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Honey and its properties: A comprehensive review

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Abstract

Honey is a most important natural product obtained from beekeeping and produced from the nectar of blossoms of flowers collected and processed by the honey bees. Honey might be the first sweetener used by ancient man in human history. Honey predominantly contains sugars (glucose, fructose, etc.) with many other compounds like proteins, amino acids, vitamins, minerals, etc. More than 400 different substances were reported to be found in honey. The properties of honey show a discrepancy as per the source of the geographical origin and floral source from which the nectar was collected. In many studies which were carried out for the study of honey properties, it was described that, since from the religious and ancient history, honey has been used as a medicine as well as food by almost all civilizations worldwide. Besides its nutritional value, honey shows many functional properties such as antimicrobial activities, anti-inflammatory effects, and antioxidant properties. Owing to its functional properties honey can be used as a drug or a preventing agent in many disorders. These functional properties of honey may be due to the rich phytochemical profile of honey. In this paper, the various properties of honey are discussed to enlighten the importance of honey as a food and medicine.

Keywords: honey, antioxidant, antibacterial, physical, chemical

Introduction

Honey is one of the most important and primary products obtained from beekeeping. It is truly a natural product with remarkable medicinal and nutritional potential (Shah & Pawar, 2021) [29]. It is said that honey may be the very first product of honey bees, used by humans, in ancient times. It is not only used as a sweetening agent but also as a medicine for plenty of clinical disorders for years (Waykar & Alqadhi, 2016) [30]. There were many shreds of evidence found in history that honey was used as a symbol of holiness in religious ceremonies as well as in the magic and therapeutic events. (Krell, 1996) [18] "Honey is a natural product which can be described as the semi-solid and supersaturated solution synthesized by the honey bees, and which is obtained from the nectar of flower" (Khan et al., 2018). Honey may be defined as "the natural and sweet substance produced by the honey bees after ripening the collected nectar of blossoms or secretions of plants" (BIS, 1994-2002). Definition of honey by the European Union is "It is the natural sweet substance that is produced by bees *Apis mellifera*, from the nectar of plants or from secretions of plants or excretions of plant-sucking insects or 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" (Chin & Sowndhararajan, 2019) [6]. Honey bees gather the nectar from the head of flowers. Some natural secretions were collected from the living parts of plants as well as from the plant-sucking insect's excretion. These secretions were transformed into honey by honey bees by adding their own specific secretions followed by deposition, dehydration, and keeping in the honeycomb for ripening and maturing (Alimentarius, 2001) [7].

Dimins et al., (2006) [10] stated that honey contains more than 400 different substances. While according to Danila et al., (2018) [8] it contains more than 180 dissimilar compounds. Unsurprisingly honey is considered a valuable and important source of energy. Owing to its antioxidant and antimicrobial properties, honey is also acknowledged as a natural medicine (Boussaid et al., 2018) [5]. Various properties of honey are reviewed by studying the published data.

Physical properties of honey

The taste, color, pH, ash, and water content, as well as other physical properties of honey, depend upon a range of environmental factors such as geographical basis, temperature, type of soil, etc. Other factors such as species of honey bees, treatment of beekeepers given to the bees, floral origin, activities of enzymes, and presence of impurities, also contribute significantly to the physical properties of honey (Khan et al., 2018; Manzoor et al., 2013) [20]. Some physic-chemical properties are even useful for detecting the botanical and geographical origin of honey. It is reported that many physic-chemical properties are observed to be different in their values for the honey samples from different geographical origins. Ash content is directly related to the amount of minerals present in the honey (Gomez et al., 2012) [13].

Preference of consumer, quality, and acceptance of honey are highly influenced by the color of honey and these properties have significance for the commercialization of honey (Da-Silva et al., 2016). It was observed that during storage, honey may develop dark color and the development of dark color may be correlated with the composition and the temperature of the storage of honey. A correlation was also found between the color and flavor of honey and its mineral content. The acidity of honey was also affected due to the mineral content of honey. All the above parameters are in a linear relationship with the electrical conductivity of honey (Sahinler & Gul, 2005) [26].

As already mentioned the taste and flavor of honey are influenced by the source of the plant. The typical taste of honey is mainly due to its sugar content. The aroma and flavor of honey mainly depend on its organic acids as well as the amino acid content. Volatile compounds, aromatic acids, and phytochemicals such as carotenoids, polyphenols, flavonoids, etc also contribute to the aroma and overall properties of honey significantly. According to the research findings, the number of volatile compounds identified in honey was approximately above figure 500. Among these volatiles, polyphenols have a very important place, as these compounds are mainly responsible for the typical taste and aroma of honey (Balasubramanyam, 2011; Bogdanov, 2017).

