



Chemical Properties and Applications of Honey: A Review

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Abstract: Honey is a sweet substance produced from the nectar of flowers by *Apis mellifera* L. It is a sweet and tasty liquid. It is one of the most common natural materials. From a chemical perspective, it can be perceived as a natural food consisting primarily of carbohydrates and water with small components such as vitamins, amino acids, proteins, organic acids, minerals, phenolic compounds (flavonoids and phenolic acids) and aromatic compounds. Its composition is particularly variable, depending on its botanical and geographical origins. Honey is used to feed bees during the winter. For the century, honey has been used both as a food and as a natural medicine, as it was prescribed by many archaic cultures to treat a wide variety of sicknesses.

Keywords: Bee honey, chemical structure, application.

1. INTRODUCTION

Honey is the natural sweet substance that honey bees produce from the nectar of flowers or from the secretion of live parts of plants or secretions of plants sucking insects on the living parts of plants, which honey bees collect, transform and combine with certain substances of their own, stored and left in the honeycomb to ripen and ripen (Codex, 2001).

The importance of honey has been known for thousands of years, it is considered the favourite food by all people in different eras and times. Since it is considered a food and medicine at the same time because it contains bioactive compounds that have important effects on human health, Honey varies according to the source of the nectar, whether it is

from flowers, plant secretions, or substances secreted by insects, and accordingly its biochemical components differ, even if in small proportions (Bogdanov *et al.*, 1999). Honey is consumed as a portion of healthy food and is also widely used in folk and clinical medicine as a treatment. It must contain the standard parameters of natural honey that are accurately diagnosed including sugar, moisture, electrical conductivity, invertase, diastase, and hydroxymethylfurfural content.

The manufacture and quality of honey also depends on some environmental factors through production such as weather, humidity inside the bee colony, condition of the nectar and handling of honey during the state of extraction and storage. The composition of honey varies according to the nutrition of the bees. Honey has been reported to contain over 200 compounds and is considered an important part of traditional medicine. Honey has many functional uses and purposes around the world such as food regulation, religious and magical ceremonies as well as Christian and veterinary medicine (Ajibola *et al.*, 2012). It is a very important energy food and is used as an ingredient in hundreds of produced foods, atmost in grain-based products, due to its flavour, sweetness, color, pumpability, caramelization, and viscosity (Nigussie *et al.*, 2012).

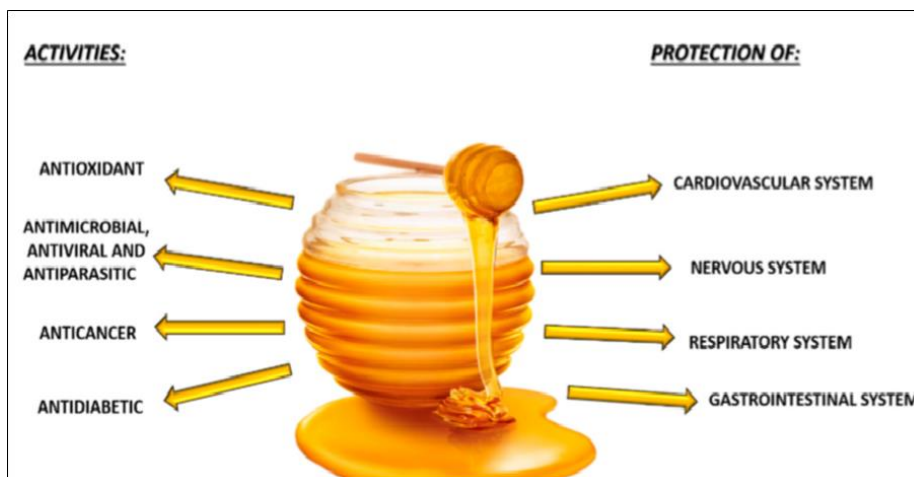


Fig. (1): Beneficial Effect of Honey Consumption [26].

2. Properties and Composition of Bee Honey

The composition of honey varies mainly by flower source, but seasonal and environmental factors and processing condition are also important.

