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Review on Medicinal and Nutritional Importance of Honey

Tizita Mamo[1*]

[1]Department of Food Science and Post Harvest Technology, College of Agriculture, Arsi University, P.O. Box 193, Ethiopia.

Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

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Review Article

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ABSTRACT

Honey is an organic natural substance that is produced from the nectar of flowers by *Apis mellifera* and is a sweet, flavourful liquid. Its composition and quality vary greatly with the botanical source of nectar as well as environmental and climatic conditions. These beneficial actions have been ascribed to its antimicrobial, anti-inflammatory and anti-oxidant potential. Honey contains sugars, organic acids, minerals, and proteins, enzymes and vitamins in trace amounts. The simple sugars in honey are responsible for its sweetness, hygroscopicity, energy value and other physical properties. Darker honeys to have higher concentrations of polyphenols, antioxidant and anti-inflammatory properties. Its greatest medicinal potential is its application as topical agent to wounds and skin infections.

Keywords: Medicine; wound.

1. INTRODUCTION

Honey is a natural substance of sweet flavour and viscous consistency produced by honeybees, especially by the species *Apis mellifera*. Honey was probably the first sweetener discovered by man, and its use dates back to the origins of mankind itself [1]. Natural medicinal products have been used for millennia in the treatment of multiple ailments. Although many have been superseded by conventional pharmaceutical approaches, there is currently,

**Corresponding author: E-mail: tizta19@gmail.com;*

resurgence in interest in the use of honey and honey products by the general public. This alternative branch of medicine is called apitherapy [2]. Honey is a natural substance produced, when the nectar and sweet deposits from plants are gathered, modified and stored in the honeycombs by honeybees of the genera *Apis* and *Melipona* [3,4]. Honeys produced by the honeybees, *Apis cerana indica* and *Apis mellifera*, in apiaries and collected by the modern extraction method are called apiary honey. They are transparent and free from foreign materials. In contrast, those produced by rock bee, *Apis dorsata*, or from wild nests of *A. cerana indica* in forests and collected by the crude method of squeezing the comb are known as forest honeys. They are turbid owing to the abundance of pollen, wax, brood (bee larvae), parts of bees, and plant materials. It is therefore necessary to filter the honey to separate the suspended particles [5]. Apparently, with the increasing interest in the use of alternative therapies coupled with the development of antibiotic-resistant bacteria, honey may finally receive its due recognition. Honey has been used for medicinal purposes for thousands of years [6]. The ancient Egyptians were known to use honey as an embalming agent and a wound dressing. It also has been used for the treatment of burns, wounds, and infections. Honey is rich in sugars such as glucose and fructose, but it also contains small amounts of vitamins, minerals, amino acids, and antioxidants such as phenolic acids and flavonoids. These nutrients help to make honey a unique, natural health product. Honey's greatest medicinal potential is its application as topical agent to wounds and skin infections [7]. Honey has anti-inflammtory, antioxidant and immune boosting property. Much of the therapeutic properties of honey are due to the high sugar concentration and the resulting osmotic effect [8], low pH and acidity [9] and due to hydrogen peroxide generated from the oxidative conversion of glucose to gluconic acid by glucose oxidase upon dilution [10]. Studies indicate that hydrogen peroxide takes the biggest credit for the medicinal value of honey. Honey applied to wounds, burns and ulcers promotes faster healing by clearing infections and rendering sterility, through promotion of tissue growth and regeneration, and preventing dehydration of the infected site [11-14].

2. FLORAL SOURCE

The floral source and geographical location from which bees harvest can greatly influence the composition and various characteristics of the honey [15]. Just as some fruits and vegetables contain higher levels of beneficial phenolic compounds, different honeys can have varying levels of these beneficial compounds. Honey is generally divided into two broad classifications, monofloral and multi-floral (wild-type) honeys. Monofloral is a loosely used definition but generally implies that the majority of the honey comes from a single floral source. The best way to confirm which floral source a honey is from is a method called pollen counting. This method determines the type and concentration of pollen in the honey. One can infer the source of the nectar used to produce the honey by determining the source of the pollen it contains. Many of the shelf-available honeys are a blend from floral sources (multi-floral) to achieve an ideal amber colour for consumer preference.

