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Investigation of the Changes in the Amounts of Macro, Micro and Toxic Elements Accumulated in Different Parts of Turkey, Chicken, Duck and Quail Eggs (Yolk, Albumen, Membrane and Shell)

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Abstract

The average K amounts of different parts of egg samples were determined between 1830.12 (chicken) and 2649.06 mg/kg (quil). While the Ca contents of turkey egg parts were determined between 363.36 (egg white) and 449895.46 mg/kg (egg shell), the Ca contents of chicken egg parts were determined between 383.69 (egg white) and 431585.99 mg/kg (egg shell). In addition, the Ca contents of duck and quail egg parts were accumulated to be between 403.38 (egg white) and 379221.79 mg/kg (egg shell) and 402.30 (egg white) and 379212.79 mg/kg (egg shell), respectively. The average Ca contents of different parts of each egg sample were determined to be between 102611.22 mg/kg (quil) and 1148339.55 mg/kg (turkey). In general, the egg part where the microelement contents accumulated the most was the egg yolk. In addition, the B content of microelements was determined mostly in the egg membrane (except duck egg). Fe contents of duck egg parts were determined to range from 0.72 (egg shell) to 130.22 (egg yolk), while Fe contents of quail egg parts were determined to range from 1.63 (egg shell) to 371.81 mg/kg (egg yolk). Average Fe amounts of egg parts ranged from 21.47 (turkey) to 97.16 mg/kg (quil). Average Cu contents of egg parts were determined to be between 5.89 (chicken) and 13.23 mg/kg (duck). Depending on the types of poultry eggs, the egg parts with the highest Al content were egg shell and egg white parts, followed by egg membrane and egg yolk parts in decreasing order. Al contents of turkey and chicken egg parts accumulated between 0.026 (egg yolk) and 0.065 mg/kg (egg white) to 0.015 (egg yolk) and 0.105 mg/kg (egg shell), respectively. As a result, the amount of toxic elements in the egg parts is found to be at very low levels.

Keywords: turkey, chicken, duck and quail egg parts, macro and microelements, toxic elements, ICP-OES

1. Introduction

Although chicken eggs are currently most commonly eaten by humans, eggs from other birds (quail eggs, ostrich eggs, duck eggs, Europe and America, South Africa, Southeast Asia, respectively) are also used for daily consumption [1]. Eggs have been a part of human diets for centuries and are a very good source of protein for humans because they contain high-quality protein and many essential nutrients [2,3]. Eggs, which contain proteins with over 90% digestibility, are considered one of the best dietary sources of high-quality protein with very high nutritional value due to their rich essential amino acid content [4,5]. As one of the largest agricultural sectors worldwide, selection for egg quality is an important component of the breeding strategies of companies marketing laying hens [6,7,8]. Eggs, which are one of the main sources of protein with high biological value, become a problem for the environment and human health if they are contaminated with toxic heavy metals. Since poultry

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usually take in heavy metals through their diet, toxic elements can accumulate in their eggs [9,10,11,12]. As a result of studies conducted by environmental scientists on the embryotoxic effects of various trace elements on birds regarding trace element levels in eggs, it has been reported that in polluted areas, excessive inclusion of certain heavy metals in feeds may occur as a result of human activity and sometimes cause deterioration in reproductive success [13,14].

