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Review Paper

Probiotic and prebiotic properties of honey: a review

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ABSTRACT

Honey is widely recognized for its diverse health-promoting properties, including antibacterial, antioxidant, anti-inflammatory, antimutagenic, anticarcinogenic, and bacteriostatic effects. Additionally, it has been effectively utilized in the treatment of wounds and sunburns. The chemical composition of honey comprises a variety of minor bioactive constituents—such as enzymes, minerals, amino acids, polyphenols, and vitamins—alongside major components predominantly consisting of monosaccharides, namely glucose and fructose. The content of bioactive compounds in honey is largely influenced by the botanical origin of the nectar and the geographical location in which it is produced. Among its numerous health-promoting effects, honey exhibits notable antioxidant, anti-inflammatory, and antimicrobial properties. In recent years, increasing scientific attention has been directed toward the probiotic and prebiotic potential of honey. Studies have revealed the presence of lactic acid bacteria in honey, which are capable of producing bioactive metabolites that can persist in varying concentrations in mature honey. Additionally, honey contains oligosaccharides—recognized as prebiotic compounds—that promote the growth and activity of probiotic bacteria, while also enhancing their survival during gastrointestinal transit and product storage. Moreover, honey's antioxidant constituents are believed to play a crucial role as prebiotic agents by protecting and stimulating the viability of probiotic microorganisms. Therefore, the objective of this paper is to present recent scientific findings on the probiotic and prebiotic properties of honey, highlighting its potential as a functional food.

1. Introduction

Honey is a natural sweet substance produced by honeybees through enzymatic transformation of floral nectar or secretions. Since ancient times, honey has been used not only as a natural sweetener but also as a therapeutic agent. Its composition is highly complex and variable, comprising at least 181 distinct components (*Baltić et al*., 2023; *Alvarez-Suarez et al*., 2010). From a chemical point of view, it could be defined as a natural food mainly composed of sugars and water together with minor constituents, such as minerals, vitamins, amino acids, organic acids, flavonoids and other phenolic compounds, and aromatic substances (*Tafere*, 2021). These minor constituents confer the functional properties of honey, and can positively influence human health. Depending on the botanical origin of the nectar, honey can contain various antimicrobial and prebiotic compounds, positioning it as a functional food beneficial to both human and animal health (*Grabowski and Klein*, 2017).

The unique composition of honey provides a selective environment conducive to the growth and

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development of specific microorganisms. The natural microbiological and physicochemical characteristics of honey are influenced by its floral source, seasonal variability, climatic conditions, geographical origin, and processing methods (*Mărgăoan et al*., 2021; *Wright et al*., 2018; *Martinello and Mutinelli*, 2021; *Jia et al*., 2020). Thus, honey might contain fungi, algae, yeasts, and lactic acid bacteria (LAB) (*Olofsson et al.*, 2014a). The presence and activity of microorganisms in honey directly impact its safety and quality.

Owing to its unique composition, honey is classified as a functional food that, in addition to its nutritional value, could exert beneficial effects on human health. Recent studies have demonstrated that honey possesses antioxidant, hepatoprotective, hypolipidemic, hypoglycaemic, and anti-obesity effects, as well as anticancer, anti-atherosclerotic, hypotensive, neuroprotective, and immunomodulatory activities (*Afrin et al*., 2020; *Wusiman et al*., 2019). These health-promoting effects are largely attributed to honey's diverse nutritional constituents, including polysaccharides and polyphenols, which contribute significantly to it's bioactive properties. The characteristics and biological activities of honey can vary depending on its botanical and geographical origin. Furthermore, scientific evidence has confirmed the prebiotic properties of honey (*Schell et al*., 2022). Accordingly, the objective of this review is to present recent findings on the probiotic and prebiotic potential of honey, which may contribute to its growing application in health and nutrition.

In addition, a literature review was conducted to identify recent scientific findings on the probiotic and prebiotic compounds present in honey and their effects on human health. The reputable scientific database, *ScienceDirect*, was utilized for the search (Figure 1). The following keywords were applied individually and in various combinations as inclusion criteria for selecting articles relevant to this review: honey, prebiotics, and probiotics.

