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*Article*

# Antibacterial and Antioxidant Potency of Floral Honeys from Different Botanical and Geographical Origins

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**Abstract:** In order to assess their physicochemical and antioxidant properties as well as their antimicrobial potency, four varieties of honey from different botanical and geographical origins were used. The agar incorporation method was used to determine the antimicrobial potency of honeys. The total phenol content was determined by a modified Folin–Ciocalteu method and the free radical scavenging activity by the $Fe^{3+}$ reducing power (FRAP) assay. Manuka honey was the most effective against *Staphylococcus aureus* Oxa R and *S. aureus* Oxa S with a Minimum Inhibitory Concentration (MIC) of 6% and 7%, respectively, whereas wild carrot honey was the most effective against *Pseudomonas aeruginosa*, with a MIC of 12%. Lavender honey was the least effective against all tested strains, even though was found to have the lowest pH and water content. Manuka honey had the highest content of polyphenols, with 899.09 ± 11.75 mg gallic acid/kg, whereas lavender honey had the lowest, with 111.42 ± 3.54 mg gallic acid/kg. A very significant correlation ($r$ value was 0.9079 at $P < 0.05$) was observed between the total polyphenolic content and the $Fe^{2+}$ content formed in the presence of the honey antioxidants. The

differences between honey samples in terms of antibacterial and antioxidant activity could be attributed to the natural variations in floral sources of nectar and the different locations.

**Keywords:** honey; antibacterial; antioxidant

## 1. Introduction

It has been demonstrated in many studies that honey has antibacterial effects, attributed to its high osmolarity, low pH, hydrogen peroxide content, and content of other, uncharacterized compounds [1,2]. The low water activity of honey is inhibitory to the growth of the majority of bacteria, but this is not the only explanation for its antimicrobial activity. Molan [3] has studied sugar syrups of the same water activity as honey and found them to be less effective than honey at inhibiting microbial growth *in vitro*. Honey is mildly acidic, with a pH between 3.2 and 4.5. The low pH alone is inhibitory to many pathogenic bacteria and, in topical applications at least, could be sufficient to exert an inhibitory effect. When consumed orally, the honey would be so diluted by body fluids that any effect of low pH is likely to be lost [1]. Hydrogen peroxide was identified as the major source of antibacterial activity in honey [4]. It is produced by the action of glucose oxidase on glucose, producing gluconic acid. This is inhibited by excessive heat and low water activity [4]. The hydrogen peroxide concentration produced in honey activated by dilution is typically about 1,000 times less than in the 3% solution commonly used as an antiseptic [3]. More recently, a correlation has been established between the level of $H_2O_2$ and the degree of antimicrobial activity of honey. It was also suggested that $H_2O_2$ alone may not be sufficient to account for the antimicrobial activity [5]. There are a range of other, largely uncharacterized, substances present in some honeys that have antibacterial effects [6]. For example, manuka honey from New Zealand with nonperoxidal antibacterial activity has been found to be effective at a low concentration [7]. Antibacterial aromatic acids [8] and 10-HDA, the main royal jelly acid with antibacterial properties [9] have also been found in honey, as well as defensin-1 [10]. The strong antibacterial activity of manuka honey is due to the presence of the antibacterial substance methylglyoxal [11]. The antifungal activity of honey against *Candida albicans* has been reported in many studies [12–14].

Phenolic compounds are amongst the most important groups of compounds occurring in plants, and are found to exhibit anticarcinogenic, anti-inflammatory, antiatherogenic, antithrombotic, immune-modulating and analgesic activities and which may exert these functions as antioxidants [15–20]. The phenolic acids are generally divided into two sub-classes: the substituted benzoic acids and cinnamic acids, whereas the flavonoids present in honey are categorized into three classes with similar structure: flavonols, flavones and flavanones. These contribute significantly to honey color, taste and flavor and have beneficial health effects [21]. The composition of honey, including its phenolic compounds, is variable, depending mainly on the floral source and also other external factors, including seasonal and environmental factors as well as processing [22]. Thus, with different compositions of active compounds in honey collected from different locations, differences in honey properties are to be expected. Diastase numbers (DN), hydroxymethylfurfural (HMF), proline and sucrose are usually used as indicators of the ripeness and quality of honeys [22–24]. As not all honeys are created equal in