SAT–LB-P-2-BFT(R)-06

QUALITY CHARACTERISTICS OF HONEY: A REVIEW

Tatjana Pavlova, MSc
Assistant Prof. Viktorija Stamatovska PhD
Assistant Prof. Tatjana Kalevska, PhD
Faculty of Technology and Technical Sciences - Veles
University "St. Kliment Ohridski"- Bitola, Republic of Macedonia
E-mail: tatjanapavlova15@yahoo.com; vikistam2@gmail.com; tkalevska@gmail.com

Assist. Prof. Ivan Dimov, PhD
Faculty of Technics and Technologies - Yambol
Trakia University - Stara Zagora, Bulgaria
E-mail: ivendi_81@abv.bg

Assistant Gjore Nakov, MSc
Department of Biotechnology and Food Technologies
University of Ruse "Angel Kanchev", Branch Razgrad, Bulgaria
Phone: +359894264250
E-mail: gnakov@uni-ruse.com

Abstract: *Honey is a sweet natural product, which is produced by bees generally from the nectar of flowers and sweet deposits from plants. It is a complex mixture that contains nutrients and bioactive compounds such as carbohydrates (primarily fructose and glucose), enzymes, proteins, amino acids, organic acids, minerals, vitamins, aromatic substances, polyphenols, pigments, beeswax, and pollen that contribute to its color, smell and flavor. The composition and quality of honey is variable and it depends mainly on the botanical source of nectar from which it is obtained, but also depend on the geographic location, seasonal and climatic conditions, processing type and storage. Due to its special composition, honey is a functional food, which is consumed for its effects on human health, with antibacterial, antioxidant, anti-inflammatory and antimicrobial properties, as well as wound and sunburn healing effects. Honey is used in pure form after little or minimal processing as liquid, crystals or other types. The uses of honey as food include flavourant and sweetener in honey cookies, dairy products and fruit juices, as well as industrial production of beverages by mixing with alcohol. In this review, the physical properties and nutritive chemical composition thoroughly reviewed to underscore the quality of honey.*

Keywords: *Honey, Quality, Nutritive chemical composition, Physical properties.*

INTRODUCTION

Honey is one of the most widely sought products due to its unique properties, which are attributed to the influence of the different groups of substances it contains (Buba, F., Gidado, A. & Shugaba, A., 2013).The bees collect the sweet juices from various honey plants, process them in their digestive systems, and then store them in wax honeycombs, which are collected by beekeepers (Jovanović, N 2015).

Codex Alimentarius Commission defined honey as the natural sweet substance, produced by honeybees from the nectar of plants or from secretions of living parts of plants, or excretions of plant-sucking insects on the living parts of plants, which the bees collect, transform by combining with specific substances of their own, deposit, dehydrate, store and leave in honeycombs to ripen and mature. The EU definition states that honey is only honey according to the definition when it is produced by *Apis mellifera* honeybees (Buba, F., Gidado, A. & Shugaba, A., 2013; Bradbear, M., 2009).

Honey may be categorised according to its origin (blossom honey, honeydew honey, monofloral honey, multifloral honey), the way it has been harvested and processed (comb honey, strained honey, chunk honey, extracted honey, pressed honey, crystallised or granulated honey,

creamed honey), and its intended use (table honey, industrial or bakers' honey) (Bradbear, M., 2009; Alvarez-Suarez, M.J., Gasparrini, M., Forbes-Hernández, Y.T., Mazzoni, L. & Giampieri, F., 2014.

Honey is a supersaturated solution of sugars mainly comprised of D-fructose, D-glucose, sucrose, maltose and higher sugars (~80% of solid mass). A wide range of minor constituents is also present in honey such as alkaloids, flavonoids/isoflavones, glycosides, phenolics, peptides/proteins, certain enzymes (invertase, amylase and glucose oxidase), carotenoid-like substances, organic acids, Maillard reaction products, vitamins, and minerals (Aurongzeb, M. & Azim, M. K., 2011; Manyi-Loh, E.C., Clarke, M.A. & Ndip, N.R., 2011; do Nascimento, S. A., Marchini, C.L. , de Carvalho, L. A. C., Araújo, D. F.D., de Olinda, A.R. & da Silveira A.T., 2015; Mannina, L., Sobolev, A.P., Di Lorenzo, A., Vista, S., Tenore, G.C. & Daglia, M., 2015).

