

## Review

# An overview of honey: Therapeutic properties and contribution in nutrition and human health

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Honey, a natural product of very high nutritive value is made when the nectar (floral) and sweet deposits from plants (non floral) are gathered, modified and stored in the honeycombs by honeybees of the genera *Apis* and *Meliponini*. Its composition and quality vary greatly with the botanical source of nectar as well as environmental and climatic conditions. Depending on its quality, honey can contribute to the health and nutritional status of humans. These beneficial actions have been ascribed to its antimicrobial, anti-inflammatory and anti-oxidant potential. Interestingly, honey is gradually receiving attention as a complementary and or an alternative source of treatment in modern medicines. It is active against antibiotic-sensitive and antibiotic-resistant strains of micro-organisms and has the potential not to select for further resistant strains.

**Key words:** Honey, natural product, drug, food.

## INTRODUCTION

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 Although many have been superseded by conventional pharmaceutical approaches, there is currently, resurgence in interest in the use of honey and honey products by the general public. This alternative branch of medicine is called apitherapy (Gosh and Playford, 2003). 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 *Meliponini* (Namias, 2003; Al-jabri, 2005).

They can be classified based on the source of nectar. These include floral and non floral honeys. Honeys can either be unifloral or multifloral, depending whether the honey collected is from the nectar of the same flower or from nectar of flowers of various types. Non floral honey (honey dew) is made by bees that extract sugars from the living tissues of plants or fruits, and/or scavenge the excretions of insects (aphids) that tap the veins of higher plants (Subrahmanyam, 2007).

There are basically two main types of honey, apiary and forest honeys. 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 (Subrahmanyam, 2007). 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. In this review, we highlight on the components present in honey, its therapeutic properties beneficial to human health as well as its nutritional value.

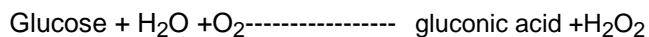
## COMPOSITION OF HONEY

Because honey inherits plants properties, its color, aroma, flavor, density, and physical and chemical

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properties depend on the flowers used by bees, although weather conditions as well as processing also influences its composition and properties (Ramirez and Montenegro, 2004). As a result, the nutritional values and profiles vary accordingly and can thus influence the value of a specific honey for health promoting purposes (Bansal et al., 2005). Honey is essentially concentrated aqueous solution of inverted sugars, but it also contains a very complex mixture of other saccharides, proteins, enzymes, amino acids, organic acids, polyphenols, and carotenoid-like substances, maillard reaction products, vitamins and minerals (Gheldof et al., 2002). Carbohydrates constitute about 95 to 97% of the dry weight of honey (Alvarez-Saurez et al., 2009). Fructose and glucose are the most predominant sugars present and are responsible for most of the physical and nutritional characteristics of honey (Sato and Miyata, 2000). Smaller quantities of other sugars are also present such as disaccharides, trisaccharides and oligosaccharides that are formed during the ripening and storage effects of bee enzymes and the acids of honey (Ball, 2007).

Water is quantitatively the second most important component of honey. Its content depends on a number of environmental factors during production such as weather and humidity inside the hive, but also on nectar conditions and treatment of honey during extraction and storage (Molan, 2002). Only honeys with less than 18% water can be stored with little or no risk of fermentation. The protein content of honey is roughly 0.5% of which are mainly enzymes and free amino acids. Glucose oxidase produces hydrogen peroxide alongside gluconic acid from glucose in the presence of water (Bogdanov et al., 2008).



Likewise, invertase converts sucrose to fructose and glucose. Dextrin and maltose are produced from long starch chains or glycogen by the activity of the enzyme amylase (Bansal et al., 2005). However, catalase found in small amounts in honey produces oxygen and water from hydrogen peroxide. The inverse relationship between catalase activity and hydrogen peroxide content has been used to determine the hydrogen peroxide level of honey called the "inhibine number". It is therefore, clear, that the absolute level of hydrogen peroxide in any honey is determined by the respective levels of glucose oxidase and catalase (Weston, 2000).