Minerals have important biological functions and since they must be taken in sufficient amounts, the mineral requirements of laying hens must be met for optimum egg production [15]. Chicken eggs are a cheap source of protein and due to their high consumption rate, it has led to high eggshell production [2]. Egg shells, which are mostly composed of calcium carbonate and glycoprotein matrix, vary greatly in texture [3]. The outer part of the egg shell, consisting of a thin protein layer called cuticle, prevents bacteria from entering the embryo [16]. Eggshells are used as art pieces in mosaic making, as adhesives in musical instruments, and as photography auxiliary materials [17]. Yumurta kabuğu zar tozu ayrıca kağıt ekonomisi veya tarımda kireç birikimi veya sürdürülebilir olarak kullanımlarının yanı sıra yumurta kabuğu zar proteinlerinden biyolojik olarak parçalanabilir plastiklerin üretimi yapılmaktadır [18]. It has been stated that eggshells, a natural source of calcium, contain magnesium, copper, iron, manganese, molybdenum, sulfur and many other useful elements [17]. Therefore, the use of dried eggshells as a source of calcium in animal feed has increased recently [3]. Therefore, considering their elemental content, the effectiveness of converting egg shell, membrane, yolk and albumen into beneficial use becomes an idea worth investigating. Our study aimed to provide a basis for the composition of domestic poultry eggs in macro, micro and toxic elements. The aim of this study was to determine the amounts of macro, micro- and toxic element accumulations in different parts (yolk, white, membrane and shell) of different poultry eggs.

2. Materials and Methods

2.1. Materials

The turkey, chicken, duck and quail eggs were provided from Konya provinces in 2025 (Fig. 1).

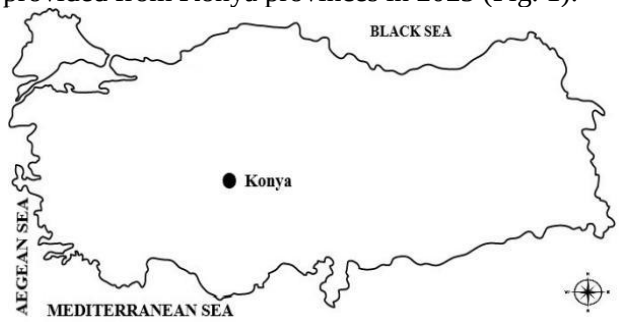

Figure 1. Location where the egg samples used in this study were obtained.

Parts of each egg (shell, white, yolk and membrane parts) were separated manually after the eggs were boiled (Fig. 2). HNO_3 and H_2O_2 are analytical grade and Merck company (Darmstadt, Germany).

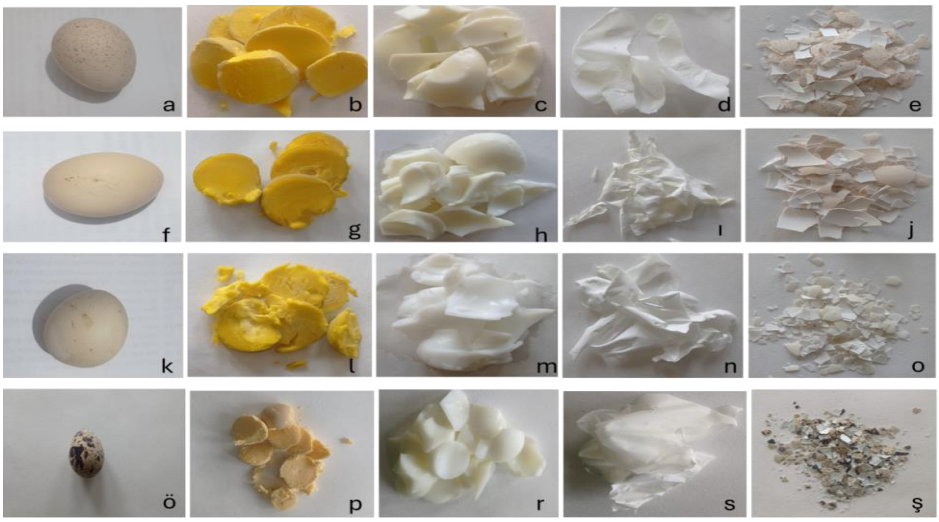

Figure 2. Poultry eggs and parts (a- Turkey egg, b-Turkey egg yolk, c-Turkey egg white, d-Turkey egg shell membranes, e-Turkey eggshell, f-Chicken egg, g-Chicken egg yolk, h-Chicken egg white, ı-Chicken egg shell membranes, j-Chicken eggshell, k-Duck egg, l-Duck egg yolk, m-Duck egg white, n-Duck egg shell membranes, o-Duck eggshell, ö-Quail egg, p-Quil egg yolk, r-Quail egg white, s-Quail egg shell membranes, ş-Quail eggshell

