

THE EVALUATION OF SUNFLOWER (*HELIANTHUS ANNUUS* L.) HONEY FOR APITHERAPEUTIC PURPOSES – A REVIEW

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ABSTRACT

Sunflower honey, one of the essential flower honey, is also produced from the nectar of the sunflower plant. Sunflower (*Helianthus annuus* L.) honey is a sweet food made by bees using nectar from flowers and is a good source of natural dietary antioxidants. This review highlights the need for further scientific investigation to present the full potential of sunflower honey and its wider use in modern medicine. Sunflower (*Helianthus annuus* L.) honey, as a valuable monofloral honey type, has significant potential for apitherapeutic applications due to its unique and complex composition and bioactive properties. Its antioxidant, antimicrobial and anti-inflammatory effects suggest a promising role in disease prevention and as a complementary treatment option for various health conditions.

Key words: Sunflower honey, apitherapy, physicochemical properties.

Introduction

Sunflower (*Helianthus annuus* L.) is a significant oilseed crop cultivated worldwide for its versatile uses in the food, industrial, and pharmaceutical sectors (Giannini et al., 2022). It has been reported that sunflower (*Helianthus annuus* L.), a member of the Compositae family, has several uses for oil extraction and use as animal feed (Ardiarin et al., 2021). Beside of these benefits, it is a very good nectar source for honey bees for honey production. This review highlights the need for further scientific investigation to present the full potential of sunflower honey and its wider use in modern medicine. It can be stated that the medical use of sunflower honey, one of the important monofloral honey sources we have discussed in this review, and its properties that can be used for apitherapeutic purposes such as disease prevention and support in treatment, should be supported by scientific in vivo research on patients.

Honey

As known, honey is the natural sweet substance produced by honey bees from the nectar of plants or from secretions of living parts of plants or excretions of plant-sucking insects on the living parts of plants, that bees collect and transform by combining it with specific substances of their own and leave in honeycomb to ripen and mature (Anonymous, 2001). Honey has been used in the food industry and medicinally since ancient times (Alvarez-Suarez *et al.*, 2010; Truzzi *et al.*, 2014). It is reported that honey bees produce flower honey from the nectar of plants such as acacia, cotton, citrus, sunflower, clover, and thyme. In contrast, honey bees produce secretion honey by collecting the secretions of insects living on plants or the secretions produced by plants for self-protection and converting them into honey with various enzymes (Çınar and Ekşi 2012; Yiğit, 2024). Although the botanical origin of honey is determined by melissopalynology, the identification and quantification of pollen grains present in honey, physicochemical analyses are performed in addition to pollen analysis to determine the exact origin of honey and improve honey characterization (Truzzi *et al.*, 2014). Monofloral honey contains above of 45% pollen from one plant (Melliou and Chinou, 2011). Honey contains almost 200 distinct ingredients. Honey is a functional food that is nutrient-dense, easy to digest and has therapeutic and preventive qualities against a variety of ailments since it contains organic acids, vitamins, flavonoids, minerals, amino acids, phenolic acids and enzymes (Mutlu *et al.*, 2017; Yücel *et al.*, 2017). Honey's chemical composition differs depending on its botanical and geographic origin. Yet according to Öztürk *et al.* (2015) and Yücel *et al.* (2017), honey is made up of both macro and micro components, including carbohydrates (82%), water (17%), minerals (0.7%), protein (0.3%), vitamins, phenolic compounds, free amino acids and organic acids. Due to this strong variation in its structure, honey has significant cytotoxic activity against a broad spectrum of bacteria. Pathogenic bacteria such as *Escherichia coli*, *Salmonella typhimurium*, *Staphylococcus aureus*, *Micrococcus luteus* and *Klebsiella pneumonia* have been widely used to demonstrate the effectiveness of honey varieties in treating wound infections. Honey primarily contains phenolic and flavonoid compounds such as cinnamic acid, oleic acid, gallic acid, syringic acid, chlorogenic acid, ferulic acid, caffeic acid, myricetin, coumaric acid, hesperetin, isorhamnetin, quercetin, chrysin, luteolin, galanin, and kaempferol, it is a very powerful antioxidant as well. Honey's in vitro antioxidant activity has been extensively studied, demonstrating its antioxidant properties and abundance of antioxidants.