Approximately 18 essential and non-essential amino acids are present in honey. Proline is the primary amino acid, and lysine being the second most prevalent (Iglesias et al., 2004). Nevertheless, there are other amino acids whose relative proportions depend on the honey's origin. In other words, the amino acid profile of a honey could be a characteristic of its botanical origin.

Vitamins, minerals and trace compounds in honey depend on its botanical and geographical origin (National

Honey Board, 2003). These compounds include thiamin, riboflavin, niacin etc (vitamins), Cr, Ba, Ni etc (trace) and P, S, Ca etc (mineral) elements. On the basis of the multitude of known and unknown biological functions, trace elements play a key role in the biomedical activities associated with this food (Conti, 2000).

The main volatile compounds in honey have their origins, in general terms, in different chemical families, such as: alcohols, ketones, aldehydes, acids, esters, terpenes (Zhou et al., 2002; Bastos and Alves, 2003). Organic acids have been found as volatile compounds in different type of honeys. However, the predominant acid found in honey is gluconic acid (2, 3, 4, 5, 6-pentahydroxyhexanoic acid) making it to be a characteristically acidic medium with pH range of 3.4 to 6.1 (average 3.9) (Iurlina and Fritz, 2005). Its presence in all honeys originates largely from the enzymatic action of glucose oxidase on glucose in the presence of water (French et al., 2005) and to a lesser extent may be produced by bacteria of the genus *Gluconobacter* which are occasionally isolated from ripening nectar (Davis, 2005).

Specific volatile compounds can be considered as aroma fingerprints because they provide information about the botanic origin of the honey (Escriche et al., 2009). Aroma is one of the most important features, since it also allows detection of adulteration of the product (Barra et al., 2010). Polyphenols are another group of compounds, in terms of the appearance and functional properties of honey. They are potential biochemical markers for authenticating the geographical and anti-oxidant properties. These compounds include phenolic acids (benzoic and cinnamic acids) and flavonoids (flavanones, flavanols) and they contribute significantly to the anti-oxidant capacity of honey (Gheldof et al., 2002). However; the anti-oxidant capacity varies greatly depending on the floral source, possibly due to the differences in the content of plant secondary metabolites and enzyme activity (Gheldof et al., 2003).

## THERAPEUTIC PROPERTIES OF HONEY

Meda et al. (2004) reported that honey is becoming acceptable as a reputable and effective therapeutic agent by practitioners of conventional medicine and by the general public. Its beneficial role has been endorsed to its antimicrobial, anti-inflammatory and anti-oxidant activities as well as boosting of the immune system (Table 1).

### Antimicrobial activity

The antimicrobial activity is very important therapeutically, especially in situation where the body's immune response is insufficient to clear infection. In other words, it has shown powerful antimicrobial effects against

**Table 1.** Summary of honey's therapeutic properties and their beneficial effects.

Properties	Attributed factors	Actions	References
Antimicrobial (antibacterial, antiviral, antifungal, antiparasitic)	high osmolarity, acidity, hydrogen peroxide and non-peroxide components (phytochemicals)	Inhibitory and/or killing	Bansal et al. (2005) Fahey and Stephenson (2002) Irish et al. (2006) Manyi-Loh et al. (2010b) Ndip et al. (2007)
Anti-inflammatory	Leucocytes	Reduces inflammation, soothes and minimize scarring in wounds.	Dunford et al. (2000)
Antioxidant	Phenolic acids Flavonoids	Prevents formation of free radicals. Scavenge peroxy and free radicals	Gheldof et al. (2002) Baltrušaityt et al. (2007)
Immunological	Leucocytes macrophages	Cytokine production Provides substrate for glycolysis	Tonks et al. (2007)

pathogenic and non-pathogenic micro-organisms (yeasts and fungi) even against those that developed resistance to many antibiotics (Zaghloul et al., 2001). The antimicrobial effects could be bacteriostatic or bactericidal depending on the concentration that is used. However, such activity has been attributed to certain factors like high osmolarity (low water activity), acidity (low pH), and hydrogen peroxide and non-peroxide components (Taormina et al., 2001; Tanih et al., 2009).

