



COMPARING THE QUALITY OF HONEY FROM BEEKEEPERS AND HONEY FROM THE MARKET CHAIN

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ABSTRACT

Honey is a valuable food for its beneficial nutritional and dietetic effects. The quality of honey fluctuates considerably according to various criteria, the adulteration of honey with cheaper substitutes is not negligible. The quality of honey in the market chain with honey taken from beekeepers was compared in this study. A total of 10 samples from each group were tested for basic qualitative markers and compared with legislative criteria. The samples were analysed for fructose and glucose content, water content, titratable acidity and two tests for illegal sugar additions. The results revealed the addition of 25% of the technical syrup in one sample of honey from the market chain, one sample had the sum of fructose and glucose 56,3%, it is below the required limit 60% (differed by 6,3%). In other parameters the samples complied with the valid legislation. All tested parameters in honey from beekeepers met the criteria of the legislation, only 1 sample of blossom honey had the sum of fructose and glucose just below the required limit. The sum of fructose and glucose in this sample was 58.3 %, it differed by 2.9% from the required content of 60%. Sensory analysis was used to assess four samples of honey from beekeepers collected by different techniques. Results have not shown significant difference in sensory properties between manually pressed honey and honey obtained after whirling. The responses characterizing the favourable sensory properties of the examined honey samples were prevailing. The difference between the perception of honey after whirling and honey harvested by press manually was not demonstrated in sensory properties.

Keywords: blossom honey; honeydew honey; adulteration; beekeeper; market chain

INTRODUCTION

Honey is a sweet primary product of bees (*Apies* family) used from history as a food source, as a sweetener, but also for other purposes, including therapeutic use. Blossom honey is obtained from the nectar of flowers, honeydew honey from secretions of aphids plant sucking insects (Alvarez-Suarez et al., 2014). Composition of honey depends on many parameters and may be different according type (blossom or honeydew), pollen collection locality, season, variety of flora and also according to the method of honey harvesting and post-harvest handling, including storage. Honey contain many nutritionally important chemical components, such as sugars, oligosaccharides, organic acids, enzymes, minerals, polyphenols, vitamins and aminoacids with important functions in human nutrition, or treatment and prevention of various diseases. Most of them are associated with antioxidant, anti-inflammatory, antibacterial and antiviral functions, antihypercholesterolemic, antiulcerous, vasodilatative, hypotensive and even antitumor functions (Bogdanov, 2011; Viuda et al., 2008; Hadagali and Chua, 2014).

The main components of honey are sugars. Monosaccharides, fructose and glucose forms about 70 % of sugar content, disaccharides, trisaccharides and

oligosaccharides forms the rest, about 10 % of carbohydrates of honey (Miguel et al., 2017). Table 1 shows the chemical composition of honey according to Santos-Buelga and González-Paramás (2017).

Table 1 Chemical composition of honey (Santos-Buelga and González-Paramás. In: Alvarez-Suarez, 2017).

Major constituents (%)	Mean	SD	Range
Water	17.90	3.16	13.21 – 26.50
Fructose	39.44	2.11	37.07 – 42.65
Glucose	28.15	5.74	18.20 – 32.10
Sucrose	3.19	3.81	0.36 – 16.57
Other sugars	8.5		0.1 16.0
Minor constituents (%)			
Minerals	0.36	0.18	0.11 – 0.72
Total protein	1.13	1.22	0.22 – 2.93
Acids (as gluconic acid)			0.17 – 1.17
Vitamins, enzymes, aromas	<0.1		
Phenolic compounds	0.1		0.02 – 0.2

Proteins in honey are present in enzymes diastase, amylase, invertase, glucose oxidase, etc. as well as

individual amino acids, where proline is the most important (Miguel et al., 2017).

The content of vitamins (vitamins of group B, ascorbic acid) is very low in honey. Although, it contains a negligible amount of vitamins, honey is a significant factor in both, prevention and support in treatment of diseases, probably through the combination of vitamins with other biologically active substances.

