Chemia Naissensis, Vol 6, Issue 2, POPULAR SCIENTIFIC ARTICLE, 100-109
DOI: 10.46793/ChemN6.2.100K

Honey: food and a therapeutic agent

Danijela Kostić[1*], Aneta Georgijev[2], Biljana Arsić[1]

1 - University of Niš, Faculty of Sciences and Mathematics, Department of Chemistry, Višegradska 33, 18000 Niš, Republic of Serbia

2 - Timomed D.O.O., Kej Veljka Vlahovica 7a, 19350 Knjaževac, Republic of Serbia

ABSTRACT

Honeybees produce honey. Humans have used honey for more than 9,000 years as food and medicine. Honey has a complex chemical composition (sugars, organic acids, amino acids, peptides, enzymes, micro and macroelements, water-soluble vitamins and natural phenolic compounds), varying depending on the botanical source. Besides its significant role in traditional medicine, honey also has a place in modern medicine. Research has shown that honey has an inhibitory effect on about 60 types of bacteria, some types of fungi and viruses. The antioxidant capacity of honey is significant for many diseases and is primarily due to many natural phenolic compounds in honey. Therefore, honey is also used to treat inflammatory, dermal, diabetic, gastrointestinal, cardiovascular, and neoplastic conditions. This article briefly overviews the composition, physico-chemical properties and application of natural honey as a nutraceutical agent.

Keywords: honey, composition, organoleptic characteristic, food, therapeutic agent

[*] Corresponding author: danijela.kostic@pmf.edu.rs

Introduction

Bee honey is considered the most consumed bee product. It is defined by the Codex Alimentarius as a sweet substance produced by Apis mellifera bees from the flower's nectar or secretions of plants, which bees collect, transform by combining with their specific enzymes and store in honeycombs (CODEX ALIMENTARIUS, International Food Standards, STANDARD FOR HONEY CXS 12-1981). Unlike white sugar and other sweeteners, honey is a treasure trove of substances necessary for the healthy functioning of the body.

History of honey use

Evidence from Stone Age paintings shows that treatment of disease with bee products such as honey originated 9000 years ago (Figure 1).

Figure 1. A honey hunter (a cave painting from Spain) (~8000 BCE) (Qamar & Rehman, 2020)

Ancient scrolls, tablets and books-Sumerian clay tablets (6200 BC), Egyptian documents (1900–1250 BC), Veda (a body of Hindu religious texts) (5000 years old), Holy Koran, Bible, and Hippocrates (460–357 BC) illustrated that honey had been widely used as a medicine. Quran vividly indicated the activity of therapeutic value of honey. According to this holy book of Muslims, the Lord inspired the bees to build their hives in hills, on trees, and in man's habitations; from within their bodies comes a drink of varying colours, representing a healing for humankind. In Hinduism, honey contains specific religious attributes as one of the "five nectars" (Qamar & Rehman, 2020). Jewish traditions link honey to the New Year, and use of honey-dipped apples as a traditional meal on the day (Qamar & Rehman, 2020). Honey was used for a variety of disease conditions, including eye diseases, throat infections, asthma, tuberculosis, hiccups, fatigue, hepatitis, dizziness, constipation, worm infestation, piles, eczema, healing of ulcers, and wounds (The History of Honey and Beekeeping: https://localhoneyfinder.org/HistoryOfHoney.php).

Organoleptic characteristics of honey

The organoleptic analysis includes honey's taste, colour, aroma, and viscosity. The taste is something that the sense of taste can feel, and the colour is visible and can be observed in honey. Aroma is the result of sensing through smell. The smell is also an indicator of damage to the product (Lawless, 1991). For example, a foul odour indicates the product has been damaged. In honey products, the quality standard for the aroma and colour of honey depends on the origin and type of flower (Puscion-Jakubik et al., 2020). In addition, the colour varies from white, yellow, brown, red to black. The colour variation depends on the nectar of the flower (Puscion-Jakubik et al., 2020). The colour of honey can divide types into white, light, and dark honey. Red honey is usually dark honey, which was previously yellow, then brownish yellow, and then becomes slightly reddish. White honey is not much different from red honey. The only difference is the flower nectar that is sucked by the worker bees. White honey is mainly obtained from citrus, kapok, and durian trees, while dark honey is from daisies and insect fluids (Anupama et al., 2003).

Chemical composition of honey

About 300 substances in honey have been reported, and research on this topic is continued.