Furthermore, honey is a supersaturated sugar solution; these sugars have high affinity for water molecules leaving little or no water to support the growth of micro-organisms (bacteria and yeast). Consequently, the micro-organisms become dehydrated and eventually die (Malika et al., 2004). In addition, the natural acidity of honey will inhibit many pathogens. The usual pH range of most of the pathogens is around 4.0- 4.5. However, the major antimicrobial activity has been found to be due to hydrogen peroxide (Temaru et al., 2007), produced by the oxidation of glucose by the enzyme glucose-oxidase, when honey is diluted (Iurlina and Fritz, 2005). As hydrogen peroxide decomposes, it generates highly reactive free radicals that react and kill the bacteria. In most cases, the peroxide activity in honey can be destroyed easily by heat or the presence of catalase.

Notwithstanding, some honeys have antibacterial action separate to the peroxide effect, resulting in a much more persistent and stable antibacterial action (non-peroxide activity) (Alvarez-Saurez et al., 2009). They are however called "non-peroxide honeys. Manuka honey (*Leptospermum scoparium*) from New Zealand and jelly bush (*Leptospermum polygalifolium*) from Australia are non-peroxide honeys which are postulated to possess unidentified active components in addition to the production of hydrogen peroxide. They retain their

antimicrobial activity even in the presence of catalase (Snow and Harris, 2004).

Weston (2000) suggested that the main part of this activity might be of honeybee origin, while part may be of plant origin. The compounds exhibiting this activity can be extracted with organic solvents (e.g. n-hexane, diethyl ether, chloroform, ethyl acetate) (Taormina et al., 2001) by liquid-liquid (Zaghloul et al., 2001; Manyi-Loh et al., 2010b) or solid phase extraction methods (Aljabri and Yusoff, 2003). The extracted compounds have been reported to include flavonoids, phenolic acids, ascorbic acid, carotenoid-like substances, organic acids, neutral lipids, Maillard reaction products, amino acids and proteins (Vela et al., 2007).

Weston (2000) stated that flavonoids, benzoic and cinnamic acids contribute to the antibacterial activity of honey but that the contribution of these components in reality is small compared to the contribution from hydrogen peroxide. Nonetheless, Weston (2000) further mentioned that the reaction of hydrogen peroxide with benzoic acids can create peroxyacids which are more stable and more powerful antimicrobial agent than hydrogen peroxide. Consequently, these acids will escape destruction when catalase is added to a solution of honey prior to an antibacterial assay.

Several studies have investigated the antimicrobial activity of honey against various micro-organisms (Baltrušaityt et al., 2007; Ndip et al., 2007; Manyi-Loh et al., 2010b). This was done by agar well diffusion technique as described by the method of Dastouri et al. (2008) or disc diffusion as per the method of Ndip et al. (2007). In both techniques various concentrations of volume/volume or mass/volume of honey were employed and the diameter of zone of inhibition was a measure of the antibacterial activity. By implication, the greater/larger

the zone of inhibition, the more active that honey concentration was considered to be.

Most studies now report antibacterial activity as minimum inhibitory concentration (MIC) which can be determined by agar dilution method (Mulu et al., 2004) or broth dilution method (Manyi-Loh et al., 2010b). The latter method can be carried out by tube dilution (Aljabri and Yusoff, 2003; Ndip et al., 2007) or micro dilution in microtitre plates as per the method of Tan et al. (2009). However, MIC is considered as the lowest concentration of honey that inhibited bacterial growth (no visible growth or turbidity). Other important effects of honey have been linked to its oligosaccharides. They have prebiotic effects, similar to that of fructo oligosaccharides (Sanz et al., 2005). The oligosaccharides have been reported to cause an increase in population of bifidobacteria and lactobacilli, which are responsible for maintaining a healthy intestinal microflora in humans. As a matter of fact, *Lactobacillus* spp. protect the body against infections like salmonellosis; and *Bifidobacterium* spp restrict the over-growth of the gut walls by yeasts or bacterial pathogens and, perhaps reduce the risk of colon cancer by out-competing putrefactive bacteria capable of liberating carcinogens (Kleerebezem and Vaughan, 2009).

