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Nutraceutical and Therapeutic Properties of Honey: A Review

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Abstract: Honeybees are considered an asset to mankind due to their services to the ecosystem and their cherished products. Honey is a natural byproduct produced by honeybees using plant nectar and sugary non-floral deposits. The bees regurgitate and evaporate these substances to prepare honey and store it in honeycombs, which is considered one of nature's wonders. Honey has been used by various civilizations as food and medicine due to its highly nutritious properties. There has been a close association between honey bees and humans since the Stone Age and attributable to this beneficial relationship, beekeeping became an important part of ancient civilizations and is continued till today. Beekeeping comprises owning and rearing bees for honey and several other products like beeswax, royal jelly, bee pollen, etc. which are also in vast demand in the market these days. The most prominent primary products of beekeeping include wax, honey, pollen, royal jelly, propolis, and bee venom. Out of all the bee products, the demand for honey is the highest due to its several beneficial uses. In this review, information about composition, properties, importance, and therapeutic properties of honey have been compiled.

Keywords: Honey, Diseases, Immunomodulator, Nutraceutical, Honeybees, Beekeeping

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Introduction

For centuries, natural medicines have been utilized to cure an extensive range of illnesses. Even though traditional pharmaceutical approaches have replaced many, the general public's enthusiasm for using honey and honey products is currently experiencing a renaissance (Manyi-Loh *et al.*, 2011, Parey *et al.*, 2021). For over 4,000 years honey has been used in traditional Ayurvedic treatment of several

diseases. It was believed to balance the body's three humors and was regarded as nature's greatest gift to humanity by the ancient Vedic civilization. In Ayurvedic texts, honey is referred to as Madhu or Kshaudra and is considered one of the most significant herbal remedies (Liyanage and Mawatha, 2017). Since the dawn of time, honey has been an essential meal for *Homo sapiens*, as it was the only naturally occurring

sweetener accessible. Honey was first mentioned in writing on a Sumerian tablet from 2100–2000 BC, which describes its usage as an ointment and medication. Honey was employed for both medicinal and nutritive purposes in the majority of ancient societies (Sonika *et al.*, 2021; Kumar *et al.*, 2022)

There are four main species of bees commonly used in India for the production of honey i.e. *Apis dorsata* (Rock bee), *Apis florea* (little bee), *Apis mellifera* (European bee), and *Apis cerana* (Asian honey bee) (Kamboj and Rajni, 2012). Apiary honey and wild honey are the two primary varieties of honey produced by honey bees. Apiary honey is produced by honeybees, such as *Apis cerana indica* and *Apis mellifera*, in controlled environments like apiaries, and is extracted using modern methods. This type of honey is transparent and free from any impurities. However, forest honey is produced by *Apis dorsata* (rock bees) or by wild nests of *A. cerana indica* in forests. This type of honey is collected using a crude method of squeezing the comb and may contain foreign materials (Manyi-Loh *et al.*, 2011). Honey extracted from combs and apiaries contains pollens, beeswax, and other undesirable elements that are required to be removed to enhance product quality and shelf life. Thus, honey goes through processing before being put into bottles or other packaging. However, the scale of operation determines the kind of machinery and processing procedures employed. The heating and filtering phases of the honey preparation are crucial. Pollens, beeswax, and other components are typically separated by pressure filtering and straining. By using heat or thermal processing, honey may be made with less moisture content, which slows down the fermentation process and gets rid of the bacteria that cause spoiling (Subramanian *et al.*, 2007). Around 1.2 million tons of honey are produced commercially worldwide each year indicating an average daily consumption of 0.64 g (Toniazzi *et al.*, 2023). The primary honey-producing countries include China, Turkey, Argentina, Ukraine, Mexico, and the United States (Meo *et al.*, 2017). The composition

of honey can vary depending on factors such as nectar source, season, geography, and storage conditions (Khan *et al.*, 2017)

Chemical Composition of Honey:

Natural honey is a complex mixture that contains approximately 200 different substances. It is primarily made up of water and various sugars, in addition to other components such as organic acids, proteins, enzymes, pigments, phenolic compounds, vitamins (like pyridoxine, thiamine, riboflavin, niacin, and pantothenic acid), and minerals (including phosphorus, calcium, sodium, copper, manganese, iron, magnesium, zinc, and potassium). Additionally, a variety of volatile compounds are also present in natural honey. (da Silva *et al.*, 2016).

