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COMPARATIVE STUDY OF WATER CONTENT IN HONEY PRODUCED IN DIFFERENT YEARS

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Abstract

One hundred thirty-three honey samples of different floral origin from two different production years (2017 and 2018) from Serbia were examined in order to determine water content. The water content in honey affects physical, microbiological, sensory properties, and commercial value of honey. The water content in all examined honey samples produced in 2017 (56) was below maximum permissible level set by local regulations for honey. Out of the total of 77 tested honey samples that were produced in 2018, 3 samples (3.9%) did not comply with the provisions of the Regulation. By analysing honey samples originating from 2017, there was a significant difference between the water contents betwen linden honey and honeydew (p = 0.0027). The same result was obtained based on the water content in different honey types from the year 2018 (p = 0.00022). Using the F test, it has been shown that there is no significant difference in the water content between certain types of honey produced in these two years (2017 and 2018).

Key words*:* honey, water

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KOMPARATIVNA ANALIZA SADRŽAJA VODE U MEDU PROIZVEDNOM U RAZLIČITIM GODINAMA

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Kratak sadržaj

Ispitano je 133 uzorka meda različitog biljnog porekla iz dve različite proizvodne godine (2017. i 2018.), poreklom iz Srbije, kako bi se odredio sadržaj vode. Sadržaj vode u medu utiče na fizičke, mikrobiološke, senzorne osobine i komercijalnu vrednost meda. Sadržaj vode u svim ispitivanim uzorcima meda proizvedenim u 2017. godini (56) bio je ispod maksimalno dozvoljenog nivoa utvrđenog Pravilnikom o kvalitetu meda. Od ukupno 77 testiranih uzoraka meda koji su proizvedeni u 2018. godini, u 3 uzorka (3,9%), sadržaj vode nije odgovarao uslovima Pravilnika. Analizom uzoraka meda iz 2017. godine utvrđena je statistički značajna razlika u sadržaju vode između lipovog meda i medljikovca ($p = 0,0027$). Statistička značajnost utvrđena je i za proizvodnu 2018. godinu ($p = 0,00022$). Primenom F testa, nisu utvrđene značajna razlika u sadržaju vode između pojedinih vrsta meda iz dve proizvodne godine (2017. i 2018.).

Ključne reči: med, voda

INTRODUCTION

Natural honey is sticky, viscous solution containing about 80–85% carbohydrates (mainly glucose and fructose), 15–17% water, 0.1–0.4% proteins, 0.2% ash and minor amounts of amino acids, enzymes, vitamins and other substances such as phenolic antioxidants (Buba et al., 2013; Kek et al., 2017). Honey is a natural food consumed without any processing and is characterized by its complex composition, which varies in accordance with the bee species, geographical region, available floral source and storage conditions (Karabagias et al., 2014). Serbia has a very long tradition of beekeeping. Its favourable climate, good geographical conditions and a variety of botanical species provide a great potential for the development of apiculture (Jarić et al., 2013).

The water content (moisture) in honey depends on the production season, floral source, abundance of nectar flow, soil, ventilation of the beehive, colony

strength, and meteorological conditions in the area of honey production, primarily air humidity (Escuerdo et al., 2014; Kirs et al., 2011; Lazarević et al., 2017; Sousa et al., 2016). An important factor that could affect the water content is honey maturation and harvest time. According to most of national good beekeeping practice recommendations, beekeeper should harvest honey when at least 2/3 wax combs in frames are covered with wax lids.

Moisture substantially affects some physical properties of honey (crystallization, viscosity, rheological behaviour). Other parameters such as appearance, colour, palatability, taste, specific weight, solubility, conservation, and to a large extent commercial value of honey are also important (Azeredo et al., *2003;* Escuerdo et al., 2014; Prica et al., 2014). High moisture of honey is also an indicator of honey adulteration (Nyau et al., 2010; Obiegbuna et al., 2017). The water in honey is of major importance to its stability against fermentation and granulation. The low water content protects honey from microbiological activity and thus it can be preserved for longer periods (Akhtar et al., 2014). The higher the moisture, the higher the probability that honey will ferment upon storage by osmotolerant yeasts (Viuda-Martos et al., 2010). Tosi et al. (2004) suggested that inhibition of honey fermentation occurred when water content is below 17.1 %. Besides, honey stability is affected by the microbiological load for moisture content between 17.1% and 20%, while osmophilic yeasts may develop when the moisture contents are higher than 20%. Moreover, according to Snowdon and Cliver (1996) honey with water content over 17% is susceptible to fermentation and honey with more than 19% of water is very like to ferment. However, Boateng and Diunase (2015) stated that the levels of water between 13 and 25% are low and that yeast fermentation and bacterial growth will not be allowed. Furthermore, glucose/water ratio (G/W) was also recognised as useful for predicting the crystallisation of honey (Manikis and Thrasivoulou, 2001) and consequently the possible increase in number of microorganisms.

In accordance with the regulation concerning the quality of honey in the Republic of Serbia (Official Gazette, 101/2015), maximum value of water content in all types of honey (except in baker's honey) is set on 20%.