2.1. Carbohydrates

The main sugars are the monosaccharides fructose and glucose. In addition, about 25 glucocorticoid oligomers were detected (Al-Zoreky *et al.*, 2001). The main sugars in floral honey are sucrose, di-sucrose,

maltose, turranose and trehalose, as well as some nutrition-related sugars such as panose, 6-castose and palatinose. Compared to honey, flower honey contains higher amounts of the oligosaccharides raffinose and millilitose. In the process of assimilation after eating honey, the major carbohydrates fructose and glucose are easily transported into the blood and can be used by the human body for energy (Puscion-Jakubik *et al.*, 2020). Daily dose of 20 g honey will coat about 3% of the wanted daily energy (Aljohar *et al.*, 2018).

Table 1. Total Sugars in Blossom Honey and Honeydew [18]

	Blossom honey		Honeydew honey	
	average	min-max	average	min-max
Fructose	38.2	30-45	31.8	28-40
Glucose	31.3	24-40	26.1	19-32
Sucrose	0.7	0.1-4.8	0.5	0.1-4.7
Other disaccharides	5.0	28	4.0	16
Melezitose	<0.1		4.0	0.3-22.0
Erlose	0.8	0.56	1.0	0.16
Other oligosaccharides	3.6	0.5-1	13.1	0.1-6
Total sugars	79.7		80.5	

2.2. Proteins and Amino Acids

Proteins in honey bees come from nectar and pollen as whole parts of plants. The proteins in honey may be in the form of a very complex structure or in the form of a simple component, ie amino acids (Bilikova *et al.*, 2015; Chua *et al.*, 2015). The content of proteins and amino acids is relatively small, a maximum of 0.6%. Honey contains almost all the physiologically important amino acids (De-Melo *et al.*, 2018). One of the main amino acids, proline, is a measure of honey's ripeness. The proline content of neutral honey should be more than 200 mg/kg. Amount less than 180 mg/kg to fix that honey may have been adulterated with sugar supplement (Alvarez-Suarez *et al.*, 2018).

2.3. Enzymes

The testimony of enzymes present in honey are occasionally used as an signal for quality, freshness and overheating. Enzymes in honey are came from salivary secretion of honey bees or from the flowers visited by the bees (Bogdanov, 2009). Diastase (α - and β -amylase) conversion starch to maltose and another simple sugars is and invertase (glucosidase) catalyzesat most the conversion of sucrose to glucose and fructose but also some other sugar conversions (Ligia *et al.*, 2020; Flanjak *et al.*, 2016; Lichtenberg-Kraag, 2014). so, glucose oxidase and catalase regulate the output of H₂O₂, one of the honey antibacterial agents (Bogdanov, 2016). Honey consist of acid phosphatase whose activity is related to the fermentation operations of honey. Acid phosphatase originates at most from nectar and pollen and can be used as a parameter for honey Properties (Milek *et al.*, 2021; Flanjak *et al.*, 2016).