Sunflower Honey

Sunflower honey, one of the essential flower honey, is also produced from the nectar of the sunflower plant. Sunflower (*Helianthus annuus* L.) honey is a sweet food made by bees using nectar from flowers and is a good source of natural dietary antioxidants.

Physicochemical properties of sunflower honey

Sunflower honey can be produced where the *Helianthus* species are cultured (Şahin, 2021^b). Sunflower honey is known for its bright yellow to orange color which is attributed to the presence of pollen and specific flavonoid compounds such as pinocembrin and quercetin (Sabatier *et al.*, 1992). The color of this honey not only differentiates it visually but also relates to its floral origin and quality, as seen in studies of honey from regions like Turkey, where its distinctive yellow tint is one of its defining features (Duru *et al.*, 2023). The color intensity of sunflower honey often correlates with factors like antioxidant content and phenolic compounds, which are typical for this type of honey and contribute to its appeal and health benefits (Terrab *et al.*, 2003). This distinct

color is an essential characteristic that helps classify and ensure sunflower honey's authenticity in the market. Sunflower honey also has a pleasant flavor and unique scent (Sari and Ayyıldız, 2012).

Botanical origin significantly influences honey's physicochemical characteristics and antioxidant properties, with sunflower honey having the highest moisture, flavonoids, and HMF, and multifloral honey having the highest total sugar content (Vijan *et al.*, 2023). The primary sugars in sunflower honey include glucose and fructose, with mean values of 33.3% and 39.8%, respectively. Other sugars like maltose and sucrose are also present (Dobre *et al.*, 2012). Sunflower honey contains various minerals, including potassium, sodium, zinc, iron, calcium, and copper. The mineral content can vary significantly depending on the floral origin and region (Nanda *et al.*, 2003). Sunflower honey has a generally low water content, averaging around 16.87%, which helps ensure stability during storage and slows down microbial growth (Živkov Baloš *et al.*, 2021). Its pH level is acidic, typically around 3.64, which can enhance its shelf life and antimicrobial qualities (Živkov Baloš *et al.*, 2021). The honey has a high diastase activity, indicating minimal processing and good quality, and it also contains a notable antioxidant content that adds nutritional value (Sari and Ayyıldız, 2012). Furthermore, raw sunflower honey is one of the quickest kinds of honey to crystallize. It accomplishes this quickly, creating a solid, fondant-like texture of tiny crystals with a refreshing taste (Srinual and Pilairuk, 2009). This implies that pouring raw sunflower honey into consumer packaging is challenging, labor-intensive, and time-consuming, so some of the purest and best sunflower honey are also some of the most expensive (Milica *et al.*, 2021).

It has been reported that the rapid hardening (crystallization) of sunflower honey causes bees to be unable to consume it and to die on honey frames (Doğaroğlu, 1987). Honey crystallization varies according to storage time, temperature, and botanical origin (Smanalieva and Senge, 2009). Crystallization in honey is common in many honey types, especially those containing glucose relative to high fructose, and it has been reported that exposure of crystallized honey to excessive heat can cause severe deterioration in quality. A study in Thailand found that consumers moderately liked crystallized sunflower honey, but consumer preference dropped significantly when 25% of the honey content crystallized (Srinual and Intipunya, 2009).

