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## REVIEW

## Role of honey in modern medicine

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**Abstract** Use of honey has a very long history. Honey has been used since ancient time due to its nutritional and therapeutic values. There had been varied ways of consumption honey including its use as a sweetener and flavoring agent. Honey is produced all over the world. The most important nutriment of honey is carbohydrates present in the form of monosaccharides, fructose and glucose. Honey plays an important role as an antioxidant, anti-inflammatory, anti-bacterial agent and augments the adherence of skin grafts and wound healing process. The role of honey has been acknowledged in the scientific literature and there is convincing evidence in support of its antioxidant and antibacterial nature, cough prevention, fertility and wound healing properties. However, its use has been controversially discussed and has not been well accepted in the modern medicine. The aim of this review was explore and highlight the role of honey in modern medicine.

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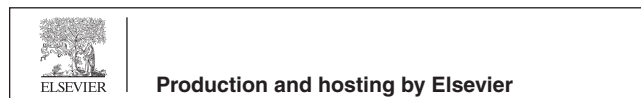
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## 1. Introduction

The consumption of honey has a very long history among human beings. It has been used in innumerable foods and beverages as sweetening and flavoring agent. Since ancient times, honey has been known for its nutritive and therapeutic values. Honey is produced all over the world. The global production of honey is approximately 1.20 million tons per annum (Bogdanov et al., 2008). China, Turkey, Argentina, Ukraine, Mexico and United States are the main producers of honey. The most important ingredient of honey is carbohydrates present in the form of monosaccharides, fructose, glucose and disaccharides, maltose, isomaltose, maltulose, sucrose and turanose and the sweetness of honey is due to presence of these ingredients. It also contains oligosaccharides including the anderose and panose and enzymes including amylase, oxidase peroxide, catalase and acid phosphorylase. Furthermore, honey contains amino acids, trace vitamin B, Vitamin B6, Vitamin C, niacin, folic acid, minerals, iron, zinc and antioxidants (David, 2007; Fatimah et al., 2013). Honey is commonly used as an anti-inflammatory, anti-oxidant and anti-bacterial agent (Noori et al., 2014).

Honey is highly valued by users for therapeutic purposes as an alternative medicine. However, its use has been controversially discussed in the literature, whether treatment with honey bee product is safe or not especially for metabolically compromised people. It is also strong believed that honey bee is a main source of nurturing and dynamism. The health promoting characteristics of bee are mainly due to the presence of multiple metabolites including folic acid, thiamine, biotin, niacin, tocopherol, polyphenols, phytosterols besides enzymes and co-enzymes. The favorable facts on the anti-oxidant, anti-bacterial, anti-fungicidal, hepato-protective are recurrently available in the scientific literature. In principle, honey is a valuable supplement for healthy population (Denisow and Denisow-Pietrzyk, 2016). Recent advances in research, literature highlighted that honey has potential biological activities with promising health promoting properties (Muhammad et al., 2016).

## 2. Types of honey

There are about 320 different varieties of honey originating from various floral sources. The flavor, color, and odor of a specific type of honey are depending on the various liquid sources of the flowers and plants visited by the honey bee. Assorted types of honey are comparable in terms of temperature, rainfall and seasonal and climactic changes. Honey color

ranges from light brown to dark brown depending on where the honey bees buzzed (<http://www.honeyo.com/types.shtml>).

## 3. Biological bioactive compounds

Honey has various essential biological bioactive compounds including vitamins “A (Retinol), Vitamin E (Tocopherol), Vitamin K (Anti-Haemorrhagic Vitamin), Vitamin B1 (Thiamine), Vitamin B2 (Riboflavin), Vitamin B6, Niacin, Vitamin C (Ascorbic acid), Panthothenic acid and phenolics, flavonoids and fatty acids” (Bogdanov et al., 2008; Muhammad et al., 2015), “cinnamic acid, hydroxybenzoic acid, octadecanoic acid, ethyl ester and flavonoids”. Moreover, it contain apigenin, pinocembrin, acacetin, abscisic acid and ferullic acid” (Marghitas et al., 2010; Muhammad et al., 2014). Furthermore, some amino acids of physiological significance are arginine, cysteine, glutamic acid, aspartic acid and proline (Qamer et al., 2007). Honey contains various flavonoid, phenolic, amino acid, protein, ascorbic acid and carotenoid contents and antimicrobial and antioxidant properties according to their weather and geographical conditions (Alvarez-Suarez et al., 2010a, b). The presence of these active compounds provides better understanding of the possible biological role of honey.

