Volume 12, Issue 3, Page 33-40, 2023 https://doi.org/10.46810/tdfd.1319524 Research Article

BİNGÖL ÜNİVERSİTESİ

Türk Doğa ve Fen Dergisi
Turkish Journal of Nature and Science
www.dergipark.gov.tr/tdfd

Determination of Some Quality Parameters of Filtered Blossom Honey Obtained from Bingöl and Its Districts

Buket ARICI[1*], İsa GÖKÇE[2]

[1] Bingöl University, Central Laboratory Application and Research Center, Bingöl, Türkiye
[2] Tokat Gaziosmanpaşa University, Pharmacy Faculty, Department of Biochemistry, Bingöl, Türkiye
Buket ARICI ORCID No: 0000-0003-2570-0524
İsa GÖKÇE ORCID No: 0000-0002-5023-9947

**Corresponding author: barici@bingol.edu.tr*

(Received: 24.06.2023, Accepted: 22.07.2023, Online Publication: 27.09.2023)

Keywords
Bingöl, Moisture, Free acidity, Electrical conductivity, pH, Color

Abstract: The most well-known bee products are honey, pollen and propolis. The most consumed bee product is honey among these. It is of great importance to investigate and follow the physicochemical properties of honey in terms of food safety. Therefore, it was aimed to determine some quality parameters for filtered blossom honey harvested from the center and 7 districts of Bingöl Province in 2021. The moisture, free acidity, electrical conductivity, pH and color parameters of the supplied filtered blossom honey samples were investigated. The average values of 22 honey samples collected from the center and districts of Bingöl were determined as; humidity 15.43±0.06, free acidity 14.584±0.427 meq kg^{-1}, electrical conductivity 0.228±0.001 (mS cm^{-1}), pH 3.48±0.015 and color parameters L*, a*, b* values 58.404±0.275, 3.906±0.033, 38.552, respectively. According to these results, it was observed that the investigated filtered blossom honeys were within the limit values specified in the Turkish Food Codex Honey Communiqué.

Bingöl ve İlçelerinden Elde Edilen Süzme Çiçek Ballarının Bazı Kalite Parametrelerinin Belirlenmesi

Anahtar Kelimeler
Bingöl, Nem, Serbest asitlik, Elektriksel iletkenlik, pH, Renk

Öz: Arıcılık ürünleri arasında en bilinen arı ürünleri bal, polen ve propolistir. Bunlar arasında en fazla tüketilen arı ürünü ise baldır. Gıda güvenliği açısından balda fizikokimyasal özelliklerin incelenmesi ve takip edilmesi büyük önem taşımaktadır. Bu bağlamda, Bingöl İli merkez ve 7 ilçesinden 2021 yılında hasat edilen süzme çiçek balları için bazı kalite parametrelerinin belirlenmesi amaçlanmıştır. Temin edilen süzme çiçek bal örneklerinin nem, serbest asitlik, elektriksel iletkenlik, pH ve renk parametreleri incelenmiştir. Bingöl merkez ve ilçelerinden toplanan 22 adet bal örneğinin ortalama değerleri; nem 15.43±0.06, serbest asitlik 14.584±0.427 meq kg^{-1}, elektriksel iletkenlik 0.228±0.001 (mS cm^{-1}), pH 3.48±0.015 ve renk parametreleri L*, a*, b* değerleri sırasıyla 58.404±0.275, 3.906±0.033, 38.552±0.217 olarak belirlenmiştir. Bu sonuçlara göre incelenen süzme çiçek ballarının Türk Gıda Kodeksi Bal Tebliği'nde belirtilen sınır değerler içerisinde olduğu görülmüştür.

1. INTRODUCTION

In addition to honey, honeybees (*Apis mellifera* L.) can also produce beeswax, royal jelly, bee pollen, propolis, and bee bread. Even while ancient civilizations have been aware of the medical benefits of these substances for thousands of years, they are mostly employed as dietary supplements or health products today. However, these natural products are great sources of macro- and micronutrients known as bioactive compounds, which work synergistically to provide these by products numerous biological actions, such as, for example, antibacterial, antioxidant, and anti-inflammatory qualities [1-3].

In the Turkish Food Codex (TGK) Honey Communique No. 2020/7, honey is defined as “plant nectars, the secretions of living parts of plants or the secretions of plant-sucking insects living on the living parts of plants, after being collected by the honey bee, combine with their own specific substances, reducing the water content, matured by storing in honeycomb and a natural

product that can be crystallized according to its nature [4].

Bingöl province, which is located in the Iran-Turan flora region, is a very suitable region for beekeeping activities with its rich flora, differences in flowering times, clean nature and climatic conditions. According to Türkiye Statistical Institute (TURKSTAT) 2022 data, Bingöl has 1033 beekeeping enterprises, 2043 old-style beehives and 158.966 new-type beehives, in total 161.009 beehives. In 2022, 1.488.937 tons of honey was produced from 161.009 beehives. Bingöl province ranks 20th in Türkiye's honey ranking [5].