3. COMPOSITION AND PHYSICAL CHARACTERISTICS OF HONEY

Honey is essentially a highly concentrated water solution of two sugars: dextrose (glucose) and levulose (fructose), with small amounts of at least 22 other more complex sugars. Honey, also, contains minor constituents such as flavouring materials, pigments, organic acids, and minerals [16] .Glucose and fructose are the only monosaccharides in honey. It is these sugars combined in various forms that comprise the di- and trisaccharide fractions of floral honey [17] and [18]. Honey's sugar accounts for 95 to 99% of honey dry matter, and 85 to 95% of total sugars [10]. These simple sugars give honey its sweetness, hygroscopic properties, energy value, and other physical properties [16]. Honey contains various organic acids which contribute to its flavour complex. Because of its great sweetness, however, the acidity of honey is largely masked. According to [16], the most important acid in honey is gluconic acid, which is derived from dextrose. Other acids isolated from honey are acetic acid, butyric acid, citric acid, malic acid, formic acid, succinic acid, lactic acid and pyroglutamic acid, and inorganic acids such as phosphoric and hydrochloric acids. Honey consists of nitrogenous compounds such as enzymes and proteins in trace quantities. These groups comprise of enzymes and some other proteins. The enzymes originate from the salivary secretions of the worker bees, which plays an important role in the formation of honey [10]. The most important enzyme in honey is invertase (also known as saccharase or sucrase), which converts the sucrose of nectar into invert sugars:

dextrose and levulose found in honey. Another important enzyme in honey is diastase (amylase). Other enzymes reported in honey are catalase and phosphatase [16]. The amount of protein in honey ranges between 0.1 to 0.6% [16,19]. Generally, the relative quantity of proteins in honey compounds is considered a quality index. Honey contains vitamins [16] and phenolic compounds [20] and [19] in trace quantities. Some of the phenolic compounds in honey responsible for antioxidant effect are flavonols, flavones, flavonones, benzoic and cinnamic acids. The fact that honey is naturally a concentrated sugar solution gives its characteristic physical properties such as high grade viscosity,stickiness, sweetness, relatively high density, tendency to absorb moisture from the air, and immunity from spoilage [10,16].

4. COLOUR OF HONEY

Honey is often graded on a number of different properties such as water content, carbohydrate content, and colour. The types and concentration of beneficial compounds in honey can greatly influence the honey's colour [21]. Consumers tend to have strong preferences when it comes to honey colour. These are the result of both individual and cultural tastes. For example, American consumers tend to prefer lighter coloured honeys while German, Swiss, and Austrians often prefer darker varieties. According to [22], however, may be changing with the emergence of artisanal honeys and increased interest in rare and novel food products. According to [23] additionally, while colour is not a perfect predictor of flavour, it can be an important indicator of quality. Colour that deviates from expectations may indicate the intentional or unintentional addition of additives, processing errors, or contamination. Generally, darker honeys have been shown to have higher concentrations of polyphenols, and thus higher antioxidant and anti-inflammatory properties.

5. MEDICINAL USES OF HONEY

Honey has been used as medicine in many cultures for a long time [10]. However, it has limited use in medicine due to lack of scientific report. In recent days, honey is becoming acceptable as a reputable and effective therapeutic agent. Its beneficial role has been endorsed to its antimicrobial, anti inflammatory and anti-oxidant activities as well as boosting of the immune system. According to E. Haffejee [24], reported in the *BMJ* on a clinical study in which they used honey in oral rehydration solution in children and infants with gastroenteritis. They found that honey shortens the duration of bacterial diarrhea in infants and young children. There have been some cases in which people have reported positive effects of using honey in treating wounds. Hurlburt, a borderline diabetic, with recurring cellulitis and staph infections tried taking antibiotics for months. There is some research to suggest that honey may be useful in minimizing seasonal allergies. *The Guardian* reported that honey even 'beats cough medicine' at alleviating and reducing the frequency of cough. A study published in the journal *Microbiology* revealed that Manuka honey is effective at treating chronic wound infections and may even prevent them from developing in the first place. Natural honey better at killing bacteria than artificial honey - Kendall Powell wrote in the journal *Nature* that "natural honey kills bacteria three times more effectively" than an artificial honey solution of the same thickness and sugar concentration [25].

