Original scientific paper
Оригиналан научни рад
UDC 638.172:577.1
DOI 10.7251/AGREN2304179B

University of Banjaluka, Faculty of Agriculture
Agro-knowledge Journal

Physicochemical and sensory parameters of black locust and chestnut honey quality

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Abstract

Black locust honey is produced from nectar collected from the Robinia tree (*Robinia pseudoacacia*). It has light yellow colour, very light and neutral fragrance, and smells of acacia blossom. It has a medium-sweet to very sweet taste, which is fairly to very long-lasting. Its aroma lasts for a short time and it slowly crystallizes. Chestnut honey is produced from nectar or collected from the sweet chestnut (*Castanea sativa*). Honey is dark brown with a red tint colour, dark colour depends on the region and year, and its aroma is very distinctive with extremely characteristic bitter taste. It rarely crystallizes. This paper presents the characteristics of quality black locust and chestnut honey produced in the territory of Bosnia and Herzegovina in the period 2012-2015. The study included 31 samples of honey. Laboratory testing of black locust and chestnut honey were carried out in accordance with the rules of the Ordinance on Honey and other Bee Products (Official Gazette of B&H, No. 37/09) and the EU Directive 2001/110/EC; CODEX STAN 12-1981. Indicators of quality (water content, electrical conductivity, total acidity, pH, hydroxymethylfurfural (HMF), and colour) and sensory properties of honey were determined. It was found that patterns of black locust and chestnut honey classified according to years showed certain variability in the physicochemical and sensory characteristics.

Key words: black locust honey, chestnut honey, physicochemical characteristics, sensory characteristics.

Introduction

Beekeeping is very important and is one of the most important links for the successful development of agriculture. The bee is the most efficient pollinator on Earth, and without well-pollinated plants there would be no fruit, no seeds, and that means no food for animals or humans. In addition to pollination, beekeepers use bees to produce the best food products and medicines, all in the name of protecting and improving human health and preventing various diseases, thus protecting and maintaining the health of the entire human population.

According to the Rulebook (Official Gazette of B&H, No. 37/09), honey is a thick, yellowish-brown, viscous liquid, or crystallized substance, has very sweet taste, sticky consistency, is produced by bees, which means humans have not yet managed to produce it artificially, as an industrial product. Unlike ordinary sugar, which is only "raw energy", honey contains simple, easily digestible sugars, fructose and glucose, but also vitamins, minerals, proteins, enzymes, plant hormones, flavonoids, and other substances.

It is often said about honey that its durability is not limited, meaning that it cannot get spoiled, but that it can only crystallize. As a product with high sugar concentration and low water activity, this is to say that it is microbiologically stable. However, honey is also susceptible to contamination by *Bacillus* spores, bee pathogens such as *Paenibacillus larvae*, *Paenibacillus alvei*, osmophilic yeasts of the genus *Saccharomyces cerevisiae* and various physical and chemical changes that cause darkening, loss of flavour, and aroma components.

The quality of honey is determined on the basis of its physicochemical characteristics, the most important of which are water content, hydroxymethylfurfural (HMF) content, acidity, pH value, electrical conductivity, sucrose content and reducing sugar content, and on its sensory characteristics, the most important being appearance, taste, and smell (Bogdanov et al., 2008).

Physicochemical and sensory quality of honey depends on a number of different factors such as geographical and plant origin, climatic conditions, production methods, bee breeds and the competence of a beekeeper, i.e., the processing method and storage conditions of honey until use.

The quality of honey is conditioned by many factors, such as the type of a plant from which the nectar is taken, the production method, the geographical and climatic characteristics of the area where honey is produced, storage, and packaging conditions. Due to many factors that affect the quality of honey, standardized honey quality is often the basic consumer requirement. They require clearer evidence of the standard quality and origin of the products they buy. In addition, the globalization of the market and the creation of conditions for the free exchange of goods between countries and continents have created the need to identify the origin of products.

