International Journal of Advance Interdisciplinary Research
Vol. 2, Special Issue 1, (Jan-March) 2026, pp. 250-256, e-ISSN: 3107-913X
DOI: https://doi.org/10.66095/ijair.2026.v2.S1.27

Honey-Derived Phytochemicals, their Composition, Activity, and Biomedical Relevance

Akanksha Yadav, Aparna Sharma and Shashi Bala*
Department of Chemistry, University of Lucknow, Lucknow
***E-mail: shashi27622@gmail.com**

Abstract: Honey, which were known as natural sweetener and also reported for various compounds like flavonoids, phenolic acids, glucose, fructose and also used as medicines. In given article, the chemical constituents and their role in treatment of various diseases like cancer, diabetes etc. was discussed. This review gives a framework for understanding that honey can work as a multifunctional chemical system and can be utilized in analytical, material, and applied chemical research.

Keywords: Honey, Flavonoids, carbohydrates, anticancer, antidiabetic

1. Introduction:

From million years ago, the history of honey spans with humans and honeybees interwoven in a beautiful journey dating back. It started from the primitive collection of wild honey by our ancestors to the well-trained practices of beekeepers and honey production today, honey is now played diverse roles in various cultures and civilizations [1]. It was classified as natural sweetener, in religious rituals and traditional medicines. Additionally, it contains cellulose, sugar, starch, and oligosaccharides [2-6]. Though, many different biological functions were known, carbohydrate play a prominent role as structural elements in organisms (such as cellulose in plant cell walls and chitin in arthropod exoskeletons), are essential for supplying and storing energy (as seen in molecules like glucose and glycogen), and support cell signaling and recognition processes through substances like glycoproteins and glycolipids. Examples include cellulose, starch, and glycogen, which are either structural components or molecules that store energy in cells [7-9]. A naturally occurring sweet material, honey is produced by honeybees (*Apis mellifera*) by transforming nectar collected from flowers or plant secretions. Naturally, honey is a naturally occurring, viscous, sweet liquid that honeybees make from blossom nectar which collected by them from their natural habitats. It is regarded as a high-energy food since it is a highly concentrated source of carbs, accounting for 82–85% of its overall makeup [10].

Herein, we are going to discuss the nutritional value, chemical constituents of honey and their role in various pharmacological and biological activities like antibacterial, antioxidant,

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anticancer, antidiabetic properties on in vivo and in vitro studies. This review will also include use of honey in green synthesis of various nanoparticles and their applications.

2. Composition of honey:

Due to its complex chemical composition, diverse biological roles, and new medicinal uses, scientific interest in it has increased significantly in recent years. Honey, contains various class of compounds which were reported for various functions, as given in table 1.

Table: 1

Major Constituents	**Category**	**Function of constituents Significance**
Fructose, glucose, sucrose, maltose	Carbohydrates	Primary energy source, low-to-moderate glycemic response
Gluconic acid, acetic acid	Organic acids	
Proline, lysine, enzymes	Proteins & amino acids	Nutritional value, enzymatic activity
Invertase, glucose oxidase, catalase	Enzymes	Antioxidant and antibacterial effects
Vitamin C & B-complex,	Vitamin	For antioxidant property and metabolism in cell
Gallic acid, Chrysin, Quercetin	Flavonoids and phenolic acid	Anti-inflamatory, wound healing and anticancer activities

Twenty-two different types of sugars have been found and measured in honey. The four monosaccharides that make up these are glucose, fructose, mannose, and rhamnose. Eleven disaccharides—sucrose, trehalose, turanose, maltose, maltulose, palatinose, melibiose, isomaltose, gentiobiose, nigerose, and kojibiose, were also found. Seven trisaccharides, including raffinose, isomaltotriose, erlose, melezitose, maltotriose, panose, and 1-kestose, are also found in honey [11]. In addition to being influenced by weather, handling, packing, and storage duration, these components also depend on the color, flavor, environment, and place of origin [12].

Honey kept in special category of food due to its high-energy food because it contains a high concentration of sugars, which account for 82–85% of simple sugars, especially fructose (about 38%) and glucose (about 31%), make up the majority of the carbs in honey. These two sugars together account for around 70% of honey's total sugar composition. The flavor,

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texture, and rate of crystallization of honey are all influenced by the ratio of fructose to glucose. For example, a higher fructose percentage produces a smoother consistency and a sweeter taste, while a higher glucose level increases the chance of crystallization. Additionally, it contains lower amounts of disaccharides like sucrose (about 1-2%) and maltose (about 7%). Honey contains small levels of oligosaccharides, such as isomaltose, turanose, and other complex sugars, in addition to monosaccharides and disaccharides (around 3–5%) [13].

