

Electrochemical Profiles and Water Content in Different Honey Varieties from Western Balkan Countries

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Abstract

Honey as a sweet and nutritionally rich substance occupies a special place in agricultural production. From a chemical point of view, it contains over 200 important compounds for the normal functioning of metabolic processes, which together make up the dry matter of honey (e.g. minerals, organic acids, phenolic compounds, vitamins etc.) In addition to dry matter, honey also contains a certain percentage of water and due to its composition of water and various substances, it is essential to give special attention to its safety and quality parameters. Electrical conductivity represents the content of mineral substances and indirectly indicates the botanical and geographical origin of honey, as well as its clarity. This parameter is one of the standard ones that is determined in honey quality control, owing to the fact that honey beside the amount of different compounds, contains minerals that can dissociate into ions in aqueous solution and thus conduct electrical energy. The pH value was also determined, which is correlated with the organic acids in honey. The water content is also one of the major parameters that indicates its microbiological stability and affects its viscosity. Its value is not constant but varies depending on the storage conditions (air humidity).

Keywords: Electrochemical conductivity, honey, pH, water

1. Introduction

Known for its healing benefits and wide application in pharmacy and medicine, honey takes a very important position in daily food intake [1]. What actually gives honey very high nutritional and medical benefits is its rich composition, which includes various compounds, mostly carbohydrates (glucose and fructose; 60 – 85%), but also compounds with high antioxidant activity (phenols and flavonoids) and microelements such as vitamins and several mineral substances [1]. All aforementioned substances together make up the dry matter of

honey, but besides the dry matter, honey also contains a certain percentage of water, whereby this water can be in a free form or bound to some other dry matter component. Owing to its varied intricate structure, in the food industry it is very necessary to pay special attention to its biochemical analyses and quality parameters [2]. Today we are familiar with a wide range of different types of honey, thanks to an essential parameter that is one of the most important among other quality parameters – electrical conductivity [2]. It exists as an important parameter in laboratory analyzes due to the presence of various organic acids and mineral salts in honey samples, which can easily dissociate into ions in aqueous solution and very simply conduct electrical energy [2, 3]. This quality parameter is correlated with the botanical origin and clarity of the honey [2, 3]. Electrical conductivity represents the ash content in the honey samples, which is attributable to

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geographical origin and degree of environmental pollution [2, 3].

Different types of honey have different degrees of acidity, which depends not only on the presence of various organic acids and their proportion and harmony, but also on the type of bee and flower too. Acidity is parameter that is very characteristic in biochemistry analysis of honey and usually in laboratory conditions it is measured using a pH meter, but there is also a determination of free acidity by titration with sodium hydroxide [3].

The water content, respecting moisture content in honey, depends on several factors (such as meteorological conditions, floral source, soil etc.) and significantly affects certain physical characteristics of honey, among which crystallization and viscosity are of great importance, while on the other hand solubility, taste and colour are commercially important properties [3]. Low water content in honey samples in addition to having a positive effect on microbiological stability, also prevents fermentation and on the opposite side, if moisture content is high, fermentation during storage is very possible by osmotolerant yeasts [3, 4].

The aim of this work was to investigate the relationship between physicochemical parameters, electrical conductivity, pH value and the abundance of water in different types of honey originating from the countries of the Western Balkans.

2. Materials and methods

In this research, four different types of honey were analyzed: rapeseed honey (3 samples), linden honey (4 samples), acacia honey (15 samples) and meadow honey (19 samples).

The countries of origin of the examined samples are: Republic of Serbia, Republic of Macedonia and Bosnia and Herzegovina. An Xsinstruments conductometer, Cond 51 + (Belgium), measuring range 0-200 mS/cm was used to determine electrical conductivity. An Abbe refractometer, AR4, Kruss, (Hamburg, Germany) with a measurement range of (1,300-1,720) nD was used to determine the water content.

The pH value was measured using a pH meter Basic 20, Crison (manufactured by Crison Instruments Barcelona Spain).

2.1. Electrical conductivity and acidity

Preparation of samples for determination of electrical conductivity and pH values was the same for both mentioned analyses: 20 g of honey samples was measured and mixed with 80 mL of distilled water, and to obtain a homogeneous mixture, magnetic stirrer was used (3000 o/min) [5, 6].

Electrical conductivity was measured by immersing a clean and dried electrode of the conductometer in the obtained homogenized sample and after the measurement was made, the obtained value was read on the display of the conductometer [5, 6]. After each measurement, the electrode is washed with distilled water and dried, to carry out each subsequent measurement [5, 6].

Measuring pH is quite similar to determining electrical conductivity, the only difference is in the device. A previously washed with distilled water and dried pH meter electrode is inserted into the prepared sample and when the measurement is finished, the value is read from the display [5, 6]. Each time before each subsequent measurement, the electrode must be washed and dried and when all measurements are completed, the electrode must be washed, dried and inserted into the KCl solution in which is always kept [5, 6].