The physicochemical properties of honey are an important indicator of the quality and origin of honey. The physicochemical characteristics of honey depend on the flowers used by the honeybees, as well as regional, beekeeping practices and environmental climatic variations. The physical properties and chemical composition of honey from different sources have been carried out by many researchers. The major quality criteria of interest are moisture content, sucrose content and reducing sugars content, pH value, electrical conductivity, ash content, free acidity, diastase activity and hydroxymethyl furfural (HMF) content (Ahmed, M., Khiati, B., Meslem A., Aissat, S. & Djebli, N., 2014; Jovanović, N., 2015; Ajibola, A., 2015; Bogdanov, S., Ruoff, K. & Oddo, L., 2004).

EXPOSITION

Chemical composition

The composition of honey varies from floral source to origin. Natural honey contains more than 300 bioactive substances, but it is mainly composed of water and sugars, primarily fructose and glucose, which accounts for 95–99% of honey dry matter, and about 4–5% of fructo-oligosaccharides (Ajibola, A., 2015). Besides fructose (38%) and glucose (31%), other identified sugars include maltose, sucrose, maltulose, turanose, isomaltose, laminaribiose, nigerose, kojibiose, gentiobiose and oligosaccharides (Ajibola, A., 2015; Ahmed, M., Khiati, B., Meslem A., Aissat, S. & Djebli, N., 2018).

According to Janevski, S., 2007, the composition of honey includes: 76% sugars (34% glucose, 40.5% fructose, 1.9% sucrose) and 5.5% other carbohydrates. Acacia and chestnut honey have a very high fructose content, rapeseed honey is distinguished with a higher proportion of glucose. The fructose/glucose ratio in various honey samples was the subject of studies conducted by a large number of researchers (Vahčić, N. & Matković, D., 2009). Primorac et al. (2009), found slightly higher fructose content (32.4%) than glucose (31.0%) in samples of honeydew honey from Croatia, while in Macedonia higher glucose content (36.8%) than fructose (33.6%) was found in the Macedonian samples. Ahmed et al. (2014) established that the content of glucose and fructose in four honey samples from different parts of western Algeria ranges from 21.45-28.26 g/100 g and 25.20-37.64 g/100 g, respectively.

Water is the second most important ingredient of honey and its content may vary from 15 to 23%. Water content influences some characteristics of honey (viscosity, specific weight, maturity, flavor and crystallization, specific gravity), and depends on the climatic conditions, the bee variety, the bee colony strength, the humidity and the air temperature in the hive, the processing and storage conditions, as well as the botanical origin of honey (Vahčić, N. & Matković, D., 2009; do Nascimento, S. A., Marchini, C.L. , de Carvalho, L. A. C., Araújo, D. F.D., de Olinda, A.R. & da Silveira A.T., 2015; Marković, M., 2014). The quantity of water in the honey is not constant due to its hygroscopicity and it changes during storage depending on the humidity of the air. It can be said that the water content in honey is an important parameter in determining its quality and its durability because it determines its stability and microbiological spoilage resistance during storage (Vahčić N. & Matković D., 2009). The higher the water content, the greater the chance of fermentation (Jovanović, 2015).

Honey contains a number of acids which include amino acids (0.05-0.1%) and organic acids (0.57%, range: 0.17-1.17%). Honey contains different free amino acids including: lysine, proline and tryptophan. The major amino acid in honey is proline (50–85%), and accepted as a criterion for the maturity of honey (Bogdanov, S., Ruoff, K. & Oddo, L., 2004; Janiszewska, K., Aniołowska, M. & Nowakowski, P., 2012). Primorac et al. (2009) determined the proline content within the range of 512.9 to 877.5 mg/kg in honeydew honey originating in Macedonia, while in Croatian honeydew honey samples significantly lower content of proline was found (261.7-749.7 mg / kg).

