International Journal of Food Science and Nutrition
ISSN: 2455-4898; Impact Factor: RJIF 5.14
Received: 13-01-2021; Accepted: 05-02-2021; Published: 09-03-2021
www.foodsciencejournal.com
Volume 6; Issue 2; 2021; Page No. 29-31

Comparative analysis of honey quality from the area of Tuzla Canton-Bosnia and Herzegovina

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Abstract
Honey, as a natural food substance, has a significant role in economic and trade activities around the world. In Bosnia and Herzegovina, beekeeping is an opportunity for the development of rural areas, and an important factor in strengthening agriculture.
The aim of this research is to compare the quality of different types of honey from two consecutive seasons. Honey samples were collected in Tuzla Canton in Bosnia and Herzegovina. Physico - chemical and sensory properties of honey were analyzed. The research was conducted according to standard methods for testing the honey quality, in accordance with the legislation on honey quality in Bosnia and Herzegovina.
The results of dry matter content of honey samples are 80.50 to 82.60% (Brix), and the total acidity of honey is 12.40 to 43.97 mEq/kg of honey. The results of the water presence in honey range from 14.60 to 18.0%, and the conductivity ranged from 0.217 mS/cm to 1.425 mS/cm. The compliance of honey samples with the prescribed legislation on honey quality in Bosnia and Herzegovina has been determined, as well as the acceptability of honey samples in terms of sensory properties of honey.

Keywords: honey quality; physico-chemical properties; sensory properties

Introduction
Honey is a natural complex mixture of very different chemical ingredients, primarily different sugars, primarily fructose and glucose, and water and other substances that reach honey during its production, which, despite the progress of the industry, cannot be replaced by any production process. Namely, honey consists of over 200 different substances (proteins, free amino acids, vitamins, organic compounds, enzymes, minerals, etc.) of extremely high nutritional value and specific sensory properties (Orhan *et al*., 2003) [1].
According to the Rulebook on honey and other bee products (Official Gazette of Bosnia and Herzegovina, No. 37/09, 65/10 and 25/11)) [2-4]: "Honey is a naturally sweet, liquid, viscous or crystallized product produced by honey bees (Apis mellifera) from the nectar of honey plants flowers or from secretions from living parts of plants or from secretions of insects of the genus Hemiptera that suck living parts of plants, which bees collect, add their own specific substances, and transform and store in honeycomb cells to "mature" .
Honey consists of a complex mixture of carbohydrates, mostly fructose and glucose, and other components, such as organic acids, amino acids, proteins, minerals, vitamins and lipids. Color, taste and smell are the most important organoleptic properties of honey and mostly depend on the plant origin of honey and the conditions of processing and storage. Also, their analysis plays a significant role in defining the overall properties of honey. Since, for some types of honey, physico-chemical analyzes do not provide sufficient characteristic values, organoleptic analysis is indispensable in assessing the honey quality (Kebbede *et al*., 2012) [5].
Due to its high nutritional value and pleasant sensory properties, as well as easy digestibility, honey has always been an important part of the diet, and due to its composition, sweetness and physico-chemical properties, it is an ideal substitute for table sugar.
The sensory properties of honey primarily depend on the botanical composition of honey, so the color of honey can vary from colorless to dark brown. Also, the consistency of honey can be liquid or viscous, partially or completely crystallized, and the intensity of the honey aroma can vary, but must originate from the original herbs. Honey must not have a foreign taste or smell, and must not be in a state of fermentation or artificially altered acidity or be heated so that natural enzymes are destroyed or significantly inactivated (Kebbede *et al*., 2012; Čalopek *et al*., 2016; Ndife *et al*. , 2014) [5-7].

Materials and Methods
Collecting honey samples
Honey samples analyzed in this study were collected from local producers (beekeepers) in Tuzla Canton, in Bosnia and Herzegovina, for two consecutive seasons. The samples were then carefully labeled and transported for analysis to the Food Analysis Laboratory, Department of Food Technology, Faculty of Technology, university of Tuzla.

Physico-Chemical analysis of honey
Physico-chemical analyzes of honey samples were performed in accordance with the Rulebook on methods for control of honey and other bee products (Official Gazette of Bosnia and Herzegovina, 37/09; 65/10 and 25/11), and standard physico-chemical parameters were determined, which indicate the quality and health safety of honey:

Dry matter content
The total dry matter of honey samples was determined by the refractometric method, using a table refractometer (ABBE, Japan), and the value was expressed as a percentage (˚Brix). For each honey sample, the refractometer was

calibrated using distilled water, set to zero, and then an appropriate honey sample was taken and the dry matter value was read.