2.2. Macro-, micro- and toxic element contents of egg parts

After 0.2 g egg part samples were inginerated in a microwave device at 210ºC and 200 PSI pressure in 5 ml of concentrated HNO_3 and 2 ml of H_2O_2 (30% w/v), the volumes of the dissolved samples were completed to 20 ml with deionized water. Then, the egg parts were separated and dissolved separately in the microwave device, and the elements were determined in the ICP-OES device. Then, macro, micro- and toxicelement concentrations in each egg part were defined by ICP-OES [19].

2.3. Statistical analysis

The statistical analysis of results obtained was determined by the JMP statistical program. Statistically differences were carried out by the analysis of variance (ANOVA) procedure in all data ($p<0.05$).

3. Results and Discussions

The macroelement contents of different parts of turkey, chicken, duck and quail eggs (egg yolk, egg white, egg membrane and egg shell) are given in Table 1.

Table 1. Macroelement contents of different parts (yolk, white, membrane and shell) of turkey, chicken, duck and quail eggs

Macroelement (mg kg-1)	Samples	Turkey	Chicken	Duck	Quil
P	Yolk	11125.64 A	7586.55 D	9072.90 C	10531.91 B
	White	1020.97 I	1079.21 HI	935.29 I	1190.11 GHI
	Membrane	239.54 KL	75.73 L	514.88 JK	594.14 J
	Shell	1735.06 F	1329.38 GH	1465.28 FG	2859.40 E
	Mean	**3530.30 B**	**2517.72 D**	**2997.09 C**	**3793.89 A**
K	Yolk	1184.87 F	944.24 FG	923.21 G	887.09 G
	White	6273.43 A	5740.48 B	5921.78 B	6465.78 A
	Membrane	2074.01 E	407.76 H	2609.31 D	2609.31 D
	Shell	245.26 HI	228.00 HI	132.71 I	364.51 HI
	Mean	**2444.39 B**	**1830.12 C**	**2396.75 B**	**2649.06 A**
Ca	Yolk	2452.05 D	2338.92 D	1562.90 D	2452.05 D
	White	363.36 D	383.69 D	403.38 D	402.30 D
	Membrane	6647.31 D	208.67 D	76755.95 C	76755.95 C
	Shell	449895.46 A	431585.99 A	379221.79 B	379212.79 B
	Mean	**114839.55 a**	**108629.32 ab**	**114486.01 a**	**102611.22 b**
Mg	Yolk	182.15 IJ	249.43 HI	139.10 IJ	225.70 IJ
	White	730.56 D	654.74 DE	783.94 D	523.09 EF
	Membrane	370.74 HI	49.50 J	449.98 FG	477.82 FG
	Shell	3484.22 C	3284.22 C	724.57 D	4261.26 A
	Mean	**1192.15 B**	**1059.47 C**	**524.40 D**	**1371.96 A**

*****$p<0.05$

Significant changes were monitored in the macroelement contents of the egg parts ($p<0.05$). P contents of turkey and chicken egg parts were determined to be between 239.54 (egg membrane) and 11125.64 mg/kg (egg yolk) to 75.73 (egg membrane) and 7586.55 mg/kg (egg yolk), respectively. While the P contents of duck egg parts varied between 514.88 (egg membrane) and 9072.90 mg/kg (egg yolk), the P contents of quail egg parts varied between 594.14 (egg shell) and 10531.91 mg/kg (egg yolk). The average P contents of the parts of each egg ranged from 2517.72 (chicken) to 3793.89 mg/kg (quil). The K contents of turkey and chicken egg parts were determined as 245.26 (egg shell) and 6273.43 mg/kg (egg white) to 228.00 (egg shell) and 5740.48 mg/kg (egg white), respectively. In addition, the K contents of duck and quail egg parts were determined between 132.71 (egg shell)