### **Anti-inflammatory activity**

Although inflammation is a vital part of the normal response to infection or injury, when it is excessive or prolonged it can prevent healing or even cause further damage (Al-jabri, 2005). The most serious consequence of excessive inflammation is the production of free radicals in the tissue. These free radicals are initiated by certain leucocytes that are stimulated as part of the inflammatory process (Van den Berg et al., 2008), as inflammation is what triggers the cascade of cellular events that give rise to the production of growth factors which control angiogenesis and proliferation of fibroblasts and epithelial cells (Simon et al., 2009). They can be extremely damaging and break down lipid, proteins and nucleic acids that are the essential components of the functioning of all cells (Dhalla et al., 2001). However, the anti-inflammatory properties of honey have been well established in a clinical setting (Subrahmanyam et al., 2003) and its action is free from adverse side effects.

### **Anti-oxidant activity**

Antioxidant capacity is the ability of honey to reduce oxidative reactions within the human body. It has been found to have a significant antioxidant content measured as its capacity to scavenge free radicals (Gheldof et al., 2002). This anti-oxidant activity may be at least part of what is responsible for its anti-inflammatory action

because oxygen free radicals are involved in various aspects of inflammation (Henriques et al., 2006). Even when the antioxidants in honey do not directly suppress the inflammatory process, they can be expected to scavenge free radicals in order to reduce the amount of damage that would otherwise have resulted. Honey exerts its anti-oxidant action by inhibiting the formation of free radicals, catalyzed by metal ions such as iron and copper. Flavonoids and other polyphenols, common constituents of honey have the potential to impound these metal ions in complexes, preventing the formation of free radicals in the first place (Makawi et al., 2009).

### **Boosting of the immune system**

As well as having a direct antibacterial action, honey may clear infection through stimulating the body's immune system to fight infections. It has been reported that honey stimulates B-lymphocytes and T-lymphocytes in cell culture to multiply, and activate neutrophils (Tonks et al., 2003). Furthermore; Jones et al. (2000) in their study reported the stimulation of monocytes in cell cultures to release the cytokines TNF-alpha, IL-1 and IL-6, the cell "messengers" that activate the many facets of the immune response to infection. Recently, Tonks et al. (2007) discovered a 5.8 kDA component of manuka honey which stimulates the production of TNF- in macrophages via Toll-like receptor. In addition, honey provides a supply of glucose, which is essential for the "respiratory burst" in macrophages that produce hydrogen peroxide, the dominant component of their bacteria-destroying activity (Molan, 2001).

Moreover, it provides substrates for glycolysis, the major mechanism for energy production in the macrophages, and thus allows them to function in damaged tissue and exudates where the oxygen supply is often poor. The acidity of honey may also assist in the bacteria-destroying action of macrophages, as an acid pH inside the phagocytic vacuole is involved in killing ingested bacteria (Molan, 2001).

### **HEALTH BENEFITS OF HONEY**

Since ancient times, honey has been used for its medicinal properties to treat a wide variety of ailments. It may be used alone or in conjunction with other substances and administered orally or topically for the eradication of certain ailments. However, misuse of antibiotics, the emergence of resistant bacteria, high cost and unavailability of some conventional drugs and increasing interest in therapeutic honey have provided an opportunity for honey to be used as a broad-spectrum antibacterial agent. The beneficial actions of honey have been established in the following.

## 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 (Al-Waili, 2003, 2004). At present Medihoney™ (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 (Molan and Betts, 2004; and Molan, 2006). 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 (Williams et al., 2009).

## 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 (Lusby et al., 2002). Bacterial colonization or infection of 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 health care workers (Tan et al., 2009).

## 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 re-growth of epithelial cells that form the new skin cover over a healed wound (Rozaini et al., 2004). Thus, prevents scarring and keloid formation, and removes the need for skin grafting even with quite large wounds (Subrahmanyam et al., 2003).