Water content in honey

The method is based on refractometric determination using an ABBE refractometer (Japan). The measurement is performed at a constant temperature of 20 ° C. Since the water content correlates with the refractive index, a decrease in the water content, or an increase in the dry matter content, the refractive index increases. With the help of the table for the calculation of water content in honey (Rulebook on honey control, "Official Gazette of Bosnia and Herzegovina", number: 37/09 Bosnia and Herzegovina), the corresponding value of the water share (%) is read.

Acidity content of honey

Free acidity is the content of free acids in honey. It was determined by titrating a honey sample solution with 0.1 M sodium hydroxide solution to pH 8.3. Results are expressed in mEq/kg of honey. The method can be applied to all honey samples. The acidity of honey is a very important parameter in assessing the quality of honey, because it significantly affects the sensory properties, and if necessary, the sweetness index and the bitterness index of honey can be determined, and those are determined as the ratio of dry matter and acidity, and vice versa (Wardy W, at all, 2009) [8]

Electrical conductivity of honey

The valuation of electrical conductivity is based on the measurement of electrical resistance which is reversed proportional to the electrical conductivity. The electrical conductivity of honey is defined as the electrical conductivity of 20% (w/v) aqueous solution of honey at 20°C, where 20% refers to the dry matter of honey. The method is suitable for measuring the electrical conductivity of honey samples whose value ranges from 0.1 to 3 mS/cm. A conductivity meter PC 52 + DHS (pH/mV/Cond/TDS/Trmp) was used to measure the electrical conductivity, with an electrode (2301 T + NEW; C = 1 + ATC 1 mt cable, 2 POLE Conductivity CeH, p/n: 50004002/830. Results are expressed in mS/cm.

Sensory analysis of honey

Sensory analysis of honey samples was conducted by a group of 5 analysts, who have experienced in sensory evaluation of honey. Procedures, condition of preparation and serving of samples were performed according to (Araujo D., *et al*. (2020) [9];. Forty grams of each sample was put into a glass vial and covered with a watch glass for sensory analysis. The samples were prepared one hour before tasting to achieve the equilibrium of the headspace and they were served at 20ºC. Four samples, labelled with three-digited random numbers, were served, one at a time, over a session. Mineral water and apple were used to cleanse the palate between samples.

Seven sensory attributes were evaluated, three for appearance (color, purity and clarity), one for odour, one for taste and two for aroma (characteristic of honey type and presence (strength) of aroma). The attributes were evaluated with different points: points from 1 to 3 for odour and purity, points from 1 to 4 for purity and presence (strength) of aroma, points from 1 to 5 for odour and taste and points from 1 to 6 for characteristic of honey type. The minimum sum of points in the overall rating for appearance is 3 points, the maximum is 10 points. The minimum sum of points in the overall rating for aroma is 2 points, the maximum is 10 points (Brčina T., *et al*, (2021.) [10].

Statistical analysis

Statistical analysis of the results was done in SPSS software (version 22). The T-test was used to test significant differences between the arithmetic means of honey samples from two seasons, for physico-chemical properties and sensory properties of honey samples. Pearson correlation coefficient was used to determine the correlation between physico-chemical properties.

Results and Discussion

The composition and sensory properties of honey primarily depend on the botanical origin of nectar, climatic conditions of the soil in which the plant is distributed, bee breeds, and individual abilities of beekeepers (Kaškoniene and Venskutonis, 2010.) [11]. Physico-chemical analyzes of honey, and the results of sensory properties are shown in Table 2.

The obtained results showed that there is no statistically significant difference between the mean values of physico-chemical parameters in relation to the season, nor in relation to the type of honey. The results for physico-chemical parameters are shown in Table 1, and the results for sensory parameters in Table 2.

Observing the results for physico-chemical parameters of honey individually, it can be seen that the values of physico-chemical parameters, for all tested samples, are in accordance with the legislation on honey quality of Bosnia and Herzegovina ("Official Gazette of Bosnia and Herzegovina", No. 37/09, 65/10 and 25/11), and the results were interpreted in accordance with the Guidelines for the interpretation of the testing results of the honey quality in Bosnia and Herzegovina.