and 5921.78 mg/kg (egg white) to 364.51 (egg shell) and 6465.78 mg/kg (egg white), respectively. The average K contents of different parts of egg samples were determined between 1830.12 (chicken) and 2649.06 mg/kg (quil). While the Ca contents of turkey egg parts were determined between 363.36 (egg white) and 449895.46 mg/kg (egg shell), the Ca contents of chicken egg parts were determined between 383.69 (egg white) and 431585.99 mg/kg (egg shell). In addition, the Ca contents of duck and quail egg parts were accumulated to be between 403.38 (egg white) and 379221.79 mg/kg (egg shell) and 402.30 (egg white) and 379212.79 mg/kg (egg shell), respectively. The average Ca contents of different parts of each egg sample were determined to be between 102611.22 mg/kg (quil) and 1148339.55 mg/kg (turkey). It shows that chicken egg shell may have a good calcium limit that can be used to meet daily calcium consumption and can be used as a supplement for bone development since the recommended daily consumption is between 700 - 1300 mg [16].

The macroelement detected in the lowest amounts in the egg sample parts was Mg. The Mg contents of turkey and chicken egg parts were determined between 182.15 (egg yolk) and 3484.22 mg/kg (egg shell) to 49.50 (egg membrane) and 3284.22 mg/kg (egg shell), respectively. While the Mg contents of duck egg parts accumulated between 139.10 (egg yolk) and 783.94 mg/kg (egg white), the Mg contents of quail egg parts were determined to be between 225.70 (egg yolk) and 4261.26 mg/kg (egg shell). The average Mg contents of egg parts varied between 524.40 (duck) and 1371.96 mg/kg (quil).

Microelement contents of egg parts of different poultry animals are provided in Table 2.

Table 2. Microelement contents of different parts (yolk, white, membrane and shell) of turkey, chicken, duck and quail eggs

Microelement (mg kg-1)	Samples	Turkey	Chicken	Duck	Quil
Fe	Yolk	77.08c*	72.77cd	130.22b	371.81a
	White	1.66 c	3.57a	2.27b	3.61a
	Membrane	5.76d	12.99a	8.19c	11.58b
	Shell	1.39c	1.84a	0.72d	1.63b
	Mean	**21.47C****	**22.79C**	**35.35B**	**97.16A**
Zn	Yolk	52.44 C	56.95 B	47.37 D	66.27 A
	White	0.87 F	0.83 F	1.47 F	2.66 F
	Membrane	0.95 F	0.65 F	3.86 EF	7.62 E
	Shell	0.58 F	0.84 F	0.56 F	0.89 F
	Mean	**13.71 B**	**14.82 B**	**13.31 B**	**19.36 A**
Cu	Yolk	3.62 D	1.50 E	1.62 E	2.66 DE
	White	1.72 E	1.71 E	6.53 D	1.85 E
	Membrane	22.33 A	18.72 B	22.94 A	17.36 B
	Shell	1.34 E	1.63 E	21.80 A	1.95 E
	Mean	**7.25 B**	**5.89 C**	**13.23 A**	**5.96 C**
Mn	Yolk	2.58 A	1.54 D	0.79 GH	0.98 EF
	White	2.20 B	1.13 E	0.65 HIJ	0.88 FG
	Membrane	1.83 C	0.81 GH	0.60 IJ	0.83 FG
	Shell	1.53 D	0.78 GH	0.54 J	0.75 GHI
	Mean	**2.04 A**	**1.06 B**	**0.65 D**	**0.86 C**
B	Yolk	1.83 EF	1.26 GH	1.64 EFG	1.77 EF
	White	2.52 CD	3.29 B	2.36 D	3.54 B
	Membrane	2.80 C	5.72 A	1.95 E	5.74 A
	Shell	1.28 GH	1.48 FGH	1.12 H	1.36 GH
	Mean	**2.11 B**	**2.94 A**	**1.77 C**	**3.10 A**