## 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 (Molan, 2002). Malodor occurs in wounds colonized by anaerobes such as *Bacteroides* and *Clostridium* species, and Gram-negative rods such as

*Pseudomonas* and *Proteus* species (Dunford et al., 2000), 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 (Simon et al., 2009).

## Bioburden

Honey has shown considerable antibacterial activity against a wide range of wound pathogens (Tan et al., 2009; Oyeleke et al., 2010), as well as against biofilms created by bacteria on wounds (Okhiria et al., 2004). A biofilm may be described as a bacterial community living within a self-produced extracellular polysaccharide (EPS) matrix that protects them from 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* (Coopet et al., 2002; George and Cutting, 2007).

Furthermore, Rendel et al. (2001) demonstrated that acidification of wounds speeds healing; this being attributed to low pH increasing the amount of oxygen off-load from hemoglobin in the capillaries. Actually, acidification prevents ammonia produced by bacteria metabolism from harming body tissues (Williams et al., 2009). Moreover, the other afore mentioned antibacterial factors in honey such as hydrogen peroxide, lysozyme and phenolic compounds also play a role at this instance.

## Anti-inflammatory action

The anti-inflammatory activity of honey has been documented in clinical studies of human burn wounds and in *in vitro* studies (Subrahmanyam et al., 2003). 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 (Dunford et al., 2000). 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 (Williams et al., 2009).

## 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* (Molan, 2001; Adebolu, 2005).

Alnaqdy et al. (2005) 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, Badaway et al. (2004) reported a remarkable antibacterial activity of bee honey and its therapeutic usefulness against *E. coli* 0157: H7 and *Salmonella typhimurium* infections.

Most recently, Abdulrhman et al. (2010), in their study, added honey to the oral rehydration solution (ORS) recommended by the World Health Organization/UNICEF (2002) to treat gastroenteritis in infants and children. They reported that the frequency of both bacterial and non bacterial diarrhea 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 work as an anti-inflammatory agent (Bansal et al., 2005).

### **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 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 (Manyi-Loh et al., 2010a). *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 were susceptible to honey (Nzeako and Al-Namaani, 2006).

Furthermore, Ndip et al. (2007) in their study to evaluate the *in vitro* anti- *H. pylori* activity of selected honeys 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 (Mulu et al., 2004; Basson and Grobler, 2008) . As a result of genetic heterogeneity exhibited by *H. pylori*, in combination with the regional variation in the antimicrobial components

present in honey, there is a difference in the concentration of honey that would inhibit *H. pylori* in specific locations (Manyi-Loh et al., 2010a). Specifically, Manyi-Loh et al. (2010b) 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, in Muscat, Oman, Nzeako and Namaani (2006) 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).

### **Other infections**

Al-waili (2004) in a study reported the usefulness of topical application of honey against Acyclovir for the treatment of recurrent herpes simplex lesions. Also, Koc et al. (2009) in their study demonstrated *in vitro* that honeys from different floral sources in Turkey had antifungal activity at high concentration of 80% v/v against 40 yeast species (*Candida albicans*, *Candida krusei*, *Candida glabrata* and *Trichosporon* spp). Cutaneous and superficial mycoses like ringworm and athletes foot are found to be responsive to honey (Bansal et al., 2005).

### **NUTRITIONAL BENEFITS OF HONEY**

For a long time in human history, honey was an important source of carbohydrates and the only widely available sweetener (Ball, 2007). 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 (Sanz et al., 2005)

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 (Blasa et al., 2006). 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 (Alvarez-Saurez et al., 2009).

Furthermore, honey appears to present another option for enhancing the safety and shelf life of foods. It has

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 food borne pathogens (Taormina et al., 2001) e.g. *E. coli* 0157:H7, *S. typhimurium*, *S. sonnei*, *B. cereus*, *L. monocytogenes* and *S. aureus*; owing to its antioxidant and antimicrobial properties.