Many scientific studies show the positive effects of honey on human health. Major positive effect on living organisms, is antioxidant activity of honey, proven *in vitro* and *in vivo* studies. *In vitro* study shows, that honey is able to scavenge free radicals, can reduce ferric cations and inhibit lipid peroxidation. *In vivo*, honey is able to stimulate the antioxidative status of mice and rats, especially glutathione defence system (Erejuwa, 2012). Other important role of honey is immunomodulatory activity in wound healing properties. The process of wound healing has four stages – haemostases, inflammation, proliferation and remodelling (Song and Salcido, 2011). This effect depends on immunostimulatory and inflammatory action and suppression of reactive oxygen intermediates which correlates with the floral origin of honey. Honey has been also used in treatment of skin disorders, such as dermatitis, eczemas, burns, and ulcers, Fournier gangrene with positive effect on this healing processes (Song and Salcido, 2011, McLoone et al., 2016).

Most of *in vitro* studies of anticancer activity of honey of various kinds to several types of human cancer cell lines were reported (Tsiapara et al., 2009). Honey was reported as an apoptotic induce factor and has antiproliferative activity by affecting cell cycle and blocking the cell cycle of cancer cell lines (Erujawa et al., 2014).

Cardiovascular disease are the most common cause of death worldwide, published by World Health Organization (WHO, 2017). Cardiovascular diseases are associated with chronic inflammation. Presence of inflammation manifests with increasing high sensitivity of C-reactive protein (CRP). Some authors reported (González-Gil et al., 2016) decreasing of CRP levels in European children when they consume regularly medium intake of honey at breakfast. The positive effects are probably connected with other beneficial elements in the diet (González-Gil et al., 2016). Other studies reported positive effect of honey in the prevention of cardiovascular diseases. According to Yaghoobi et al. (2008), natural honey decreases all risk markers in blood in both groups, healthy people and patients with high cardiovascular risk factors. Honey reduced total cholesterol (TCH), low-density lipoproteins (LDL), triacylglycerols (TG), levels of fasting blood glucose, and CRP in this study. On the other hand, honey increased high-density lipoproteins (HDL).

Honey is a beneficial in the diet for proper function of the intestinal microbiota due to the unique composition of honey containing sufficient nutrients particularly oligosaccharides (fructooligosaccharides) required for growth of intestinal microbiota such as *Lactobacillus acidophilus*, *Bifidobacterium* spp. (Roberfroid, 2000).

In addition to these positive effects, honey is recommended for antiviral effects as a support tool in the fight against viral infection.

It is not easy to prove the antitumor effects of honey and effectiveness in preventing or improving the treatment of

oncological diseases. Honey has proved the supporting effect on the body's defense against infections, the improvements in the healing of hard healing wounds, and chronic diseases. For further research on the prevention of metabolic and chronic diseases, the prevention of cardiovascular diseases, including the treatment of inflammatory skin diseases, studies of its effects have a great importance. For these properties, it is very important to maintain high quality honey in the market chain and to support the production of quality honey from local beekeepers.

Some changes in composition can occur due to the storage of honey. These changes are reflected by a change in sensory properties and reduce the quality of honey (Kňazovická et al., 2015). Some biochemical processes, such as fermentation, oxidation, hydration or dehydration and the other reactions lead to changes in acidic content and the formation compounds, like 5-hydroxymethylfurfural (5-HMF). This compound in honey is undesirable and there is established the limit value for HMF in honey. This compound can be used also as a marker of illegal honey interferences, such as heating to a temperature above 50 °C (Alvarez-Suarez, 2017).

Honey is a food that could be easily adulterated. Therefore, its quality must be regularly checked and monitored. The situation in the Czech Republic (CR) concerning honey in the market chain and the situation in beekeeping is summarized in the Situational Outlook Report of the Czech Ministry of Agriculture (MZe, 2015). The consumption of honey in the Czech Republic is low, only about 0.7 kg /person/year, but it has slightly rising tendency. Guziy et al. (2017) compared the consumption of honey in Slovakia and Russia. According to this study the consumption of honey in both countries is higher than in the CR. From 316 respondents in Slovakia, approximately 50 % of them consume about 2 -5 kg of honey/person/year. Honey supply in the market network in the CR is sufficient, the market network is complemented by increasing import of honey not only from the EU countries.

To maintain biological and nutritional value, quality and safety properties of honey, clear criteria for honey handling during its formation and subsequent harvest and storage are given. According to the quality requirements, no component of honey must be removed (except filtration), no substances should be added (in the CR according to the Decree 76/2003 Coll., Council Directive 2001/110 EU). The criteria are given in Table 2.