* $p<0.01$**; ****$p<0.05$

Significant differences were observed in the microelement contents of egg parts depending on egg types ($p<0.05$). In general, the egg part where the microelement contents accumulated the most was the egg yolk. In addition, the B content of microelements was determined mostly in the egg membrane (except duck egg). Fe contents of turkey and chicken egg parts were found between 1.39 (egg shell) and 77.08 mg/kg (egg yolk) to 1.84 (egg shell) and 72.77 mg/kg (egg yolk), respectively. Also, Fe contents of duck egg parts were determined to range from 0.72 (egg shell) to 130.22 (egg yolk), while Fe contents of quail egg parts were determined to range from 1.63 (egg shell) to 371.81 mg/kg (egg yolk). Average Fe contents of egg parts ranged from 21.47 (turkey) to 97.16 mg/kg (quil). Eggshells can be a source of iron to improve the nutritional status of diabetic patients with iron deficiency, infants, children and pregnant women at risk of anemia [2]. While the Zn contents of turkey egg parts were determined to be between 0.58 (egg shell) and 52.44 mg/kg (egg yolk), the Zn contents of chicken egg parts were determined to be between 0.65 (egg membrane) and 56.95 mg/kg (egg yolk). The Zn contents of duck and quail egg parts accumulated between 0.89 (egg shell) and 66.27 mg/kg (egg yolk) to 0.72 (egg shell) and 55.76 mg/kg (egg yolk), respectively. The average Zn contents of egg parts of each poultry egg varied between 13.31 (duck) and 19.36 mg/kg (quil). Cu contents of turkey and chicken egg parts were determined between 1.34 (egg shell) and 22.33 mg/kg (egg membrane) to 1.50 (egg yolk) and 18.72 mg/kg (egg membrane), respectively. In addition, Cu contents of duck and quail egg parts accumulated between 1.85 (egg white) and 17.36 mg/kg (egg membrane) to 2.35 (egg yolk) and 20.34 mg/kg (egg membrane), respectively. Average Cu contents of egg parts were determined to be between 5.89 (chicken) and 13.23 mg/kg (duck). While the Mn contents of turkey egg parts were determined between 1.53 (egg shell) and 2.58 mg/kg (egg shell), the Mn contents of chicken egg parts were determined between 0.78 (egg shell) and 1.54 mg/kg (egg yolk). The Mn contents of duck and quail egg parts were determined between 0.54 (egg shell) and 0.79 mg/kg (egg yolk) to 0.75 (egg shell) and 0.98 mg/kg (egg yellow), respectively. The average Mn contents of egg parts varied between 0.65 (duck) and 2.04 mg/kg (turkey). In poultry eggs, the B content was determined mostly in the egg membrane, and the average B amounts of the egg membrane varied between 1.95 (duck) and 5.74 mg/kg (quil). The B content of egg parts was determined in the highest amounts in egg white, egg yolk and egg shell parts in decreasing order after the egg membrane.