Batinić, K. & Palinić, D. (2014), quoting the findings of several scientists, stated that proteins and amino acids in honey can be of animal origin (from bees) and from plant origin (from pollen). According to some scientists, most of the protein in honey is derived from salivary glands with which bees process nectar and honeydew and turn them into honey, while according to the rest, the majority of proteins originate from protein-rich pollen (10 – 35%). Another possible source of protein is the nectar containing a minimum amount of protein (Marković, M., 2014; Vahčić, N. & Matković, D., 2009; Mendešević, N., 2014). The protein content in honey ranges from 0-1.7%, and honeydew honey contains more protein than nectar honey. During longer storage or heating, the amino acids condense with sugars creating yellow and brown products, leading to darkening of the honey (Batinić, K. & Palinić, D., 2014).

Organic acids are other important group of compounds in honey. In honey the main acid is gluconic acid, which is found together with the respective glucono-lactone in a variable equilibrium. Other acids that have been identified in honey include acetic, butyric, citric, formic, lactic, maleic, malic, oxalic, and succinic acids (Ball, W. D., 2007; Bogdanov, S., Ruoff, K. & Oddo, L., 2004; Ahmed, M., Khiati, B., Meslem A., Aissat, S. & Djebli, N., 2018). The organic acids are responsible for the acidity of honey and contribute largely to its characteristic taste (Aurongzeb, M. & Azim, M.K., 2011). Honey is deceptively acidic, as the high sugar content tends to mask the acidity in the taste. The average pH of honey is 3.9 (with a typical range of 3.4 to 6.1) (Ball, 2007; Manyi-Loh et al., 2011). These values prevent the development of microorganisms that require neutral or basic pH values, significantly limiting the spectrum of potentially contaminating microorganisms (do Nascimento, S. A., Marchini, C.L. , de Carvalho, L. A. C., Araújo, D. F.D., de Olinda, A.R. & da Silveira A.T., 2015). Darker types of honey are usually more acidic, and the storage of honey increases its acidity. Acacia, chestnut and meadow honey are characterized by a low concentration of organic acids, while dark honey is characterized by higher acidity (Vahčić, N. & Matković, D., 2009).

Honey contains different quantities of minerals ranging from 0.02 g/100 g to 1.03 g/100 g (Popov-Raljić, J., Arsić, N., Zlatković, B., Basarin, B., Mladenović, M., Laličić-Petronijević, J., Ivokov, M. & Popov, V., 2015), that varies depending on the particular botanical origin, pedoclimatic conditions and extraction technique (Hernández, O.M., Fraga, G.M.J.M, Jiménez, I.A., Jiménez, F. & Arias, J.J., 2005). The dominant element in honey is K, comprising approximately one-third of total mineral content. The blossom honey has lower mineral content than honeydew honey. Macro mineral elements, such as K, Ca, and Na, as well as trace minerals, such as Fe, Cu, Zn, and Mg, play a critical role in biological systems. In the literature there are reports of a correlation between dark honey color and the contents of Fe, Cu, Mg and other mineral substances (Aurongzeb, M. & Azim, M. K., 2011; Popov-Raljić, J., Arsić, N., Zlatković, B., Basarin, B., Mladenović, M., Laličić-Petronijević, J., Ivokov, M. & Popov, V., 2015). Vitamins C, B1 (thiamine) and B2 complex like riboflavin, nicotinic acid, B6, and panthothenic acid are also found in honey (Aurongzeb, M. & Azim, M. K., 2011; Ajibola, A., 2015; Ahmed, M., Khiati, B., Meslem A., Aissat, S. & Djebli, N., 2018)

