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Analyses of Chemical and Physical Egg Quality Parameters of Laying Hens Housed in Different Conditions in Turkey

Reyhan Selin UYSAL AFACAN*[1]

Abstract

The aim of the present study is to determine the content of chemical and physical quality parameters of hen eggs (liquid whole egg (LWE), liquid egg yolk (LEY), and liquid egg white (LEW)) produced for different housing and feeding conditions in Turkey. Chemical quality parameters (protein, lipid, and moisture) and physical quality parameters (total soluble solid (°Brix), pH, conductivity, and yolk:white ratio) were analyzed using different egg samples. Kjeldahl, wet ashing, and oven-drying official methods were used for the protein, total lipid, and moisture analyses of egg samples. The highest protein content in the LEY and LEW samples were found to be 19.0% and 15.13%, respectively for the tenth sample having fortified feeding (selenium+DHA) parameters. For LWE samples, it was also obtained 15.65% with the second sample having a not fortified feeding parameter. The highest total lipid content for LWE samples was determined as 10.43% for the seventh sample which housed under cage free conditions and fed with organic (omega3+EPA+DHA) fortifiers, while it was found with a value 25.7% for the second and third LEY samples possessing a not fortified feeding parameters. The highest moisture content was determined as 78.37%, 54.64%, and 89.11 for thirty-first LWE sample (with not fortified feeding), third LEY sample (with not fortified feeding) and sixth LEW sample (having cage free and organic parameters), respectively. As a result, the minimum, average, and maximum contents of the chemical and physical quality parameters were determined for laying hen eggs raised in several housing and feeding conditions in Turkey.

Keywords: Liquid egg, egg quality, egg component, egg analysis, laying hen

1. INTRODUCTION

Egg is one of the essential food in human diet due to its high nutrient (protein, essential lipids, vitamins and minerals) content [1]. Besides of its high nutritional values, it is one of the fundamental ingredients used in the products because of its multifunctional properties including emulsifying, foaming, gelling, thickening, and flavoring all of which provide the texture and sensory qualifications of food products [2].

In food industry, liquid egg products (whole egg, egg yolk, and egg white) usually are preferred by manufacturers instead of shell eggs because of its ease of use and microbial reliability [3]. In this point, it is crucial for the

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manufacturers to know that the quality parameters of the liquid egg products are within the expected values. The quality of egg has been determined by analyzing some interior physical (egg weight, albumen height, Haugh units, and yolk color, etc.) and chemical (contents of protein, lipid, and total solid, etc.) quality parameters [4, 5].

On the other hand, breeding conditions and age of hens could affect the level of egg components and the quality parameters of egg [6]. Therefore, it is critical for the manufacturers to know that the change in the level of the egg quality parameters according to the breeding conditions (such as feeding and housing) of hen. Hens have been breeding in different housing conditions such as conventional cage, free range, and barn [7]. In addition to this housing system, they have been feeding supplemented with several nutrients (such as chia, fish oil, and flaxseed) to improve the nutrition level (such as omega 3 fatty acids) of the egg [8]. While the housing and feeding conditions are the major factors affecting the chemical composition of egg, hen age and egg size are also one of the minor factors affecting the quality parameters of egg [9].

In these concepts, many studies have been performed in the literature results. Total fat and fatty acid contents were analyzed for different brands and housed in different systems of hen egg [10]. Effects of special dietary feeding of hen on mineral, vitamin, and albumen protein contents were investigated [11]. In another study with a special feeding, the effects of dietary Turkish propolis and vitamin C supplementation in diets were investigated on feed intake, body weight, body weight gain, feed conversion rate, digestibility, and on egg production and qualities in laying hens [12].

Fatty acid compositions were analyzed for hen egg housed in cage and cage free conditions [13]. Cholesterol, vitamins, and fatty acid compositions in egg were compared between the hen housed in conventional cage and range [14]. Chemical composition (protein and fat) and quality traits were tested for eggs yolk and from different production systems in Serbian [15]. In another study, laying performance, egg quality parameters, and yolk fatty acid profile of two Turkish layer genotypes were evaluated and their suitability for organic poultry production was investigated [16]. According to the above-mentioned research, the effect of different housing and feeding systems of hen on some chemical and quality parameters of eggs have been studied. However, in Turkey, the effect of several housing and feeding conditions of laying hen both on physical and chemical quality parameters of liquid whole egg (LWE), liquid egg yolk (LEY), and liquid egg white (LEW) has not been studied comprehensively in the literature.