2.2. Water content

The water content in honey was determined by the refractometry method, according to the studies of many researchers [3, 5-8]. The method is based on the refraction of a light beam that passes through a certain substance (honey), i.e. determining the refractive index (RI) [6, 7]. In this analysis, we do not have a sample preparation as in the determination of electrical conductivity and pH values [3, 5-8].

The water content in honey was measured at 20°C, by applying a small amount of honey to the intended spot (prism) on the digital refractometer with a glass stick. The prism is thermostated at a temperature of 20 degrees. The obtained values are read on the display and then inserted into the Chataway table to obtain final results [7, 8].

3. Results and discussion

The values obtained for rapeseed honey for electrical conductivity, pH value and water content are shown in Table 1.

According to the *Rulebook on the quality of honey and other bee products* [9] the electrical conductivity of the samples examined in the paper must not exceed 0.8 mS/cm. The values of these samples are in accordance with the regulations. According to several authors [10-12], the pH value varies between 3.2 and 4.5. The values

obtained are within the range. As for water content, according to the *Rulebook on the quality of honey and other bee products* [9] the samples examined in this research should not contain more than 20% of water. All values obtained for these samples complied with the regulation.

Table 1. Results of electrical conductivity, pH values and water content for rapeseed honey

Type of honey	Electrical conductivity [μ S/cm]	pH	Water content [%]
Rapeseed honey	140.5	4.27	19.8
	202.0	4.03	17.8
	139.5	3.97	16.8
Mean value \pm SD	160.7 \pm 35.8	4.09 \pm 0.16	18.1 \pm 1.5
RSD, %	22.28	3.88	8.42

The values obtained for acacia honey for electrical conductivity, pH value and water content are shown in Table 2. According to the *Rulebook on the quality of honey and other bee products* [9] the electrical conductivity of the samples examined in the paper must not exceed 0.8 mS/cm. The values of these samples adhere with the regulations. According to several authors [10, 11, 12], the pH

value varies between 3.2 and 4.5. The values are in compliance with this range. As for water content, according to the *Rulebook on the quality of honey and other bee products* [9] the samples examined in this research should not contain more than 20% of water. All values align with the established norms.

Table 2. Results of electrical conductivity, pH values and water content for acacia honeys

Type of honey	Electrical conductivity [μ S/cm]	pH	Water content [%]
Acacia honey	111.2	4.17	15.1
	149.1	4.05	16.5
	140.0	4.05	14.9
	171.4	4.04	16.1
	138.9	3.73	17.4
	150.9	3.76	16
	128.0	4.14	17.1
	164.9	4.27	14.9
	201.0	4.09	17.2
	203.0	3.95	16.0
	158.1	4.05	14.9
	150.2	3.97	15.2
	124.9	3.87	16.4
	68.8	4.11	17.1
	133.1	4.35	17.5
Mean value \pm SD	146.2 \pm 33.4	4.04 \pm 0.17	16.2 \pm 1.0
RSD, %	22.88	4.18	6.02

The values obtained for linden honey for electrical conductivity, pH value and water content are shown in Table 3. According to the *Rulebook on the quality of honey and other bee products* [9] the electrical conductivity of the samples examined in the paper must not exceed 0.8 mS/cm. These samples fulfill the regulatory criteria. According

to several authors [10-12], the pH value varies between 3.2 and 4.5. The values obtained are within the range. As for water content, according to the *Rulebook on the quality of honey and other bee products* [9] the samples examined in this research should not contain more than 20% of water.

Table 3. Results of electrical conductivity, pH values and water content for linden honeys

Type of honey	Electrical conductivity [$\mu\text{S}/\text{cm}$]	pH	Water content [%]
<i>Linden honey</i>	664	4.02	18.4
	658	4.48	16.8
	637	4.05	14.9
	588	3.9	17
Mean value \pm SD	636.7 \pm 34.5	4.11 \pm 0.25	16.8 \pm 1.4
RSD, %	5.42	6.16	8.58

Samples conform to the applicable standard. The values obtained for meadow honey for electrical conductivity, pH value and water content are shown in Table 4. According to the *Rulebook on the quality of honey and other bee products* [9] the electrical conductivity of the samples examined in the paper must not exceed 0.8 mS/cm. The values adhere with this value. According to several authors [10, 11, 12], the pH value varies between 3.2 and 4.5. The values are in compliance with this range. As for water content, according to the *Rulebook on the quality of honey and other bee products* [9] the samples examined in this research should not contain more than 20% of water. All values align with the established norms.