Sugars

Honey is composed primarily of fructose (32.56 to 38.2%) and glucose (28.54 to 31.3 %), disaccharides such as maltose, sucrose, isomaltose turanose, nigerose, melibiose, panose, maltotriose, melezitose (Fuente et al., 2011). Honey contains 4 to 5% fructooligosaccharides, known as probiotic agents (Ahmad et al., 2017).

Water

Water is the second most crucial component of honey. The maximum allowed water content in honey is up to 20%.

Organic acids

Organic acids are responsible for 0.57% of honey and include gluconic acid (a byproduct of enzymatic digestion of glucose). Acetic, citric, formic, glutaric, fumaric, succinic, D-gluconic, oxalic, D-glucuronic, L-malic, propionic, D-quinic, L-tartaric and many others are present in honey. The organic acids give a contribution to the acidity of honey and are mainly responsible for its characteristic taste (Suto et al., 2020).

Mineral composition

The concentration of mineral compounds goes from 0.1% to 1.0 %. Potassium is the major element, followed by Cl, S, Ca, Na, P, Mg, Si, Fe, Mn and Cu. Trace elements contents of honey depend mainly on the botanical and geographical origins of honey. Although mineral compounds in honey do not make a considerable proportion, they significantly raise the value of honey for human consumption (Tafere, 2021).

Vitamins

The vitamins of honey are mainly represented by B-group vitamins (thiamine, riboflavin, pyridoxine, pantothenic acid, nicotinic acid), and vitamin C. The content of vitamins in honey depends on its botanical origin (León-Ruiz et al., 2011; Popkova et al., 2021).

Amino acids

Honey contains most amino acids, such as proline, tyrosine, methionine, lysine, phenylalanine, histidine, glycine, *etc.* Proline is the major free amino acid in honey, and its concentration (greater than 180 mg/kg) is an indicator of the authenticity of the honey (da Silva et al., 2016). Since the nectar plant is the major provider of amino acids in honey, and geographic and floral sources can lead to subtle differences in amino acid types and content, some studies have indicated that differences in amino acids can be used as a tool for the identification of the floral source of the honey (Kowalski et al., 2017).

Enzymes

Honey contains numerous enzymes. The honey enzymes originate from bees, plant nectars, secretions or excretions of plant-sucking insects, or microorganisms such as yeasts (Alaerjani et al., 2022). Enzyme-catalyzed and non-enzymatic reactions can characterize honey. Notable examples of enzyme-catalyzed reactions are hydrogen peroxide production through glucose oxidase activity and the involvement of catalase enzymes in the conversion of hydrogen peroxide to water and oxygen (Alaerjani et al., 2022). The production of hydroxymethylfurfural (HMF) from glucose or fructose is an example of a non-enzymatic reaction in honey. The most spread enzymes in honey are glucose oxidase, protease, invertase, diastase, acid phosphatase, dihydroxyacetone phosphatase, catalase, reduced glutathione and superoxide dismutase (Alaerjani et al., 2022). Diastase enzymes are included as honey quality parameters and indicators for assessing honey storage conditions in all honey standards. Invertase is not adopted as a honey quality parameter; however, it is suggested to be a helpful quality parameter in the European standards for honey. Although diastase and invertase originate from honeybees, they can be used as indicators for honey floral origins because the concentration of the substrates affects the enzyme activity (Alaerjani et al., 2022).

The phenolic compound and flavonoid profiles

The phenolic compounds and flavonoid profiles of honey allow the evaluation of its quality, since they identify emerging risks, facilitate the differentiation of the varietals, botanical origin, and detect adulteration and bioactive compounds with health-promoting properties. The profiles of phenolic compounds and flavonoids in honey are analysed mainly by High-

Performance Liquid Chromatography (HPLC) and Fourier-Transform Infrared Spectroscopy (FTIR). The predominant phenolic compounds found in samples have been *p*-coumaric, caffeic, chlorogenic, ferulic, ellagic, protocatechuic, and vanillic acids, rutin, myricetin, apigenin and quercetin, pinocembrin, kaempferol, galangin, chrysin and hesperetin and their glucosides (Becerril-Sánchez et al., 2021).

Honey as a food

One hundred grams of honey has an energy value of 1229 kJ, and contains no fat, very little protein (about 0.4%), carbohydrates 80%, of which fructose and glucose are the most abundant. The percentage of water ranges from 15 to 20 (Bogdanov et al., 2008).

