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Contents of Some Metals in Honeys from Different Regions in Turkey

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Beekeeping is considered one of the most important agricultural activities around the world. Today the total number of bees in the world is estimated to be about 56 million, which produce about 1.2 million tons of honey (Antonescu and Mateescu, 2001). Turkey has important place among the honey producer countries, it is placed the 3rd (for bee hives) and 4th, position among the honey producing countries in the world. In Turkey, there are about 4 million bee hives producing about 74,000 million tons of honeys. Although all regions of Turkey are suitable for apiculture, the Aegean, Black Sea, and Mediterranean regions are considered to be the most important (DIE, 2005). Honey is an important food for humans. Its importance is not only nutritional, but it is also an indicator for environmental pollution (Porrini et al., 2003; Sevimli et al., 1992). Bees fly intensively in a radius of up to 3 km, and for this reason they and their products can serve as bioindicators for the contamination of the area (Bogdanov et al., 2003). A number of authors have used honey bees and/or their products for monitoring environmental pollution (Antonescu and Mateescu, 2001; Devillers et al., 2002; Nanda et al., 2003; Sevimli et al., 1992; Tong et al., 1975; Tüzen, 2002; Uren et al., 1998; Veleminsky et al., 1990). Air and water contain heavy metals from industry and traffic, which can contaminate the bee colonies and their products (Piro and Mutinelli, 2003). High authmobile traffic congestion can lead to the release of the following metals: aluminum, calcium, copper, iron, lead, magnesium, silicon, zinc, barium, cadmium, chromium, nickel, palladium, platinum, and others being emitted as air pollutants (Tong et al., 1975). The aim of this study is to evaluate some metal (Al, Co, Cr, Cu, Fe, Mn, Ni, and Zn) contents of honeys, collected from different regions of Turkey.

Materials and Methods

Samples

Forty-five natural liquid samples of honey (100 g) were collected from different beekeepers from six different regions (Fig. 1) of Turkey: Central Anatolia region (12 samples), Black Sea region (7 samples), Aegean region (10 samples), Mediterranean region (5 samples), Eastern Anatolia region (7 samples), and Southeastern Anatolia region (4 samples) during the years 2002 and 2003. The honey samples were stored in glass jars and were kept at room temperature (25°C) until analyzed.

Ash determination and mineral analysis

Two grams of honey sample were mixed with magnesium acetate (4 mg/mL). The mixture was placed in a porcelain

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Fig. 1 Locations of study area: regions of Central Anatolia, Eastern Anatolia, Southeast Anatolia, Aegean, Mediterranean, and Black Sea

crucible. After drying at 110°C for 2 h, the samples were ashed at 500°C. Care was taken during heating so that no excess foaming took place. The ash was extracted with HNO3 2N and was diluted to 30.0 mL (AOAC, 1984; Stahr, 1977). The contents of Al, Co, Cr, Cu, Fe, Mn, Ni, and Zn were determined directly in the ash solution using atomic absorption spectroscopy (GF 3000 model AAS, Graphite Furnace GF 3000, Auto Sampler GBC PAL 3000, GBC Scientific Equipment Pty Ltd, Australia). The accuracy of the instrument was periodically checked with a known standard. Calibration curves were prepared using dilutions of stock solutions. The results were read three times and the mean values and the relative standard deviations were computed.

Statistical analysis

Data were analysed statistically by one-way analysis of variance (ANOVA). When significant treatment effects were detected, DUNCAN'S multiple range test was used to identify specific differences between treatment means at a probability level of $p < 0.05$.

Results and Discussion

Mean metal contents with related standard deviation and range are shown in Table 1. The mean and standard deviation of the ash contents of 45 honey samples for Al, Co, Cu, Fe, Mn, Ni, and Mn were 12.30 ± 3.86, 0.02 ± 0.01, 0.20 ± 0.18, 0.87 ± 0.47, 4.75 ± 2.44, 0.49 ± 0.47, 0.67 ± 0.65, and 7.92 ± 3.0, respectively. Aluminum was the most abundant metal (range 7.21–19.12 ppm), followed by zinc (range 1.15–14.52 ppm) and iron (range 1.30–11.29 ppm). Manganese, nickel, and zinc contents showed statistically significant differences ($p < 0.05$) between regions.

There are limited studies for metal contents of honey in Turkey. Moreover, these studies were related to the local areas. Yılmaz and Yavuz (1999) investigated Na, K, Ca, Mg, Cu, Fe, Mn, Zn, and Co contents in honey from different parts of southeastern Anatolia. The mean values for Cu, Fe, Mn, Zn, and Co were 1.8, 6.6, 1.0, 2.7, and 1.0 ppm, respectively. In this study, Cu, Fe, Mn, Zn, and Co were 0.55, 4.1, 0.49, 7.58, and 0.02 ppm, respectively, for southeastern Anatolia. The values for Cu, Fe, Mn, and Co were higher than southeastern Anatolia honeys; also in the same study, lower Zn values were reported. In another study, Tüzen (2002) discovered some trace metal (Pb, Cd, Fe, Cu, Mn, and Zn) contents in honey samples collected from Tokat city (Central Anatolia region) in Turkey, during the years 2000 and 2001. The author observed that Cu, Fe, Mn, and Zn contents were 0.62, 5.22, 0.49, and 3.45 ppm in honey samples, respectively. In this study, the metal contents for Central Anatolia region were 0.88, 3.71, 0.29, and 7.07 ppm, respectively. These results were similar to Tüzen et al.'s (2002) results except for Zn contents.