Honey quality criteria were specified in the European directive in the EU Proposal for a directive of the European Council relating to honey (1996), respectively Council Directive 2001/110/EC (2001) and in the Codex Alimentarius (1994).

According to the Council Directive 2001/110/EC (2001) honey is natural bee product to which nothing can be added and from which nothing can be removed. International honey standards are specified in the collaborative work of the International Honey Commission (Bogdanov et al., 1999). Criteria are very strict, there is not allowed to add anything (additives or substitutes) to honey and change its composition. The quality of honey in the market chain is threatened by the problem of adulteration and unauthorized interference. Honey, as well as other food, is often falsified by illegal additions and substitutes.

In the Czech Republic the quality of honeys in the market chain is monitored by the Czech Agriculture Food Inspection Authority (CAFIA). The State Veterinary Administration (SVA) supervises breeding and cooperate with CAFIA. The State Veterinary Administration carried out checks on beekeepers in 2016 and the quality of the honey was very satisfactory. But CAFIA (2017) revealed during inspections in 2016 in market chain a total 31 % of the samples with unsatisfactory quality and approximately 40 % of the samples did not comply in the long term period of monitoring.

Table 2 Physical and chemical requirements for honey (Decree 76/2003 Coll.).

Requirement	Honey type		
	flower	honeydew	bakery (industrial)
the sum of fructose and glucose contents (wt.% of at least)	60.0	45.0	-
sucrose content (wt.% maximum)	5.0	5.0	-
water content (wt.% maximum)	20.0	20.0	23.0
acidity (meq.kg ⁻¹ maximum)	50.0	50.0	80
hydroxymethylfurfural (mg.kg ⁻¹ maximum)	40.0	40.0	-
water insoluble matter content (% by weight)	0.10	0.10	-
electrical conductivity (mS. m ⁻¹)	max. 80.0	min. 80.0	-
diastase activity (degree according Schade – at least)	8.0	8.0	-

Scientific hypothesis

The aim of our study was to determine the basic parameters of honey quality in the market chain and compare them with samples of honey from beekeepers with the expected difference between the main parameters of honey from commercial suppliers and samples from beekeepers and reveal adulteration honey by the addition of substitutes. Sensory analysis was used to identify the difference between the honey harvested by the hand press from honey harvested by whirling.

MATERIAL AND METHODOLOGY

Samples

Two groups of samples for the analyses of the basic parameters of honey quality were taken in 2016. All these samples were harvested in 2016. Each sample group contained 10 samples of honey. The samples of group A were collected in market chain from commercial suppliers. The samples group B were collected directly from beekeepers from Bohemian-Moravian Highlands.

Samples for sensory analysis

Samples group C for sensory and chemical analysis were taken from harvesting honey in 2015 and assessed in this

year. Two samples of honey (1 sample blossom honey, 1 sample honeydew honey) were harvested manually by pressing, two other samples of honey (1 sample blossom honey, 1 sample honeydew honey) were harvested by classical methods of honey extraction by whirling.

Sensory analysis of samples

Sensory analysis of samples group C was carried out at the sensory analytical laboratory under the conditions of ISO 8589:2007. The panel comprised 10 panellists selected, trained, and monitored according to Piana et al. (2004). Sensory quality was assessed using category ordinal 12-point scale. The evaluated descriptors were colour, consistency, smell and taste. Samples were coded using four-digit, randomly generated numbers and served according to the ISO 6658:2017. Drinking tap water was given as a neutraliser to the panellists between the samples.

Chemical analysis of samples

Conductivity. Determination of electrical conductivity is based on the principle of measuring electrical resistance by conductivity using the instrument (LWT-03-ATC, Voltcraft). Samples (20% honey solution) were tempered at 20 °C for 30 minutes, and then the conductivity was measured 3 times, and arithmetic mean was calculated.

Water content. Water content was determined refractometrically using the RF10 refractometer (Conrad Electronic) apparatus by applying 1 drop of sample to the surface of the refractometer prism glass. Each sample was determined 3 times and the arithmetic mean was calculated.