The goal of this study is to determine the quality of black locust and chestnut honey samples, based on the analysis of physicochemical and sensory parameters. Based on the basic goal set in this way, the specific goal of the paper is to determine the accuracy of declarations on honey samples found on the market.

Material and Methods

This research included 31 random honey samples, collected from producers from different parts of Bosnia and Herzegovina. Of these, 20 samples were black locust honey, and 11 samples chestnut honey. Sample analyses were performed in the laboratory for determining the quality of honey and bee products at the Faculty of Agriculture and Food in Sarajevo.

The physicochemical analysis of honey

Laboratory tests included the following physicochemical analyses:

Determination of water in honey using a digital ABBE refractometer, 220 V BOE 32400 - AOAC Official Method 920.182; Rulebook on methods for control of honey and other bee products (Official Gazette of B&H, No. 37/09);

Determination of total acidity (volumetric method) - Trajković et al., 1983; Official Gazette of B&H, No. 37/09;

Determination of electrical conductivity (CYBERSCAN CON 510, EUTECH INSTRUMENTS) - Vorwohl, 1964; Biber, 2013; Rulebook on methods for control of honey and other bee products Official Gazette of B&H, No. 37/09;

Determination of hydroxymethylfurfural (HMF) (PERKIN ELMER LAMBDA 25 UV / VIS measuring range 190 - 1000 nm) - Official Gazette of B&H, No. 37/09;

Determination of pH (pH-meter - pH Inolab 720 and pH Electrode SenTix 41) - AOAC Official Method 962.19;

Determination of honey colour using the Lovibond comparator NI 96785.

The sensor honey analysis

The sensory analysis of black locust and chestnut honey samples was performed by a commission consisting of 14 members, evaluating the appearance (purity, colour, consistency, texture, and crystallization), taste and aroma of honey. Sensory evaluation of honey was performed according to the method of 20 weighted points using sensory patterns. For the purposes of sensory analysis of samples, forms for sensory evaluation of honey and a form for descriptive evaluation of honey quality were used, based on which an evaluation sheet by Grujić (2003) was prepared.

Based on the sum of points awarded during the sensory evaluation of samples, each of these properties was given a final assessment because of which a judgment on the quality of the honey sample was made according to the following criteria (Table 1).

Tab. 1. Quality category of evaluated samples

Quality Category	Pondered points range
Extra class	18.01-20
I class	16.01-18.00
II class	14.00-16.00
Outside of class	<14.00
Maximum number of points	20

Results and Discussion

The aim of this study was to determine the quality of two types of honey, black locust and chestnut, based on physicochemical and sensory parameters. The paper investigated the influence of two experimental factors (type of honey and age) where there is an unequal number of repetitions within each treatment. Differences in average were tested by the LSD test for a probability level of 0.05.

The results of a physicochemical honey analysis

The physicochemical analysis of honey included determination of water content, electrical conductivity, total acidity, colour, hydroxymethylfurfural, and pH value in 31 samples.

According to the Rulebook (Official Gazette of B&H, No. 37/09), the water content in honey must not exceed 20%. EU legislation prescribes the same value except for heather and clover honey, in which the water content can be up to 23% (Council Directive 2001/110 / EC; Codex STAN 12-1981). The average water content in honey based on the analyzed years ranged from 16.50%-18.63% in the black locust honey and in the chestnut honey it ranged from 17.27%-17.63%. A slightly larger deviation from the mean value was in 2013 for the black locust honey, while the smallest was in 2015. Based on the results obtained, two samples do not meet the requirements prescribed by the Rulebook (Official Gazette of B&H, No. 37/09). The cause of increased water content in honey can be insufficient maturity of honey before the process of extracting, forgery, or improper handling. Also, one of the causes of higher water content in the chestnut samples can be due to weather conditions.