The water content of honey is also very important in accordance with its characteristics. Moisture content greatly influences the preservation properties of honey. It affects other physical characteristics of honey that are flavor, taste, color, viscosity, crystallization, specific gravity, and solubility. Electrical conductivity, acidity, and ash content are interrelated (Da-Silva et al., 2016; Gomez et al., 2012) [13].

Chemistry of Honey

Sucrose, fructose, glucose, and maltose are the sugars contributing primarily to the chief constituents of honey. In addition to this tri-saccharide melezitose and other low-molecular-weight oligosaccharides, minerals, proteins, amino acids, vitamins, polyphenols, and aromatic compounds are also present in honey in a small amount. The previous study pointed out that a furanic compound 5-hydroxymethylfurfural (5-HMF) forms in honey due to heating or storage for a long time as a result of the Maillard reaction. Practically HMF is not present or present in a very low amount in the fresh honey. It was reported that due to the cytotoxic, mutagenic, genotoxic, and carcinogenic effect of 5-HMF, heated honey can prove toxic (Ota et al. 2019; Boussaid et al., 2018; Gomez et al., 2012) [5, 13]. It was concluded on and after the study that the HMF content increased above the permitted limit and the diastase activities decreased below the standard value when honey samples were stored above 35^0C temperature for more than six months (Korkmaz & Kuplulu, 2017). The level of diastase, a natural enzyme of honey, depends on the freshness over and above the floral and geographical source of the product. Thus both HMF and diastase activity are the indicators of freshness and aging of honey (Gomes et al., 2010).

Codex Alimentarius has given the honey specifications which vary as per the country of origin. Indian standard extracted honey specifications decided by the Bureau of Indian Standards (BIS, 1994-2002) are given in table 1.

Table 1: Indian standard extracted honey specifications (BIS, 1994-2002)

S N	Characteristics	Minimum/ Maximum	Special Grade	A Grade	Standard Grade
1	Specific gravity at 27^0C	Min	1.37	1.37	1.37
2	Moisture, (percent by mass)	Max	20	22	25
3	Total reducing sugar, (percent by mass)	Min	70	65	65
4	Sucrose, (percent by mass)	Max	5	5	5
5	Fructose: Glucose Ratio	Min	1.0	1.0	1.0
6	Ash, (percent by mass)	Max	0.5	0.5	0.5
7	Acidity (percent by mass)	Max	0.2	0.2	0.2
8	Hydroxymethylfurfural (HMF), mg/kg of honey	Max	80	80	80
9	Total count of pollens and plant elements/ gram of honey	Max	50000	50000	50000
10	Optical density, in % at 660 nm	Max	0.3	0.3	0.3
11	Fiehe's test	--	Negative	Negative	Negative

Besides these above nutrients Sodium, Potassium, Phosphorus, Zinc, Calcium, Selenium, Magnesium, Iron, Copper, Manganese, and Chromium are the minerals found within honey. In addition to these other trace elements such as Aluminium, Arsenic, Barium, Boron, Bromine, Cadmium, Cobalt, Iodine, etc. are present in honey. Honey restrains some essential vitamins that are vitamin K, ascorbic acid, and vitamin B (1, 2, 3, 5, 6, and 9) in a considerable amount. The number and amount of vitamins and minerals vary according to floral origin (Bogdanov, 2017).

Functional properties of honey

The prime functional properties of honey are its antimicrobial and antioxidant activity. These activities protect the host from oxidative substances and microbial infections respectively. Honey also shows antitumor, anti-inflammatory, anti-browning, and antiviral activities to a considerable extent. The bioactive compounds of honey, accountable for the functional properties, are affected by the flora and the ecological basis of the product.

Apitherapy is now developed as a branch of medicine which deals with the use of honey as well as other products of beekeeping for the treatment of many diseases (Saber, 2015).
It is revealed that honey serves as a source of some probiotics. Probiotics are the substances or organisms which contribute to the intestinal balance. They are useful to prevent pathological conditions. The oligosaccharides of honey have the potential to show probiotic activity. These compounds support the growth of beneficial microorganisms, such as Lactobacillus and Bifidobacterium in the GI tract (Luchese et al., 2017).