In the present study, moisture, free acidity, electrical conductivity, pH and color parameters were determined in strained blossom honey samples. Humidity is a parameter that affects the color, taste, aroma, solubility and specific gravity of honey, as well as its physical properties such as viscosity, crystallization, and the shelf life of honey [6]. The high moisture content in honey allows for crystallization and the development of osmotolerant (resistant to high sugar concentration) yeasts. When osmotolerant yeasts use the sugar in the environment, ethyl alcohol and carbon dioxide are released, which causes the honey to ferment. Alcohol formed as a result of fermentation transforms into acetic acid and water in the presence of oxygen and creates a sour taste in honey [7]. According to the Turkish Food Codex Honey Communiqué (2020/7) and the European Union Honey Directive, the moisture content of honey should not be more than 20% in blossom honey, secretory honey, blossom and secretory honey mixtures, 23% in puree (Calluna vulgaris), heather (Erica spp), and bakery honeys and 25% in heather based bakery honeys. The electrical conductivity of honey is a method used both to determine the botanical origin of honey and to distinguish between floral and secretory honeys. The electrical conductivity of secretory honey is higher than blossom honey [8,9]. The electrical conductivity value varies in proportion to the mineral content of honey [10].

One of the quality parameters of honey is free acidity. Free acidity creates the aroma of honey and increases the antioxidant activity of honey. It also gives information about the origin of honey. Acetic acid, butyric acid, formic acid, gluconic acid, lactic acid, malic acid, citric acid, succinic acid and oxalic acid are the acids found in honey [11]. According to the Turkish Food Codex Honey Communiqué (2020/7), the free acidity value in honey should not be more than 50 meq kg^{-1} in blossom honey, secretory honey, blossom honey and secretory honey mixture and 80 meq kg^{-1} in bakery honey.

The pH value affects the enzymatic activity, microorganism growth, shelf life, stability and texture of honey [12]. The pH value of honey is determined by the amount of mineral substances and organic acids in its content. The pH values of honeys rich in mineral substances are mostly high [13]. There is no regulation in the Turkish Food Codex Honey Communiqué on the pH value of honey.

In addition to taste and aroma, color which is one of the quality standards of honey, it is a parameter used to determine the origin of honey [14]. According to clause 5/d of the Turkish Food Codex Honey Communiqué (2020/7), there is the phrase “The color of honey can vary from water white to dark amber”.

With this study, the determination of the quality parameters of the honey obtained from the center and districts of Bingöl and its compliance with the standard were investigated. For this purpose, moisture, free acidity, pH, electrical conductivity and color parameters of 22 filtered blossom honey samples produced in the center and seven districts of Bingöl in 2021 were determined and their compliance with the standard was investigated.

2. MATERIAL AND METHOD

Bingöl, which is located in the Upper Euphrates section of the Eastern Anatolia Region, is at an altitude of 1151 m from the sea, and is located between 41°-20' and 39°-56' east longitudes and 39°-31' and 36°-28' north latitudes. Bingöl province has 7 districts in total, namely Yedisu, Genç, Karlıova, Yayladere, Solhan, Kiğı and Adaklı. In 2021, 22 honey samples were obtained from 8 different regions of Bingöl province. After the honey samples were coded, they were stored in glass jars at room temperature, dry, out of direct light, until analysis. Honey samples were homogenized before each analysis.

2.1. Determination of the Moisture

Abbe type refractometer was used for moisture analysis of honey samples. This method, which uses the refractive index, was proposed by Bogdanov [15]. Firstly, 1 g of the honey samples, which were mixed thoroughly with the help of glass baguette and became homogeneous, was weighed. The weighed honey samples were evenly spread on the prism section of the refractometer and the moisture content of the honey was measured by the ruler on the lens part. The measurements were repeated three times for each honey.

2.2. Determination of the Electrical Conductivity

For the measurement of the conductivity of the honey samples, taking into account the moisture value of each honey, honey containing 20 g of dry matter was weighed into 50 mL falcon tubes and dissolved in some ultrapure water. Each of the dissolved honeys was taken into 100 mL balloon joe and the solution volume was completed to 100 mL with ultrapure water. The ambient temperature was set to 20 °C and the solutions were transferred to 40 mL beakers. The measurement of the solutions was recorded with the Consort Brand C3010 model conductor, which was calibrated [15].

2.3. Determination of the pH

After calibration of Thermo Scientific brand ORION 3 STAR model pH meter with buffer solutions (pH:4.01, pH:7.00 and pH:10.01), the electrode of the pH meter

was immersed in honey samples dissolved in ultrapure water and the pH values of the samples were read [15].

2.4. Determination of the Free Acidity

10 g of honey from each honey sample was weighed in 250 mL beakers and thoroughly dissolved with 75 mL ultrapure water using a magnetic stirrer. 5 drops of phenolphthalein were added to the dissolved honey samples and while the electrode of the pH meter remained in the solution and stirring with the magnetic stirrer, the samples were titrated within 60 seconds with 0.05 N NaOH solution poured in a controlled manner from the burette until the color change turned pink (pH=8.3). The amount of solution used in the titration was recorded and calculations were made with the help of the following equation [15].

$$SA = \frac{50.a}{m} \quad (1)$$

In the equation, SA is the amount of free acidity (meq kg-1), α is the amount of used NaOH solution (mL), and m is the amount of measured honey sample (g).