6. ANTIBACTERIAL ACTIVITY

Honey has proven antimicrobial activity [22]. Honey inhibits a broad spectrum of bacterial species. The alcohol extracts of honey exhibit an inhibitory effect to array of bacterial species including aerobes and anaerobes, Gram positives, and Gram negatives [23]. Honey has powerful antimicrobial effects against pathogenic and nonpathogenic micro-organisms (yeasts and fungi), even against those that developed resistance to many antibiotics. The antimicrobial effects could be bacteriostatic or bactericidal depending on the concentration that is used [26] .methanol, ethanol, and ethyl acetate extracts of honey exhibits in vitro antibacterial activity against Gram-positive bacteria (*Staphylococcus aureus, Bacillus subtilis, Bacillus cereus, Enterococcus faecalis, and Micrococcus luteus*) and Gram-negative bacteria (*Escherichia coli, Pseudomonas aeruginosa, and Salmonella typhi*) [23]. Honey has bactericidal effect against *P. aeruginosa* [27]. At Minimum Inhibitory Concentrations (MIC) of 9.5% (w/v), and Minimum Bactericidal Concentration (MBC) of 12% (w/v), honey exhibits bactericidal effect with a 5 log reduction estimated within 257 min. Honey with carbohydrate solutions ≥ 15% (v/v) effectively inhibits H. pylori [8]. *In vitro* tests of isolates of *Campylobacter spp.* are highly susceptible to honey solution [28]. [11], bacterial isolates from wounds of hospital patients: *Aeromonas schubertii, Haemophilius paraphrohaemlyticus, Micrococcus luteus,*

Cellulosimicrobium cellulans, Listonella anguillarum and Acinetobacter baumannii, exhibit sensitivity to solutions of honey at various concentrations ranging between 25% and 40%. Many bacterial pathogens have developed resistance to antibiotic introduced into clinical practice. Using a medical-grade honey, wound pathogens, including those with high levels of innate or acquired antibiotic resistance, were killed by 4.0–14.8% honey, which is a concentration that can be maintained in the wound environment. Resistance to honey could not be induced under conditions that rapidly induced resistance to antibiotics [29]. Methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-sensitive *enterococci* (VSE) isolated from infected wounds and 20 strains of *vancomycinresistant enterococci* shown sensitivity to honey at various concentrations [30]. Honey exhibits synergistic effect against MRSA [31], where, sub-lethal concentrations of manuka honey (6%w/v) have a marked effect in enhancing the susceptibility of Methicillin-resistant *Staphylococcus* aureus to Oxacillin, and reverses resistance developed against the drug. Progresses are made in enhancing the antibacterial efficacy of honey by combining with other ingredients. According to [32], medical grade honey enriched with antimicrobial peptides such as synthetic Bactericidal Peptide 2 (BP2) has rapid bactericidal activity against *Pseudomonas aeruginosa, Staphylococcus epidermidis, Enterococcus faecium, Burkholderia cepacia*, and methicillin-resistant *S. aureus (MRSA).*

7. ANTI-INFLAMMATORY PROPERTIES

Though honey has been used as a health product for thousands of years, only recently have studies been conducted to confirm its potential to help reduce inflammation [33]. Different varietal honeys have been tested to determine their capacity to reduce reactive oxygen species that contribute to inflammation. After application of honey to wounds and infections, the number of inflammatory cells was shown to be reduced, suggesting honey's benefits in wound treatment applications [34]. Honey's Sometimes there are detrimental events in the animal body that cause negative compounds (i.e., free radicals) to form. These compounds have been shown to cause damage to animal cells, damage that can contribute to the acceleration of cancer, cardiovascular disease, and other age-related diseases [35]. Phenolic compounds found in honey and other plant materials are known to have antioxidant capacities that can help eliminate or reduce free radicals in the body [36]. These compounds may help reduce the negative effects of free radical formation. These compounds also contribute to the taste and aroma of honeys. Phenolics are generally known to have a bitter taste and may be why some darker varieties of honeys, though thought to be more beneficial, are not preferred as a sweetener [37]. The anti-inflammatory activity of honey has been documented in clinical studies of human burn wounds and in *in vitro* studies [38]. The potential consequences of effectively managing inflammation include rapid reduction of pain, edema, and exudates; additionally hypertrophic scarring is minimized by avoiding protracted inflammation that may result in fibrosis [39]. Subsequently, reducing inflammation lessens exudates production and dressing change frequently, which may conserve resources in terms of dressings used, staff time, and unnecessary disturbance of the patient and the wound bed [40].