Tab. 2. Physicochemical parameters of the black locust acacia honey from the first year (2012)

SAMPLE	Water (%)	Conductivity (mS/cm)	Acid (Meqv./1000g)	HMF (mg/kg)	pH	Colour (mm)
210	19.60	0.24	30.00	8.53	3.81	35.00
211	17.80	0.57	37.00	3.97	4.16	30.00
212	18.60	0.23	32.00	14.15	3.69	35.00
213	19.80	0.23	30.00	22.46	3.69	43.00
214	18.20	0.27	20.00	31.36	3.74	65.00
215	17.80	0.14	16.00	10.78	3.58	98.00
Min	17.80	0.14	16.00	3.97	3.58	30.00
Max	19.80	0.57	37.00	31.36	4.16	98.00
Xs	18.63	0.28	27.50	15.21	3.78	56.00
Sd	0.88	0.15	7.89	10.05	0.20	39.54

Tab. 3. Physicochemical parameters of the black locust honey from the second year (2013)

SAMPLE	Water (%)	Conductivity (mS/cm)	Acid (Meqv./1000g)	HMF (mg/kg)	pH	Colour (mm)
216	16.80	0.27	24.00	23.28	3.93	26.00
217	17.60	0.30	23.00	7.63	4.02	25.00
218	16.40	0.39	21.00	5.91	4.17	78.00
219	17.80	0.40	21.00	2.47	4.12	64.00
220	17.20	0.49	29.00	3.67	4.35	49.00
221	15.20	0.40	20.00	5.91	4.42	25.00
223	20.40	0.34	20.00	11.45	4.13	89.00
224	18.00	0.31	16.00	6.59	3.96	121.00
Min	15.20	0.27	16.00	2.47	3.93	25.00
Max	20.40	0.49	29.00	23.28	4.42	121.00
Xs	17.43	0.36	21.75	8.36	4.14	59.63
Sd	1.50	0.07	3.77	6.60	0.18	35.11

The average value of % water is in line with the types of honey analyzed in Portugal (17.8%), Italy (17.4% and 17.3%), and northern Argentina (17.4%) (Feas et al., 2010). The average value of water content in the black locust honey from Croatia was 17.13 ± 1.06%, which is slightly lower than the water content obtained in the black locust honey samples analyzed in this paper (Krpan et al., 2009).

According to the EU Rulebook and Directive, honeydew and chestnut honey must have an electrical conductivity of more than 0.8 mS/cm, and nectar and mixed honey of less than 0.8 mS/cm. The average value for electrical conductivity in the black locust honey ranged from 0.26-0.36 mS/cm, while in the chestnut honey it ranged from 1.5-2.07 mS/cm.

Tab. 4. Physicochemical parameters of the black locust honey in the third year (2015)

SAMPLE	Water (%)	Conductivity (mS/cm)	Acid (Meqv./1000g)	HMF (mg/kg)	pH	Colour (mm)
225	16.40	0.33	20.00	4.27	4.15	30.00
226	16.80	0.18	15.00	-	4.17	0.00
227	16.20	0.19	15.00	5.09	4.41	0.00
228	17.00	0.23	18.00	16.92	4.21	10.00
229	15.60	0.16	11.00	0.45	4.30	0.00
230	17.00	0.45	15.00	2.54	4.57	24.00
Min	15.60	0.16	11.00	0.45	4.15	0.00
Max	17.00	0.45	20.00	16.92	4.57	30.00
Xs	16.50	0.26	15.67	5.85	4.30	10.67
Sd	0.55	0.11	3.08	6.44	0.16	13.37

Tab. 5. Physicochemical parameters of the chestnut honey from the first year (2012)

SAMPLE	Water (%)	Conductivity (mS/cm)	Acid (Meqv./1000g)	HMF (mg/kg)	pH	Color (mm)
161	17.20	1.85	30.00	0.00	5.21	98.00
162	17.60	1.72	25.00	0.00	5.09	88.00
163	17.40	1.94	33.00	0.00	4.44	150.00
164	14.80	1.65	28.00	0.00	5.05	91.00
165	17.40	2.01	25.00	0.00	4.71	122.00
166	18.60	2.03	20.00	96.48	4.53	150.00
167	20.20	2.07	19.00	0.00	3.61	150.00
168	17.80	1.88	17.00	1.65	5.50	97.00
Min	14.80	1.72	17.00	1.65	3.61	88.00
Max	20.20	2.07	33.00	96.48	5.50	150.00
Xs	17.63	1.89	24.63	49.07	4.77	118.25
Sd	1.51	0.64	5.63	67.05	0.59	28.18