The objective of the present study was to determine the content (the level of maximum, minimum, and average points) of chemical (protein, lipid, and moisture) and physical (yolk:white ratio, °Brix, pH, and conductivity) quality parameters of eggs (LWE, LEY, and LEW samples) produced in Turkey in different feeding and housing conditions such as cage, cage free, organic, fed with enriched dietary (omega 3, eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA), and selenium).

2. MATERIAL AND METHOD

2.1. Materials

A set of fresh shell egg samples (n=34) were purchased from the local markets in Turkey, housed and fed under a variety of parameters, including caged, cage free, and organic and enriched with omega 3, EPA, DHA, and selenium. In terms of the freshness of the egg samples, attention was paid to purchase only those whose production date was within the first week. Only medium-sized eggs were used in the analysis. In addition, egg samples were also classified according to whether the hen was young or not. Housing, feeding, and hen age parameters of LWE, LEY, and LEW

samples are listed in Table 1. As can be seen in the table; these parameters can be categorized as cage (n=19), cage-free (n=15), and organic (n=11) housing systems; various feeding systems fortified with omega 3, (omega3 + EPA + DHA), and (selenium + DHA) or not and hen ages young or not.

Table 1 Housing and feeding parameters of liquid egg samples

No	Cage	Cage free	Organic	Fortified (Omega3)	Fortified (Omega3+EPA+DHA)	Fortified (Selenium+DHA)	Hen age (Young)
1¶	X						
2¶	X						
3¶	X						X
4¶	X						X
5¶		X	X				X
6¶		X	X				
7¶		X	X		X		
8¶	X						
9¶	X			X			
10¶	X					X	
11¶		X	X				
12¶		X					
13¶		X	X				
14		X					
15		X					
16		X					
17	X						
18		X	X				
19	X						X
20		X	X				
21		X	X				
22	X						
23	X						
24	X						X
25	X						X
26		X	X				
27	X						
28	X						
29	X						X
30		X	X				
31	X						
32	X						
33		X	X				
34	X						

¶ The bold numbers indicate shell egg samples whose liquid whole egg, liquid egg yolk, and liquid egg white were analysed.

All samples of LWE (n=34), LEY (n=13) and LEW (n=13) were prepared using shell eggs at laboratory scale. LEY and LEW samples were prepared manually, shell egg was broken and separated as white and yolk. Then the white and yolk samples were homogenized (IKA T-18 Ultra Turrax Digital Homogenizer, IKA Company, Deutschland, Germany) separately at 615×g for 3 minutes. The LWE egg samples were also manually broken as a whole egg and homogenized at 615×g for 3 minutes. Yolk:white ratio of LWE samples were determined by weighing their weight (yolk and white) separately and then calculated the ratio of yolk:white as percentage. The quality of liquid egg samples

was evaluated by analyzing chemical parameters such as the content of protein, total lipid, and moisture and by measuring of physical parameters that are °Brix, pH, and conductivity.

2.2. Chemical analyses of liquid egg samples

LWE, LEY, LEW samples were prepared for the protein, total lipid, and moisture analyses. Kjeldahl analysis was performed to measure the protein content in accordance with the method proposed by AOAC. Moisture content of the egg samples was also determined by AOAC method [17]. The percentage of nitrogen is multiplied by a conversion factor of 6.25 to calculate the percentage of protein in the egg samples. Total lipid content of the egg samples was detected as defined in the Official Methods of Analysis of AOAC [18].

2.3. Physical measurements of liquid egg samples

Total soluble solid (TSS, °Brix), pH, and electrical conductivity values of liquid egg samples were measured. The pH values of LWE, LEY, and LEW samples were measured by using pH meter (Mettler-Toledo, Columbus, USA) at the ambition temperature. TSS contents of LWE, LEY and LEW samples were measured with an optical refractometer (RFM 330, Bellinghma + Stanley Ltd, UK). 1 mL was poured into the refractometer glass prism, and the measurements were taken at 25°C. Then, the measured data were recorded as °Brix value of the sample. Conductivity measurements of LWE samples were also taken using a handheld conductivity meter (HI8734, Hanna Instruments, Melbourne, Australia). Then, the reading was recorded as conductivity value of the sample.

