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REVIEW ARTICLE

Honey: A realistic antimicrobial for disorders of the skin

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Resistance of pathogenic microorganisms to antibiotics is a serious global health concern. In this review, research investigating the antimicrobial properties of honeys from around the world against skin relevant microbes is evaluated. A plethora of *in vitro* studies have revealed that honeys from all over the world have potent microbicidal activity against dermatologically important microbes. Moreover, *in vitro* studies have shown that honey can reduce microbial pathogenicity as well as reverse antimicrobial resistance. Studies investigating the antimicrobial properties of honey *in vivo* have been more controversial. It is evident that innovative research is required to exploit the antimicrobial properties of honey for clinical use and to determine the efficacy of honey in the treatment of a range of skin disorders with a microbiological etiology.

Introduction

In traditional medicine, honey has been recognized around the world for its skin-healing properties. The ancient Greeks and Egyptians, for example, used topical application of honey to treat skin wounds and burns, and Persian traditional medicine documented honey to be effective in the treatment of wounds, eczema, and inflammation.[1,2]

Microorganisms have been associated with the pathophysiology of a range of dermatological disorders. Wound infections, for example, are commonly caused by the microorganisms *Staphylococcus aureus*, *Pseudomonas aeruginosa*, and *Escherichia coli*, and infection with *S. aureus* is common in atopic dermatitis.[3,4] Another example is *Malassezia* yeasts, which have been associated with the skin conditions pityriasis versicolor, seborrheic dermatitis, atopic dermatitis, and psoriasis.[5] Conventional treatments for some of these conditions are unsatisfactory, e.g.,

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corticosteroids cause skin thinning and UV radiation therapy has been associated with the development of skin cancer.[6]

Scientists first reported the ability of honey to kill disease-causing microbes in the late 1800s, but with the advent of antibiotics in the early 1900s, scientific interest in honey waned.[7] Today, with the emergence of antibiotic-resistant microbial strains, such as methicillin-resistant *S. aureus* (MRSA)—a cause of difficult-to-treat wound infections and a global health concern, honey has again caught the attention of medical researchers.[7,8]

In clinical practice today, Manuka honey produced by honey bees (*Apis mellifera*) collecting nectar from the Manuka tree (*Leptospermum scoparium*) is used topically in the management of wound infections.[9] Products include gamma-irradiated honey in gels, ointments, and impregnated dressings. Revamil honey is another medical-grade honey commonly used in clinical practice for wound care.[10] It is produced in greenhouses by manufacturers in The Netherlands, but further details about the origin of this honey have not been disclosed.

In this review, research findings on the antimicrobial activities of honeys from around the world, against skin relevant microbes, are evaluated. Furthermore, mechanisms of the antimicrobial properties of honey are explored. The principal aim was to understand more about the therapeutic potential of honey as a treatment option for skin diseases with a microbiological etiology.

Antimicrobial properties of Manuka honey against skin relevant microbes: *in vitro* studies

The most widely researched honey, to date, is Manuka honey from New Zealand. Studies have shown that Manuka honey has antimicrobial activity *in vitro* against the most common wound-infecting microorganisms, including MRSA, *S. aureus*, *P. aeruginosa*, and *E. coli*.[11,12] Manuka honey can also inhibit the growth of *Streptococcus pyogenes*, a cause of cellulitis, impetigo, and necrotizing fasciitis, and the dermatophyte *Trichophyton mentagrophyte*, a cause of ringworm.[11,13] Indeed, Manuka honey has been shown to inhibit the growth of a range of dermatophytes, including *Epidermophyton floccosum*, *Microsporum canis*, *Microsporum gypseum*, *Trichophyton rubrum*, and *Trichophyton tonsurans*, indicating that honey may be a therapeutic in the treatment of dermatophytosis (tinea infections).[13] Studies have reported that *Candida albicans* is more resistant to Manuka honey than many other microbial species.[14,15] Manuka honey has also been shown to have antiviral activity *in vitro* against varicella zoster virus, suggesting that honey may be a therapeutic for viral skin rashes.[16] The antiviral properties of honey against other skin relevant viruses such as human papilloma virus may be worth investigating.

As the antimicrobial activity of honey varies not only between different types of honey but also between batches of the same type of honey, Manuka honey is often ascribed a unique Manuka factor (UMF). The UMF is a measure of the strength of the antibacterial activity of the honey against *S. aureus* and is calculated based on the concentration of a phenol solution that gives a similar zone of growth inhibition, in a radial diffusion assay, to the honey being tested. A criticism of the UMF classification is that it is a measure of activity against *S. aureus* only and not against other relevant microbes.

Antimicrobial activity of honeys from around the world against skin relevant microbes: *in vitro* studies

A plethora of scientific papers have reported *in vitro* antimicrobial activity of honeys from all over the world; some examples are discussed in this section.

Honey produced in South Gondar, Ethiopia, by the bee *Apis mellipodae*, a stingless bee, is used in traditional medicine in Ethiopia to treat a variety of diseases including skin infections.[17] Using the method of agar well diffusion, Andualem[17] demonstrated that this honey inhibited the growth of the wound-infecting microbes *E. coli* and *S. aureus* with minimal inhibitory concentrations (MICs) of 12.5% and 6.25%, respectively.

In a study by Pimentel et al,[18] honey samples collected from the stingless bee *Melipona compressipes manaosensis* in Manaus, Amazonas, Brazil, were active against *E. coli*, *S. aureus*, *Proteus vulgaris*, and *Klebsiella* species. Using agar well diffusion assays, it was demonstrated that honey collected during the rainy season inhibited the growth of *E. coli* only in the undiluted form, while honey collected during the dry season inhibited the growth of *E. coli*, *S. aureus*, and a range of other microbes at much more diluted concentrations. These results clearly show the influence of seasonality on the antibacterial activity of honey. Plant-derived factors or entomological factors such as the health of the bee colonies can be affected by seasons, with consequences for the antimicrobial activity of the honey produced. Researchers also compared the ability of honey to inhibit microbial growth evaluated by agar well diffusion with that assessed by a broth dilution assay, and found that the broth dilution assay was a more sensitive method, most likely due to better movement of the antimicrobial components of honey in liquid broth than in agar. Rutin, a flavonoid previously shown to have antibacterial activity, was identified in honey by high-performance liquid chromatography.

Kuncic et al[19] reported that Slovenian honeys from diverse floral origins had antibacterial activity against *E. coli*, *P. aeruginosa*, and *S. aureus*. Slovenian chestnut and pasture honeys were found to be most active; for example, the MIC of the chestnut honey against *S. aureus* was found to be 2.5%. *C. albicans* was not inhibited by any of the Slovenian honeys tested, and *Candida parapsilosis* and *Candida tropicalis* were inhibited only by honey of concentrations higher than 50%.

In other studies, the growth of *C. albicans* was inhibited by Jujube honey, a honey obtained from bee keepers in Albaha, Saudi Arabia, prepared by bees feeding on the plant *Ziziphus jujuba*, and by a mixture of honey, olive oil, and beeswax containing multifloral honey from the United Arab Emirates.[20,21] Such findings indicate the potential of some honeys for use in the treatment of skin disorders caused by *C. albicans* such as cutaneous candidiasis.

Tualang honey, obtained from bees (*Apis dorsata*) feeding on Tualang trees (*Koompassia excelsa*) in the jungles of Malaysia, was found to inhibit the growth of MRSA, *S.*