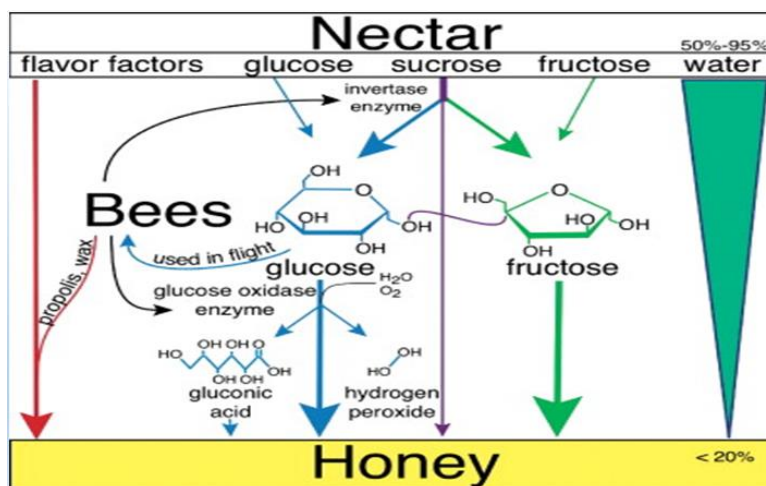


Fig. (2): Mechanism of Honey Synthesis with Contribution of Enzymatic Activity

2.4. Vitamins

Honey include vitamins that come mostly from pollen visited by bees, as well as nectar or aphids (Bogdanov *et al.*, 2016; León-Ruiz *et al.*, 2013). The value of vitamins in honey is too short to consider this food as a good source of these nutrients. The amount of water-soluble vitamins is higher than the volume of fat-soluble vitamins, because honey hardly contains fatty substances. The most important vitamin in honey is vitamin C (ascorbic acid), which has antioxidant activity (Kesic *et al.*, 2009; Bundit *et al.*, 2016; Bogdanov *et al.*, 2016). Vitamins of group B were also detected in different amounts. Several fat-soluble vitamins such as vitamin A, E, D, and K are found in trace amounts (Bogdanov *et al.*, 2016; León-Ruiz *et al.*, 2013; Karimah *et al.*, 2020).

2.5. Phenolic and Aromatic Compounds

Phenolic compounds are secondary metabolites derived from plants. These compounds have been applied as chemochemical markers in plant systematics. Phenolic acids and polyphenols are secondary metabolites derived from plants. These compounds have been used as chemomarkers in plant systematics. They have been suggested as potential markers for determining the botanical origin of honey (Dzugan *et al.*, 2018; Cianciosi *et al.*, 2018; Becerril-Sánchez *et al.*, 2021). Dark-colored honey contains more phenolic acid, while it has less flavonoids than light-colored honeys (Jibril *et al.*, 2019; Cianciosi *et al.*, 2018; Ahmad *et al.*, 2017). The volatile honey is the substances responsible for the smell of honey. Research on volatile compounds in honey began in the early 1960s. Recently, by researching volatiles isolated from honey (Oršolic' *et al.*, 2020; Ahmad *et al.*, 2017), it was found that

many volatile compounds originate perhaps from the plant, but several of them are added by bees. Until the present time about 600 compounds have been characterized in different honeys (Bakchiche *et al.*, 2017; Wabaidur *et al.*, (2020).

2.6. Hydroxymethylfurfural (HMF)

An organic compound recognized as 5-hydroxymethylfurfural (HMF) is created from reducing monosaccharides such as fructose in honey. HMF It is a six-carbon heterocyclic compound composed of reactive groups of aldehydes and alcohols (hydroxymethyl) (Shapla *et al.*, 2018; Bogdanov, 2016). The structure loop is centered on the furan moieties, while the two active groups, i.e., the formyl and hydroxymethyl groups, are linked at the second and fifth positions, respectively (Fig. 3). The value of HMF present in honey is the reference used as a guide to how much heating has occurred; The higher the HMF content, the lower the quality of the honey (Tesfaye *et al.*, (2016; Shapla *et al.*, (2018). However, 5-HMF alone cannot be used to reduce the intensity of heat treatment, because anther factors can affect HMF levels, such as sugar type, pH, presence of organic acids, moisture and cast source. Therefore, HMF content only gives an indication of overheating or improper storage conditions (Bogdanov, 2016; Kaid, 2021). HMF is a yellow solid that has a low melting point but has a high melting point but is highly soluble in water. As indicated by the Codex Alimentarius and EU standards, HMF maximum is 40 mg/kg for the mixture or processed honey, and a maximum of 80 mg/kg for honeys with a tropical origin (Bogdanov, 2014; Codex Alimentarius Commission, 2019).