3. CONCLUSIONS AND DISCUSSION

For liquid whole egg (LWE) samples, the chemical parameter values with protein, lipid, moisture, and physical parameter values, TSS (°Brix), pH, conductivity, and yolk:white ratio are presented in Table 2. As can be seen from the table, yolk:white ratios of egg are observed between 25.7:74.3 and 36.1:63.9. The average yolk:white ratio of LWE was calculated as 31:69 that value seems to be compatible with the literature results [19, 20]. As can be given in Table 2, protein values of the LWE samples were observed in the range from 11.59% to 15.65%. The average protein value of these samples is obtained as 12.84%. When detected values were compared to with the findings in the literature, proteins of LWE was found consistent with the reported results [21].

The average total lipid values of LWE samples were obtained 7.71%. The total lipid values were observed between in the range of 5.47–10.43%. The range of the lipid values were consistent with the literature results [22]. It can be seen in Table 2 that feeding with (omega3 + EPA + DHA) fortifiers affected to increase in lipid value of egg such as seventh sample (10.43%) which is the highest lipid value among the samples. Then, usage of fortifiers (omega 3) and (selenium + DHA) also led to increment in lipid values as 9.93% (ninth) and 9.01% (tenth sample). Huang, et al. [23] reported that feeding with dietary fish oil affected on omega-3 fatty acid levels (EPA and DHA) in hen egg.

Table 2 Values of chemical and physical parameters of liquid whole egg samples

No	Protein (%)	Lipid (%)	Moisture (%)	°Brix	pH	Conductivity (m/S)	Yolk:White Ratio (w:w, %)
1	14.08±0.57	7.98±0.69	78.06±0.03	22.5	7.59	5.92	30.5:69.5
2	15.65±0.66	8.39±0.58	77.91±0.01	22.2	7.20	6.48	28.7:71.3
3	15.18±0.17	7.07±0.26	76.88±0.03	22.5	7.41	6.22	34.5:65.5
4	15.15±0.16	9.36±0.40	76.16±0.01	25.4	7.45	6.36	29.7:70.3
5	13.20±0.05	6.99±0.40	76.23±0.03	25.1	7.40	6.22	32.3:67.7
6	13.61±0.31	8.55±0.90	76.38±0.02	24.6	7.38	5.11	33.2:66.8
7	14.87±0.35	10.43±0.45	76.62±0.03	22.2	7.41	5.13	36.1:63.9
8	14.62±0.27	7.87±0.88	77.64±0.05	22.5	7.56	6.42	32.6:67.4
9	13.64±0.30	9.93±0.50	75.11±0.02	26.3	7.60	6.37	31.1:68.9
10	13.98±0.03	9.01±0.30	77.12±0.07	23.6	7.59	6.37	32.6:67.4
11	15.21±0.74	7.78±0.28	76.31±0.19	25.5	7.55	6.50	29.8:70.2
12	13.98±0.65	7.67±0.91	76.83±0.27	24.4	7.59	6.21	33.4:66.6
13	13.80±0.29	6.29±0.34	78.58±0.09	23.0	7.70	6.22	27.0:73.0
14	13.96±0.25	6.75±0.21	76.18±0.02	26.9	7.12	6.50	28.0:72.0
15	13.13±0.21	6.32±0.25	76.43±0.01	25.6	7.34	6.55	30.0:70.0
16	14.58±0.27	7.03±0.32	75.82±0.01	27.6	7.25	6.10	29.5:70.5
17	14.12±0.10	6.95±0.52	77.94±0.02	24.8	7.61	6.52	25.7:74.3
18	13.84±0.35	7.80±0.30	77.48±0.00	26.3	7.54	6.49	29.6:70.4
19	14.04±0.44	5.50±0.21	76.54±0.01	25.9	7.43	6.34	30.1:69.9
20	13.49±0.17	8.15±0.65	75.77±0.01	28.0	7.39	6.21	32.9:67.1
21	14.73±0.15	7.35±0.47	75.87±0.01	24.9	7.67	6.36	29.3:70.7
22	15.22±0.19	6.90±0.80	75.68±0.01	28.0	7.55	6.40	29.0:71.0
23	13.72±0.07	7.02±0.55	74.94±0.01	27.3	7.17	6.50	35.5:64.5
24	13.72±0.29	7.05±0.22	76.17±0.02	27.0	7.39	6.20	31.4:68.6
25	12.08±0.07	8.10±0.32	76.59±0.01	26.2	7.53	5.70	33.2:66.8
26	12.31±0.30	8.14±0.78	75.89±0.02	27.2	7.38	5.10	30.5:69.5
27	12.22±0.18	6.77±0.57	76.89±0.01	25.9	7.63	6.10	28.5:71.5
28	12.50±0.03	6.81±0.86	76.88±0.03	26.2	7.58	5.60	34.6:65.4
29	12.35±0.36	5.47±0.19	77.30±0.02	25.7	7.60	5.90	29.9:70.1
30	13.73±0.34	7.21±0.09	76.67±0.01	26.8	7.81	6.20	27.2:72.8
31	11.59±0.59	6.82±0.15	78.37±0.00	24.5	7.68	6.50	31.3:68.7
32	12.06±0.04	7.31±0.86	76.82±0.01	26.6	7.58	6.20	33.2:66.8
33	12.92±0.06	8.70±0.26	76.08±0.00	26.5	7.69	6.10	30.7:69.3
34	12.46±0.11	7.39±0.05	76.01±0.00	27.5	7.55	6.40	30.4:69.6