Overall, from the data shown in the tables, it can be seen that rapeseed honey has a low conductivity value, but also that honey with a higher pH value also has a larger amount of water. Acacia honeys are generally characterized as the type of honey with the lowest electrical conductivity, as confirmed by this test, and also by the lowest value of the standard deviation of the results. When it comes to pH value, the range of pH values for acacia honeys was in the range of 3.73 to 4.35, and no dependence with the percentage of water present can be observed. While linden honey showed a significantly higher value of electrical conductivity with a mean value of 636.7 $\mu\text{S}/\text{cm}$, with a pH value of up to 4.48.

Table 4. Results of electrical conductivity, pH values and water content for meadow honeys

Type of honey	Electrical conductivity [$\mu\text{S}/\text{cm}$]	pH	Water content [%]
<i>Meadow honeys</i>	202	4.09	16.6
	272	4.02	16.4
	664	4.38	15.9
	387	3.65	16.8
	463	4.04	16.0
	524	3.84	16.8
	634	4.32	16.3
	465	3.88	16.1
	276	3.57	15.6
	556	4.04	17.01
	472	3.55	16.4
	328	3.57	16.4
	679	4.12	16.0
	747	4.5	15.9
	753	4.33	15.0
	705	3.87	15.2
	719	4.73	15.9
	788	4.06	16.8
481	3.97	14.8	
Mean value \pm SD	532.3 \pm 181.9	4.03 \pm 0.33	16.17 \pm 0.62
RSD, %	34.17	8.08	3.84

On the other hand, meadow honeys had the widest range of obtained values for electrical conductivity from 202 to 788 $\mu\text{S}/\text{c}$, which is the upper limit of finding mineral substances in this type of honey. Also, it can be seen that the mean

value of the amount of water present in honey is 16.2%, which indicates proper storage of honey and its top quality, considering that smaller amounts of water indicate higher quality honey that will ferment significantly less over time.

4. Conclusions

In this paper, four different types of honey were examined. According to the presented results, all samples are in accordance with given parameters, but what can be clearly seen is that the values vary, depending on the type and honey samples themselves. The obtained results depend on the physical properties of honey: Color (the lighter the color, the lower electrical conductivity), the content of mineral substances, organic acids (it has an effect on pH value and electrical conductivity as well). Based on the water content, it is possible to recognize counterfeit honey samples, which contain a significantly higher percentage of water. All in all, the importance of the parameters examined in this work is paramount, because they indicate the safety, biochemical and microbiological stability of honey.

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References

1. Ogwu, M. C., Izah, S. C., Honey as a Natural Antimicrobial, *Antibiotics*, 2025, 14(3), 255
2. Tasic, A., Pezo, L., Loncar, B., Pešić, M. B., Tesic, Z., Kalaba, M., Assessing the Impact of Botanical Origins, Harvest Years, and Geographical Variability on the Physicochemical Quality of Serbian Honey, *Foods*, 2024, 13, 1530
3. Zivkov Balos, M., Popov, N., Vidakovic, S., Ljubojevic Pelic, D., Pelic, M., Mihaljev, Z., Jaksic, S., Electrical conductivity and acidity of honey, *Archives of Veterinary Medicine*, 2018, 11(1), 91-101
4. Chiachung, C., Relationship between Water Activity and Moisture Content in Floral Honey, *Foods* 2019, 8, 30
5. Loncar, V., Determination of antioxidant activity of different types of honey, Master's thesis, Josip Juraj Strossmayer University of Osijek, Faculty of Agriculture, 2017
6. Ana – Marija C., Antioxidant capacity and physico – chemical parameters of rapeseed honey (*Brassica sp.*), Undergraduate thesis, Josip Juraj Strossmayer University of Osijek, Faculty of Food Technology, 2015
7. Gita Maulidyah Indraswari Suhri A., Bahar, I., Water Content of Stingless Bee Honey Varies by Season, *Jurnal Biologi Tropis*, 2023, 23(2), 16-22
8. Gleiter, R. A., Horn, H., Isengard, H.-D., Influence of type and state of crystallisation on the water activity of honey, *Food Chemistry*, 2006, 96(3), 441-445
9. Rulebook on Quality of Honey and Other Bee Products: Official Gazette of the Republic of Serbia: Belgrade, Serbia 2015, 101/15
10. Maric, A.; Assessment of honey quality and extraction of hydroxymethylfurfural from honey using ionic liquids, Doctoral dissertation, Faculty of Science, University of Novi Sad, 2023
11. Alves, A., Ramos, A., Goncalves, M. M., Bernardo M., Mendes, B., Antioxidant activity, quality parameters and mineral content of Portuguese monofloral honeys, *Journal of Food Composition and Analysis*, 2013, 30(2), 130-138
12. Gomes, S., Dias, L. G., Moreira, L. L., Rodrigues P., Estenviho, L., Physicochemical, microbiological and antimicrobial properties of commercial honeys from Portugal, *Food and Chemical Toxicology*, 2009, 48(2), 544-548