2.5. Determination of the Color

Before the analysis process, honey samples were kept in a water bath set at 50°C for 30 minutes [16]. Honey samples taken from the water bath were mixed for 3 minutes until homogeneity was achieved. Honey samples taken from the water bath were mixed for 3 minutes until provided homogeneity. Then, the samples were taken into 4 mL spectrophotometer cuvettes for color analysis and measured in a Konica Minolta, CR-5 model colorimeter device. Thus, L*, a* and b* color parameters of honey samples were determined. Then, Hue angle (h°) was calculated by using a* and b* parameters in Equation 2.

$$h° = tan^{-1}\left(b*/a*\right) \quad (2)$$

L, darkness/lightness (0: darkness; 100: lightness); a (-a, greenness; +a, redness); and b (-b, blueness; +b, yellowness) values are defined. Experiments were repeated three times and the results were averaged.

3. RESULTS AND DISCUSSION

In the present study, quality standards were determined by investigating the moisture, electrical conductivity, free acidity, pH and color parameters of 22 filtered blossom honey harvested in 2021 from the center and seven districts of Bingöl province. The experimental results of humidity are presented in Table 1 and Figure 1. The maximum relative standard deviation of the humidity parameter was determined as 1.61%. As can be seen from Table 1 and Figure 1, coded as A2 and KA2 honey samples have the lowest moisture content with a value of 14.00%, while the coded as LAV honey sample has the highest moisture content with a value of 16.93%. There is 21% difference between the lowest and highest humidity levels. Since the maximum amount of moisture that can be found in blossom honeys is 20% according to the Turkish Food Codex Honey Communiqué (2020/7), it has been observed that investigated all honey samples comply with this Communiqué.

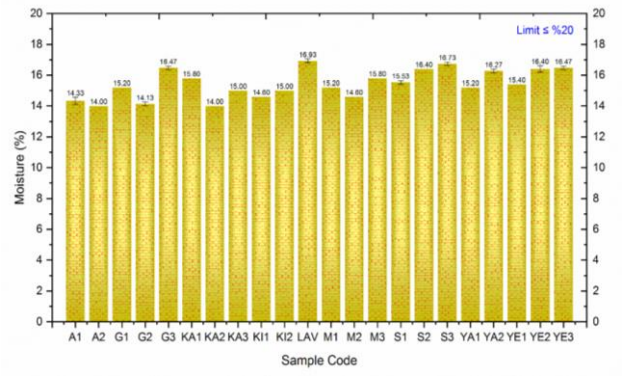

Figure 1. The graph for moisture results of the investigated honey samples

Table 1. The moisture, electrical conductivity, pH and free acidity results of the investigated honey samples

Sample Code	Moisture (%)	Electrical Conductivity (mS cm^{-1})	pH	Free Acidity (meq kg^{-1})
A1	14.33±0.23	0.178± 0.001	3.43±0.009	12.161±0.286
A2	14.00±0.00	0.495± 0.003	4.17±0.029	20.825±0.767
G1	15.20±0.00	0.195± 0.001	3.38±0.016	14.326±0.766
G2	14.13±0.12	0.162± 0.001	3.43±0.056	11.163±1.041
G3	16.47±0.12	0.216± 0.001	3.27±0.012	16.491±0.500
KA1	15.80±0.00	0.137± 0.001	3.43±0.009	7.496±0.499
KA2	14.00±0.00	0.385± 0.002	3.61±0.009	22.322±0.283
KA3	15.00±0.00	0.249± 0.001	3.29±0.005	17.157±0.287
KI1	14.60±0.00	0.226± 0.001	3.34±0.009	16.991±0.004
KI2	15.00±0.00	0.267± 0.001	3.58±0.019	14.658±0.288
LAV	16.93±0.12	0.199± 0.001	3.29±0.025	14.493±0.499
M1	15.20±0.00	0.263± 0.002	3.39±0.012	18.323±0.580
M2	14.60±0.00	0.196± 0.001	3.26±0.009	14.659±0.288
M3	15.80±0.00	0.329± 0.004	3.57±0.005	19.324±0.285
S1	15.53±0.12	0.165± 0.001	3.38±0.008	11.328±0.287
S2	16.40±0.00	0.196± 0.001	3.43±0.012	14.159±0.288
S3	16.73±0.12	0.184± 0.001	3.31±0.012	13.658±0.287
YA1	15.20±0.00	0.175± 0.001	3.39±0.008	12.328±0.287
YA2	16.27±0.12	0.188± 0.001	3.69±0.005	10.495±0.501
YE1	15.40±0.00	0.222± 0.001	3.57±0.009	13.164±0.290
YE2	16.40±0.20	0.216± 0.001	3.44±0.016	13.327±0.574
YE3	16.47±0.12	0.180± 0.001	3.42±0.024	11.995±0.499

Zaitoun et al. [17] found the highest moisture value of 16.78% in their study on Jordan honey, and Sopade et al. [18] found the highest moisture value of 18% in their study on Australian honey, while the lowest moisture value was found to be 15.8%. Escriche et al. [19] found

the moisture value was the lowest 16.63% and the highest 23.3% in Mozambique honey; Çiftçi [20] found the moisture content in the range of 15.48-17.63%; Kalafat Kul [21] reported that the humidity values are in the range of 15.6%-20.3%. In previous studies, moisture values for blossom honey in Bingöl province were determined as 15.70% [22], 15.39% [23], and 15.43% [24]. Considering the results of these studies, it is seen that there is a general agreement between the moisture content of the honey samples in the present study and the studies in the literature.