One of the characteristics that differentiate honey from other sweeteners is the presence of enzymes. Honey naturally contains small amounts of enzymes that are introduced into honey by the bees during various phases of the honey manufacturing process (https://www.honey.com/files/general/refguide.pdf; Batinić, K. & Palinić, D., 2014). The predominant enzymes in honey are diastase (amylase),which digest starch to maltose and is relatively stable to heat and storage; invertase (saccharase or α-glucosidase), which catalyses the conversion of sucrose to glucose and fructose; and glucose oxidase, which regulate the production

of hydrogen peroxide H_2O_2. The invertase also catalyses many other sugar conversions and is mainly responsible for the sugar patterns of honey. Other enzymes such as catalase and acid phosphatase, are generally present in lesser amounts. While enzyme type is fairly uniform across honey varieties the amount of enzyme present can vary widely. Enzymes play an important role in honey and contribute to its functional properties (Buba, F., Gidado, A. & Shugaba, A., 2013; https://www.honey.com/files/general/refguide.pdf; Batinić, K. & Palinić, D., 2014).

Because polyphenols are present in all plants, they are also found in honey. Honey contains complex mixtures of polyphenols depending on the climate, region, soil, pollution levels, storage and many other factors. These differences are possible because certain polyphenols are specific to particular plants and hence are found only in honey produced by bees from those plants (Predescu, C., Papuc, C. & Nicorescu, P., 2015). Polyphenols in honey are mainly flavonoids (e.g. quercetin, luteolin, kaempferol, apigenin, chrysin, galangin), phenolic acids and phenolic acid derivatives. These are compounds known to have antioxidant properties (Tomás-Barberán, F.A., Martos, I., Ferreres, F., Radovic, B.S. & Anklam, E., 2001; Singh, P. M., Chourasia, R. H., Agarwal, M., Malhotra, A., Sharma ,M., Sharma, D. & Khan S., 2012). The content of flavonoids is 0.5% in pollen, 10% in propolis and ≈ 6 mg/kg in honey (Pyrzynska, K. & Biesaga, M., 2009). According to Jovanović, N., 2015 the the content of flavonoids in honey ranging between 60 and 460 mg/100 g.

Some types of honey contain very small quantities of bitter substances. These include glycosides, alkaloids, polyphenols, and terpenoids. According to Bradbear, N., 2009 several types of plants (*Agave* spp., *Datura* sp., *Euphorbia* sp., *Senecio* sp.) produce a bitter taste when used for honey.

Hydroxymethylfurfural (HMF) is a chemical compound, a breakdown product of of simple sugars (such as fructose) that is formed slowly and naturally during the storage of honey, and much more quickly when honey is heated (Bradbear, N., 2009). Several factors influence the levels of HMF, such as temperature and time of heating, storage conditions, pH and type of honey, thus it provides an indication of overheating and storage in poor conditions (Ahmed, S., Sulaiman, A.S., Baig, A. A., Ibrahim, M., Liaqat, S., Fatima, S., Jabeen, S., Shamim, N. & Othman, H. N., 2014). Many studies confirmed that the content of HMF increases with heating and storage (Batinić, K. & Palinić, D., 2014; Vahčić, N. & Matković, D. 2009). When honey is subjected to high temperatures, inadequate storage conditions or addition of invert sugar, the HMF content increases and it is one of the most common degrading products in honey, indicating its aging (do Nascimento, S. A., Marchini, C.L. , de Carvalho, L. A. C., Araújo, D. F.D., de Olinda, A.R. & da Silveira A.T., 2015). A disproportionately high content (more than 100 mg/kg) can be indicative of honey falsification (Batinić, K. & Palinić, D., 2014; Vahčić, N. & Matković, D., 2009).

Physical characteristics

The chemical composition of honey affects several of its physical characteristics (crystallization, viscosity, hygroscopicity, electrical conductivity, optical properties, surface tension, color) (Ball, W.D., 2007; Batinić, K. & Palinić, D., 2014). The physical appearance of honey varies with the methods of extraction, processing, packaging and preservation (Ajibola, A., 2015).