Sunflower honey contains identifiable pollen, characterized by specific proteins and a distinct nutritional profile. The pollen contributes to the honey's authenticity, medicinal properties, and physical characteristics like crystallization behavior. Sunflower honey can be authenticated using techniques like melissopalynology and ELISA based on pollen content. Pollen content can be as high as 30% in honey samples, and specific proteins from sunflower pollen can be detected to confirm floral origin (Baroni *et al.*, 2004). Sunflower pollen contains a relatively low protein content compared to other pollens, with essential amino acids like methionine and tryptophan sometimes below honeybee requirements. Proline, glutamic acid, and aspartic acid are among the major amino acids in sunflower pollen (Dabija, 2010; Nicolson and Human, 2012). Sunflower pollen exhibits anti-parasitic properties, effectively reducing pathogen loads in bees, including *Crithidia bombi* and *Nosema ceranae*. This suggests that sunflower pollen contributes to the overall health of pollinators and may add medicinal value to sunflower honey (Giacomini *et al.*, 2018). The presence of sunflower pollen influences the crystallization process of honey. Sunflower honey typically has a lower fructose-to-glucose ratio, which correlates with faster crystallization compared to other honey types (Escuredo *et al.*, 2014). In a recent study, Živkov Baloš *et al.* (2023) evaluated the physicochemical parameters of sunflower honey during storage, focusing on changes in its quality and stability over

time. Their findings highlighted the importance of proper storage conditions in preserving the therapeutic potential of honey, particularly its physicochemical parameters such as pH, moisture content, electrical conductivity and enzymatic activity. The study showed that after 18 months of storage at room temperature, there can be a significant decrease in diastase activity and pH. In general, this can potentially reduce the bioactive properties of honey.

Biological properties

Sunflower (*Helianthus annuus* L.) honey is attracting attention for its potential apitherapeutic properties, combining the nutritional and medicinal benefits of honey with unique bioactive compounds. Sunflower honey is a good source of natural dietary antioxidants. It has significant total phenolic content and exhibits potent antioxidant and antiradical activities, as determined by methods like the Folin-Ciocalteu, DPPH, and phosphomolybdenum assays (Sari *et al.*, 2012). Sunflower honey has antioxidant properties due to flavonoids, phenolic acids, and ellagic acid, which are suggested as chemotaxonomic markers for sunflower, heather and citrus honey (Aydoğan-Coşkun *et al.*, 2020). Sunflower honey contains powerful antioxidants in the form of phenolic and flavonoid compounds. Predescu *et al.* (2015) studied total phenolic and total flavonoid content of sunflower honey samples from Romania. Their results for total phenolic content are similar to other studies (Bertoncelj *et al.*, 2007). Honey quality and potential therapeutic benefits can be assessed by measuring its total phenolic content. Furthermore, these phenolic compounds are crucial for the honey's bioactivity and health benefits (Guzelmeric *et al.*, 2020). Sunflower honey has antimicrobial properties, effectively inhibiting the growth of mixed microbial associations and various pathogens, possibly due to its phytoncide content (Romanishina *et al.*, 2022). Sunflower honey shows anti-inflammatory properties and enzyme inhibitory activities, such as against COX-1 and COX-2 enzymes, which are linked to inflammatory processes (Duru *et al.*, 2023).

Benefits of Sunflower Honey for Apitherapeutic purpose

Honey is an important energy source for the human body due to its sugar content, and it is also vital for health because of some secondary components, such as phenols (Monica and Cornelia, 2017). Although the composition and properties of honey vary depending on the flower species visited by bees, regional and climatic conditions, and beekeeping practices (Azaredo *et al.*, 2003; Mărghițaș *et al.*, 2009; Truzzi *et al.*, 2014), it has been reported that the physicochemical properties of honey from the same flower source may vary to some extent due to different climatic conditions or different geographical origins (Anklam, 1998; Juan-Borrás *et al.*, 2014). According to studies, sunflower honey is rich in macro and micro components such as phenolic compounds, vitamins, free amino acids, and organic acids. These factors have highlighted honey's antimicrobial and antioxidant properties, as well as its positive effects on the digestive system and its ability to eliminate tumors and cancerous cells (Mutlu *et al.*, 2017). Minerals such as magnesium, calcium, and potassium are essential for healthy bones and muscles. In particular, it is used for coughs, sore throats, and colds thanks to its soothing and softening action on the respiratory track and enhanced immunity.