Based on the results obtained, the black locust and chestnut honey samples meet the requirements of electrical conductivity according to the Rulebook (Official Gazette of B&H, No. 37/09). The average value of electrical conductivity in the black locust honey has been slightly higher compared to the types of honey analyzed by other authors, such as the results for the black locust honey produced in the European Union countries, where the mean value of 0.16 mS/cm was obtained (Persano et al., 2004), as well as Slovenian black locust black locust honey, where in one study the average values obtained ranged from 0.162-0.177 mS/cm (Kropf, 2009) and 0.19 mS/cm in another (Bartoncelj et al., 2011). The reason for high values of electrical conductivity in the analyzed black locust honey samples may be the presence of another type of honey.

According to the Rulebook and directives in neighbouring countries, the EU Directive and the Codex Alimentarius, the total acidity of honey must not exceed 50 meq/kg (Official Gazette of B&H No. 37/09; 2001/110 / EC; Codex APARTMENT 12-1981). The average value for the total acidity ranged from 21.65-25.82 meq/kg. The black locust honey had the largest deviation from the mean value, while the chestnut honey had the smallest. The average acidity of 271 honey samples in Slovenia was 16.29 meq/kg for the black locust honey, while the average acidity of the chestnut honey was 15.13 meq/kg (Kropf, 2009). The average content of total acidity in a total of 200 black locust samples ranged from 8.16-12.94 meq/kg (Uršulin-Trstenjak et al., 2015). Comparing the results obtained in this paper with the average values of other authors for the black locust and chestnut honey, it can be concluded that there are no significant differences in the content of total acidity in the honey.

Tab. 6. Physicochemical parameters of the chestnut honey from the second year (2013)

SAMPLE	Water (%)	Conductivity (mS/cm)	Acid (Meqv./1000g)	HMF (mg/kg)	pH	Colour (nm)
169	18.40	1.62	29.00	4.87	3.76	111.00
170	16.40	2.02	28.00	4.80	4.76	134.00
171	17.00	2.06	30.00	7.48	4.70	150.00
Min	16.40	1.62	28.00	4.80	3.76	111.00
Max	18.40	2.06	30.00	7.48	4.76	150.00
Xs	17.27	1.50	29.00	5.72	4.41	131.67
Sd	1.03	0.81	1.00	1.53	0.56	19.60

The average values obtained for hydroxymethylfurfural for the tested samples are in accordance with the permitted values according to the Rulebook (Official Gazette of B&H, No. 37/09). The content of hydroxymethylfurfural in the black locust honey according to the stated years does not exceed the limit prescribed by the Ordinance, the average value of HMF ranging from 5.85 to 15.21 mg/kg. The largest deviation from the mean was in 2012. The content of hydroxymethylfurfural in the chestnut honey exceeded the limit prescribed by the Ordinance (Official Gazette of B&H, No. 37/09), the average value of HMF ranging from 5.72 to 49.07 mg/kg. One sample from 2012 exceeded the limit prescribed by the Ordinance. Also, the largest deviation from the mean was in 2012. The reason for this could be extremely high temperatures that were recorded during 2012 in Bosnia and Herzegovina, and the lack of precipitation during that year. Saric et al. (2008) examined the quality of 254 samples of different types of honey from Croatia during three different seasons. The average HMF content in the black locust honey samples was 7.2 mg/kg, and in the chestnut honey samples 4.8 mg/kg. The average HMF content of chestnut honey from Greece was 4.5 mg/kg (Trasyvoulou and Manikis, 1995).