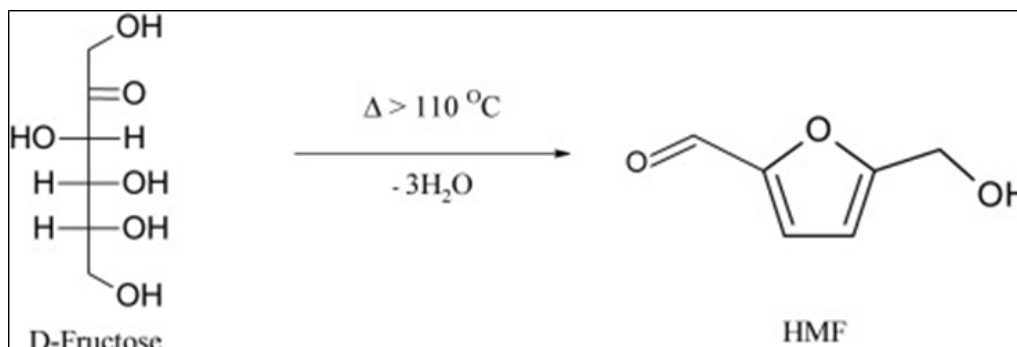


Fig. (3): Figuration of HMF in Honey [66]

2.7. Minerals

Honey contains different amounts of minerals. The main element present in honey is potassium, as well as many others (as shown in Table 2). Potassium with an average of approximately one-third of the total, is a major mineral, but there are a variety of trace elements and some studies have shown that the content of trace elements in honey is mainly made up of honeysuckle origin (Bogdanov, 2009). Minerals have about 3.58% (Nayik and Nada, 2015; Cornelia and chis, 2011). Although this part of the honey does not make a large

amount, the minerals in the honey increase the value of honey for human consumption. Honey contains many minerals: potassium, sulfur, chlorine, calcium, phosphorous, sodium, magnesium, iron, silicon, manganese, and copper (Bogdanov (2016; Sommano *et al.*, 2020). When the observed mean value, dark species of honey are prosperous in minerals than lighter. naturally, singles can find a darker species that are poorer than some lighter types (Mulugeta *et al.*, 2017; Saeed and Jayashankar, 2020).

Table 2. Minerals in Honey in Relation to Human Requirements [18]

Minerals	Unit	Average amount in 100g honey	Recommended daily intake
Calcium	mg	4-30	1000
Chlorine	mg	2-20	
Copper	mg	0.01-0.1	2
Iron	mg	1-3.4	18
Magnesium	mg	0.7-13	400
Phosphorous	mg	2-60	1000
Potassium	mg	10-470	-
Sodium	mg	0.6-40	-
Zinc	mg	0.2-0.5	15

2.8. PH and Acidity

Organic acids are also components of honey. Before that, it was considered that the bees had combined bee venom with the stomach in the honeycomb with honey and extracted it thus preserved. Given that one of the major components of bee venom is formic acid, the idea was that honey contains formic acid (Bogdanov, 2009; Alvarez-Suarez, 2017). Some people even insisted to others not to use honey because of it. Studies have shown that they are completely different acids that are formed in honey, especially apple and citric acid. Honey is a medium that does not change its pH by adding small amounts of acids and bases. The dielectric ability is due to the content of carbonates, phosphates, and other mineral salts (Rahaman, 2015; AL-Farsi *et al.*, 2018; Pauliuc *et al.*, 2020; Tomczyk *et al.*, 2022).

2.9. Moisture

The moisture content of honey is the quality part that determines the honey's ability to stay fresh and avoid spoilage caused by yeast fermentation. Raw honey can have a moisture content of less than 14% and the lower the moisture content, the higher the overall

value of honey (Alvarez-Suarez, 2017; El-Sohaimy *et al.*, 2015; Sakac *et al.*, 2019). It is universally known that high-quality honey should have a moisture content of less than 20%. Low moisture content is desirable because honey may begin to ferment and lose its quality if the moisture in the honey is more than 20%. Unpasteurized honey is fermented because it contains wild yeast. But due to the higher sugar concentration in honey, these yeasts are less likely to cause fermentation of honey with low moisture content (Reshma *et al.*, 2016; Da Silva *et al.*, 2016; Tomczyk *et al.*, 2019; Bobis *et al.*, 2021).

3. Bee Honey as Nutrient for Humans

Honey is a useful source of carbohydrate-rich foods and usually contains a rich variety of micro-components such as proteins, minerals, vitamins, etc., adding nutritional diversity to human food (Kasprzyk *et al.*, 2018; Willix *et al.*, 2012). At present, the world's annual honey production is nearly 1.3 million tons, which is less than 1% of the total sugar production. Today, honey is another natural, unprocessed food.