Enrichment of eggs with omega 3 sources is an applied method to increase and improve the fatty acid profiles in hen eggs [24]. The moisture level of LWE samples were obtained in the range from 74.94% to 78.58%. The average level of moisture was calculated as 76.64%. The moisture range was found compatible with another studies. Besides chemical parameters of egg, value, TSS content (°Brix) was also measured for LWE samples. TSS content of LWE samples were obtained within the range of 22.2–28.0 °Brix. The average TSS content of LWE samples were calculated as 25.57 °Brix. Average value of TSS content with 26.03 °Brix was found in consistent with the literature results.

Another physical parameter of egg, pH value was also controlled. The pH value of LWE egg was observed between these values of

7.12–7.81. the average value of pH measurements of LWE samples was obtained as 7.5. In another study, pH value of LWE was measured as 7.67 that is consistent with the result of present study [25]. pH measurement has an important role to indicate the fresh of shell egg. Storage can affect some characteristics of egg such as loss of carbon dioxide that causes to increase in the pH of the albumen albumen [26]. The last analysis from physical measurements was electrical conductivity of LWE samples. Electrical conductivity of egg is one of the main characteristics of egg that changes according to storage time. Measurement of electrical conductivity uses to check the physical change during storage period of egg [27]. In the present study, results of conductivity measurements of LWE were obtained in the range from 5.10–6.55 m/S. The average value of electrical conductivity of egg was calculated as 6.16 m/S.

For liquid egg yolk (LEY) and white (LEW) samples, physical and chemical analyses were also performed. Using a set of 13 egg samples, values of protein, lipid, moisture, TSS (°Brix), and pH were analyzed. The housing and feeding properties of the egg samples are also presented in Table 1. As can be seen in the table, the differences between the samples include several housing and feeding systems, organic egg, and hen ages. Protein values of LEY and LEW samples are shown in Figure 1.

As can be seen in Figure 1, protein values were in the range of 16.74–19.0% and 10.69–15.13% for LEY and LEW samples, respectively. The average protein values of LEY and LEW samples were 17.89% and 12.57%. Obtained values were found consistent with the literature results. Among yolk components, proteins are the main molecules, which compose 64% of yolk granules on a moisture-free basis. Most yolk protein structure exists in lipoprotein structure such as low-density lipoprotein (LDL) and high-density lipoprotein (HDL). The other proteins are available as apoproteins (phosvitin and livetin) [28].

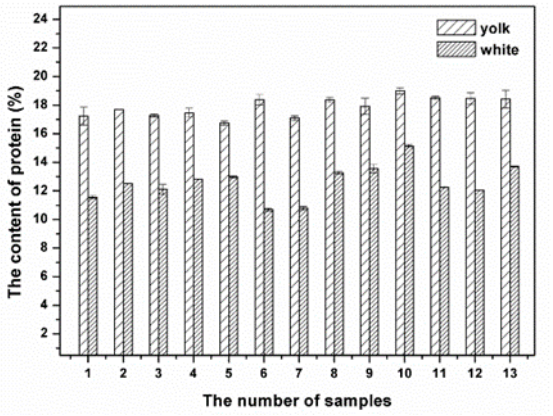

Figure 1 The protein contents (%) of liquid egg yolk (LEY) and liquid egg white (LEW) samples

Egg white (albumen) is approximately 10% aqueous solution of various proteins that mainly comprises of ovalbumin (54%), conalbumin (12%), ovomucoid (11%), ovomucin (3.5%) [29]. Lipid values of LEY and LEW samples are presented in Figure 2.