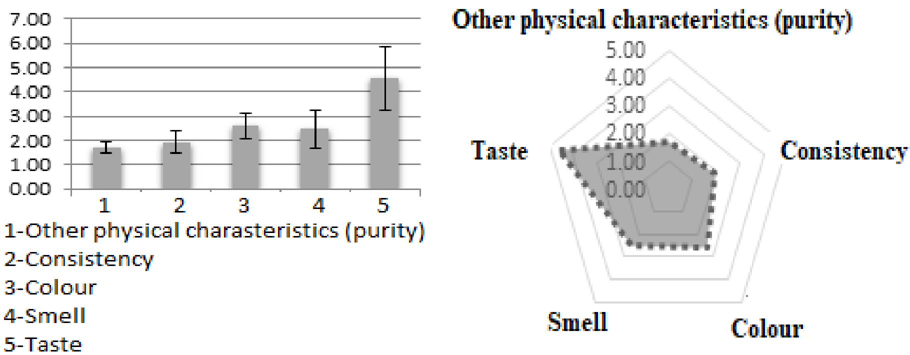
Honey is acidic, i.e., it has a pH value of less than 7. It should be noted that the pH value of honey is not directly related to free acidity, due to the buffering properties of phosphates, carbonates, and other mineral salts which are naturally present in honey. The average pH value ranged from 4.08 to 4.67. The chestnut honey had the largest deviation from the mean, while the black locust honey had the smallest. Most of the analyzed types of honey in the world whose pH values have been recorded in published scientific papers range from 3.5 to 4.5 (Bogdanov, 2007). Determination of colour using a Lovibond comparator is based on measuring the transmittance of a honey sample at 430 and 530 nm. Transmittance is expressed over millimetres of the Pfund scale, which is divided into 7 categories, from transparent to dark amber (Flanjak, 2013).

Based on the presented charts, the average values for the colour of honey in 2012 and 2013 were approximately in the amount of 59.67 mm and 59.63 mm. The largest deviation from the mean value was recorded in 2012. The lowest mean value for colour in the black locust honey was recorded in 2015 at 10.67 mm. In the case of the chestnut honey, the highest average value for colour was in 2013 in the amount of 131.67 mm, where the smallest deviation from the mean value was recorded, while the lowest average value for the colour of the chestnut honey was 118.25 nm. Szabó et al. (2016) determined the colour for 21 samples of different types of honey from Hungary, of which 4 black locust honey samples and 1 chestnut honey sample. The average colour values for the black locust honey samples were 8 nm, 17 nm, and 83 nm, while for the chestnut honey the average colour value was 48 nm. Comparing the obtained results with the average values of other authors for black locust, a significantly higher value is observed. The reason for the higher value of the tested samples is the area where the bees were during the grazing period or untimely vomiting, i.e., as a result of a beekeeper’s mistake. The average colour values of the chestnut honey are close to the values obtained by other authors.

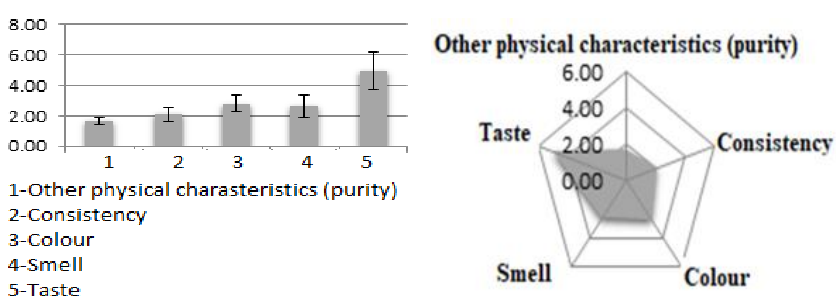
Sensory Analysis Results

Based on graphs 1 and 2, in the case of the black locust honey from 2012, the taste had the highest average sensory evaluation for this honey, while the purity had the lowest values. A larger deviation from the mean value is expressed in taste.