Sunflower honey has strong antiviral, anti-inflammatory, antiparasitic, antitumor and antimutagenic effects like other honey (Karadal and Yıldırım, 2012). It has been emphasized that honey can prevent wound infection, digestive problems, eye inflammation, and H₂O absorption in case of diarrhea and that honey contains a high osmotic pressure that can draw H₂O from bacterial cells, causing them to die rapidly (Chanchao *et al.*, 2006).

Like all types of honey, sunflower honey has numerous health benefits. It is rich in vitamins, minerals, and antioxidants, it helps strengthen the immune system and fight infection. The presence of B-group vitamins promotes energy production and the proper functioning of the nervous system. Its antioxidants effectively fight free radicals, contributing to an anti-inflammatory lifestyle. Antioxidant compounds that help protect the body's cells against damage caused by free radicals. Also, sunflower honey is perfect for lowering cholesterol thanks to phytosterols. Therefore, sunflower honey supports health conditions. Not only that, this honey has the ability to remineralize, i.e., a natural mineral salt supplement rich in calcium and magnesium, and therefore recommended for all people with weak bones or who have risk factors for osteoporosis. Also, sunflower honey has a protective effect for Alzheimer's and neurodegenerative diseases (Mateescu, 2016; Şahin, 2021^a).

One of the most important properties of sunflower honey is its antibacterial activity. It was emphasized that honey can be used as a source of bioactive compounds with the potential to treat bacterial pathogenic infections. In the analysis of Eucalyptus, Sunflower, and commercial honey (Qurshi Honey Gold), all honey samples showed maximum inhibition zones against *Klebsiella pneumoniae* at 100% concentration, and inhibition zones against *Serratia marcescens* at the same concentration while eucalyptus and sunflower honey showed 24.33±4.04 mm, 36.3±1.5 mm, 32.00±1.00 mm, and 27.2±1.53 mm against *Staphylococcus aureus* and *Pseudomonas aeruginosa*, respectively (Awan *et al.*, 2014). These studies showed that honey could be a cost-effective source of bioactive compounds that could treat bacterial pathogenic infections. Sunflower, astragalus, chestnut and citrus honeys showed the highest activity against *Salmonella typhimurium* under heat and light-free storage conditions (Engin *et al.*, 2022). In a study conducted in Egypt, it was reported that sunflower honey showed antibacterial activity against *Escherichia coli* and *Salmonella typhimurium* (El-Sofany *et al.*, 2018). In a study for *Staphylococcus aureus*, *Serratia marcescens*, *Rhodococcus equi*, *Listeria monocytogenes*, it was reported that forest meadow honey showed the best antibacterial activity (minimum inhibitory concentration: 6.25%), followed by sunflower honey (minimum inhibitory concentration: 12.5%) and acacia honey (minimum inhibitory concentration: 25%) (Đurović *et al.*, 2022). In the study, H₂O₂ in sunflower honey was 37.2 ± 20.6 µg/g honey and *Pseudomonas aeruginosa* was less sensitive to the antibacterial activity of honey compared to *Staphylococcus aureus* (Farkasovska *et al.*, 2019). In the study on the antimicrobial activity of organic sunflower honey samples in Serbia, it was found that all bacteria (*Escherichia coli*, *Staphylococcus aureus*, *Salmonella enterica*, *Bacillus subtilis* and *Yersinia enterocolitica*) showed significant zones of inhibition at honey concentrations of 40 – 100%, which is a satisfactory result for flower honey (Milosavljević *et al.*, 2021). Ten honey samples from Romania including sunflower were tested to determine their antibacterial properties against *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Escherichia coli*, *Bacillus cereus*, *Bacillus subtilis*, *Pseudomonas aeruginosa*, *Salmonella enterica* serovar *Typhimurium* and *Listeria monocytogenes*. The bacterial strains are isolated from patients in hospital with different kind of infections. The minimum inhibitory concentration (MIC) of sunflower honey is 3.12% and inhibition zone ranging from 14 to 18.5 mm diameter for the all bacterial strains. The polyfloral and sunflower honey samples demonstrated a pronounced antibacterial effect against *Listeria monocytogenes* (Junie *et al.*, 2016). Sunflower honey also has antibacterial activity against respiratory tract pathogens such as *Haemophilus spp.*, *Pseudomonas aeruginosa*, and *Streptococcus pneumoniae* (Balázs *et al.*, 2021).