## 4. Antioxidant properties

The word “oxidative stress” defines the inadequate balance between free radicals and antioxidant protective activity (Bogdanov et al., 2008). Antioxidant is an element that can inhibit the oxidation of other molecules. Oxidation is a biochemical reaction that generates free radicals to chain reaction that may harm the cells, tissues and ultimately the physiological functions. Antioxidants such as vitamin C terminate the chain reactions to protect the body from free radicals. To balance the oxidative state, human body maintain complex systems of overlapping antioxidants. The food containing antioxidants have been shown to improve the health. The literature suggests that honey contains potent anti-oxidative agents. The role of honey also depends on its concentration and its geographically origin. As an antioxidant, honey has numerous preemptive properties against many clinical conditions such as inflammatory disorders, coronary artery diseases, neurological worsening, aging and cancer. Increase in phenolic compound in honey provides antioxidant property (Kishore et al., 2011). The substances such as polyphenols and phenolic acids found in honey vary according to the geographical and climatic condition; for example, flavanol kaempferol can be

found in rosemary honey and quercetin in sunflower honey (Akan and Garip, 2011).

Alvarez-Suarez et al. (2012) determined the role of phenolics from monofloral honeys on human Red Blood Cells (RBCs) membranes against oxidative damage. The results show that honey constrains RBCs oxidative damage most probably due to its assimilation into cell membrane and capability to enter and reach at the cytosol. Honey contains appropriate antioxidants which are responsible for biological activity, defense and increase RBCs functions.

## 5. Antimicrobial activity

In modern medicine the therapeutic use of honey requires that it must exhibit consistent and standardized antimicrobial activity. Pharmaceutical and biological scientists need to identify the floral species which give anti-microbial characteristics. Honeys contain low pH and high osmolarity combined through the enzymatic assembly of hydrogen peroxide exerts an anti-microbial result (Bang et al., 2003).

The practice of honey in wound dressing is gaining popularity in modern medicine as an outcome of its anti-microbial function (Ismail et al., 2015). Moreover, some specific kinds of honey show broad-spectrum antimicrobial role against antibiotic resistant bacterial pathogens (Blair et al., 2009; Cooper et al., 2002a, b; French et al., 2005). The floral sources are responsible for differences in the type and level of antimicrobial activity (Brady et al., 2004). It is mainly based on the environmental conditions and geographical location of the floral sources (Price and Morgan, 2006).

Julie et al. (2011) found that honey has clinical potential and shows a extensive range of antibacterial activity with an accepted possible therapeutic use. The anti-bacterial action was mainly due to hydrogen peroxide formed by the bee-derived enzyme glucose oxidase. Antibacterial activity of honey is mostly reliant on its peroxide activity and non-peroxide mechanisms. Mohd et al. (2013) reported that, honey has antibacterial impact resulting from overall and non-peroxide activities. There is evidence that honey has required broad spectrum activity against Gram-positive and negative bacteria (Katrina and Calvin, 2014).

## 6. Honey in cough

Cough is a major concern for all people and is one of the most frequent complaints presented to almost all general physicians. Cough is common among children allied with multi-factorial etio-pathological causes. The occurrence of etiology depends on the age, geographical, environmental, weather and epidemiology conditions. The etio-pathology of cough in pediatric population varies from young adults (Chang and Widdicombe, 2007; Chang, 2010). The adverse effects are more harmful among children than in adults. The children immune system is immature, therefore, they have amplified susceptibility to numerous infections accompanying with prolonged or chronic coughing (Ahmad, 2016). Cough in pediatrics has recently attracted more research interest and understanding its management is vital for their future respiratory health. Many medicines used for children cough management carry possible jeopardies of drowsiness (Paul et al., 2004).

Paul et al. (2007) reported clinical symptoms improvements between the various treatment groups and honey. Honey reliably scoring was meaningfully superior in the cough frequency treatment. In the present study, we reviewed the research literature and found that honey has an excellent safety profile and beneficial effects on the cough prevention. Cohen et al. (2012) conducted a study on three hundred children age ranges 1–5 years with upper respiratory tract infection, nocturnal cough and illness duration was about one week. The authors compared the effect of a single nighttime dose of three types of honey (eucalyptus honey, citrus honey and labiatae honey to placebo (silan date extract) on cough. In all three honey products groups, there was a significant greater improvement compared to the placebo group. Parents ranked the honey products better than the silan date extract and reported that honey is better for the symptomatic relief of night time cough and sleep difficulty allied with childhood upper respiratory infection.