There is no recommended daily intake of honey. However, honey should be consumed in moderate quantities due to its high sugar content. The World Health Organization (WHO) recommends that free sugars should not represent more than 10% of a daily energy intake. For a person requiring 2000 kcal per day, ~ 60 grams of honey (if honey is used as the unique external source of sugar) is recommended. Due to the reason that honey may contain the bacteria *Clostridium botulinum* (which can cause severe infection in infants), it is recommended to avoid its consumption in children below 12 months of age (WHO, 2015).

Honey as a therapeutic agent

For ages, honey has been traditionally used to treat human diseases (Figure 2). Recently, it has become acceptable as a therapeutic agent that is relatively cheap and lacks side effects. The therapeutic and beneficial properties of honey are present due to:

- Its antibacterial, antiviral, antifungal, and antiparasitic activities against various organisms.
- Its anti-inflammatory and immunomodulatory activities because of substantial amounts of phenolic contents.
- Its antioxidant capacity to scavenge free radicals.
- Its natural immune-boosting capability.

DOI: 10.46793/ChemN6.2.100K

Honey could also be used to treat other medical conditions, such as:

- *Escherichia coli*, *Salmonella* and *Shigella* caused diarrhea.
- Various gastrointestinal conditions such as gastric and duodenal ulcers, and gastritis.
- Canine recurrent dermatitis, seborrheic dermatitis and diaper dermatitis.
- Diabetics, based on results from animal model studies, preclinical and clinical studies, and human studies.
- Cancer and tumour, may be due to its antiapoptotic, antitumor, antiproliferative, antimutagenic, and estrogenic modulatory activities.
- Wounds, especially in diabetic patients.

The most known factors that give honey its above-mentioned properties include its acidity, hydrogen peroxide, high sugar, and other non-peroxide properties (Bucekova et al., 2019). The therapeutic properties of honey can be diminished by its exposure to heat or higher temperature, and also under the influence of light, sunlight, or UV light.

In general, honey has profound potential as a therapeutic agent which might complement/replace conventional drugs. Therefore, further research is still needed to establish the scientific basis for classifying honey as a medical agent (Nweze et al., 2020).

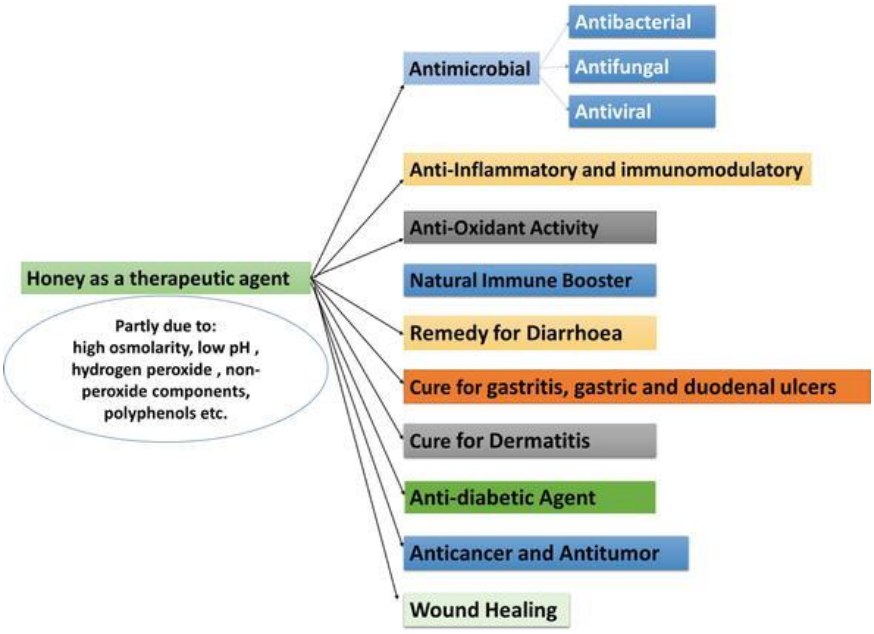

Figure 2. Bee honey as a therapeutic agent (Nweze et al., 2020)

Conclusion

Besides macroconstituents, honey contains microconstituents responsible for its nutraceutical properties. Therefore, it is not surprising that its use and significance originate from the distant past of humankind. Properties of honey depend on botanical origin. Further studies will enable the use of honey as a medicinal agent.

Acknowledgement

Authors want to thank CA22105 – BeSafeBeeHoney.

Conflict-of-Interest Statement

None.

References

Ahmad, R. S., Hussain, M. B., Saeed, F., Waheed, M., Tufail, T. (2017). Phytochemistry, metabolism, and ethnomedical scenario of honey: A concurrent review. International Journal of Food Properties, 20(S1), S254–S269.