Freshly extracted honey is a viscous liquid food, and its viscosity depends on the various honey constituents. Hence, the viscosity is greatly influenced by the composition of honey, mainly its water content (Ajibola, A., 2015). In contact with the air, honey absorbs water, a phenomenon known as hygroscopicity. The water content absorbed depends on the relative humidity of the air. The hygroscopicity of honey is conditioned by the large amount of sugar. This process can increase the amount of water in the surface layer of the honey that can affect its quality during storage (fermentation) (Bartulović, M., 2015). Honey will absorb moisture from air at a relative humidity of about 60%. Another factor affecting the physical appearance of honey is surface tension, which is influenced by the colloidal substances in the honey, a reflection of the honey's botanical origin. The surface tension and high viscosity of honey cause the foaming appearance of honey (Ajibola, A., 2015).

Honey is a supersaturated glucose solution and it spontaneously enters a state of balance by crystallizing the excess glucose in the solution. Glucose loses water (becomes glucose

monohydrate) and passes in crystalline form. Water, previously bound to glucose, becomes free, increasing the water content of uncrystallised parts of the honey. Honey therefore becomes prone to fermentation and spoilage. The fructose remains in liquid form and forms a thin layer around the glucose crystals. Honey changes colour, it becomes brighter, it is no longer translucent, and changes its taste (Batinić, K. & Palinić, D., 2014). Glucose crystallizes very easily and quickly, while in fructose it is more difficult. The consequence is a not fully-crystallized honey. If there is a higher glucose content in honey, that honey crystallizes rapidly (e.g., meadow, mountain, clover honey). In acacia honey, there is a higher fructose content and therefore this type of honey crystallizes only after long storage (Jovanović, N., 2015). The speed of honey to crystallize depends not only on its composition, but also on the presence of catalysts, like seed crystals, pollen grains and pieces of beeswax in the honey (Erez, E. M., Karabacak, O., Kayci, L., Fidan, M. & Kaya, Y., 2015).

Colour is the physical property perceived most immediately by the consumer. The determination of colour is a useful classification criterion for honeys (Bogdanov, S., Ruoff, K. & Oddo, L., 2004). The colour of liquid honey varies from clear and colourless, yellow, amber to dark amber or black. The colour varies with honey's origin, age, and storage conditions, but transparency or clarity depends on the amount of suspended particles such as pollen. Other honey colours are bright yellow (sunflower), reddish undertones (chest nut), greyish (eucalyptus) and greenish (honeydew). Heat also affects the physical appearance of honey, including colour, crystallization, taste, and fragrance. In fact, natural honey becomes dark in colour when heated (Ajibola, A., 2015).

The electrical conductivity of honey is very small and depends on the mineral, organic acid and protein content of honey. Therefore, electric conductivity is a parameter which is often used in routine honey quality control, and can be considered a valid criterion for determining the botanical origin of a honey sample (Bogdanov et al., 2004). The greater the content, the greater the value of electrical conductivity. The usual values range from 0.39-0.76 mS/cm. Chestnut honey and honeydew honey have high electrical conductivity, while acacia and meadow honey have lower conductivity (Batinić, K. & Palinić, D., 2014; Jovanović, N., 2015; Bartulović, M., 2015).

Aqueous honey solution is optically active, i.e. capable of rotating the polarized light angle (Šarić, G., Matković, D., Hruškar, M. & Vahčić, N., 2008; Bartulović, M., 2015). Optical activity is a function of the proportions of individual carbohydrates in the honey. Fructose rotates the plane of polarized light to the left, and glucose, all disaccharides, trisaccharides and higher oligosaccharides to the right (Vahčić, N. & Matković, D., 2009). Because of the higher fructose mass fraction, nectar honey rotates the polarized light angle to the left, i.e. it has negative optical activity. On the other hand, because of its higher oligosaccharide mass fraction (mainly melecitose and elose), honeydew rotates the polarized light angle to the right, i.e. it has positive optical activity (Šarić, G., Matković, D., Hruškar, M. & Vahčić, N., 2008).