2. Probiotic properties of honey

Recent studies have demonstrated that honey can serve as a source of probiotic bacteria, primarily originating from the gut microbiota of honeybees, although environmental sources also contribute. Probiotics are live microorganisms and substances that contribute to the maintenance of intestinal microbial balance (*Mustar and Ibrahim*, 2022). The primary criteria for the selection of probiotic bacteria are resistance to gastrointestinal conditions; clear taxonomic identification at the genus, species, and strain levels along with their origin; antimicrobial activity; ability to adhere to the intestinal epithelium; interaction with the host's intestinal microbiota; and absence of pathogenicity and infectivity. Additional selection criteria encompass bile salt metabolism, lack of haemolytic activity, and absence of antibiotic resistance genes. From a safety perspective, probiotic

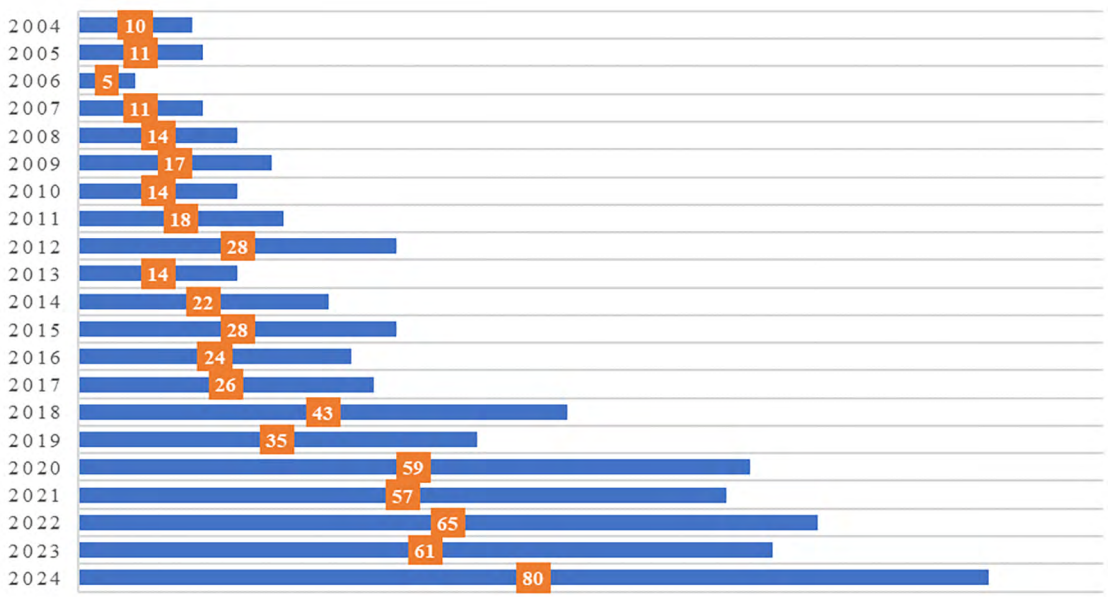

Figure 1. Number of published studies over the past 20 years (data retrieved from the ScienceDirect database using the search query "Probiotics and Prebiotics in Honey")

bacteria must be non-pathogenic, have no history of association with disease, not deconjugate bile salts or produce toxins, and must neither harbour nor transfer antibiotic resistance genes (*Schell et al*., 2022).

Recent studies have shown that lactic acid bacteria (LAB) are naturally present in the stomach of honeybees and are, therefore, introduced into honey during its production (*Suraiami and Nurliayana*, 2022). During the honey-making process, the enzyme glucose oxidase catalyses the conversion of glucose into gluconic acid, leading to the acidification of honey, which plays a crucial role in its preservation. This acidic environment inhibits the growth of most pathogenic and spoilage microorganisms. As a result of honey's acidity, the predominant microbial populations are yeasts and lactic acid bacteria. Among the LAB, several strains are recognized as probiotic microorganisms. The dominant probiotic bacterial populations belong to the genera *Lactobacillus* and *Bifidobacterium*. The most commonly species isolated from the stomach of the giant honeybee *Apis dorsata* include *Lactobacillus apis, Lactobacillus insectis, Lactobacillus alvei, Lactobacillus plantarum, Lactobacillus pentosus, Lactobacillus parabuchneri, Lactobacillus kunkeei, Lactobacillus kefiri* (*Tajabadi et al.*, 2011), and *Lactobacillus acidophilus*. Within the *Bifidobacterium* genus, novel species, such as *Bifidobacterium asteroides* and *Bifidobacterium coryneforme*, have also been identified in honeybees (*Olofsson et al*., 2014b). *Olofsson et al.* (2014b) reported the presence of different lactic acid bacterial strains originating from the gut of honeybees (*Apis mellifera*) in fresh honey. According to these authors, many of honey's unexplained therapeutic and antimicrobial properties may be attributed to these LAB symbionts. Their research also demonstrated that all tested LAB strains produced organic acids, albeit in varying amounts.