Another investigated quality parameter is the electrical conductivity of honey. The experimental results of this parameter are presented comparatively in Table 1 and Figure 2. It was determined that the relative standard deviation in the electrical conductivity results of the investigated honey samples was between 0.37% and 1.22%. The average electrical conductivity of the investigated 22 filtered blossom honeys was determined as 0.228 mS cm^{-1}. Among the honey samples, it was determined that the coded as A2 sample had the highest electrical conductivity with value of 0.495 mS cm^{-1} and the coded as KA1 sample had the lowest electrical conductivity with value of 0.137 mS cm^{-1}. There is a 261% difference between the lowest and highest electrical conductivity values. Since the electrical conductivity of blossom honey is reported to be maximum 0.8 mS cm^{-1} according to the Turkish Food Codex Honey Communiqué, it has been observed that all the studied honey samples are in compliance with this Communiqué.

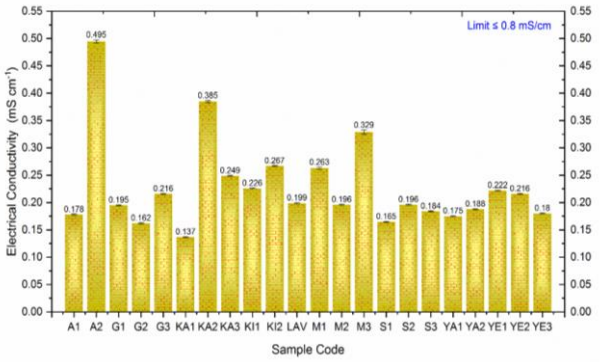

Figure 2. The graph for electrical conductivity results of the investigated honey samples

It has been reported that the electrical conductivity value for 46 secretion and nectar honeys obtained from different regions of Madrid, the capital of Spain, is between 0.119 -1.515 mS cm^{-1}[25]. Again, in a study on monofloral honeys in Spain, it was reported that the electrical conductivity values for honeys ranged from 0.30-0.99 mS cm^{-1}[26]. In 50 honey samples produced and offered for sale in Türkiye, the electrical conductivity value was 0.14-0.95 mS cm^{-1}[27]; In the study conducted on blossom honey obtained from Eastern Anatolia and Eastern Black Sea regions, the electrical conductivity values were recorded to be between 0.18 mS cm^{-1} and 0.47 mS cm^{-1}[28]. In the study on the physicochemical properties of different honeys, the electrical conductivity values for blossom honeys were found to be in the range of 0.11-0.89 mS cm^{-1}[29]. Simsek et al. [22] found the electrical conductivity values of 2 different honey samples belonging to the province of Bingöl as 0.19 mS cm^{-1} and 0.35 mS cm^{-1}. Since the electrical conductivity values of the investigated blossom honeys in the present study vary in the range of 0.137 to 0.495 mS cm^{-1}, it can be said that the electrical conductivity of these honey samples is generally compatible with the electrical conductivity of other honeys in the literature.

Free acidity, which is related to the aroma and antioxidant activity of honey, is another investigated parameter. The experimental results of this parameter are presented in Table 1 and Figure 3, and the maximum relative standard deviation of this parameter was determined as 9.33%. It was determined that the average free acidity value of the investigated honey samples was 14.584 meq kg^{-1}. It was observed that the free acidity values of the coded as A2 and KA2 samples were the highest, while the coded as KA1 sample had the lowest free acidity values. The highest free acid value was determined to be approximately 3 times greater than the lowest. When Table 1 and Figure 3 are examined, it is obvious that all studied honey samples are in compliance with the Turkish Food Codex Honey Communiqué (2020/7).

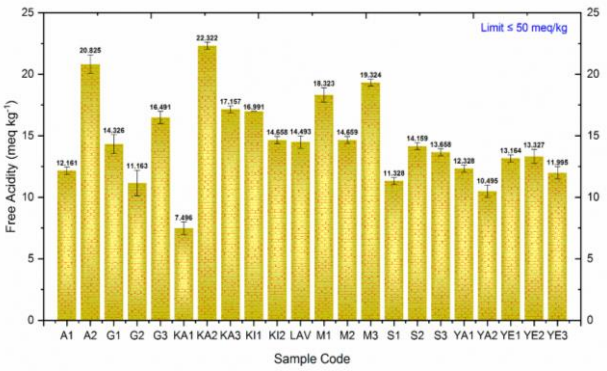

Figure 3. The graph for free acidity results of the investigated honey samples

In the study conducted in Eastern and Southeastern Anatolia, the average free acidity value of honey samples was 22.3 meq kg^{-1}[30], the average free acidity value in the honey obtained in Argentina was 20.6 meq kg^{-1}[31], the acidity value of highland honey in a study conducted in Hatay region was 32.3 meq kg^{-1}[32], the acidity value in sunflower honey from Tekirdağ region was 30.75 meq kg-1[33] and in a study conducted on Brazilian honeys, free acidity values have been reported to vary between 24.66-59.66 meq kg^{-1} [34]. In studies conducted in Madrid, the free acidity value of blossom and secretory honeys was between 13.1-51.2 meq kg^{-1}[25] and in a study conducted in Tunisia with honeys of different origins, the free acidity values were reported between 8.15 meq kg^{-1} and 27.77 meq kg^{-1}[35]. Ünal and Küplülü [36] reported the free acidity values were 8.23-33.21 meq kg^{-1} for some honey samples, Finola et al. [31] obtained the average free acidity value as 2.6 meq kg^{-1} for some Argentina honeys. Aydın et al. [37] was reported that the acidity level was between 6-24 meq kg^{-1}

for filtered honey offered for consumption in Kars province. Yaşar and Söğütlü [38] determined the average free acidity was determined as 10.675 meq kg^{-1} for 8 blossom honeys in Bingöl and its districts. It has been observed that there is a parallelism between the free acidity values of the honey samples in the present study and those in the literature.