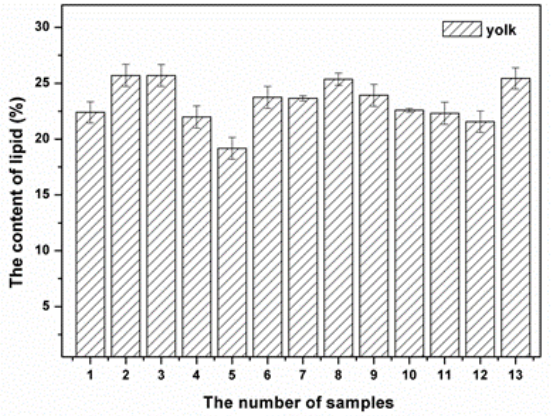

Figure 2 The total lipid contents (%) of liquid egg yolk (LEY) samples

As expected, for LEY samples, high lipid values were obtained between 19.17–25.7%. The average lipid value was calculated as 23.35%. On the other hand, the lipid content of LEW was relatively low and obtained as <0.1%. Thus, this value can be neglected in the LEW samples. Consequently, the measured values were compared with the findings in another studies, lipid values of LEY and LEW were found consistent with the reported results.

Moisture contents of LEY and LEW samples are demonstrated in Figure 3. Moisture contents were found between 49.26–54.64% and 86.54–89.11% for LEY and LEW samples, respectively. The average moisture values of LEY and LEW samples were 51.85% and 87.51%. As lipid and protein contents are high in LEY, dry matter content in LEY is lower compared to the LEW samples. Moisture results of the LEY and LEW samples were found consistent with the literature results [30].

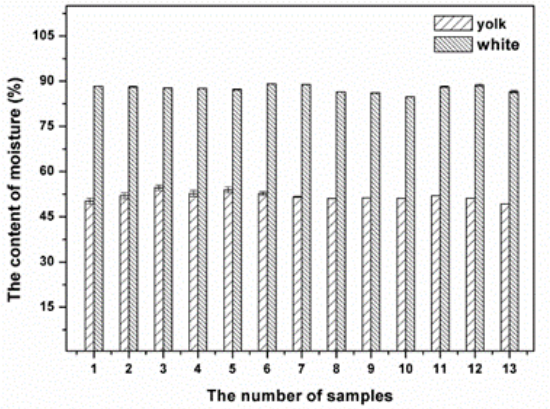

Figure 3 The moisture contents (%) of liquid egg yolk (LEY) and liquid egg white (LEW) samples

°Brix measurement, one of the physical analyses of egg samples, was performed to determine TSS content of the LEY and LEW samples. The TSS contents of LEY and LEW samples are shown in Figure 4. The TSS contents of the LEY and LEW samples were obtained in the range of 45.6–48.4 °Brix and 13.5–19.2 °Brix, respectively. Average TSS contents of the LEY and LEW samples were calculated as 46.6 and 16.2 °Brix, respectively. °Brix measurement can be used in the quality control analysis of eggs. As can be seen in Figures 3 and 4, moisture and TSS values of the LEY and LEW samples seem compatible when these values are compared to each other.

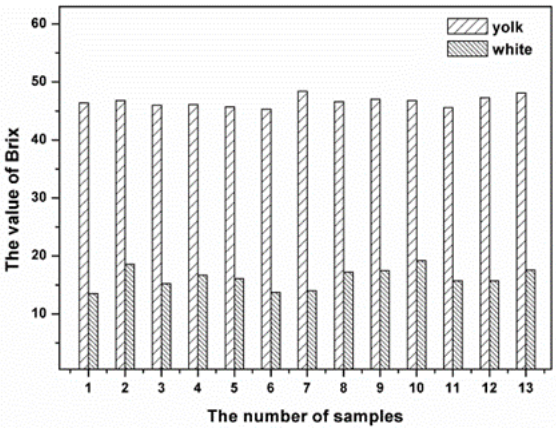

Figure 4 The total soluble solid contents (°Brix) of liquid egg yolk (LEY) and liquid egg white (LEW) samples

The last measurements of LEY and LEW samples were pH analysis. pH values of these samples are demonstrated in Figure 5. While pH values of the LEY samples were observed between 6.08–6.37, the LEW samples were between 8.84–9.04. The average pH values of the LEY and LEW samples were calculated as 6.2 and 8.9.