Sugar content. The content of fructose, glucose and sucrose were analysed by HPLC (Varian 9010, U.S.A) in both groups of samples (samples group A and B), after clarification by solutions Carrez I and Carrez II under these conditions: Agilent Hi-Plex Ca column, 7.7 x 300 mm, 8 µm (p/n PL1170-6810), mobile phase 100% deionised H₂O, flow rate 0.6 ml.min⁻¹, injection volume 20µl, temperature 85 °C, detector RI, using glucose, fructose and sucrose standards p.a. (Sigma-Aldrich) at a concentration of 10 mg.mL⁻¹, calibration in the range of 1-100 mg.mL⁻¹. From the recorded and evaluated areas of the peaks of each standard, the values were extrapolated and used to evaluate the calculation of the sugar content of each sample. Injection of each sample and standards was performed twice and the values were expressed as the arithmetic mean of the peak areas from which the concentration of each sugar was expressed.

Hydroxymethylfurfural (HMF) was analysed in the accredited Testing Laboratory of the Bee Research Institute in Dol, in the CR, using the HPLC method (Agilent, USA), UV detector, C18 reverse phase chromatographic column (Zorbax Eclipse XDB C18 150x4.6 mm, particle size 5µm), detection at 285 nm wavelength, column temperature 35 °C, 20µl injection volume. Mobile phase was mixture of water/methanol 90:10, flow rate 1 ml.min⁻¹. Calibration of the method was performed using the HMF standard p.a. (Sigma-Aldrich) in the concentration range 1-500 mg.L⁻¹. Titratable acidity was determined by titration of honey with a solution of 1M NaOH using phenolphthalein as the indicator. Each sample weighing 20.0 g of honey was quantitatively transferred into a 100 ml volumetric flask and filled to the mark with distilled water. Titration of each

sample was carried out 2 times and the results were averaged (Vorlová et al., 2002).

Fiehe test with tannin for the detection of adulteration of honey by starch sugar, syrup and malt extracts, was performed according to the methodology ČSN (1974) and Vorlová et al. (2002).

Honey violation by technical syrup was performed with liquid samples of honey by pouring into a beaker with water. The test is evaluated immediately, in the case of falsification, the honey violation by technical syrup is reflected by typical landfilling (Vorlová et al., 2002).

The samples group C were used for chemical analysis, the content of sugars, water, HMF, conductivity, starch and presence of unauthorized addition of caramel. All these parameters were analysed by the Testing laboratory of the Bee Research Institute in Dol, Czech Republic.

Statistical analysis

Statistical analysis was performed using software Statistica 12 (StatSoft, Inc., Texas, USA). Shapiro-Wilk test of normality was used at the level of significance $\alpha = 0.05$. Two-way ANOVA with interactions at the 95% probability level was used to detect statistically significant differences between samples and two-tailed t-test with test of equal and unequal variance. All measured parameters were performed in triplicates and results are expressed as mean with standard deviation (SD). Differences at $p \leq 0.05$ were considered to be statistically significant.

RESULTS AND DISCUSSION

The group A honey samples from market chain consists of 7 samples of blossom honey and 3 samples of honeydew honey. Results of chemical composition honey from market chain are given in Table 3.

The measured parameters of samples group A were compared with the values given by the Decree 76/2003

Coll. (2003), and the Council Directive 2001/110/EC (2001) respectively. According to these regulations, only 1 sample of blossom honey from market had lower sum of fructose and glucose content. Other samples have sufficient content of sugars, for blossom honeys more than 60% and for honeydew more than 45%.

Other parameters, such as the water content (limit less than 20 %) and titratable acidity (less than 50 meqv.kg⁻¹) were according to these regulations. No positive test on presence of adulteration of honey by starch sugar, syrup and malt extracts were detected. But in the group A, the addition of 25% of technical syrup in 1 honey sample was proven.

The group B honey samples from beekeepers consists of 5 samples of blossom honey and 5 samples of honeydew honey. Results of chemical composition honey from beekeepers are given in Table 4.

The measured parameters of samples group B were compared with the values given by the Decree 76/2003 Coll. and the Council Directive 2001/110/EC (2001), respectively. According to these regulations only 1 sample of blossom honey from beekeepers had the sum of fructose and glucose content 58.3%, which was just below the required limit 60%, see Table 2. Other samples have sufficient content of sugars, for blossom honeys more than 60% and for honeydew more than 45%.

Other tested parameters, water content less than 20% and titratable acidity less than 50 meq.kg⁻¹, were according to these regulations. No positive test on the presence of adulteration of honey by starch sugar, syrup and malt extracts, was detected. No sample from this group B was positively tested for adulteration by technical syrup.