3. Prebiotic properties of honey

The beneficial effects of probiotic bacteria can be further enhanced by the presence of specific compounds, molecular groups, extracts, or functional ingredients in their environment—collectively referred to as prebiotics. Prebiotics are substances that beneficially affect the host by selectively stimulating the growth and/or activity of one or a limited number of probiotic bacteria in the colon (*Coppola et al*., 2025).

Honey oligosaccharides have potentially prebiotic activity. These compounds selectively stimulate the growth of beneficial microorganisms, such as *Lactobacillus* and *Bifidobacterium* (*Coppola et al*., 2025). *Sanz et al.* (2005) conducted a study on how honey oligosaccharide affects the bacteria population in human gastrointestinal tract and found honeys that contain higher amount of oligosaccharide resulted in prolific growth of beneficial bacteria. The main oligosaccharides in honeys were the disaccharides, turanose, nigerose, melibiose, sucrose, isomaltose and four trisaccharides, maltotriose, panose, melezitose, and raffinose. The highest amounts of maltulose and turanose (0.66–3.52 g/100 g and 0.72–2.87 g/100 g of honey, respectively) were in samples of honey from different regions of Spain and commercially available nectar and honeydew honeys. The trisaccharides, melezitose and panose, were the most abundant oligosaccharides in New Zealand honey (*Sanz et al*., 2005).

Bacteria from the *Lactobacillus* and *Bifidobacterium* genera are benefited in environments with low redox potential, and the presence of antioxidant compounds in honey is important in this regard. Flavonoids, amino acids, and phenolic acids are the main antioxidant compounds in honey. Most valuable and superior antioxidant compounds of honey, such as some phenolic compounds and glutathione, are unstable over time and thermolabile. Thus, its final quality is compromised when raw honey goes through conventional thermal processing (*Mustar and Ibrahim*, 2022). While it is well-documented that honey can positively influence gut microbial balance (*Mustar and Ibrahim*, 2022), the specific interaction between Rosaceae-type honey and probiotic *Lactobacillus* strains remains insufficiently explored. It can be hypothesized that the complex mixture of bioactive compounds in such honey varieties supports the growth of certain probiotic bacteria strains.

These findings are consistent with earlier studies that reported a stimulatory effect of honey on the growth of specific probiotic microorganisms. For instance, *Rosendale et al.* (2008) observed enhancements in the biological activity of *Lactobacillus* and *Bifidobacterium* species, including increased production of certain organic acids. Moreover, monofloral honeys have also been shown to promote the growth and activity of probiotic bacteria. Similarly, various types of *Eucalyptus* honey have been shown to stimulate the growth of *Lactobacillus plantarum* and *Lactobacillus rhamnosus*, while lime honey has been reported to influence the cytotoxicity of *Lactobacillus* strains cultured in its presence (*Abadi et al*., 2023).

4. Conclusion

Based on the literature review, there is a limited amount of experimental data on the probiotic and prebiotic properties of honey published within the last decade, highlighting a clear opportunity for further research. Additional studies are necessary to investigate probiotic strains in honey, with strong resistance to pathogenic microorganisms, intended for both human and animal consumption or as potential therapeutic agents.

A similar gap exists in honey prebiotic research, where the majority of studies have been conducted *in vitro*, typically using normal intestinal microorganisms derived from human faecal samples exposed to various concentrations of selected honey types. In conclusion, honey and honeybees—which show considerable potential as sources of probiotics and prebiotics—warrant greater scientific attention and more comprehensive investigation. Advancing this field of study could significantly contribute to the development of alternative therapeutic strategies, particularly against antibiotic-resistant pathogens.

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