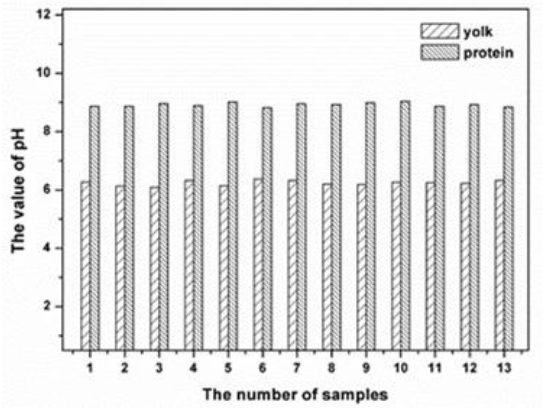

Figure 5 The values of pH measurements of liquid egg yolk (LEY) and liquid egg white (LEW) samples

In a study, the mean pH value of egg albumen was detected as 8.8 [31]. pH measurements are associated with the freshness and storage of egg albumen. As can be mentioned in the above, storage can affect the pH value of egg albumen due to loss of carbon dioxide that causes to increase in the pH of the albumen [32]. In another study, pH values of fresh egg albumen (the first day) were measured as about 7.9 then, it increased to the value of 8.9 during the egg storage (within about five

days). In another work, pH value of albumen increased from 7.4 to 8.6 in daily storage. Then, in the second day of storage, it raised up to 9.0 [33].

These results show that pH of albumen is very sensitive to the storage of egg. In the experiments, it was tried to use fresh eggs (within the first week of production date). However, the egg samples were purchased from the market, getting a daily egg has been difficult. Thus, used eggs in the experiments might be a few days old. Consequently, the maximum, minimum, and average values of protein, lipid, moisture, TSS (°Brix), conductivity, and pH analyses of liquid egg samples, which were produced under several housing and breeding parameters of hen egg in Turkey, were presented and evaluated with the literature results. In conclusion, these results will provide important contributions to the the literature and the food industry regarding egg quality parameters.

4. CONCLUSION

The present study provides measurements of chemical and physical parameters of eggs with a wide range of samples. Analyses were performed for the LWE, LEY, and LEW samples. The average yolk:white ratio of the egg samples was obtained as 31:69. The protein values of LWE, LEY, and LEW samples were found in the range of 11.59–15.65%, 16.74–19.00%, and 10.69–15.13%, respectively. The highest lipid value was analyzed for the LEY samples. These values of the egg samples, LWE, LEY, and LEW, were obtained between 5.47–10.43%, 19.17–25.7%, and <0.1%, respectively. The least moisture level was also found for the LEY samples due to the high value of lipid and protein. The moisture levels of the samples were observed in the range from 74.94 to 78.58%, 49.26 to 54.64%, and 86.54 to 89.11%. On the other hand, TSS values were measured proportional to the total solid contents of the samples (LWE, LEY, and LEW) such as, 22.2–28.0 °Brix, 45.6–48.4 °Brix, and 13.5–19.2 °Brix. The average pH level of the LEW, LEY, and LEW samples were measured as 7.67, 6.2 and 8.9. At last, conductivity measurements of the LWE samples were resulted as the average value of 6.16 m/S.

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Authors' Contribution
The authors contributed equally to the study.

The Declaration of Conflict of Interest/ Common Interest
No conflict of interest or common interest has been declared by the authors.

The Declaration of Ethics Committee Approval
This study does not require ethics permission or any special permission.

The Declaration of Research and Publication Ethics
The authors of the paper declare that they comply with the scientific, ethical and quotation rules of SAUJS in all processes of the paper and that they do not make any falsification on the data collected. In addition, they declare that Sakarya University Journal of Science and its editorial board have no responsibility for any ethical violations that may be encountered, and that this study has not been evaluated in any academic publication environment other than Sakarya University Journal of Science.

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