To compare the difference between handpressed honey and honey harvested by whirling (4 samples of group C obtained from the beekeeper) the chemical analysis of samples, which were primarily designed for sensory analysis, was performed, too. These samples of honey were analysed for

Table 3 Chemical composition honey from market chain (group A).

Parameter	Fru+Glu blossom (%)	Fru+Glu honeydew (%)	Sucrose %	Water %	Acidity meq.kg ⁻¹	Fiehe test	Test adulter.
min	56.3	46.6	0.8	17.9	11		
max	86.9	62.0	3.7	19.6	35	NEG	POS
Ø ±SD	72.9	55.1	1.6 ±0.79	18.6	19.7		
Ø ±SD total	65.9 ±12.1					*10	**1

Note: *Fiehe test, number of negative findings, ** test adulteration by technical syrup, number of positive findings, NEG – negative proof, POS – positive proof.

Table 4 Chemical composition honey from beekeepers (group B).

Parameter	Fru+Glu blossom (%)	Fru+Glu honeydew (%)	Sucrose %	Water %	Acidity meq.kg ⁻¹	Fiehe test	Test adulter.
min	58.3	46.2	0.2	17.9	6		
max	83.7	72.6	2.3	18.7	24	NEG	NEG
Ø ±SD	70.8	52.6	0.9 ± 0.57	18.3	14.3		
Ø ±SD total	61.7 ±10.7					*10	**10

Note: * Fieho test, number of negative findings, ** test adulteration by technical syrup, number of negative findings, NEG – negative proof.

Table 5 Chemical composition of samples from beekeepers (group C).

Sample	water	Fru	Glu	Suc	Fru+Glu	HMF	conductivity	starch	caramel
Group C	%	%	%	%	%	mg.kg ⁻¹	mS.m ⁻¹		
1.blossom whirling	17.3	34.0	30.0	0.2	64.0	<1.8	69.8	NEG	NEG
2.blossom pressed	18.0	33.5	30.5	0.2	64.0	<1.8	65.0	NEG	NEG
3.honeydew whirling	15.7	31.0	27.0	0.7	57.0	<1.8	83.3	NEG	NEG
4.honeydew pressed	14.8	26.5	22.7	1.1	49.2	<1.8	92.5	NEG	NEG

Note: Testing Laboratory of the Bee Research Institute in Dol, CR. Water – water content, Fru – fructose, Glu – glucose, Suc – sucrose, Fru+Glu sum fructose and glucose, HMF – hydroxymethylfurfural, NEG – negative proof.

their main chemical composition and results are given in Table 5.

According to the results of measured parameters, there was no difference between the whirling samples of honey and the pressed honey in group C. The difference was evident in the sugary content between honeydew and blossom honey. Honeydew honey shows lower levels of sum fructose and glucose in comparison to blossom honey. This difference was expected and corresponds with our results in Table 3 and Table 4. The median value of honeydew from the market chain (group A) had a sum of fructose and glucose 55.1%, and for blossom honey 72.9%. The expected difference was also confirmed in samples from beekeepers (group B). Honeydew samples had a mean value of the sum of fructose and glucose 52.6%, unlike blossom honeys 70.8%. A lower total average of 61.7 ±10.7% of the sum of fructose and glucose in samples from beekeepers is due to the higher number of samples honeydews in group B (5 samples honeydew's honeys with naturally lower content of sugars) unlike the samples of group A (only 3 samples honeydew's honeys) with a total average of 65.9 ±12.1%. This statistical comparison of samples in group C was not done due to a small number of samples in this group. The difference in the chemical composition of honey harvested by different techniques was not proved. All samples of group C honeys listed in Table 5 comply with the Decree 76/2003 Coll. (2003), Council Directive 2001/110/EC (2001) respectively, in all measured parameters, including conductivity, where samples of honeydew had higher conductivity than minimum required by the standard (minimum 80 mS.m⁻¹). On the other hand, for blossom honey samples the values were lower than the allowed maximum 80 mS.m⁻¹. The results corresponds with the balanced composition and quality of honey from beekeeper. The water content in the individual samples of honey in both, groups A and B (Table 3, Table 4) and in the other 4 samples group C (Table 5) did not exceed the water content requirement of 20% (in Decree 76/2003 Coll., 2001/110/EC). This limit is set to determine of honey to ferment. According to Titěra (2006), the optimal average water content for blossom honey is 17.2% and for honeydew 16.3%. The water content when honey begins to ferment is above 21%.