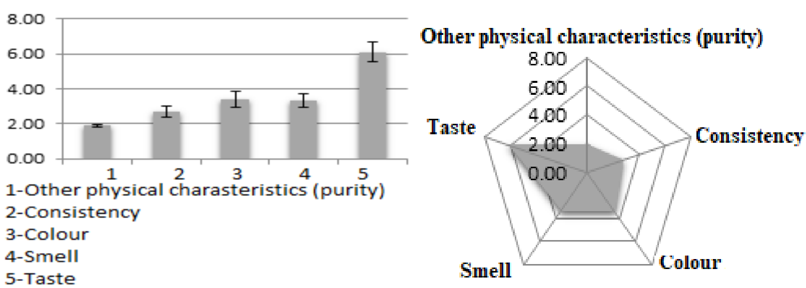
Following graphs 3 and 4, the highest average value of the sensory evaluation of the black locust honey in 2013 was given to taste, while the lowest to purity. Deviation from the mean value was greatest in taste and least in purity. Based on graphs 5 and 6, the taste received the highest average value for the sensory evaluation of the black locust honey in 2015, while purity had the lowest. Deviation from the mean value was greatest for taste and least in purity.



Graphs 1. and 2. Sensory evaluation of the black locust honey from 2012

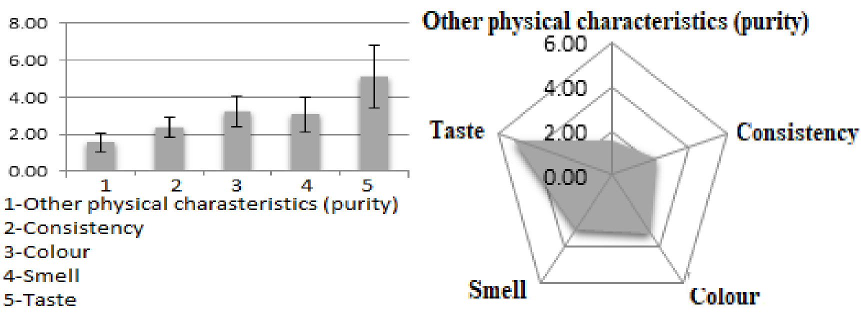


Graphs 3. and 4. Sensory evaluation of the black locust honey from 2013

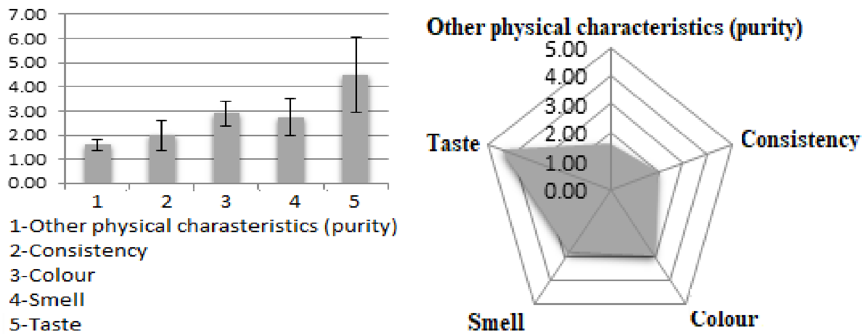


Graphs 5. and 6. Sensory evaluation of the black locust honey from 2015

Taking into consideration graphs 7 and 8, the highest average value of the sensory evaluation of the chestnut honey from 2012 was given to taste, while the lowest to purity. Deviation from the mean value was greatest for taste and least for purity.



Graphs 7. and 8. Sensory evaluation of the chestnut honey from 2012



Graphs 9. and 10. Sensory evaluation of the chestnut honey from 2013

Graphs 9 and 10 that the highest average value of the sensory evaluation of the chestnut honey from 2013 was given to taste, while the lowest to purity. Deviation from the mean value was greatest for taste and least for purity.

Honey Classes

Based on the sensory evaluation, i.e., according to the number of points obtained, the honey samples were classified into classes.

Out of a total of 31 samples, 5 were classified in the Extra Class. Of these, 2 samples of the black locust honey from 2015, and 3 chestnut honey samples from 2013. None of the 2012 samples fell into this class. The reason for this may be a long period of storage of honey samples, and the method of processing or handling before taking samples.

The first class includes 6 samples, of which 5 samples of the black locust honey and 1 chestnut honey sample.