The purpose of this study was to determine water content in honey collected during 2017 and 2018, in order to obtain the information about the honey quality and safety. In addition, analysis of variance and F test were applied to determine the significance of statistical differences between the water contents in different honey types and in production years.

MATERIAL AND METHODS

Honey samples

A total of 133 honey samples were collected directly from beekeepers. The collected samples were produced in different regions of Serbia. In the year 2017 the total of 56 samples were collected, while the number of samples from 2018 was 77. All collected samples were in their original packaging and transferred to the laboratory of Scientific Veterinary Institute "Novi Sad" for examination. Honey analyses were carried out immediately after sampling.

A total of 133 examined samples included 55 samples of meadow honey, 35 samples of acacia honey, 13 samples of linden honey, 12 samples of honeydew, 11 samples of polyfloral honey and 7 samples of sunflower honey.

Water content analysis

Water content was determined by refractometry, measuring the refractive index (RI) according to Harmonised methods of the International Honey Commission Methods (2009), using a standard model Abbetype refractometer a 20° C. Water content (%) was then obtained from the Chataway table.

Statistical analysis

Statistical analysis was performed by the PAST software package, version 2.12, Oslo, Norway. Data were grouped according to the type of honey and presented as mean ± standard error, minimum and maximum values. Statistical data analysis included analysis of variance (one-way ANOVA), as well as Tukey's pairwise comparison. Using the F test, it was examined whether there is a significant difference between the water content in certain types of honey in those two years.

RESULTS AND DISCUSSION

Average values of water content in different honey types produced in 2017 and 2018, obtained in this study are summarized in Table 1. The obtained values were compared with the values that are prescribed by Regulation on the quality of honey in the Republic of Serbia (Official Gazette, 101/2015). The results were compared with the results from other authors from Serbia and other countries. The water content in all investigated honey samples produced

in 2017 was below 20%, which is the maximum permissible level set by local regulations for honeys (Official Gazette, 101/2015). Our results also demonstrated a low water content of honeydew honey and high water content of linden honey, compared to other examined honey types. Out of the total of 77 tested honey samples that were produced in the 2018, 3 samples (3.9%) did not comply with the provisions of the Regulation.

Table 1. Water content of different types of honey in three production years

TYPE OF HONEY	Total no. of samples	Water content (%)			
		Production year			
		2018		2017	
		No. of samples	$\bar{x}$ ± SD Range	No. of samples	$\bar{x}$ ± SD Range
Meadow	55	37	16.5 ± 1.2 14.0 - 18.0	18	17.3 ± 1.0 ^{bxy} 15.2 - 19.0
Acacia	35	19	16.2 ± 1.4 13.8 - 20.8	16	17.0 ± 1.0^{bxy} 15.8 - 19.0
Linden	13	7	18.9 ± 1.8^{ax} 15.4 - 20.6	6	18.2 ± 0.9 ^{ax} 17.2 - 19.4
Polyfloral	11	2	17.1 ± 0.1 17.0 - 17.2	9	17.2 ± 1.2 15.6 - 19.6
Honey-dew	12	6	15.2 ± 0.8^{by} 14.4 - 16.4	6	16.2 ± 1.4 ^{by} 14.2 - 18.2
Sunflower	7	6	17.4 ± 1.1 16.0 - 18.6	1	15.6 15.6

^{a,b} $p< 0.05$ ^{x,y} $p< 0.01$

Within the group of linden honey, water content was above 20% in 2 out of 7 tested samples (28.6%). In the group of acacia, water content was above 20% in 1 out of 19 tested samples (5.3%). Similarly to the results for honey produced in 2017, the data indicated a low water content of honeydew honey and high water content of linden honey, as compared with other examined honey types. In a study conducted on honey produced in 2013, out of the total number of 50 honey samples, the content of water did not comply with the provisions of the Regulation in only one sample (Prica et al., 2014). Water content in the examined samples ranged between 14.2 and 20.2%, with an average of 16.5±1.01%. In this study, we also established a low water content of honeydew, but high water content of polyfloral honey.

By analysing honey samples from the year 2017, there was a significant difference between the water content in linden honey and honeydew ($p = 0.0027$). The same result was obtained for water content in different honey types from the year 2018, meaning that there was a significant difference at the 0.01 level between honeydew and linden honey ($p = 0.00022$). Additionally, for samples from 2018, there was a significant difference between meadow and linden honey ($p = 0.037$), as well as between acacia and linden honey ($p = 0.012$), at the 0.05 level.

The F test showed that there is no significant difference in the water content between certain types of honey produced in the two years. In terms of the average weather conditions, the vegetation period was warmer and drier in 2017, while the vegetation period of 2018 was also warmer, but somewhat humid (RHSS, 2017-2018). However, despite the differences in climate conditions between the two observed years, we did not find statistically significant differences in the content of water in honey produced in 2017 and 2018. The water content of all groups of honey are summarized for both production years (2017 and 2018) and are shown in Figure 1.