The detection of illegal honey interferences such as heat treatment, to re-liquefy the crystallized honey by heating to a temperature higher than the allowed temperature (maximum 50 °C) or detection of additions of illegal ingredients and adulteration of honey by adding cheaper substitutes (e.g. technical syrup and others), are possible due to the specific markers. HMF is used as a marker of honey heat treatment and its value increases with the heating temperature. To detect adulteration of honey with unauthorized additives there are assays which show even low levels of substitutes, such as Fiehe test (it already detects addition of 1% starch, 2% addition is clearly demonstrable) and the test of addition of technical syrups (Vorlová et al., 2006).

In this study we analysed all collected samples of honey group A and group B for both markers by the Fiehe test and by the second test to prove the adulteration of honey by technical syrup. In all the samples group A and group B, there was only 1 positive sample in group A for about 25% presence of addition of technical syrup (proof was repeated three times). Both these tests, for the presence of illegal substitutes to honey (starch or syrup) are easy to perform, but do not replace the analytical methods. However, they serve for quick detection of unauthorized interferences in honey. In contrast, HMF analysis is quantitative, expensive and requires instrumentation.

The presence of undesirable impurities, such as residues of pesticides or presence of toxic elements has not been tested in this study. But, the presence of toxic elements as zinc, copper, lead, arsenic and cadmium in honey samples from some areas has been reported in some studies (Roman and Popiela, 2011). This study demonstrated that the most problematic element of honey in small area in Poland was lead. This fact can be probably caused by higher human activities in this locality. But our study was focused only on the main parameters of honey.

The results of chemical analyses of all, group A and group B honey samples, sum of fructose and glucose, water content and titration acidity were assessed in accordance with the Decree 76/2003 Coll. (2003), and the Council Directive 2001/110/EC (2001), respectively. For all analysed samples, the given limits have been met, with the exception of 1 sample of honey from the market chain

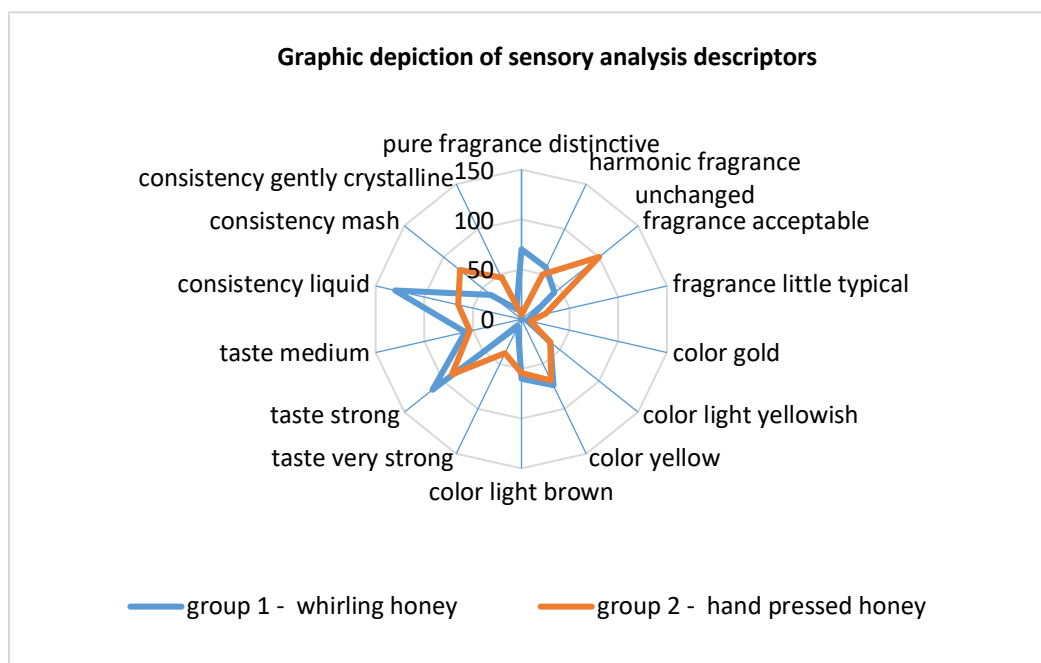


Figure 1 Sensory analysis honey from beekeepers harvested by different technics.