In a recent study Gruznov *et al.* (2024) studied the antibacterial activity of linden, buckwheat and sunflower honey. The antimicrobial activity of sunflower honey against *Staphylococcus aureus* (with an average inhibition zone diameter of 20 mm) has been demonstrated, as its ability to suppress the growth of *E. coli* (18 mm) and *Bacillus cereus* (12 mm). The honey samples stored at 5 and 0°C exhibited the most pronounced inhibitory effect. The antibacterial effect can be attributed to the low pH, high osmolarity, and the presence of hydrogen peroxide, which is a natural byproduct of honey's enzymatic activity.

Manuka honey as a monofloral honey has been studied for its antimicrobial activity and unique properties (Johnston *et al.*, 2018). Anthimidou and Mossialos (2013) studied antibacterial activity of Greek and Cypriot honeys using agar diffusion assay against *Staphylococcus aureus* and *Pseudomonas aeruginosa* in comparison to manuka honey. Their minimum inhibitory concentrations (MICs) ranged from 6.25% to 25% (v/v) compared to 12.5% (v/v) for manuka honey. In recent study Wadi (2022) established antibacterial activity of 32 honey samples including sunflower honey against 8 clinical isolates including *Staphylococcus aureus* and *Pseudomonas aeruginosa*. The author concluded that antibacterial activity is influenced by different factors. Some of them do not depend on the floral origin. The antibacterial potency of Manuka honey was found to be related to the Unique Manuka Factor (UMF) rating. Manuka honey generally has higher antibacterial activity. It contains a high concentration of methylglyoxal. It is regarded as the primary antibacterial component in Manuka honey (Albaridi, 2019).

Sunflower honey has antiproliferative activity against the growth of selected human cancer cell lines such as breast (MCF7), cervix (HeLa) and colon (HT-29). $IC_{50}^{MCF7} = 27.7 \pm 1.95$ mg/mL $IC_{50}^{HeLa} = 24.8 \pm 0.28$ mg/mL, $IC_{50}^{HT-29} = 35.6 \pm 2.68$ mg/mL and $IC_{50}^{MRC-5} = 20.7 \pm 2.56$ mg/mL (Sakac *et al.*, 2022).

Since honey is a natural product, it is critical to understand the impact of bee species, geographical and botanical origin, processing, and storage on its antifungal properties. The most common infectious fungal infections affecting humans are cutaneous fungal infections or dermatomycoses. The common etiologic agents of dermatomycoses are dermatophytes and keratinophilic fungi called *Candida albicans*. Dermatophytes are divided into three genera: Trichophyton, Microsporum and Epidermophyton. The difference in floral sources can lead to differences in the properties of honey, including its constituents and antimicrobial properties. In the study for *Trichophyton mentagrophytes*, *Trichophyton mentagrophytes*, *Candida albicans*, *Epidermophyton floccosum* and *Microsporum gypseum* sunflower honey gave the minimum inhibitory concentration of 0.42, 0.25, 0.58, 0.25 in the order of test (Batac *et al.*, 2020).

Sunflower honey's anti-inflammatory properties make it effective for wound healing and alleviating inflammatory conditions. Topical application has shown potential in accelerating tissue regeneration and reducing swelling in skin injuries. Iosageanu *et al.* (2024) studied the effect of honey on the inflammatory phase of wound healing. Tumor necrosis factor alpha (TNF- α) secretion was slightly stimulated (854.21 – 870.81 pg/mL) by sunflower honey and multifloral honey.