## 7. Honey in wound healing

The medicinal significance of honey has been reported in the historical scientific literatures. The healing property of honey is mainly due to its antibacterial activity, maintaining a moist wound condition and its high viscosity that helps to provide a protective barrier to prevent the infection (Manisha and Shyamapada, 2011; Hananeh et al., 2015). Honey has been identified for its outcome on the healing process (Nasir et al., 2010) with multiple positive effects on wound (Jull et al., 2013) and is considered to enhance circulation and healing growth. In research literature, honey has received high attention in the domain of wound healing (Cooper and Jenkin, 2009; Gethin and Cowman, 2009) especially the burn wopunds (Jull et al., 2013). Honey is effective on various kinds of wounds where other wound healing methods are unsuccessful (Ligouri and Peters, 2010). Honey minimizes the risk of infection in wounds (Moore and Young, 2011; Wilkinson et al., 2011).

In addition, honey enhances the adherence of skin grafts, has antibacterial and anti-inflammatory effects with higher healing degree. Honey significantly decreases the infection rate on the 5th day of the injury, and minimizes pain and hospital stay. Moreover, honey has durable adhesive characteristics for skin graft fixation with minimum graft contraction (Maghsoudi and Moradi, 2015) and honey dressing enhances the healing process of the surgical wounds (Goharshenasan et al., 2016) (see Table 1).

**Table 1** Summary of promising properties of honey.

Antioxidant
Anti-inflammatory
Antibacterial, antiviral and anti-parasitic activity
Anti-mutagenic and antitumor activity
Cough reducing
Wound healing
Improves serum testosterone levels
Increase sperm count
Enhance fertility

## 8. Honey and glycemic index

The impact of carbohydrates diet on human health has been controversially debated particularly to understand about in what way carbohydrates diet change the blood glucose. Presently, the importance of carbohydrate is frequently demonstrated as glycemic index (GI). Carbohydrates with minimum and maximum GI provide low and high blood glucose respectively. It is established fact that uni-floral honeys have varying fructose contents and fructose/glucose ratios (Persano and Piro, 2004). Acacia and yellow box types of honey have comparatively higher concentration of fructose with lower GI. The GI concept claims to predict the role of carbohydrates in both health and metabolic and endocrine related disorders (Ludwig, 2000). Little GI honeys are more valued compared to high GI. The diet with low GI provides benefits with respect to metabolic including diabetes mellitus and in coronary artery heart disease (Jenkins et al., 2002). The ingesting of honey with a low GI, such as acacia honey have physiological advantageous effects and may be used among patients with endocrine functions impaired patients (Peretti et al., 1994; Al-Waili, 2003). Although, the use of honey in diabetic patients have been controversially discussed.

## 9. Honey and fertility

Historically, Egyptians presented honey for fertility. Moreover, many cultures traditionally consumed honey for enhancement of vitality among males. It has been described that there are several causes of infertility and potential remedies. In view of rich content of vitamins, iron, calcium, other minerals amino acids and immune-enhancing properties, numerous observations have shown that honey bee pollen are thought to improve egg quality and general fertility and fecundity. Honey has been advised in men with problems of impotence and women with problems related to infertility including erratic ovulation. For infertile or sub-fertile men, a drink of honey added with warm milk is believed to improve considerable amount of sperm count. Honey is known to be rich in vitamin B, an essential substance for the production of testosterone. Some literature has acknowledged a positive correlation between honey intake and testosterone concentration. In men with dysfunctional erection or impotence, it has been theorized that given honey's high content of nitric oxide – a chemical substance involved in vasodilatation, it can create and improve erection. It has been shown that an amount of 100 grams of honey is sufficient to increase nitric oxide levels in the blood by up to 50%. Complementary and alternative medicine teachings believe that honey improves sperm quality in men and strengthens the ovaries and uterus in women. In a recent study authors have reported that the supplementation of honey to cryoprotectant solution results in enhancement of overall sperm quality (Fakhrildin and Alsaadi, 2014). Using male rabbits, other researchers have demonstrated that rabbits that were fed bee pollen experienced improved fertility and semen quality. Moreover, young rabbits that were fed bee pollen gained more body weight and a higher survival rate (Attia et al., 2011). Another group of researchers have shown that the couples having trouble conceiving naturally when underwent vaginal application of bee honey and royal jelly around the

time of sexual intercourse got an improved fertility (Abdelhafiz and Muhamad, 2008).

## 10. Conclusion

Honey is highly nutritional with promising properties of anti-oxidant, anti-inflammatory, anti-bacterial agent as well as cough reducing and wound healing characteristics. Honey also improves the serum testosterone concentration, sperm count and fertility. The foremost concern in the medicinal application of honey in modern medicine is variation in its composition and lack of clinical trials. In principle, we recommend honey is a valuable dietary supplement. However, the use of honey in subjects with metabolic disorders including diabetes mellitus needs to be further investigated.

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