Sevimli et al. (1992) investigated the metal contents in honey. Samples were collected from different cities of Turkey, Malatya, Bolu, Firuzkoy, Odemis, and Finike. Fe, Zn, Cr, and Co contents were 2.1–67.0, 0.009–6.0, 0.043–1.07, and 0.019–0.073 ppm, respectively. In this study, Fe, Zn, Cr, and Co for the different regions were 1.30–11.29, 1.15–14.52, 0.06–0.94, and 0.01–0.06 ppm, respectively. These findings are compatible with those of Sevimli et al. (1992). Uren et al. (1998) investigated Pb, Cd, Fe, Cu, Zn, Mn, and Mg contents of Turkish honey. Iron, Cu, Zn, and Mn contents in flower honeys were 4.90, 0.35, 0.97, and 0.30 ppm, respectively. In this study Fe, Cu, Zn, and Mn contents were 4.75, 0.8, 7.92, and 0.49 ppm, respectively, for all regions. Fe contents were similar in this study (Uren et al., 1998). Cu, Zn, and Mn contents were higher than the study results of Uren et al. (1998). Erbilir and Erdogrul (2005) investigated Cu, Mn, Fe, and Ni contents in Kahramanmaras, Turkey. These metal contents in honey were lower than results obtained in this study.

On the other hand, Fe, Ni, Cu, Mn, Cr, and Zn contents in this study were lower than those reported by Adebiyi et al. (2004) and Nanda et al. (2003). Also, Cu and Zn contents were higher than those reported by Tong et al. (1975), Antonescu and Mateescu (2001) and Devillers et al. (2002).

Table 1 Metal contents in honey samples according to regions*

Regions	Al	Co	Cr	Cu	Fe	Mn	Ni	Zn
Central Anatolian	11.87± 4.29	0.02 ± 0.01	0.17 ± 0.15	0.88 ± 0.59	3.71 ± 2.76	0.29 ± 0.25[a]	0.24 ± 0.12 [a]	7.07 ± 2.07[a]
(*n*:12)	(7.51–18.82)	(0.01–0.06)	(0.06–0.63)	(0.40–2.53)	(1.30–10.96)	(0.05–0.79)	(0.10–0.43)	(1.15–10.33)
Black Sea	12.65 ± 4.40	0.02 ± 0.01	0.17 ± 0.07	0.93 ± 0.36	5.38 ± 1.49	1.02 ± 1.13[b]	0.30 ± 0.26 [a]	11.53 ± 1.46[b]
(*n*:7)	(7.21–16.16)	(0.01–0.03)	(.27) 0.1–0	(0.48–1.42)	(2.99–7.82)	(0.17–2.65)	(0.08–0.87)	(9.80–13.40)
Aegean	13.68 ± 5.06	0.03 ± 0.02	0.17 ± 0.13	0.97 ± 0.58	4.93 ± 2.35	0.56 ± 0.30[a,b]	0.29 ± 0.19[a]	7.67 ± 3.09[a]
(*n*:10)	(7.32–19.12)	(0.01–0.07)	(0.07–0.52)	(0.45–2.47)	(2.53–8.94)	(0.18–1.03)	(0.11–.78)	(3.97–11.64)
Mediterranean	12.24 ± 2.59	0.03 ± 0.01	0.23 ± 0.10	0.71 ± 0.36	5.40 ± 1.66	0.38 ± 0.05[a]	1.39 ± 0.73[b]	9.02 ± 3.7[a,b]
(*n*:5)	(8.63–14.26)	(0.01–0.05)	(0.09–0.32)	(0.21–1.31)	(3.83–8.10)	(0.30–0.43)	(0.78–.20)	(6.13–14.52)
East Anatolian	11.61 ± 2. 72	0.03 ± 0.02	0.2 ± 0.27	0.96 ± 0.45	5.43 ± 3.53	0.44 ± 2.96[a]	1.48 ± 0.42[b]	6.24 ± 2.81[a]
(*n*:7)	(7.80–15.02)	(0.01–0.09)	(0.07–0.82)	(0.54–1.59)	(1.99–11.29)	(0.14–1.28)	(0.71–2.05)	(2.33–10.38)
South-East Anatolian	10.31 ± 0.19	0.02 ± 0.01	0.37 ± 0.39	0.55 ± 0.04	4.1 ± 1.79	0.49 ± 0.12[a,b]	1.63 ± 0.43[b]	7.58 ± 1.53[a]
(*n*:4)	(10.17–10.45)	(0.01–0.03)	(0.09–0.94)	(0.49–0.58)	(2.84–6.66)	(0.32–0.60)	(1.18–2.17)	(6.03–9.61)

* as ppm: mean ± standard deviation and range

[a,b] Means within in the same columns with different letters are statistically significant ($p < 0.05$)

Results from this study for Al were higher than the results of Devillers et al. (2002), however, this study's results were lower than those of Tong et al. (1975). Fe, Ni, and Cr contents were similar to those reported by Tong et al. (1975), Antonescu and Mateescu (2001), and Devillers et al. (2002).

There are some differences and similarities among the results. This observation can be related to various factors, such as industry, mining, emission of automobile exhaust gases, and different botanical origins. However, other factors, such as geographical conditions, are also expected to affect the mineral content. Also, honey that comes into contact with metal containers or equipment during storage, processing, or shipping, may have elevated levels of some metals, such as iron. The sources of some elements (Fe, Ni, Cd) was considered to be the steel or galvanized containers used in processing or storage (Erbilir and Erdogrul, 2005; Griffth et al., 2001; Veleminsky et al., 1990).

Mineral contents determined in honeys of different regions of Turkey showed differences. Mineral contents of honey are highly dependent on the type of flower from which bees take nectar. Extensive research is required to establish physicochemical properties and mineral content variations according to the geographical area. The determination of reliable levels was considered very useful for both the constant monitoring and the prevention of future problems due to the emission of heavy metals in the environment.

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