Toxic element contents of egg parts of different poultry animals are presented in Table 3. In general, it is understood from Table 3 that toxic element contents of egg parts are at the lowest levels. Depending on the types of poultry eggs, the egg parts with the highest Al content were egg shell and egg white parts, followed by egg membrane and egg yolk parts in decreasing order. Al contents of turkey and chicken egg parts accumulated between 0.026 (egg yolk) and 0.065 mg/kg (egg white) to 0.015 (egg yolk) and 0.105 mg/kg (egg shell), respectively. In addition, duck and quail egg parts were found to contain 0.017 (egg yolk) and 0.064 mg/kg (egg white) to 0.011 (egg shell) and 0.047 mg/kg (egg white), respectively. The average Al contents of egg parts of poultry types varied between 0.030 (quil) and 0.047 mg/kg (chicken). Depending on the egg types, the average As contents of egg parts were determined between 0.059 (duck) and 0.090 mg/kg (quil). As contents of duck and quail egg parts accumulated between 0.016 (egg yolk) and 0.111 mg/kg (egg membrane) to 0.033 (egg white) and 0.139 mg/kg (egg shell), respectively. The highest mean As in egg parts was detected in egg shell, followed by egg membrane, egg yolk and egg white parts in decreasing order. Depending on the egg types, the average Ba and Cd contents of the egg parts were determined between 0.014 (quil) and 0.078 mg/kg (chicken) to 0.0028 (duck) and 0.0063 mg/kg (turkey), respectively. In addition, the average Co element contents of the egg parts were determined between 0.0024 (quil) and 0.0094 mg/kg (turkey), while the average Cr contents of the egg parts were determined between 0.0016 (turkey) and 0.0024 mg/kg (quil) depending on the egg types. Mo contents of turkey and chicken egg parts were determined between 0.0047 (egg white) and 0.1853 mg/kg (egg shell) to 0.0357 (egg yolk) and 0.0955 mg/kg (egg white), respectively. Depending on egg types, the highest average Ni (0.0045 mg/kg), Pb (0.0060 mg/kg) and Se (0.219 mg/kg) contents of egg parts were determined in quail, duck and quail eggs, respectively. In general, Se contents of quail egg parts ranged from 0.137 (egg yolk) to 0.456 mg/kg (egg membrane), and were higher than those of turkey, chicken and duck egg parts. It was observed that the richest parts of poultry eggs in terms of P and K content were egg yolk and egg white, respectively. In addition, it was determined that the richest egg layers in terms of Ca content

were egg shell, followed by egg membrane, egg yolk and egg white in decreasing order.

Table 3. Toxic element contents of different parts (yolk, white, membrane and shell) of turkey, chicken, duck and quail eggs

Toxic element (mg kg^{-1})	Sample	Turkey	Chicken	Duck	Quil
	Yolk	0.026 GHI	0.015 IJ	0.017 HIJ	0.034 EFG
	White	0.065 B	0.035 EFG	0.064 B	0.047 CDE
Al	Membrane	0.048 CD	0.034 FG	0.047 CD	0.029 FGH
	Shell	0.057 BC	0.105 A	0.041 EFG	0.011 J
	Mean	**0.04 A**	**0.047 AB**	**0.042 B**	**0.030 C**
	Yolk	0.025 GH	0.048 DE	0.016 HI	0.097 C
	White	0.054 D	0.009 I	0.054 D	0.033 FG
As	Membrane	0.041 EF	0.037 F	0.111 B	0.091 C
	Shell	0.146 A	0.146 A	0.056 D	0.139 A
	Mean	**0.066 B**	**0.060 C**	**0.059 C**	**0.090 A**
	Yolk	0.0068 E	0.030 D	0.0027 E	0.0062 E
	White	0.0014 E	0.0013 E	0.0014 E	0.0014 E
Ba	Membrane	0.0011 E	0.0015 E	0.0085 E	0.0018 E
	Shell	0.054 C	0.2803 A	0.066 B	0.049 C
	Mean	**0.016 B**	**0.078 A**	**0.019 B**	**0.014 B**
	Yolk	0.0013 H	0.0035 E	0.0026 G	0.0046 D
	White	0.0094	0.0015 H	0.0037 E	0.0015 H
Cd	Membrane	0.0106 A	0.0045 D	0.0016 H	0.0095 B
	Shell	0.0038 E	0.0038 E	0.0034 EF	0.0063 C
	Mean	**0.0063 A**	**0.0031 C**	**0.0028 C**	**0.0055 B**
	Yolk	0.0017 I	0.0015 I	0.0037 G	0.0004 J
	White	0.0130 B	0.0062 E	0.0079 D	0.0015 I
Co	Membrane	0.0044 FG	0.0093 C	0.0053 EF	0.0044 FG
	Shell	0.0175 A	0.0076 D	0.0007 IJ	0.0034 H
	Mean	**0.0094 A**	**0.0061 B**	**0.0044 C**	**0.0024 D**
	Yolk	0.0025 B	0.0024 B	0.0027 B	0.0035 A
	White	0.0016 C	0.0013 CD	0.0023 B	0.0014 CD
Cr	Membrane	0.0013 CD	0.0033 A	0.0024 B	0.0036 A
	Shell	0.0009 DE	0.0005 EF	0.0001 F	0.0012 CD
	Mean	**0.0016 C**	**0.0019 B**	**0.0019 B**	**0.0024 A**
	Yolk	0.105 D	0.0357 I	0.0933 EF	0.0198 J
	White	0.0047 L	0.0955 E	0.0446 GH	0.0179 JK
Mo	Membrane	0.0514 G	0.0369 HI	0.0094 KL	0.242 A
	Shell	0.1853 C	0.0479 G	0.0852 F	0.2051 B
	Mean	**0.087**	**0.054**	**0.058**	**0.121**
	Yolk	0.0015 H	0.0017 H	0.0026 G	0.0039 D
	White	0.0024 G	0.0037 DE	0.0016 H	0.0054 B
Ni	Membrane	0.0031 EF	0.0045 C	0.0028 FG	0.0123 A
	Shell	0.0015 H	0.0006 I	0.0006 I	0.0006 I
	Mean	**0.0022 C**	**0.0026 B**	**0.0019 C**	**0.0060 A**
	Yolk	0.0016 EF	0.0003 I	0.0018 DEF	0.00045 B
	White	0.0009 GHI	0.0009 GHI	0.0013 FGH	0.0023 D
Pb	Membrane	0.0022 DE	0.0007 I	0.0008 HI	0.0094 A
	Shell	0.0031 C	0.0015 FG	0.0008 HI	0.0018 DEF
	Mean	**0.0019 B**	**0.0009 D**	**0.0045 A**	**0.0012 C**
	Yolk	0.056 H	0.073 G	0.023 I	0.137 CD
	White	0.025 I	0.045 H	0.091 F	0.134 D
Se	Membrane	0.086 FG	0.046 H	0.164 B	0.456 A
	Shell	0.137 CD	0.055 H	0.112 E	0.152 CD
	Mean	**0.076 C**	**0.055 D**	**0.097 B**	**0.219 A**