8. HONEY IN THE TREATMENT OF WOUNDS

A broad spectrum of wounds is being treated all over the world with natural unprocessed honeys from different sources [41,42]. At present Medihoney TM (a blend of manuka and jelly bush honey) has been one of the first medically certified honeys licensed as medical product for professional wound care in Europe, America and Australia [43,44]. In addition, dressings impregnated with honey under controlled conditions and sterilized by gamma irradiation are available in Australia and New Zealand. Honey is equally found as an active ingredient in products such as ointments for the treatment of minor burns and cuts in Nigeria [45].

9. CROSS-CONTAMINATION

The viscous nature of honey is believed to provide a moist wound environment that allows skin cells to re-grow across the wound as well as it provides a protective barrier that helps safeguard patients by preventing cross-contamination [46]. Bacterial colonization or infection of the wound may occur with micro-organisms that originate from the patient's endogenous skin, gastrointestinal and respiratory flora through contact with contaminated external environmental surfaces, water, air and soiled hands of healthcare workers [47].

10. STIMULATION OF TISSUE GROWTH

The re-growth of tissue is very important in the wound healing process. Honey stimulates the formation of new blood capillaries (angiogenesis), the growth of fibroblasts that replace connective tissue of the deeper layer of the skin and produce the collagen fibers that give the strength to the repair. In addition, it stimulates the regrowth of epithelial cells that form the new skin cover over a healed wound [48]. Thus, prevents scarring and keloid formation, and removes the need for skin grafting even with quite large wounds [49].

11. DEBRIDEMENT ACTION

It has been established that dressings that create the type of moist wound environment that honey provides facilitate the process of autolytic debridement. The high osmotic pressure of honey draws lymph from the deeper tissues and constantly bathes the wound bed. Proteases contained in the lymph in effect contribute to the debriding activity [32]. Malodor occurs in wounds colonized by anaerobes such as *Bacteroides* and *Clostridium* species, and Gram-negative rods such as *Pseudomonas* and *Proteus* species [50], because they metabolize proteins; so they produce malodorous substances e.g. ammonia and sulphur compounds as end products. Amazingly, honey provides bacteria an alternative source of energy (glucose), producing lactic acid when metabolized [51].

12. BIOBURDEN

Honey has shown considerable antibacterial activity against a wide range of wound pathogens [42,49], as well as against biofilms created by bacteria on wounds [48]. A biofilm may be described as a bacterial community living within a self-produced extracellular polysaccharide (EPS) matrix that protects them from the antimicrobial and phagocytic onslaught. Most interestingly, honey has been used to heal recalcitrant wounds whereby it was found to be effective *in vitro* against a wide range of multiresistant organisms including methicillin-resistant *Staphylococcus aureus* (MRSA), vancomycin-resistant *Enterococci* (VRE) and multiresistant *Pseudomonas aeruginosa* [28,50]. Furthermore, [50] demonstrated that acidification of wounds speeds healing; this being attributed to low pH increasing the amount of oxygen offload from hemoglobin in the capillaries. Actually, acidification prevents ammonia produced by bacteria metabolism from harming body tissues [40]. Moreover, the other afore mentioned antibacterial factors in honey such as hydrogen peroxide, lysozyme and phenolic compounds also plays a role at this instance.

13. GASTROENTERITIS

Acute gastroenteritis is an acute inflammation of the gastrointestinal tract that may be caused by a variety of microbes (viruses, bacteria, and parasites). Pure honey has demonstrated bactericidal activity against many enteropathogenic organisms, including those of the *Salmonella* and *Shigella* species, and enteropathogenic *Escherichia coli* [52,53]. According to [54], in an *in vitro* study demonstrated that honey prevented the attachment of *Salmonella* bacteria to mucosal epithelial cells; attachment is however, considered the initial event in the development of bacterial infections of the gastrointestinal tract. Seemingly, [53] reported a remarkable antibacterial activity of bee honey and its therapeutic usefulness against *E. coli* 0157: H7 and *Salmonella typhimurium* infections. Most recently, [55], in their study, added honey to the oral rehydration solution (ORS) recommended by [56] to treat gastroenteritis in infants and children. They reported that the frequency of both bacterial and non-bacterial diarrhoea was reduced. Most probably, adding honey to ORS is technically easier, less expensive and of course, made the solution a little bit sweet and possibly more acceptable. Owing to the high sugar content in honey, it could be used to promote sodium and water absorption from the bowel. It also helps to repair the damaged intestinal mucosa, stimulates the growth of new tissues and works as an anti-inflammatory agent [57].