The values of dry matter of honey samples for the observed seasons are from 80.5 to 82.60% (Brix), and the water content is from 16 to 18%, so it can be concluded that these parameters are in accordance with the prescribed legislation of Bosnia and Herzegovina. The content of free acidity in honey samples is from 12.40 to 43.97 mEq/kg of honey, which is also in accordance with the applicable legislation and the prescribed maximum value of honey acidity of 50 mEq/kg

Table 1: Physico-Chemical Properties of Honey

Season	Type of honey	Dry matter, % (˚Brix)	Water contents % (˚Brix)	Electrical conductivity, mS/cm	Acidity of honey, mEq/kg of honey
1	Forest honey	81,70	16,20	0,5860	37,75
1	Forest honey	80,50	15,00	0,6420	22,50
1	Meadow honey	82,60	16,20	0,7190	43,97
1	Meadow honey	82,00	17,00	0,5070	32,25
1	Black locust honey	82,60	16,40	0,2960	16,00
1	Black locust honey	82,50	16,60	0,2170	12,25

2	Forest honey	80,60	17,80	0,8690	31,60
2	Forest honey	80,50	17,20	1,0580	38,50
2	Meadow honey	82,00	14,60	1,4250	38,80
2	Meadow honey	80,50	17,60	0,5130	25,40
2	Black locust honey	82,00	16,60	0,2270	12,40
2	Black locust honey	80,50	18,00	0,2800	18,40

The measured values of electrical conductivity of honey samples range from 0.217 to 1.425 mS/cm, while the current legislation prescribes m max. 0.8 mS/cm for tested types of honey.

Table 2: Sensory properties of honey

Season	Type of honey	Purity	Color	Clarity	Odour	Taste	Characteristic of honey type	The presence of aroma	Total (max 30)
1	Forest honey	2.36	3.00	2.36	3.84	3.84	4.40	3.58	23.38
1	Forest honey	2.70	2.62	2.14	2.80	3.78	3.76	2.74	20.54
1	Meadow honey	2.56	2.92	2.26	3.70	3.78	5.16	3.62	24,00
1	Meadow honey	1.90	3.00	2.54	3.52	3.52	4.50	3.34	22.32
1	Black locust honey	3.16	2.40	2.92	3.54	4.14	3.62	2.88	24.60
1	Black locust honey	3.20	2.68	2.90	3.50	3.62	4.20	3.60	25.60
2	Forest honey	3.00	2.40	2.40	4.40	4.20	5.00	3.20	24.60
2	Forest honey	3.00	2.60	2.60	4.40	4.40	5.00	3.60	25.60
2	Meadow honey	3.00	3.00	3.00	4.20	4.60	5.20	3.60	26.60
2	Meadow honey	2.80	2.80	2.80	4.20	4.40	4.80	3.60	25.40
2	Black locust honey	2.80	2.20	2.80	4.00	4.20	4.80	3.40	24.20
2	Black locust honey	3.00	2.80	3.00	3.80	4.00	4.80	3.20	24.60

According to the results of the sensory analysis (Table 2), it is evident that the samples from season 2 have a higher total number of points compared to the samples from season 1 However, the T test showed that there was no statistically significant difference between the mean values between the two seasons for the total score.

All three types of honey (forest, meadow, black locust) from season 2 had better ratings for properties - purity, odour, taste and aroma (characteristic of honey type), compared to the tested samples of honey from season 1, but the T test showed statistically significant difference in arithmetic values only for sensory properties of odor ($t=3,904$; $p=0,004<0,05$), taste ($t=4,263$; $p=0,002<0,05$), and characteristic of honey type ($t=2,787$; $p=0.019<0.05$).

Based on the results for color sensory properties, all three types of honey from season 1 were better rated compared to season 2, however, although there is a difference in points, the T-test showed that there is no statistically significant difference between the mean values of each type of honey for the observed seasons.

Conclusion

Based on the research results, it can be concluded that the quality of the examined types of honey from Tuzla Canton in Bosnia and Herzegovina, in terms of physicochemical and sensory properties, is harmonized with the honey quality prescribed by the current legislation of Bosnia and Herzegovina. Also, it can be concluded that there are no statistically significant differences in the quality of individual examined parameters, which indicates the fact that the beekeepers are educated, as well as high potential for beekeeping development in the studied area.

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