Honey's sugar content is not comprised of a single sugar but is made up of three types of sugar and accounts for 95 – 99% of honey dry matter. These include fructose, also known as fruit sugar, which is the most abundant at 41%; glucose, also known as grape sugar, which makes up about 34%; and sucrose, or ordinary sugar, which only accounts for 1-2% (Tafere, 2021). The origin and type of honey can also be described based on the type of sugars and the amount of different kinds of sugars present in honey. The high amount of glucose in honey helps in its easy crystallization, while honey having a high amount of fructose crystallizes slowly (Weber *et al.*, 2022).

The second crucial ingredient in honey is water. The amount of water present in honey acts as a very important factor for honey storage. Honey with less than 18% water can be stored for a longer duration with little or no risk of fermentation. The water content of honey depends upon the weather conditions, nectar, and humidity inside the colony of the bee. Organic acids make up 0.57% of honey, including gluconic acid which is produced during the enzymatic digestion of glucose. The acidity of honey is caused by these organic acids, which also significantly contribute to its unique flavor. (Eteraf-Oskouei and Najafi, 2013).

Honey also comprises a wide range of enzymes such as oxidase, invertase, amylase, and catalase. Whereas the primary enzymes that are found in honey are glucose oxidase, diastase (amylase), and invertase (saccharase). The production of honey depends heavily on these enzymes. The glucose oxidase enzyme is accountable for producing hydrogen peroxide, which provides antimicrobial properties to the honey (Eteraf-Oskouei and Najafi, 2013). It is also rich in flavonoids and phenolic acids, which act as natural antioxidants and exhibit a broad range of biological effects (da Silva *et al.*, 2016). Along with the other components minerals are also present in honey in trace amounts with potassium being the most abundant.

Physical Properties of Honey:

The physical characteristics of honey include color, pH, enzyme activity, ash content, electrical conductivity, viscosity, water activity, specific gravity, hygroscopicity, and flavor. These characteristics vary based on the species of honeybee, its geographical origin, and the presence of any impurities.

- (i) **Colour:** Honey can range in colour from pale yellow to dark crimson or black, depending on the plant source. Temperature changes may lead to darker hues (Khan *et al.*, 2018, Shivani *et al.*, 2021). It mainly varies with the botanical origin, storage condition, and presence of suspended particles like pollen.
- (ii) **Moisture:** For all types of honey sample, the moisture content is required to be present within limits i.e. <20%. In Indian honey moisture content vary from 17.2-21.6%. The low moisture content of honey indicates its good quality and storage capacity of honey. Raw honey contains a large amount of moisture due to less processing (Krishnasree and Ukkuru, 2017). *Apis mellifera* honey contains 14-21 % water content. A high concentration of water in honey leads to easy fermentation. The moisture content of honey varies with different botanical origins of

honey, environmental conditions, processing, etc. (Gallina *et al.*, 2010; Shivani *et al.*, 2021). The proportion of honey's moisture content is influenced by several factors such as the nectar's botanical and geographical origin, weather patterns, harvesting season, beekeeper management, processing and storage conditions, etc. It is an important physicochemical property of honey that impacts the shelf life of honey.

- (iii) **pH:** The pH level of honey differs based on the geography of the area, indicating its purity (Khan *et al.*, 2018). Honey is acidic due to the presence of organic acids which also imparts flavor to it and keeps it stable against microbial spoilage. During the extraction process, the pH level of the honey samples is crucial since it influences the texture, stability, and shelf life of the honey (Khalil *et al.*, 2012; Shivani *et al.*, 2021).
- (iv) **Viscosity:** Honey is a sticky liquid that has a varying viscosity depending on its composition, water content, and temperature. When the water content of honey is increased, it becomes less thick. Although the amount, of proteins and other colloidal substances in honey may be insignificant, they can still contribute to making honey more viscous (Kolayl *et al.*, 2013).
- (v) **Optical rotation:** Optical rotation is a parameter that is used to determine the botanical source and adulteration of honey. Honey has the unique property of rotating the polarization plane of polarized light which depends on the types and proportions of sugars present in it. Each sugar has a specific effect on the optical rotation, and the total optical rotation is dependent on its concentration. For instance, fructose exhibits a negative optical rotation, while glucose displays a positive one (Kolayl *et al.*, 2013).
- (vi) **Hygroscopicity:** Hygroscopicity is the ability of honey to absorb and retain moisture from

the environment, which is largely due to its high concentration of fructose (Kolayl *et al.*, 2013).