Class II includes 10 samples, of which 7 samples of black locust honey and 3 chestnut honey samples. Outside the class included 10 samples, i.e., 6 black locust honey samples and 4 chestnut honey samples. The reason for a large number of samples outside the class is a very low grade for purity and consistency, texture, and crystallization of honey. In most samples, the isolated phases were clearly visible, which is why they were poorly evaluated. The reason that led to this assessment is the age of the honey, which is confirmed by the fact that no sample from 2015 has been classified in this class.

Conclusion

The results of this paper should help define the quality and characteristics of the black locust and chestnut honey depending on the year of production. The aim of this study was to determine the quality of two types of honey, black locust and chestnut based on physicochemical and sensory parameters. Based on the basic goal set in this way, the specific goal of the work was to determine the accuracy of declarations on honey samples that are on the market. The paper examined 31 black locust and chestnut honey samples collected from producers from Bosnia and Herzegovina during 2012-2015 years.

Based on the results obtained in this paper we can conclude the following:

Based on the overall physicochemical and sensory quality, it can be concluded that the honey from different parts of Bosnia and Herzegovina has shown approximately the same and not very high quality. Beekeepers need government support in subsidizing the cost of procuring equipment and medicines according to EU standards to be able to reach a high level of yield per hive. This points to the need to educate beekeepers about modern beekeeping technologies so as to achieve maximum honey yields, but also about honey handling after the extraction from honeycombs, packaging, declaration, and storage, as well as educating beekeepers how to prepare their communities for winter survival until their first grazing.

Beekeepers' associations from FB&H, RS, and Brčko District should unite and it is important to establish beekeepers' associations at the state level (organize workshops, study trips, include regional and international consultants).

The future production and processing of bee products should find its foothold in the abundant resources of the whole of B&H and long tradition of numerous beekeeping areas. Council Directive 2001/110/EC set out specific requirements for honey. Given that buyers from the EU want to be able to trace the origin of honey all the way to the beekeepers - honey producers, it is necessary to establish a traceability system, and this is also necessary for the HACCP system.

In order for beekeepers to be able to progress, they need to further develop the raw material base, start building processing plants, and apply EU standardization. Further, production organizations need assistance to obtain HACCP, organic certification, and Fair-Trade certification to be in a position to compete in the international honey market, and to achieve a better price.

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Физичко-хемијски и сензорни параметри квалитета багремовог и кестеновог меда

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Сажетак

Багремов мед се производи од нектара, сакупљеног са цвјетова багремовог дрвета (*Robinia pseudoacacia*). Изразито је свијетло-жуте боје, врло благог и неутралног мириса, мирише на багремов цвијет. Окус варира од средње до јако слатког, врло је дуготрајан. Његова арома је краткотрајна, те споро кристализира. Кестенов мед се производи од нектара прикупљених са цвјетова питомог кестена (*Castanea sativa*). Мед је тамно-смеђе боје са црвенкастим тоном, а тамна боја варира овисно о подручју и години, препознатљивог је мириса и изразито карактеристичног горког окуса. Кестенов мед ријетко кристализира. У овом раду је дат приказ карактеристика квалитета багремовог и кестеновог меда произведеног на подручју Босне и Херцеговине у периоду од 2012 – 2015. године. Испитан је 31 узорак меда. Лабораторијска испитивања багремовог и кестеновог меда су проведена у складу са правилима Правилника о меду и другим пчелињим производима (Сл. гласник БиХ, бр. 37/09) и Директиве EU 2001/110/EC; Codex STAN 12-1981. Одређени су показатељи квалитета (садржај воде, електрична проводљивост, укупна киселост, pH вриједност, хидроксиметилфурфурал (ХМФ) и боја) и сензорна својства меда. Установљено је да узорци багремовог и кестеновог меда класифицирани према годинама, показују одређену варијабилност у физичко – хемијским и сензорним својствима.

Кључне ријечи: багремов мед, кестенов мед, физичко – хемијске карактеристике, сензорне карактеристике

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Received: October 10, 2023
Accepted: November 14, 2023