The pH indicator, which generally varies according to the minerals and organic acids in honey, is another determined parameter. The experimental results of the pH parameter are presented in Table 1 and Figure 4. The maximum relative standard deviation of this parameter was determined as 1.63%. While the average pH values of 22 investigated blossom honeys were determined as 3.48, it was observed that the pH value of the coded as A2 sample was the highest (4.17) and the pH value of the coded as M2 sample was the lowest (3.26). It was determined that there was difference of approximately 28% between the lowest and highest pH values.

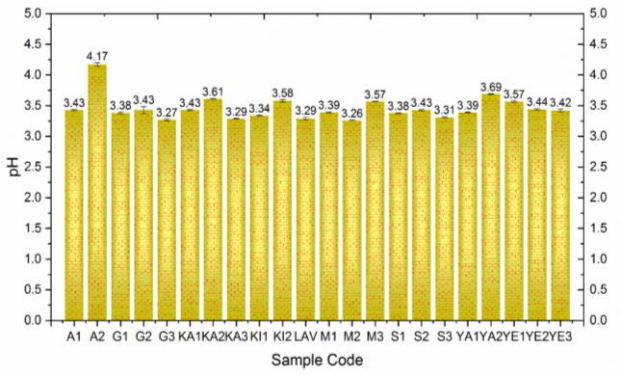

Figure 4. The graph for pH results of the investigated honey samples

pH values in the studies has been reported as; the average pH value is 3.8 in honeys in the Eastern and Southeastern Anatolia regions [30], 3.33-6.30 for Pakistan honey [39], 3.62-5.46 for Indian honeys [16], 3.65 for Brazilian honey [40]. It has been reported that the pH value is in the range of 3.63-5.01 [25] for honeys from Madrid, and in the range of 3.7-4.5 [41] for highland honey from the Ordu region. The pH values of blossom honey produced in Argentina are between 3.00 and 3.88 [42] and pH values were found to be in the range of 3.37−3.89 for Hatay region of blossom honey, [43]. The average pH value for 200 honey samples from Türkiye was reported as 3.30 [44] and the average pH value for 7 honey samples in Bingöl was reported as 2.81 [24]. When the literature studies are examined, the pH values for the honey samples of the present study are similar to those in the literature.

The last parameter that determines honey quality in the present study is color. The color of honey can be affected by the vitamins it contains, the total ash amount, the plant flora from which the nectar is taken, the application of heat treatment, the storage period, the harvest method, and the amount of phenolic substances [45]. L*, a*, b* and h° parameters were obtained to determine the colors of the investigated honey samples in the present study. Experimental results of these parameters are presented in Table 2 and Figure 5.

Table 2. L*, a*, b* and h° values for the investigated honey samples

Sample Code	L*	a*	b*	h°
A1	60.02±0.32	3.27±0.01	36.57±0.14	84.89±0.002
A2	63.96±0.15	10.90±0.03	61.94±0.09	80.02±0.001
G1	75.58±0.21	3.01±0.03	44.21±0.09	86.11±0.009
G2	66.94±0.18	1.92±0.02	31.21±0.03	86.49±0.010
G3	78.76±0.26	2.69±0.03	46.50±0.23	86.69±0.011
KA1	37.99±0.17	0.63±0.03	15.55±0.17	87.67±0.149
KA2	35.24±0.06	8.27±0.05	41.14±0.06	78.63±0.003
KA3	46.14±0.24	5.76±0.02	42.94±0.39	82.35±0.008
KI1	28.85±0.15	4.56±0.07	29.58±0.05	81.24±0.021
KI2	32.95±0.13	2.49±0.05	27.55±0.08	84.84±0.029
LAV	70.14±0.03	4.08±0.01	37.86±0.02	83.85±0.001
M1	65.46±0.12	7.10±0.03	58.08±0.37	83.03±0.004
M2	63.58±0.71	2.93±0.02	37.75±0.31	85.56±0.008
M3	59.00±1.02	9.58±0.19	54.54±1.46	80.04±0.089
S1	48.84±0.40	0.19±0.02	21.33±0.01	89.50±0.599
S2	61.45±0.08	1.50±0.02	34.95±0.22	87.54±0.013
S3	69.69±0.11	2.57±0.01	39.88±0.06	86.32±0.001
YA1	52.54±0.23	3.04±0.01	31.80±0.20	84.55±0.003
YA2	74.58±0.11	1.64±0.02	37.08±0.03	87.46±0.008
YE1	54.46±0.27	3.93±0.06	37.18±0.12	83.97±0.018
YE2	65.64±0.93	3.00±0.03	38.93±0.56	85.59±0.027
YE3	73.07±0.17	2.88±0.02	41.55±0.12	86.04±0.004

Evaluation of the obtained results of L*, a*, b* and h° parameters can be done with the help of Figure 6. The maximum relative standard deviations of L*, a*, b* and h° parameters were determined as 1.74%, 8.18%, 2.67% and 0.67%, respectively. As seen in Table 2 and Figure 5, L*, a*, b* and h° values vary between 78.76-28.85, 10.90-0.19, 61.94-15.55 and 89.50-78.63, respectively. The sample coded as G3 has the highest L* value, sample coded as A2 has a* and b* values, the sample coded as KI1 has the lowest L* value, sample coded as S1 has a* value and sample coded as KA1 has b* value. When the L*, a*, b* and h° values are examined by considering Figure 6, it can be said that the studied honey samples have generally extra light amber color.