Honey has a characteristic microflora that can be of primary and secondary origin. It can be said that honey is an environment that allows the growth and reproduction of microorganisms. If the sugar concentration is above 20%, microorganisms do not grow. Under certain conditions, when the water content in honey is above 20%, osmophilic yeasts can grow and cause fermentation processes. Fermentation happens due to two reasons: hydroscopy and the presence of osmophilic and other types yeasts that sustain high concentrations of sugar (Bartulović, M., 2015).

CONCLUSION

The physicochemical properties of honey are an important indicator of the quality and origin of honey. The physical properties and chemical composition of honey from different sources have been carried out by many researchers.This paper presents an overview of the quality characteristics that honey has on the basis of data from the available literature. In its chemical composition, honey is a mixture of carbohydrates (mainly glucose and fructose) and water, and a smaller content of organic acids, minerals, vitamins, enzymes, proteins, polyphenols and other substances. The chemical composition of honey affects of its physical characteristics such as crystallization, viscosity, hygroscopicity, electrical conductivity, optical properties, surface tension, and color.

REFERENCES

Ahmed, S., Sulaiman, A.S., Baig, A. A., Ibrahim, M., Liaqat, S., Fatima, S., Jabeen, S., Shamim, N. & Othman, H. N. (2018). *Honey as a Potential Natural Antioxidant Medicine: An Insight into Its Molecular Mechanisms of Action*. Oxidative Medicine and Cellular Longevity, Vol. 2018, Article ID 8367846, 19 pages, https://doi.org/10.1155/2018/8367846.

Ahmed, M., Khiati, B., Meslem A., Aissat, S. & Djebli, N. (2014). *Evaluation of Physicochemical and Antioxidant Properties of Raw Honey from Algeria*. J Microbial Biochem Technol., S4: 006. doi:10.4172/1948-5948.S4-006.

Ajibola, A. (2015). *Physico-Chemical and Physiological Values of Honey and Its Importance as a Functional Food*. Int J Food Nutr Sci, 2(2), 180-188.

Alvarez-Suarez, M.J., Gasparrini, M., Forbes-Hernández, Y.T., Mazzoni, L. & Giampieri, F. (2014). *The Composition and Biological Activity of Honey: A Focus on Manuka Honey*. Foods, 3, 420-432.

Aurongzeb, M. & Azim, M. K. (2011). *Antimicrobial properties of natural honey: a review of literature*. Pak. J. Biochem. Mol. Biol., 44(3), 118-124.

Ball, W. D. (2007). *The Chemical Composition of Honey*. J. Chem. Educ., 84(10), 1643-1646.

Bartulović, M. (2015). *Proizvodnja i plasman meda OPG-a Antunović*. Diplomski rad, Poljoprivredni fakultet – Osijek, Sveučilište Josipa Jurja Strossmayera, Osijek.

Batinić, K. & Palinić, D. (2014). *Priručnik o medu*. Sveučilišta u Mostaru, Agronomski i prehrambeno-tehnološki fakultet- Mostar, Federalni agromediteranski zavod Mostar.

Bogdanov, S., Ruoff, K. & Oddo, L. (2004). *Physico-chemical methods for the characterization of unifl oral honeys: a review*. Apidologie, 35, S4–S17.

Bradbear, N. (2009). *Bees and their role in forest livelihoods*. A guide to the services provided by bees and the sustainable harvesting, processing and marketing of their products, Food and Agriculture Organization of the United Nations, Rome, 81-88.

Buba, F., Gidado, A. & Shugaba, A. (2013). *Analysis of Biochemical Composition of Honey Samples from North-East Nigeria*. Biochem Anal Biochem., 2(3):139.

do Nascimento, S. A., Marchini, C.L. , de Carvalho, L. A. C., Araújo, D. F.D., de Olinda, A.R. & da Silveira A.T. (2015). *Physical-Chemical Parameters of Honey of Stingless Bee (Hymenoptera: Apidae)*. American Chemical Science Journal, 7(3), 139-149.

Erez, E. M., Karabacak, O., Kayci, L., Fidan, M. & Kaya, Y. (2015). *Characterization of Multifloral Honeys of Pervari Region with Different Properties*. Turk J Agric Res., 2, 40-46.