The average P and K contents of quail eggs were higher than those of other eggs. When the egg parts were considered, the highest average Ca content was observed in turkey eggs, followed by duck, chicken and quail eggs in decreasing order. As in Calcium (Ca), the highest Mg content in egg samples was determined in egg shells. This situation may be due to the consumption of Ca and Mg elements (such as Mg CO_3, Ca CO_3, magnesium silicate), which are found in different forms in nature, together with the feed by poultry animals. The poorest part of the egg samples in terms of Mg was egg yolk. However, it was observed that egg yolks were richer in terms of Fe, Zn and Mn compared to other egg parts. In addition, the highest Fe was detected in duck and quail egg yolks. In addition, the Zn content of duck and quail egg membranes is higher than that of other eggs. This may be due to the metabolic activities of ducks and quails. In addition, the egg layer richest in copper was the egg membrane. Interestingly, the Cu content in duck egg shell was found to be similar to the Cu value of other poultry egg membranes. This may be due to the contamination of duck eggs with copper alloy material. At the same time, the Cu content of duck egg white layer was higher than that of other eggs. In general, the highest average B content of egg parts was observed in quail eggs, followed by chicken, turkey and duck eggs in decreasing order. Although there were statistical differences between the Al, As, Ba, Cd, Co, Cr, Ni, Pb contents of the egg parts, they were found to be close to each other. However, the Mo and Se content amounts of the egg membrane and egg shell parts of the quail egg were higher than the element amounts in the other egg parts. This may be due to the fact that quail absorbs the elements in feed more than other poultry. As a result, the amount of toxic elements in the egg parts is found to be at very low levels, and it has been revealed that the parts of this food do not pose a risk depending on where they are used.

