285-296.

Puglisi, M. J., Fernandez, M. L. 2022. The Health Benefits of Egg Protein. Nutrients, *14*(14): 2904.

Samli, H., Agma, A., Senkoylu, N. 2005. Effects of Storage Time and Temperature on Egg Quality in Old Laying Hens. Journal of Applied Poultry Research, *14*(3): 548-553.

Sarıca, M., Erensayın, C. (2014). Tavukçuluk Ürünleri. In M. Türkoğlu M. Sarıca (Eds.), Tavukçuluk Bilimi Yetiştirme, Besleme ve Hastalıklar (Vol. 4, pp. 110-139.). Bey Ofset Matbaacılık.

Sariyel, V., Aygun, A., Coklar, H., Narinc, D., Akbulut, M. 2022. Effects of Prestorage Application of Gum Arabic Coating on the Quality of Table Eggs During Storage. Kafkas Üniversitesi Veteriner Fakültesi Dergisi, *28*(3): 363-370.

Sert, D., Aygun, A., Demir, M. 2011. Effects of Ultrasonic Treatment and Storage Temperature on Egg Quality. Poultry science, *90*(4): 869-875.

Sheng, L., Huang, M., Wang, J., Xu, Q., Hammad, H., Ma, M. 2018. A Study of Storage Impact on Ovalbumin Structure of Chicken Egg. Journal of Food Engineering, *219*: 1-7.

Shin, D., Narciso-Gaytán, C., Regenstein, J. M., Sánchez-Plata, M. X. 2012. Effect of Various Refrigeration Temperatures on Quality of Shell Eggs. Journal of the Science of Food and Agriculture, *92*(7): 1341-1345.

Silversides, F., Budgell, K. 2004. The Relationships among Measures of Egg Albumen Height, Ph, and Whipping Volume. Poultry science, *83*(10): 1619-1623.

Stadelman, W. (1995). The Preservation of Quality in Shell Eggs. In W. Stadelman O. J. Cotterill (Eds.), *Egg Science and Technology* (Vol. 4, pp. 67-79). Food Products Press.

Şenköylü, N. (2001). *Modern Tavuk Üretimi* (Vol. 3. Baskı). Anadolu Matbaacılık.

Tan, F., Rungruengpet, W., Simsiri, U., Kaewkot, C., Sun, Y., Chumngoen, W. 2022. Influences of Egg Washing and Storage Temperature on Quality and Shelf Life of Duck Eggs During Storage. Brazilian Journal of Poultry Science, *24*(4): 1-8.

Tian, Y., Zhu, H., Zhang, L., Chen, H. 2022. Consumer Preference for Nutritionally Fortified Eggs and Impact of Health Benefit Information. Foods, *11*(8): 1145.

Yenilmez, F., Bulancak, A. 2020. Microbiological Quality of Table Eggs Sold at Different Sales Location. Çukurova Tarım ve Gıda Bilimleri Dergisi, *35*(2): 115-124.