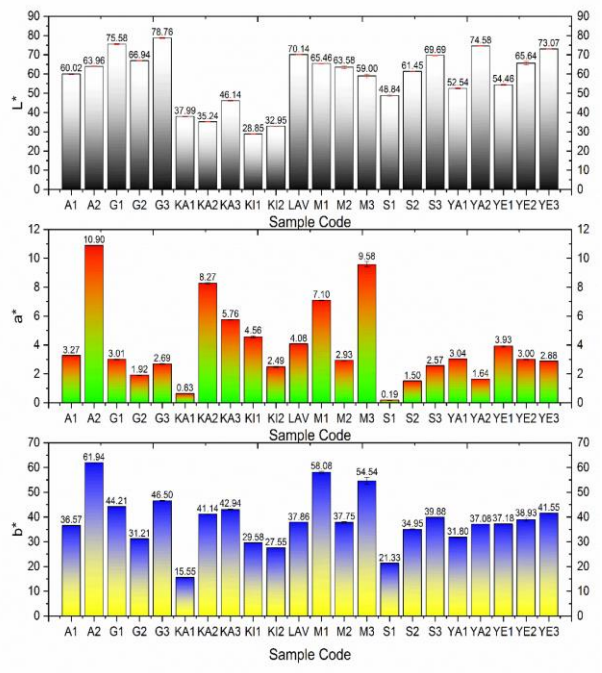

Figure 5. The graph for L*, a* and b* results of the investigated honey samples

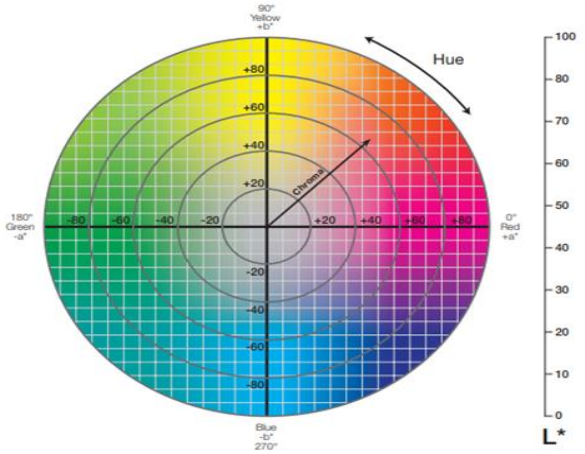

Figure 6. Color space notations [46]

In the study on Aegean Region honeys, the color values were found as L* 7.03-39.26; a* 1.23-13.32 and b* 2.34-17.27 [47]; in the color analysis for 80 honeys obtained from different regions in Brazil, it was determined that the L* value was between 43.02-81.21, a* value was between 2.91-63.40, and b* value was between 25.44-43.47 [48]. For the Mediterranean, Aegean, Southeastern Anatolia and Central Anatolia regions of Türkiye, it was reported that the L* values of the honey samples were between 24.56-41.21, a* values were between 0.11-1.00 and b* values were between 0.87-9.84 [49]. In another study, it was determined that the L* value was between as 19.75-28.00, a* value was between as -0.56 and 0.07 and b* value was between as 0.45-2.85 for blossom honey obtained from various regions of Türkiye [50]. When the studies in the literature are examined, the honey samples in the study present in terms of L* and b* parameters are generally similar to the honey samples from Brazil and the honey samples from the Aegean region in terms of a* parameter.

4. CONCLUSION

The moisture, electrical conductivity, free acidity, pH and color parameters of filtered blossom honey collected from the center and seven districts of Bingöl province were determined and their quality was revealed. While the humidity parameter was observed in the lowest samples coded as A2 and KA2, the highest sample coded as LAV, the highest electrical conductivity was observed in the A2 coded sample and the lowest KA1 coded sample. The highest free acidity value was observed in the A2 and KA2 coded samples, the lowest in the KA1 coded sample, while the highest pH value was observed in the A2 coded sample and the lowest in the M2 coded sample. When the L*, a*, b* and h° parameters of the investigated honey samples are taken into consideration, it was determined that they generally have an extra light amber color.

According to the analyzed parameters, 22 honey samples collected from the center and districts of Bingöl were found to be in compliance with the Turkish Food Codex Honey Communiqué (2020/7). There is no standard set in pH analysis, but the results found are in line with previous studies. Honey is extremely important because it is a healthy food and contributes to the country's economy. Therefore, in order to produce quality honey that supports the country's economy, the determined standards should not be ignored. In order to increase the quality and production capacity of Bingöl honey, whose place and recognition in the international market are increasing day by day, it is necessary to increase the awareness of producers and consumers in line with the findings of such studies.

Acknowledgement

The authors are greatly thankful to Bingöl University "Central Laboratory Application and Research Center" for analyses support.

REFERENCES

[1] Ayna A, Tunc A, Özbolat SN, Bengü AŞ, Aykutoğlu G, Canli D, et al. Anticancer, and antioxidant activities of royal jelly on HT-29 colon cancer cells and melissopalynological analysis. Turkish Journal of Botany. 2021;45(8), 809-19.