Honey consumption varies greatly from country to country (Borowska, 2016).

4. Medicinal Applications of Bee Honey

Honey has been shown to have antibacterial, antiarrhythmic, antibacterial, anticancer, antifungal, antidiabetic, anti-ischemic, anti-inflammatory, anti-inflammatory, anti-mutagenic, antibacterial, antioxidant, anti-platelet, anti-parasitic activity. , anti-proliferative, anti-proliferative, anticoagulant. ; It also has a cardioprotective, hypotensive, diuretic, antihypertensive, antispasmodic, hypoglycemic, hypocholesterolemic, mineral acetate and neuroprotective effect (Szweda, 2017; Chang *et al.*, 2011; Gheldof *et al.*, 2002; Gomes *et al.*, 2010). Honey has been reported to be beneficial in a large number of human ailments including allergies, bronchitis, asthma, colds, hay fever, influenza, nasal congestion, sinusitis, rhinitis, upper respiratory infections, sore throat, anxiety, cough, fatigue, migraines (stress related), Burns, cuts, lacerations, wounds (veins, malignancies and diabetes), pressure ulcers, perianal ulcers, malignant ulcers and gluteofemoral fistulas, bedsores, postoperative infections in adults and newborns, necrotizing fasciitis, insect bites, sinuses, Infections (bacterial containing antibiotic-resistant strains and fungi), Conjunctivitis, septicemia and other eye diseases, acne, endophthalmitis, chronic seborrheic dermatitis, eczema, dandruff, psoriasis, inflammation, stomach pain, gingivitis, stomach ulcers, digestive disorders, vomiting, constipation, diarrhea, inflammation Colon, diabetes, dehydration, osteoporosis, insomnia, chronic fatigue syndrome, high blood pressure, anemia, immune disorders, multiple sclerosis. Hepatitis, cardiovascular disease, cancer, tumors, and inflammation of the oral mucosa caused by radiotherapy/chemotherapy (Al-Waili *et al.*, 2004; Bahrami *et al.*, 2009; Cortes *et al.*, 2011; Mandal and Mandal, 2011). Honey is also used in skin moisturizers and hair rinse cream (Singh *et al.*, 2012).

5. Antioxidant Activity of Bee Honey

An antioxidant is a relatively stable molecule, ion or radical capable of delaying or preventing the oxidation of other molecules. And it can be known that they are substances that have the ability to prevent the start of oxidation and to end or slow down the development of the chain of reactions that lead to the production of free radicals, as it works to donate an electron to the free radical and oxidizes instead of the body cells and prevents its deterioration as it produces weak, inactive radicals and becomes relatively stable radicals (Nagmoti, 2012; Anantharaju *et al.*, 2016; Weston *et al.*,). Honey contains many bioactive compounds with antioxidant and microbial properties, as honey contains two types of antioxidants, such as: enzymatic antioxidants, as well as non-enzymatic antioxidants. activity of honey, which may be because of has many of bioactive compounds as well as bee peptides. In a study by Bose *et al.*, (2020) show the activity of honey

and its purified protein, as well as peptides as antioxidants through their ability to Free radical scavengers DPPH, as the results indicated that the antioxidant activity in scavenging free radicals was graded as follows: 73.16%, 68.55% and 59.71% Each of: honey, honey peptide and protein respectively. He indicated that raw honey showed the highest antioxidant activity as a result of containing many chemical compounds with antioxidant properties such as: enzymes, phenolic compounds, carotenoids, vitamin C and organic acids. This is followed by honey peptide as a result of its structure specific to the type and sequence of amino acids within the peptide chain, as well as its low molecular weight compared to protein.