The depletion of the neurotransmitter acetylcholine, which is degraded by the enzyme acetylcholinesterase, has been highlighted as a factor in the etiology of Alzheimer's disease. For this aim, anticholinesterase activity was found in all sunflower honey that was gathered from wholesalers throughout Turkey and four different districts of the province of Adana. Acetylcholinesterase and butyrylcholinesterase were inhibited by honey samples made in a controlled dose-dependent manner in the range of 28.33 – 34.86% and 27.57 – 39.75%, respectively, at 10 mg/mL. Nonetheless,

samples of sunflower honey from different wholesalers had concentrations of 14.77 – 21.36% and 14.18 – 23.64%, respectively. Compared to samples produced under control, the anticholinesterase activity of processed sunflower honey samples was either lower or nonexistent. It has also been reported that the filtration process and the honey sample's shelf life may impact the enzyme inhibitory activity and that conditions like honey processing and storage also impact the honey's composition (Şahin^b, 2021).

In vitro antioxidant, anti-inflammatory, anticholinesterase, anti-tyrosinase, anti-urease, antimicrobial, anti-tyrosinase and anti-quorum sensing activities and phenolic profiles analysis of sunflower honey samples collected from 7 different cities of Turkey showed that the samples had significant anti-inflammatory, anti-quorum and antioxidant sensing activities and all sunflower honey had significant anti-inflammatory, anti-quorum and antioxidant sensing activities. It has also been determined that samples from Havza and Vezirköprü in Samsun can be used against peptic ulcer, samples from Adana Seyhan and Çerkezköy and Muratlı in Tekirdağ and Pazar and Erbaa in Tokat can be used for melanoma (Emin Duru *et al.*, 2023). In the study conducted in Bulgarian sunflower honey, it was stated that it can be used in human health due to the presence of biologically active compounds (Balkanska and Shumkova, 2022).

Sunflower honey contains flavonoids such as quercetin, chrysin, and pinocembrin, which contribute to its therapeutic qualities, including anti-inflammatory, antioxidant and potential cardiovascular benefits (Sabatier *et al.*, 1992; Alvarez-Suarez *et al.*, 2013).

Sunflower honey has a moderate glycemic index (GI), largely due to its composition of sugars, primarily fructose and glucose, which affect how it influences blood sugar levels. Generally, honey varieties have GI values ranging from low to moderate (between 32 and 85, depending on floral sources), with the fructose-to-glucose ratio playing a critical role in determining these values (Bogdanov *et al.*, 2008). Sunflower honey contains phenolic compounds that deliver high antioxidant activity, which is beneficial for reducing oxidative stress and inflammation. This property is particularly useful in managing cardiovascular health by preventing lipid oxidation and improving endothelial function (Cianciosi *et al.*, 2018; Miguel *et al.*, 2017). Sunflower honey has demonstrated antibacterial effects, particularly against biofilm-forming respiratory bacteria. It effectively inhibits pathogens responsible for respiratory infections, highlighting its role in preventing bacterial growth and biofilm formation (Balázs *et al.*, 2021). Sunflower honey is rich in flavonoids like quercetin and chrysin, contributing to its therapeutic benefits. These compounds help reduce inflammation and oxidative stress, providing cardiovascular protection and enhancing immune response (Sabatier *et al.*, 1992). Studies show that sunflower honey inhibits lipid peroxidation, which may protect against cellular damage and slow the progression of chronic diseases. This is attributed to its effective radical scavenging abilities (Şahin, 2021^b).

Conclusion

Sunflower (*Helianthus annuus* L.) honey, as a valuable monofloral honey type, has significant potential for apitherapeutic applications due to its unique and complex composition and bioactive properties. Its antioxidant, antimicrobial and anti-inflammatory effects suggest a promising role in disease prevention and as a complementary treatment option for various health conditions. Despite its potential, particularly the in vivo studies and clinical trials needed to confirm its efficacy, safety

and mechanisms of action. The establishment of standardised protocols for its medical use, including dosage and quality control measures, will be essential for the integration of sunflower honey into the therapeutic practice.

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