The Healing Properties of Honey- A Natural Remedy for Disease:

Because of the unique physical characteristics and chemical composition of honey, it has a vast array of nutritional and therapeutic applications (ii) because of its properties such as antidiabetic, antihyperglycemic, antimicrobial, antioxidant, and immunomodulatory. Honey has been an inseparable part of human history, serving as a vital ingredient in various cultures across the world. Honey's health benefits are mentioned in several religious books. In the long provenance of its connection to dietary customs, it has also been approved for its usage in religious ceremonies. It has additionally been utilized for several therapeutic applications in conventional medicine. Its primary application in the past has been the treatment of burns and wounds. Honey is additionally effective medicinally in treating respiratory disorders, skin conditions, eye disorders, digestive issues (particularly constipation and diarrhea), and oral ailments (Qamar and Rehman, 2020)

Its innate sweetness and medicinal properties have made it a popular choice for centuries however, it is gaining more attention in the present day as a nutraceutical from medical scientists and researchers.

- (i) **Antimicrobial properties of honey:** Humans have been aware of natural honey's antibacterial qualities for ages, and it is primarily because of the osmotic effect i.e. if honey comes in contact with bacteria, it absorbs the water content through the cell wall effectively dehydrating and killing the bacteria. Honey was used to treat infected wounds even before bacteria were discovered. Honey has been reported to have an inhibitory or suppressive effect on around 60 species of bacteria, including aerobes and anaerobes, gram-positives, and gram-negatives. It has also been observed to have antifungal action

against some yeasts and species of *Aspergillus* and *Penicillium*, additionally all common dermatophytes (Aurongzeb and Azim, 2011). The enzymatic reaction that generates hydrogen peroxide is responsible for the antibacterial action observed in most honey (Mandal and Mandal, 2011).

Antioxidative properties of honey: Honey is also known to show antioxidative properties due to its richness in phenolic acids, flavonoids, and other antioxidants such as Ascorbic acid, catalase, glucose oxidase, carotenoid derivatives, proteins, amino acids, and organic acids. These antioxidants shield the body from lethal free radicals which can damage the cells and tissues, and have several preventative effects against various diseases, such as cancer, cardiovascular diseases, arthritis, autoimmune disorders, wound healing, infectious diseases, inflammatory processes, and aging. Multiple studies on the antioxidant characteristics of honey have been conducted (Khalil *et al.*, 2010; Rajpoot *et al.*, 2022; Kumari *et al.*, 2023; Hajam *et al.*, 2023).

- (iii) **Anti-inflammatory properties of honey:** Honey has been utilized as a potent medicinal agent and dietary supplement for thousands of years. Honey has various therapeutic properties like anti-microbial, antioxidant, and anti-inflammatory. It is mostly used in wound healing and anti-inflammation as it helps in cleaning the wound and removing the dead tissue that provides favourable condition for the growth of microbes. Due to its rapid cleaning and destruction of bacteria, it aids in the reduction of inflammation and stimulates cell growth. Scientific observations show that honey has a direct anti-inflammatory effect when it is applied as a medication. Further evidence about the anti-inflammatory properties of honey shows that, when honey was applied to a burnt area, there was a reduction in the number of inflammatory cells present in that area. A decrease in inflammation was also seen when honey was

administered to areas of localized edema, redness, discomfort, and heat-related to inflammation. (Hadagali and Chua, 2014).

(iv) Immunomodulatory properties of honey:

Honey is an organic source of many live enzymes, a complete range of vitamins, 22 amino acids, 27 minerals, and many other effective antioxidants and natural antibiotics that help in fighting infections and account for boosting immunity (Kumar *et al.*, 2022). Due to all the different properties possessed by honey, it can cure several health ailments, combat infection, and strengthen the immune system therefore acting as an immunomodulator. According to the ancient text of Ayurveda honey is a boon to those with low immunity and is highly effective as it enters directly into the bloodstream due to the existence of dextrin content.

Importance of Honey:

Honey is used as a source of food from ancient times by early members of the genus *Homo*. Honey and honey bee larva consumption provides a sufficient amount of energy, and by consuming honey the early *Homo* can nutritionally compete with others (Crittenden, 2011). Honey has several beneficial constituents used in health enhancement and body system improvement. Natural honey is a sweet liquid material with high nutritional and therapeutic value. The properties of honey vary due to its botanical origin, which is the collection of nectar from different sources. Honey is also used as medicine for various diseases, which provides health benefits to the patient (Ajibola, 2015).

- (i) Honey as a nutrient:** Honey contains 75-80% carbohydrates, 15-20% water is used as a natural sweetener, and also contains minerals, vitamins, organic acids, and proteins. Honey is used as a food ingredient and can be consumed directly. The different enzymatic activities of honey make it a unique constituent to prevent the bacterial growth. Honey contains 75% of monosaccharides and

10-15% of disaccharides, other sugars are also present in traces. The sugars provide the viscosity and increase the energy value of honey (Aga *et al.*, 2023). Honey has prebiotic properties due to the presence of oligosaccharides and helps in the growth of probiotic bacteria like *Bifidobacterium* and lactobacilli bacteria. The composition of honey changes due to changes in nectar collected from different types of flora. Honey is also used in commercial food products like cheese, and yogurt, and is used with ginger and turmeric at room temperature without any heat treatment (Gulec and Sharper, 2022).