Alaerjani, W. M. A., Abu-Melha, S., Alshareef, R. M. H., Al-Farhan, B. S., Ghramh, H. A., Al-Shehri, B. M. A., Bajaber, M. A., Khan, K. A., Alrooqi, M. M., Modawe, G. A., Mohammed, M. E. A. (2022). Biochemical reactions and their biological contributions in honey. Molecules, 27(15), 4719. doi: 10.3390/molecules27154719.

Anupama, D., Bhat, K. K., Sapna, V. K. (2003). Sensory and physico-chemical properties of commercial samples of honey. Food Research International, 36(2), 183-191.

Becerril-Sánchez, A. L., Quintero-Salazar, B., Dublán-García, O., Escalona-Buendía, H. B. (2021**).** Phenolic compounds in honey and their relationship with antioxidant activity, botanical origin, and color. Antioxidants, 10(11), 1700. https://doi.org/10.3390/antiox10111700

Bogdanov, S., Jurendic, T., Sieber, R., Gallmann, P. (2008). Honey for nutrition and health: a review. Journal of the American College of Nutrition, 27(6), 677-689.

Bucekova, M., Jardekova, L., Juricova, V., Bugarova, V., Di Marco G., Gismondi A., Leonardi, D., Farkasovska, J., Godocikova, J., Laho, M., Klaudiny, J., Majtan, V., Canini, A., Majtan, J. (2019). Antibacterial activity of different blossom honeys: new findings. Molecules, 24(8), 1573.

da Silva, P. M., Gauche, C., Gonzaga, L. V., Costa, A. C. O., Fett, R. (2016). Honey: chemical composition, stability and authenticity. Food Chemistry, 196, 309–323.

Tafere, D. A. (2021). Chemical composition and uses of honey: a review. Journal of Food Science and Nutrition Research, 4(3), 194-201.

Fuente, E., Ruiz-Matute, A. I., Valencia-Barrera, R. M., Sanz, J., & Castro, I. M. (2011). Carbohydrate composition of Spanish unifloral honeys. Food Chemistry, 129, 1483–1489.

Kowalski, S., Kopuncová, M., Ciesarová, Z., Kukurová, K. (2017). Free amino acids profile of Polish and Slovak honeys based on LC–MS/MS method without the prior derivatization. Journal of Food Science and Technology, 54, 3716–3723. doi: 10.1007/s13197-017-2838-7

Lawless, H. (1991). The sense of smell in food quality and sensory evaluation. Journal of Food Quality, 33-60.

León-Ruiz, V., Vera, S., González-Porto, A.V., San Andrés, M. P. (2011). Vitamin C and sugar levels as simple markers for discriminating Spanish honey sources. Journal of Food Science, 76(3), C356-C361. doi: 10.1111/j.1750-3841.2011.02041.x

Nweze, A. J., Olovo, C. V., Nweze, E. I., John, O. O., Paul, C. (2020). Therapeutic properties of honey. In V. De Alencar, A. De Toledo (Eds.), Honey analysis: new advances and challenges. IntechOpen. Available from: http://dx.doi.org/10.5772/intechopen.86416

Popkova, M. A., Budnikova, N. V., Paramzina, I. A. (2021). Water-soluble vitamins in honeys of various botanical origin and their change during storage of honey. IOP Conference Series: Earth and Environmental Science, Volume 845, International Conference on Agricultural Science and Engineering 12-14 April 2021, Michurinsk, Russian Federation, doi:10.1088/1755-1315/845/1/012116

Puscion-Jakubik, A., Borawska, M. H., Socha, K. (2020). Modern methods for assessing the quality of bee honey and botanical origin identification. Foods, 9(8), 1028; doi:10.3390/foods9081028

Qamar, W., Rehman, M. U. (2020). Brief history and traditional uses of honey. In M. U. Rehman, S. Majid (Eds.), Therapeutic applications of honey and its phytochemicals. Vol. 1, Springer Nature Singapore Pte Ltd.

Suto, M., Kawashima, H. & Nakamura, Y. (2020). Determination of organic acids in honey by liquid chromatography with tandem mass spectrometry. Food Analytical Methods, 13, 2249–2257. https://doi.org/10.1007/s12161-020-01845-w

The History of Honey and Beekeeping, https://localhoneyfinder.org/ HistoryOfHoney.php

WHO (2015). Sugars intake for adults and children – guidelines. Geneva, Switzerland: WHO.