Hernández, O.M., Fraga, G.M.J.M, Jiménez, I.A., Jiménez, F. & Arias, J.J. (2005). *Characterization of honey from the Canary Islands: determination of the mineral content by atomic absorption spectrophotometry*. Food Chemistry, 93, 449–458.

Honey-A Reference Guide to Nature's Sweetener (PDF). National Honey Board, URL: https://www.honey.com/files/general/refguide.pdf (Accessed on 05.09.2018).

Janevski, S. (2007). *Prirodno lekuvanje so med*. Martina komerc, Skopje.

Janiszewska, K., Aniołowska, M. & Nowakowski, P. (2012). *Free Amino Acids Content of Honeys from Poland*. Pol. J. Food Nutr. Sci., (62)2, 85-89.

Jovanović, N. (2015). *Antimikrobna i antioksidativna aktivnost različitih uzoraka meda iz okoline Niša*, Magistersi rad. Prirodno matematicki fakultet -Niš, Univerzitet u Niš.

Mannina, L., Sobolev, A.P., Di Lorenzo, A., Vista, S., Tenore, G.C. & Daglia, M. (2015). *Chemical Composition of Different Botanical Origin Honeys Produced by Sicilian Black Honeybees (Apis mellifera ssp. sicula)*. J. Agric. Food Chem., 63(25), 5864−5874.

Manyi-Loh, E.C., Clarke, M.A. & Ndip, N.R. (2011). *An overview of honey: Therapeutic properties and contribution in nutrition and human health*. Afr. J. Microbiol. Res., 5(8), 844-852.

Marković, M. (2014). *Upotreba meda u prehrambenoj industriji*. Završni rad. Sveučilište J. J. Strossmayera u Osijeku, Prehrambeno-Tehnoloski Fakultet, Osijek.

Mendešević, N., (2014). *Povezanost izabranih fizikalno-kemijskih karakteristika i vremena skladištenja meda.* Završni rad, Sveučilište J. J. Strossmayera u Osijeku, Prehrambeno-Tehnoloski Fakultet, Osijek.

Popov-Raljić, J., Arsić, N., Zlatković, B., Basarin, B., Mladenović, M., Laličić-Petronijević, J., Ivokov, M. & Popov, V. (2015). *Evaluation of color, mineral substances and sensory uniqueness of meadow and acacia honey from Serbia*. Romanian Biotechnological Letters, 20(5), 10784-10799.

Predescu, C., Papuc, C. & Nicorescu, P. (2015). *Antioxidantactivity of sunflower and meadow honey*. Scientific Works. Series C. Veterinary Medicine, LXI (1), 45-50.

Primorac, Lj., Angelkov, B., Mandić, L. M., Kenjerić, D., Nedeljko, M., Flanjak, I., Pirički, P. A. & Arapceska M. (2009). *Comparison of the Croatian and Macedonian honeydew honey*. JCEA, 10(3), 263-270.

Pyrzynska, K. & Biesaga, M. (2009). *Analysis of phenolic acids and flavonoids in honey*. Trends in Analytical Chemistry, 28(7), 893-902.

Šarić, G., Matković, D., Hruškar, M. & Vahčić, N. (2008). *Characterisation of Croatian Honey*. Food Technol. Biotechnol., 46(4), 355–367.

Singh, P. M., Chourasia, R. H., Agarwal, M., Malhotra, A., Sharma ,M., Sharma, D. & Khan S. (2012). *Honey as complementary medicine: - A review*. International Journal of Pharma and Bio Sciences, 3(2), P12- P31.

Tomás-Barberán, F.A., Martos, I., Ferreres, F., Radovic, B.S. & Anklam, E. (2001). *HPLC flavonoid profiles as markers for the botanical origin of European unifloral honeys*. J Sci Food Agric., 81, 485– 496.

Vahčić, N. & Matković, D. (2009). Kemijske, fizikalne i senzorske značajke meda. URL: https://dokumen.tips/download/link/kemijske-fizikalne-i-senzorske-karakteristike-meda (Accessed on 01.09.2018).