Antimicrobial Properties
The common microflora found in honey mostly contains spore-forming bacteria and yeast. Honey shows antimicrobial properties against many microorganisms by preventing their growth. The exact reason behind the antimicrobial activity of honey is not known yet. However, it was reported by many researchers that microbial growth is inhibited by a number of different issues, which are high concentration of sugar, generation of H_2O_2 (hydrogen peroxide), low pH, and presence of phenolic, proteinaceous, or other unidentified compounds (Khan et al., 2018).
There was a fine relationship found between the competence of honey to produce H_2O_2 and the inhibition against microorganisms (Bogdanov, 2017). It was reported that honey shows antibacterial activity against many species such as *Bacillus cereus, Staphylococcus aureus, aeruginosa, Escherichia coli, S. aureus, Pseudomonas aeruginosa, and Escherichia coli P* (Nafea et al., 2011) [22]. *Salmonella typhimurium, Vibrio cholera, Staphylococcus aureus, L. monocytogenes, E. coli, Mycobacterium tuberculosis, S. typhi, Helicobacter pylori,* and *Shigella sp.* are some pathogens against which honey shows the inhibitory properties. It was stated that honey supports probiotic microorganisms such as *Bifidobacterium bifidum, L. delbrukeii subsp bulgaricus, S. thermophilus,* and *L. acidophilus* in their growth (Ismail, 2017).
Honey also shows its inhibitory activities against some species of fungi. It was stated that some honey bacteria produce antibiotic-like antifungal peptide compounds (Bogdanov, 2017). It was revealed from some studies that the antifungal activity is due to the ethanolic extract of honey (Khan et al., 2018).

Antioxidant properties of honey
The major death-causing chronic diseases for example diabetes mellitus, cancer, Alzheimer's, atherosclerosis, and hypertension are closely related to oxidative stress. The supplementations of antioxidants are useful to prevent oxidative damage. Thus it is said that honey is a naturally obtainable product, which shows antioxidant properties.
The study demonstrated the effects of honey in rats as an antioxidant and anti-diabetic agent (Erejuwa et al., 2012). Phenolic acids, flavonoids as well as certain vital enzymes that are found in honey, had served as antioxidants. Study shows that consumers are now insisting on the antioxidants in the food. Since honey is rich in other antioxidants, for instance, organic acids, derivatives of carotenoid, vitamin C, proteins, amino acids, and some enzymes like glucose oxidase & catalase, with than phenolic acids and flavonoids, honey is now a popular source of phytochemicals/ antioxidants among the modern consumers (Khalil et al., 2010; Roy & Ganguly, 2014; Moussa et al., 2012).
It was reported that honey can prevent the spoilage caused in foods due to oxidation reactions, such as enzymatic browning of fruits and vegetables and lipid oxidation in animal meat. The antioxidants are found to be very effective against several diseases like inflammatory disorders, neurological problems, cancers, wounds, diseases causing infections, cardiovascular diseases, as well as aging. Antioxidants neutralize free radicals to maintain health (Khalil et al., 2010; Roy & Ganguly, 2014).

Antihepatotoxicity
Honey shows hepatoprotective activity. Due to the antioxidant effect of honey, it is effective in decreasing harmful radicals which protect the liver (Bogdanov, 2017).

Anti-inflammatory effect and therapeutic properties
Honey is useful in clearing infections rapidly. It heals the inflammation, pain, and swelling quickly. Honey is useful in the treatment of ulcers such as leg ulcers, diabetic foot, and pressure ulcers (Sampath Kumar et al., 2010) [27]. According to Abeshu & Gelata, (2016) honey is a natural material that is effective in the wound healing treatment. As it has no side effects or any type of allergy, it is the safest medicine for faster wound healing. Honey creates a thick and viscous cover over the wound that prevents the bacteria to spread the infection (Scepankova et al., 2017) [28].

Other therapeutic properties
Though honey is comprised of a high amount of sugars, due to the production of lower glycemic index honey is not harmful to diabetic patients. Honey is effective in the prevention and treatment of gastrointestinal disorders (Abeshu & Gelata, 2016). Besides this, honey is reported to have anticarcinogenic, antimutagenic, radiation protective, antinociceptive, anti-osteoporosis, and antineurogenerative properties. It works as a probiotic and prebeiotic (Bogdanov, 2017)

Conclusion

It is concluded from the study that honey is a natural substance extensively used by humans as food and medicine. The physical and chemical properties of honey vary with the variety of honey. The geographical and the floral source of honey influence its physicochemical and medicinal properties. Honey shows many functional properties such as antimicrobial properties, antioxidant properties and many therapeutic properties. It also acts as an anti-tumor and anti-inflammatory agent. The numerous properties of honey are the result of its composition. The presences of more than 400 substances make honey a unique product. Thus there is a need for more research to explore various hidden properties of honey.

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