6. Antimicrobial Activity of Bee Honey

The antimicrobial activity of bee honey has been recognized since the 19th century. There are a large number of in vitro and limited clinical studies that have extensive antimicrobial (antibacterial, antibacterial, antifungal, and antiviral) activity of honey which may be due to its low pH, high sugar content, osmotic effect, hydrogen peroxide (established by glucose oxidase in honey), catalase, lysozyme, polyphenols, flavonoids, phenolic acids and methylglyoxal (created by conversion of dihydroxyacetone through the ripening of honey), bee peptides (natural antibacterial agents defensin-1, abidacin, and immunomodulators 241). Characterization of anti-inflammatory honey (Kucuk *et al.*, 2007; Al-Hindi *et al.*, 2011; Weston *et al.*, 2000). as well, because honey content some propolis and bee pollen, part of the antimicrobial activity of honey may be because of the presence of antimicrobial substances present in these compositions (Viuda-Martos *et al.*, 2008; Redzic. *Et al.*, 2011).

7. Bee Honey Properties in Wound Healing

The development of wound infection has adverse effects on patients by causing increased pain, discomfort and inconvenience and can lead to life-threatening illness or even death (Robson *et al.*, 1997). It also interrupts the state of recovery, contributes to the extension of hospital stay, as well as increases the prices of treatment in terms of antibiotics, dressings and staff time. Wound healing can be affected by endogenous (pathophysiological) and exogenous (microorganism) factors (Pereira *et al.*, 3016). The risk of wound infection increases as local conditions agree for bacteria to invade and grow. Honey is one of the natural remedies found in treating wounds. It promotes rapid wound healing through the development of regenerative tissue and effects of epithelialization, with the formation of small or no scars. Furthermore it, Prostaglandins and nitric oxides play a major role in the healing process. Honey has been proven to be safe to use. The external use of honey dressings as well as their application to the mucous layers in the body cavities did not show signs of allergic reaction and side effects (Eteraf-Oskouei and Najafi, 2013).

8. Other Applications

Hypertension is one of mainly cardiovascular risk agents (Poulter, 2003). Because the persistent rise in blood pressure results in a change in the structure of the heart muscle and coronary vessels, it moves to left ventricular hypertrophy with cardiac dysfunction such as arrhythmia and congestive heart attack, among others (Standridge, 2005). And therefore; High blood pressure has become a related health problem, as blood pressure rises with age and life expectancy nowadays becomes longer. Recent research has proven that consuming honey and honey derivatives can help reduce the risk of high blood pressure (Hiwatashi *et al.*, 2010). Anti-infective activity as well as hypertension and hypertrophy is one of the main causes of cardiovascular risk and other diseases (Willerson & Ridker, 2004). Reactive oxygen species are important factors responsible for injuries through ammunition (Singer & Clark, 1999). Honey has shown that it can be reduced in several experiments on laboratory animals (Bogdanov, 2016; Owoyele *et al.*, 2014). Sucking on honey by mice with intestinal diseases was an effective treatment for acute colitis, potentially due to the blocking of free radical production. Glam honey from Malaysia is produced due to rat rubbing caused by carrageenan. In humans, ingestion of honey has been shown to be suitable for reducing sedative agents such as thromboxane and prostaglandins (Al-Waili & Boni, 2003). In vitro isolation of human neutrophil superoxide was reduced by New Zealand honey Rewarua, Manuka and Kanuka. The antifungal action of honey therapy has been referenced to abovonoids (Candiracci *et al.*, 2012). showed that such polyphenols as quercetin and quercetin had anti-inflammatory actions but with different mechanisms. However, according to Farooqui and Farooqui (2014), the molecular technology for the anti-angiogenic action of Avonoids has not yet been established. Furthermore, research is needed to survey the potentially interesting anti-inflammatories efficacy of honey.

CONCLUSION

Elevated-quality honey has a variety of positive nutritional and health effects. The quality of honey depends on its floral origin and chemical contents. Honey has been consistently included in the diet for not only the nutritional aspects but also for the health properties. The main components of nutrition and health are carbohydrates, which makes them an excellent source of energy, especially for children and athletes. Honey is healthy, nutritious and functional food. Except for the nutritional value, it inhibits many other organisms that cause food spoilage. Since it has a high efficiency in antioxidants, it is preferred not only for direct exhaustion but also as supportive or preservative in foods. To take advantage of the miracles of honey you must avoid honey tricks. The quality and consumption of honey should be increased. Adulteration of honey, decreases yield of honest

producers and it also has negative results on consumers' nutrition and truth.

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