- (ii) Medicinal property of honey:** Honey has great medicinal value, commonly used in wound healing and the treatment of skin infections. The therapeutic properties of honey are due to the high sugar concentration, low pH, and the hydrogen peroxide generated by the oxidation of glucose to gluconic acid with the help of the enzyme glucose oxidase upon dilution. Honey is used in the treatment of gastrointestinal disorders like ulcers, gastroenteritis, etc. The sweetness of honey is approximately equal to that of sugar but does not show any hyperglycemic effect, and used as a sweetener by diabetic patients (Zafar *et al.*, 2020). Honey acts as an immune booster, and helps in the rapid multiplication of β -cells and T-cells in culture. It helps in the activation of IL-1 and IL-6 which activate the target cell for immune response. In macrophages, glycolysis helps in the production of energy, and honey provides a substrate for glycolysis (Manye-Loh *et al.*, 2011). Raw honey has positive effects on dental health. Asian polyfloral honey is used to prevent oral infection. The antibacterial properties of honey are helpful in the reduction of dental susceptibilities, that prevent bacterial growth. Honey also contains calcium, fluoride, phosphorous, and other colloidal substances, and is also effective in oral surgeries. It is also used in the management of eye disorders in modern ophthalmology. African people use honey for

the treatment of measles. Natural honey is applied to the eyes to prevent scarring of cornea and eye infections. Honey is used in the field of ophthalmology for the management of conjunctivitis, measles, keratitis, and coronary opacity.

(iii) **Cardiovascular diseases:** When honey is taken orally it reduces the cardiovascular risk factors, and it does not cause any health hazards to heart patients. Honey helps in the reduction of antioxidant concentration in blood which reduces the risk of development of cardiovascular diseases. The common risk factors associated with cardiovascular diseases are, hypertension and diabetes mellitus. Honey also prevents the development of these risk factors in patients.

(iv) **Metabolic effect:** Honey is used as a glycemic food, and helps to maintain the blood glucose level. Metabolic disorders are associated with obesity, hypertension, hyperglycemia, etc. These disorders are not seen in the individual who takes natural honey instead of artificial sugars. Honey helps in the reduction of cholesterol, triglycerides, and glucose in patients with diabetes mellitus.

(v) **Cancer therapy:** Several studies show that honey of different geographical origins has anti-cancerous properties. It helps in the reduction of inflammation and risk factors associated with the pathogenesis of cancer. Honey shows anti-tumorous properties by promoting early cell death and inhibiting cell proliferation in cancer cells. Honey stimulates the release of cytotoxic hydrogen peroxidase and acts as a scavenger of ROS. It shows the cytotoxic activity selectively toward the cancerous cells, not toward the normal cells (Ajibola, 2015).

(vi) **Honey in the cosmetic industry:** There are historical records of honey being used in hair conditioning, skin juvenile, reduce wrinkle formation, etc. Honey is used in cosmetic products like ointments, hydrating creams,

tonic lotion, shampoo, conditioners, sunscreen, etc. In these products honey is used in the range of 1-10%, it can be increased up to 70%, by mixing it with emulsifiers, oil, gel, and polymer entrapment. Honey is used in these cosmetic products due to its antioxidant properties and ability to activate the expression of matrix metalloproteinase (Burlando and Cornara, 2013).

(vii) **Economic importance of honey:** Honey is used as a most important food item, more than 300 items are manufactured from honey. Honey and its products provide benefits to society, both economically and ecologically. China is the largest producer of honey followed by some other major producers such as Canada and Turkey. Worldwide production of honey is 1.72 million metric tons per year. There is a highly competitive global market, that depends on environmental conditions and changes in climatic conditions, that cause changes in the production of honey. Globally honey demand depends on nature, location of honey production, application, and packaging. Honey is commercially used in the food industry and cosmetic industries (Puranik *et al.*, 2023).

Conclusion

Honey is known to mankind since time immemorial. Its properties make it an extraordinary natural edible item. It is the only natural sweetener that does not have any negative impacts on any physiological system in human beings to date. A person of any gender, age, and level can consume without a medical prescription or advice from a medical practitioner. Therefore, honey has been the status of “Amrut” in religious books.

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