[2] Bengü AŞ, Ayna A, Özbolat S, Tunc A, Aykutoğlu G, Çiftci M, et al. Content and antimicrobial activities of bingol royal jelly. Türk Tarım ve Doğa Bilimleri Dergisi. 2020;7(2), 480-6.

[3] Ayna A, Darendelioğlu E. Evaluation of the biological activities of royal jelly on prostate and breast cancer cells. Türk Doğa ve Fen Dergisi. 2022;11(3), 166-70.

[4] Anonim, 2020. Türk Gıda Kodeksi Bal Tebliği, Tarım ve Orman Bakanlığı, Ankara, 2020/7.

[5] TÜİK [Internet]. Türkiye İstatistik Kurumu; 2023 [cited 2023 Jun 23]. Available from: https://www.tuik.gov.tr/

[6] Mutlu C, Erbaş M, Tontul SA. Bal ve diğer arı ürünlerinin bazı özellikleri ve insan sağlığı üzerine etkileri. Akademik Gıda. 2017;15(1);75-83.
[7] Snowdon JA, Cliver DO. Microorganisms in honey.Int JFood Microbiol.1996; 31(1-3): 1-26.
[8] Marghitaş LA, Dezmirean D, Popescu O, Maghear O, Moise A, Bobiş O. Correlation between ash content and electrical conductivity in honeydew honey from Romania. In1st World Honeydew Honey Symposium, Tzarevo, Bulgaria 2008 (Vol. 30).
[9] Bogdanov S, Vit P, Kilchenmann V. Sugar profiles and conductivity of stingless bee honeys from Venezuela. Apidologie. 1996;27(6):445-50.
[10] Andrade P, Ferreres F, Gil MI, Tomás-Barberán FA. Determination of phenolic compounds in honeys with different floral origin by capillary zone electrophoresis. Food Chem. 1997;60(1):79-84.
[11] Ötleş S. Bal ve bal teknolojisi (kimyası ve analizleri) Alaşehir Meslek Yüksekokulu Yayınları. Manisa, Yayın. 1995(2).
[12] Gomes S, Dias LG, Moreira LL, Rodrigues P, Estevinho L. Physicochemical, microbiological and antimicrobial properties of commercial honeys from Portugal. Food ChemToxicol. 2010;48(2):544-8.
[13] Lawless HT, Horne J, Giasi P. Astringency of organic acids is related to pH. ChemSenses. 1996;21(4):397-403.
[14] González-Miret ML, Ayala F, Terrab A, Echávarri JF, Negueruela AI, Heredia FJ. Simplified method for calculating colour of honey by application of the characteristic vector method. Food Res Int. 2007;40(8):1080-6.
[15] Bogdanov S, Martin P, Lullmann C. Harmonised methods of the international honey commission. Swiss Bee Research Centre, FAM, Liebefeld. 2002;5:1-62.
[16] Anupama D, Bhat KK, Sapna VK. Sensory and physico-chemical properties of commercial samples of honey. Food Res Int. 2003;36(2):183-91.
[17] Zaitoun S, Ghzawi AA, Al-Malah KI, Abu-Jdayil B. Rheological properties of selected light colored Jordanian honey. Int J Food Proper. 2001;4(1):139-48.
[18] Sopade PA, Halley P, Bhandari B, D'arcy B, Doebler C, Caffin N. Application of the Williams–Landel–Ferry model to the viscosity–temperature relationship of Australian honeys. J Food Eng. 2003;56(1):67-75.
[19] Escriche I, Tanleque-Alberto F, Visquert M, Oroian M. Physicochemical and rheological characterization of honey from Mozambique. LWT-Food Sci Technol. 2017;86:108-15.
[20] Çiftçi M, Parlat SS. Konya Bölgesindeki arketlerde satılan farklı ticari çiçek ballarının bazı kimyasal özelliklerinin Türk Gıda Kodeksi-Bal Tebliğine uygunluğunun Araştırılması. Selcuk J Agr Food Sci. 2018;32(1):38-42.
[21] Kalafat Kul M. Gümüşhane yöresi çiçek ballarının kalite özellikleri ve antioksidan aktiviteleri [dissertation]. Gümüşhane: Gümüşhane University; 2020.
[22] Simsek A, Bilsel M, Goren AC. 13C/12C pattern of honey from Turkey and determination of adulteration in commercially available honey samples using EA-IRMS. Food Chem. 2012;130(4):1115-21.
[23] Bengü AŞ, Kutlu MA. Bingöl'de üretilen ballarda bazi kalite kriterlerinin belirlenmesi. Türk Doğa ve Fen Derg. 2018;7(1):7-10.
[24] Yılmaz AT, Yaşar S. Chemical investigations on honey produced in Bingol and surroundings. Uludağ Arıcılık Derg. 2020;20(1):72-80.
[25] Soria AC, González M, De Lorenzo C, Martınez-Castro I, Sanz J. Characterization of artisanal honeys from Madrid (Central Spain) on the basis of their melissopalynological, physicochemical and volatile composition data. Food Chem. 2004;85(1):121-30.
[26] Manzanares AB, García ZH, Galdón BR, Rodríguez ER, Romero CD. Physicochemical characteristics of minor monofloral honeys from Tenerife, Spain. LWT-Food SciTechnol. 2014;55(2):572-8.
[27] Çetin K, Alkın E, Uçurum HÖ. Piyasada satılan çiçek ballarının kalite kriterlerinin belirlenmesi. Gıda ve Yem Bilimi-Teknolojisi Derg. 2011;11:49-56.
[28] Batu A, Küçük E, Çimen M. Doğu Anadolu ve Doğu Karadeniz Bölgeleri çiçek ballarının fizikokimyasal ve biyokimyasal değerlerinin belirlenmesi. Gıda Teknolojileri Elektronik Derg. 2013;8(1):52-62.
[29] Yıldız İ. Çam, pamuk, yayla ve ayçiçeği ballarinin fizikokimyasal özelliklerinin belirlenmesi. Uludağ Arıcılık Derg. 2016;16(1):12-9.
[30] Yılmaz H, Küfrevioğlu İ. Composition of honeys collected from eastern and south-eastern anatolia and effect of storage on hydroxymethylfurfural content and diastase activity. Turk J Agr For. 2001;25(5):347-9.
[31] Finola MS, Lasagno MC, Marioli JM. Microbiological and chemical characterization of honeys from central Argentina. Food Chem. 2007;100(4):1649-53.
[32] Şahinler N, Şahinler S, Gül A. Hatay yöresi ballarının bileşimi ve biyokimyasal analizi. MKÜ Ziraat Fak Derg. 2001;6:93-108.
[33] Yardibi MF. Tekirdağ yöresinde ürretilen ayçiçeği ballarının bazı kimyasal özelliklerinin belirlenmesi [dissertation]. Tekirdağ: Namık Kemal University;2008.
[34] Silva TM, Dos Santos FP, Evangelista-Rodrigues A, Da Silva EM, Da Silva GS, De Novais JS, et al. Phenolic compounds, melissopalynological, physicochemical analysis and antioxidant activity of jandaíra (Melipona subnitida) honey. J Food ComposAnal. 2013;29(1):10-8.
[35] Boussaid A, Chouaibi M, Rezig L, Missaoui R, Donsí F, Ferrari G, Hamdi S. Physicochemical, rheological, and thermal properties of six types of honey from various floral origins in Tunisia. Int J Food Proper. 2015;18(12):2624-37.