(group A), where we have proven 25% addition of technical syrup.

For 1 sample of honey from beekeepers (group B), the sum of fructose and glucose was just below the required value, the difference was 2.9%.

According to the Czech Agriculture Food Inspection Authority (CAFIA, 2017), approximately 40% of honey samples in the market chain do not meet the quality parameters over the long term. However, the results of the CAFIA summarized the data by 2016. In the study of Cwiková et al. (2015) only 4 from 21 honey samples complied with the requirements for content of sugars according to the Council Directive 2001/110/EC (2001) relating to honey. In comparison with the results of the Czech Agriculture Food Inspection Authority, our results showed a better quality of honey in the market chain and from beekeepers, too. From a total of 20 samples only 2 samples did not meet legislative requirements. The current tightening of control seems to be the positive effect to improve quality of offered honey.

The main parameters of honey samples results were evaluated statistically. The Shapiro-Wilk's test confirmed the normal distribution ($p > 0.05$, normality was not rejected) in the measured parameters: water content, titratable acidity and sum of glucose and fructose.

Statistically significant differences for water content ($p = 0.0224$), titratable acidity ($p = 0.0400$) and sum of fructose and glucose ($p = 0.0009$) between honeydew honey and blossom honey were found in 20 samples of honey. For the statistical evaluation of the measured parameters between groups A (market) and B (beekeepers) a two-tailed t-test with equal variance ($F < F_{crit}$) for acidity and water content, two-tailed test t-test with unequal variance ($F > F_{crit}$) for sum fructose and glucose were used. A two-tailed t-test showed a statistically significant difference ($p = 0.039$) for titratable acidity between samples from the market chain (group A) and samples from beekeepers (group B). In the other parameters, as water content

($p = 0.1435$) and sum of fructose and glucose ($p = 0.1883$) the difference were statistically insignificant.

The difference between the sum of glucose and fructose in honeydew honey and blossom honey is expected and as in line with the Council Directive 2001/110/EC (2001) giving different requirements for content of sugars in honey from different origin. Statistically significant difference in acidity, little higher in group B, honey samples from market chain, can be explained by the time of storage. We assume that samples obtain from beekeepers were fresh, and time of storage was shorter than in case of honey samples from market chain. According to the study Kňazovická et al. (2015), the authors recorded small increase of acidity honey samples after half year of storage.

Sensory analysis of honey samples group C was focused on 4 samples only from beekeepers harvested by different techniques. Some of differences were found in consistency and smell but generally there were not big differences in sensory profiles between manually pressed and whirling samples. This indicate that harvesting technique has no significant impact on the composition and properties of honey (Figure 1).

There are not many scientific studies documenting the proven therapeutic effects of honey for human health. But its preventive effect is observed and monitored for years. Data on the health status of the population published by the WHO (2017) are alarming. Cardiovascular diseases worldwide are the most common cause of death, over the past 15 years the number of deaths for cardiovascular disease has increased. Ischemic heart disease and stroke are the world's biggest killers. In 2000, worldwide, 5.41 million people died of stroke; in 2015, it was 6.24 million people. The number is even higher in deaths for coronary heart disease. In 2000, worldwide 6.88 million of people died on ischemic heart disease, in 2015 it was 8.76 million of people. For diabetes and its complications were reported in 2000, fewer than 1 million deaths worldwide, but in 2015 it was 1.59 million deaths (WHO, 2017).

If the honey has proven anti-inflammatory effect, it may play an important role in the diet with other nutritional important elements, beneficial to health, as a whole grain foods and fresh fruit and vegetables, effective in prevention of cardiovascular diseases (González, et al., 2016). Studies on the health effects of honey are highly desirable. The basic premise is accessible, safe and quality honey for consumers.

CONCLUSION

Our results proved in all honey samples taken from beekeepers and samples from the market, with only one exception and with one small difference, the compliance of tested quality parameters with the values required by legislative criteria for honey. Statistically significant difference in the content of sum fructose and glucose, water content and titratable acidity were found between honeydew honey and blossom honey. Statistically significant difference between honey samples from market chain and honey samples from beekeepers was found only in titratable acidity. Sensory analysis showed no differences between sensory properties of honey obtained by whirling and hand pressed honey. Because of biologically important ingredients, easy accessibility and easy use honey is considered as an important ingredient in nutrition and could be recommended in the prevention of various diseases.

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