14. GASTRITIS, GASTRIC AND DUODENAL ULCERS

Gastritis, gastric and duodenal ulcers are complications resulting from infection with *Helicobacter pylori*. Conventional treatment for the eradication of *H. pylori* is far from satisfactory; thus there is a search for alternative treatment. Honey-derived remedies constitute a potential source of new compounds that may be useful in the management of *H. pylori* infections [58]. *In vitro* studies suggested that honey possesses bactericidal activity against *H. pylori* and could be used in combination with the antibiotics in the triple therapy in a bid to help eradication. Even isolates that exhibited

resistance to other antimicrobial agents was susceptible to honey [59]. Furthermore,[60] in their study to evaluate the *in vitro* anti- *H. pylori* activity of selected honey at different concentrations (10, 20, 50 and 75% v/v) reported that there was variation in the antibacterial activity of honeys obtained from different countries and regions. This is as a result of different climatic conditions that influence the distribution of flowers and vegetative species from which honeybees collect nectar and sweet plant deposits to produce honey [61,62]. As a result of geneticheterogeneity exhibited by *H. pylori*, in combination with the regional variation in the antimicrobial components Manyi-Loh et al. 849 present in honey, there is a difference in the concentration of honey that would inhibit *H. pylori* in specific locations [59]. Specifically, [63] reported the sensitivity of *H. pylori* isolates obtained from patients in the Eastern Cape of South Africa to honey concentration of _10% v/v. Seemingly, [58] demonstrated that their isolates were sensitive to honey dilutions as low as 1:2 but with prominent inhibition at no dilution that is (100% concentration).

15. NUTRITIONAL BENEFITS OF HONEY

For a long time in human history, honey was an important source of carbohydrates and the only widely available sweetener [10]. Dr. Fessenden said that “honey’s many benefits are interrelated, much like the cells of a honeycomb, and at the very least, there are no known medical reasons not to enjoy honey as part of a healthy diet and lifestyle for adults and children over the age of twelve months” [64]. For a long time in human history, honey was an important source of carbohydrates and the only widely available sweetener [65]. It is found to be a suitable sweetener in fermented milk product without inhibiting the growth of common bacteria like *Streptococcus thermophilus, Lactobacillus acidophilus, Lactobacillus delbruekii* and *Bifidobacterium bifidum* which are important for maintaining a healthy gastrointestinal tract. Seemingly, in order to maximize the impact of probiotic cultures following ingestion, honey has to be employed as a dietary adjunct. In this respect, it acts as a prebiotic, which is defined as a non-digestible food ingredient that beneficially affects the host by selectively stimulating the growth and/or activity of a limited number of bacteria (bifidobacteria and lactobacilli) in the intestines [66] On the account of the nutritional value (303 kcal/100 g honey) and fast absorption of its carbohydrate, honey is a food suitable for humans of every age [67]. Simply, when orally consumed, its carbohydrates are easily digested and quickly transported into the blood and can be utilized for energy requirements by the human body. It is for this reason that honey is particularly recommended for children and sportsmen because it can help to improve on the efficiency of the system of the elderly and invalids [68]. Furthermore, honey appears to present another option for enhancing the safety and shelf life of foods. It has 850 Afr. J. Microbiol. Res. been reported to be effective against enzymatic browning of fruits and vegetables, oxidative degeneration of some foods and in controlling the growth of or eliminating foodborne pathogens [69] e.g. *E. coli* 0157:H7, *S. typhimurium*, *S. sonnei*, *B. cereus*, *L. monocytogenes* and *S. aureus*; owing to its antioxidant and antimicrobial properties.

16. CONCLUSION

Honey is a natural sweet, viscous substance produced by honeybees. It is, a natural substance has been used since ancient time for medicinal purposes. Due to the validation of ethno pharmacological claims, scientists also accept honey as a new effective medicine for many diseases. It is made up of a vast amount of different compounds that can be of nutritional and health benefits. Its therapeutic potential has been credited to its antimicrobial, anti-inflammatory and anti-oxidant properties as well as boosting of the immune system.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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