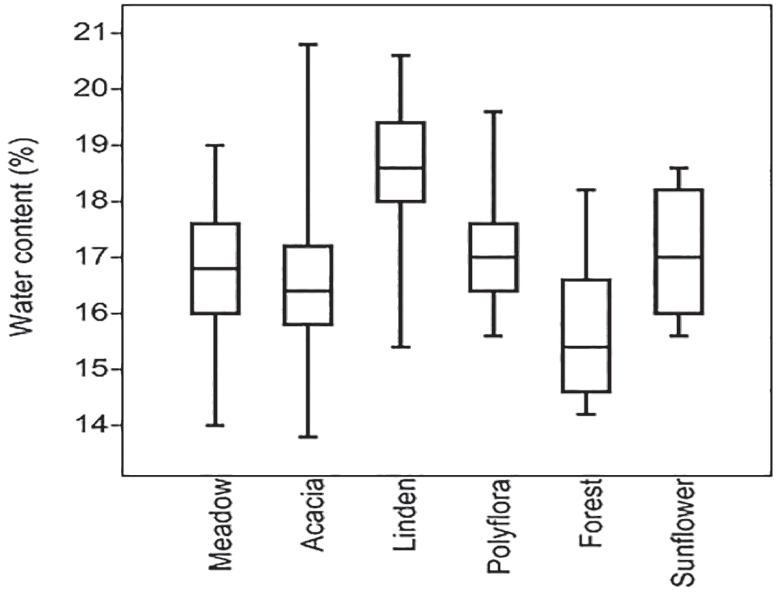

Figure 1. Water content summarized for both production years (2017 and 2018)

Box and whisker plots (Figure 1) compare the water content. The horizontal line in the centre of the box represents the median. The crossed vertical lines above and below the box represent the maximum and minimum values.

Similar values for water in honey are reported by other authors from our and other countries (Vranić et al., 2017; Acquarone et al., 2007; Boussaid et al., 2018; Chakir et al., 2016; Kirs et al., 2011; Sousa et al., 2016; Esccuerdo et al., 2014; Karabagias et al., 2014).

The water content in honey affects physical, microbiological, sensory properties, and commercial value of honey. Honey contains concentrated water solution of two main sugars: fructose and glucose, with small amounts of various complex sugars (Escuredo et al., 2014; Valdés-Silverio et al., 2018). Important aspect of carbohydrate composition in honey is crystallization ability. Over time, liquid honey tends to crystallize. Glucose, the main sugar component of most honeys, may precipitate out spontaneously in the form of glucose monohydrate, and the solution then reverts to the more stable saturated state (Zamora and Chirife, 2006). The moisture substantially affects crystallization process, so it is very important to monitor and control its content in honey. Glucose/water (G/W) ratio is the parameter indicating the ability of honey to crystallize. Generally, honeys with low G/W ratio do not crystallize easily (Escuredo et al., 2014). Mainly, honeys crystallizes faster with G/W ratio higher than 2.16%. On the other hand, honeys with G/W ratio lower than 1.70% remain liquid for a longer period of time (Smanalieva and Senge, 2009). It should be considered that G/W ratio is not always an appropriate index for honey crystallization tendency, so it should be taken only tentatively (Manikis and Thrasyvoulou, 2001; Pascual-Maté et al., 2018). Crystallization of honey is an undesirable process because it affects honey processing during extraction, filtration, mixing and bottling (Dobre et al., 2012; Laos et al., 2011). Crystalized honey is less appealing to the consumer, who prefers it liquid and transparent (Kabbani et al., 2011). *T*osi et al. (2004) noted that crystalline and liquid phases may coexists one period of a time during honey crystallisation and in such liquid phase water activity increases due to the fact that formation of crystal leads to the release of water from the solid phase. Finally, the normally present microorganisms in honey develop and consequently lead to sensory modification of honey and alteration in quality. Yeasts and spore-forming bacteria are commonly found in honey (Finola et al., 2007). According to the results reported by Zamora et al. (2006) the concentrations of the yeasts are in correlation with the water availability. Furthermore, total plate counts, coliforms and yeasts can be used as indicators of the sanitary quality of honey (Naman et al., 2005). The knowledge about the moisture content affecting growth

of microorganisms in honey is important for control of the spoilage of honey (Snowdon and Cliver, 1996). The type of honey and moisture content are important factors affecting a number of microorganisms in honey (Namini et al., 2018). The growth of microorganisms might be controlled by the intrinsic properties of honey such as pH, water content, oxidation-reduction potential, nutrient content, etc. (Iurlina and Fritz, 2005).

CONCLUSIONS

The study indicated that water content in the examined honeys varied according to botanical origin. The content of water in all examined honey samples produced in 2017 (56) was below the maximum permissible level. Out of the total of 77 tested honey samples produced in 2018, the water content did not correspond to the requirements of the Regulation in 3 samples (3.9%).

Statistically significant differences for water content have been established between linden honey and honeydew. There was no significant difference in the water content between certain types of honey produced in the two years (2017 and 2018). The results obtained by applying routine analysis of water content may be useful for comparing our research with similar studies from other regions and can contribute to the information relevant for predicting the crystallization, viscosity, rheological behaviour of honey as well as microbiological quality.

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