Flavonoids are one of the main bioactive elements in honey that support its potential for medicinal use [14]. The main phenolic compounds in honey are flavonoids and phenolic acids, which both greatly enhance the antibacterial, anti-inflammatory, and antioxidant qualities of honey. These substances serve as free radical scavengers, reducing oxidative stress and enhancing the health advantages of honey. Depending on a number of variables, including soil type, climate, bee species, and floral source, honey's phenolic chemical content and diversity can vary greatly. Generally speaking, darker honeys have more phenolics than lighter ones, which is frequently associated with increased antioxidant activity. Honey's medicinal potential and use as a naturally occurring food rich in antioxidants are both influenced by phenolic chemicals, which are essential to its functional qualities [13,15].

3. Biological activity in honey:

We know that honey has a variety of biological actions that support its many medicinal benefits. One of its main benefits is its strong defense against free radicals, which helps protect cells and vital biological molecules from the damage caused by oxidative stress, which is a major cause of aging and a number of chronic diseases. Furthermore, studies have demonstrated honey reported for various properties like; anti-inflammatory, anti-cancer, and immune-regulating agent [16-18], which discussed as follows:

3.1 Antioxidant activity presence in honey:

Flavonoids, phenolic acids, enzymes (including catalase and glucose oxidase), ascorbic acid, and carotenoids are among the bioactive substances that contribute to honey's antioxidant potential. These antioxidants protect cellular components including lipids, proteins, and DNA from potential harm by reducing oxidative stress and neutralizing free radicals. Furthermore, honey may regulate lipid metabolism and prevent inflammation brought on by hyperglycemia, supporting, overall metabolic balance in diabetic situations. Many of the ingredients in honey include antioxidant qualities, which can help reduce oxidative stress,

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which is known to have a role in cancer formation. Research has shown that honey can inhibit angiogenesis, prevent cell growth, and promote apoptosis (programmed cell death) in a range of cancer cell types. It can also affect important molecular pathways involved in tumor growth and metastasis and modify the immune response. Honey shows promise as a natural, supplementary medicine in cancer treatment and prevention through these processes [19-21].

3.2 Anti-cancer activity presence in honey:

The key factor contributing to honey's capacity to combat cancer is its high concentration of healthy substances like flavonoids and phenolic acids, which are essential in halting the formation of tumors and the spread of cancer. It has been shown in earlier literature reviews to have antimetastatic, antiproliferative, and general anticancer properties, especially in colorectal and breast malignancies. Notably, honey exhibits selective toxicity toward cancer cells while sparing healthy, normal cells, indicating that it may be used in conjunction with traditional cancer treatments as a therapeutic or supportive agent [22].

3.3 Anti-fungal activity presence in honey:

Honey's complex chemical makeup and numerous bioactive chemicals are responsible for its strong antifungal action. High sugar concentration, low water activity, acidic pH, and the presence of hydrogen peroxide, phenolic compounds, and flavonoids are the main factors contributing to its antifungal properties. These elements produce an atmosphere that prevents the growth and reproduction of fungi. Due to its high sugar content, honey has an osmotic impact that causes microbial cells to lose water, which inhibits growth and causes dehydration. Honey's antifungal properties are further enhanced by the enzymatic production of hydrogen peroxide by glucose oxidase, which damages fungal cell walls and disrupts vital cellular functions [23].

3.4 Anti-microbial activity presence in honey:

Worldwide, antimicrobial medicines are essential for managing and preventing infectious infections. Honey's antibacterial properties stem from a number of interconnected physicochemical and biological elements. It has an osmotic impact that dehydrates and inhibits the growth of bacteria and fungi due to its high sugar content and low water activity. Furthermore, the pH of honey, which is normally between 3.2 and 4.5, makes it an unfriendly environment for the majority of harmful microorganisms [24].

3.5 Antidiabetic activity presence in honey:

Flavonoids, phenolic acids, and oligosaccharides are among the distinct bioactive substances found in honey that have been shown to have antidiabetic properties. It is made mostly of natural sugars, mainly glucose and fructose, which have a lower glycemic reaction than processed carbohydrates. When taken in moderation, honey also improves insulin sensitivity and encourages better glycemic management. These substances have antioxidant qualities that may preserve pancreatic β-cells, improving insulin production and sensitivity, and aid in reducing oxidative stress, a key factor in problems from diabetes mellitus [25].

4. Future aspects for uses of honey as medicine:

Honey, which were used as medicines since long time for purpose of taste, as medicine due to its various properties and presence of different compounds but here is a need to develop a method or any product in which can be use for treatment of diseases in form of nanoproducts. Besides this, we should discover the novel compounds which can be isolated from honey sample and undergo for screening of their biological activities like antidiabetic, antioxidant, antimicrobial properties etc.

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