[36] Cenk ÜN, Küplülü Ö. Chemical quality of strained honey consumed in Ankara. Ankara Üniv Vet Fak Derg. 2006;53(1):1-4.
[37] Aydın BD, Sezer Ç, Oral NB. Kars' ta satışa sunulan süzme balların kalite niteliklerinin araştırılması. Kafkas Ünv Vet Fak Derg. 2008;14(1):89-94.
[38] Yaşar S, Söğütlü İ. Investigation of Acidity, Diastase Number, HMF, Insoluble Dry Matter and Ash Percentage Values of Some Honey Samples Produced in Bingöl and Districts. Van Vet J. 2020;31(1):42-5.
[39] Kamal A, Raza S, Rashid N, Hameed T, Gilani M, Qureshi MA, et al. Comparative study of honey collected from different flora of Pakistan. Online JB Sci. 2002;2:626-7.
[40] Da C Azeredo L, Azeredo MA, De Souza SR, Dutra VM. Protein contents and physicochemical properties in honey samples of Apis mellifera of different floral origins. Food Chem. 2003;80(2):249-54.
[41] Günbey VS, Günbey B, Güney F, Yılmaz Ö. Ordu ili bal üreticilerinden elde edilen balların biyokimyasal yapısının incelenmesi. Arıcılık Araştırma Derg. 2010;2(4):20-3.
[42] Acquarone C, Buera P, Elizalde B. Pattern of pH and electrical conductivity upon honey dilution as a complementary tool for discriminating geographical origin of honeys. Food Chem. 2007;101(2):695-703.
[43] Yücel Y, Sultanoglu P. Characterization of honeys from Hatay Region by their physicochemical properties combined with chemometrics. Food Biosci. 2013;1:16-25.
[44] Gül A. Türkiye'de üretilen bazı balların yapısal özelliklerinin gıda güvenliği bakımından araştırılması [dissertation]. Hatay: Mustafa Kemal Üniversitesi University; 2008.
[45] Sorkun K, Yılmaz B, Özkırım A, Özkök A, Gençay Ö, Bölükbaşı DN. Yaşam için arılar. Türkiye Arı Yetiştiricileri Merkez Birliği Yayın. 2012(5).
[46] URL-1 [Internet]. 2023 [cited 2023 Jun 23]. Available from:https://leventkirca.com.tr/hue-acisi-nedir-excelde-hue-acisi-nasil-hesaplanir
[47] Kaplan HB. Ege Bölgesi Ballarının Kimyasal Özellikleri [dissertation]. Denizli: Pamukkale University; 2014.
[48] Ribeiro RD, Mársico ET, Da Silva Carneiro C, Monteiro ML, Júnior CA, Mano S, et al. Classification of Brazilian honeys by physical and chemical analytical methods and low field nuclear magnetic resonance (LF 1H NMR). LWT-Food Sci Technol. 2014;55(1):90-5.
[49] Ölmez Ç. Türkiye'de üretilen farklı çiçek ve salgı bal çeşitlerinin bazı kalitatif ve besinsel özellikleri [dissertation]. Konya: Selçuk University; 2009.
[50] Durmaz NE. Çiçek Ballarının Fenolik Bileşik ve Aroma Bileşenleri Üzerine Araştırma [dissertation]. Ankara: Ankara University; 2020.