Heavy metal contamination of food is a serious threat and heavy metals, which generally have toxic effects at low concentrations, are released into the environment from both anthropogenic and natural sources, as long-term exposure can lead to human health risks [20]. In other study, Wet egg yolks of domestic bird species chicken, turkey, goose, duck and pigeon contained 21207, 26950, 20182, 19497, 23524 ng/g Zn, 224, 289, 168, 294 and 438 ng/g Se, 715, 1883, 981, 1772 and 1264 Mn, 1272, 3047, 1108, 1559 and 1351 ng/g Cu, 236, 111, 80, 4 39 and 395 Mo, 15.4, 9.4, 12.2, 14.5 and 12.4 ng/g As, 1.44, 1.17, 0.923, 0.844, 1.13 ng/g Cd, respectively [9]. In other study, the yolk part of chicken eggs contained 0.003 ppm Mn [15]. Egg White, egg yolk and egg Shell parts of chicken eggs contained an average of 639.20, 176.03 and 1488.01 Mg, 665.93, 3856.23 and 521.04 mg/kg P, 4151.84, 593.43 and 156.72 K, 453.49, 1225.18 and 74,643.56 mg/kg Ca, respectively [5]. Chicken Eggshell (mg/L) contained 2300.33 mg/L Ca, 850 Mg, 33.83 Na, 17.06 K, 1.4 Fe, 0.99 Zn and 0.063 Cu [3]. In two experimental groups, the zinc level of the yolk was found to be in range of 13.6 to 23.5 ppm, respectively [21]. Burger and Gochfeld, [22] found that some eggs contained up to 4.0 ppm Cd, whereas most eggs were below the detection limit (0.5 ppm). In another study, level of manganese was found as 0.03 ppm and 0.66 ppm Mn in yolk and albumen, respectively [23]. In other study, the yolk part of chicken eggs contained 0.003 ppm Mn [15]. Quail egg yolk was found to be richer in Ca (1184 mg/kg) but poorer in P, Mg and Zn than chicken egg yolk, and the levels of P, Mg and Zn elements in chicken egg were determined to be approximately 5120, 209 and 46 mg/kg, respectively [24]. The contents of Mn, Fe, Co, Zn and Cu (2.96, 183.50, 0.48, 48.47 and 4.67 Fg/g dry weight, respectively) were highest in quail egg [25]. In recent years, with the increase in egg production and consumption, egg shell waste, which can be used as a valuable product as an attractive source of calcium for human nutrition, poses serious health risks [3,26,27]. The content of egg shell generally consists of 94% calcium carbonate, 1% magnesium carbonate and 1% calcium phosphate and is a cheap source of calcium that can be accessed at home [28]. Egg shell powder has excellent potential use as a calcium supplement in human nutrition and positively affects the development of human bone mass [3,28]. While chicken eggshell can function as a magnesium dietary supplement, magnesium deficiency in the animal diet can cause a number of diseases and sometimes death [3]. In our study, the element concentrations detected in the egg pieces differed from the toxic limits reported in the literature [23,29,9,25,5]. The factors that cause differences in the mineral content of eggs may vary depending on the mineral content and sources in the diet, cultivation systems and different geographical regions [30].

4. Conclusions

The It was observed that the richest parts of poultry eggs in terms of P and K content were egg yolk and

egg white, respectively. In addition, it was determined that the richest egg layers in terms of Ca content were egg shell, followed by egg membrane, egg yolk and egg white in decreasing order. The average P and K contents of quail eggs were higher than those of other eggs. When the egg parts were considered, the highest average Ca content was observed in turkey eggs, followed by duck, chicken and quail eggs in decreasing order. The poorest part of the egg samples in terms of Mg was egg yolk. However, it was observed that egg yolks were richer in terms of Fe, Zn and Mn compared to other egg parts. Although there were statistical differences between the Al, As, Ba, Cd, Co, Cr, Ni, Pb contents of the egg parts, they were found to be close to each other. As a result, the amount of toxic elements in the egg parts is found to be at very low levels, and it has been revealed that the parts of this food do not pose a risk depending on where they are used.

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