## INNOCUOUS ATTRIBUTES OF HONEY

The intrinsic properties of honey (low pH, high sugar content) affect the growth and survival of many species of micro-organisms. In consequence, honey can be expected to contain a small number and limited variety of micro-organisms (Iurlina and Fritz, 2005); and is relatively free of adverse effects. Topical application of honey may lead to transient stinging sensation. There can be allergic reactions to proteins secreted by bees and from proteins derived from plant pollen (Simon et al., 2009). In addition, there is risk of infantile botulism in a situation where the honey is contaminated with spores of *Clostridium botulinum*. After ingestion, *C. botulinum* spores can germinate, grow and produce toxin in the lower bowel of some infants less than one year, since the intestinal flora is not developed (Brown, 2000).

## CONCLUSION

Honey, an age-old remedy has been rediscovered in modern times. 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. Moreover, the effectiveness of honey against antibiotic-sensitive and resistant micro-organisms, the ease of administration for the treatment of wounds, lack of side effects in alleviating gastric pain and shortening the duration of diarrhea and its low likelihood of selecting for further resistant strains culminate to the fact that this agent may represent a satisfactory alternative/complementary means of chemoprophylaxis and or chemotherapy.

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## REFERENCES

Abdulrhman MA, Mekaway MA, Awadalla MM (2010). Bee products added to the Oral rehydration solution in treatment of gastroenteritis in infants and children. *J. Med. Food.*, 13: 605-609.

- Adebolu TT (2005). Effect of natural honey on local isolates of diarrhoea-causing bacteria in South Western Nigeria. *Afr. J. Biotechnol.*, 4: 1172-1174.
- Al-jabri AA (2005). Honey, milk and antibiotics. *Afr. J. Biotechnol.*, 4: 1580-1587.
- Aljadi AM, Yusoff KM (2003). Isolation and Identification of Phenolic Acids in Malaysia Honey with Antibacterial Properties. *Turk. J. Med. Sci.*, 33: 229-236.
- Alnaqdy A, Al-jabri A, Al-Mahrooqi Z, Nzeako B, Nsanze H (2005). Inhibition effect of honey on the adherence of Salmonella to intestinal epithelial cells *in vitro*. *Int. J. Food Microbiol.*, 103: 347-351.
- Alvarez-Saurez JM, Tulipani S, Romandini S, Bertoli F, Battino M (2009). Contribution of honey in nutrition and human health: a review. *Mediterr. J. Nutr. Metab. Springer*. DOI 10.1007/s12349-009-0051-6, pp. 1-9.
- Al-Waili NS (2003). Topical application of natural honey, bee wax and olive oil mixture for atopic dermatitis or psoriasis: partially controlled, single blinded study. *Complement. Ther. Med.*, 11: 226-234.
- Al-Waili NS (2004). Investigating the antimicrobial activity of natural honey and its effects on the pathogenic bacterial infections of surgical wounds and conjunctiva. *J. Med. Food.*, 7: 210-222.
- Badaway OFH, Shaffi SSA, Tharwat EE, Kamal AM (2004). Antibacterial activity of bee honey and its therapeutic usefulness against *Escherichia coli* 0157:H7 and *Salmonella typhimurium* infection. *Rev. Sci. Tech. Off. Int. Epiz.*, 23(3): 1011-1022.
- Ball DW (2007). The chemical composition of honey. *J. Chem. Educ.*, 84(10): 1643-1646.
- Baltrušaitytė V, Venskutonis PR, eksterytė V (2007). Radical scavenging activity of different floral origin honey and bee bread phenolic extracts. *Food Chem.*, 101: 502-514.
- Bansal V, Medhi B, Pandhi P (2005). Honey-A remedy rediscovered and its therapeutic utility. *Kathmandu Univ. Med. J.*, 3: 305-309.
- Barra MPG, Ponce-Díaz MC, Venegas-Gallegos C (2010). Volatile compounds in honey produced in the central valley of Nuble province, Chile. *Chilean J. Agric. Res.*, 70: 75-84.
- Basson NJ, Grobler SR (2008). Antimicrobial activity of two South African honeys produced from indigenous *Leucospermum cordifolium* and *Erica* on selected micro-organisms. *BMC Complement. Altern. Med.*, 8: 41.
- Bastos C, Alves R (2003). Compostos voláteis em méis florais. *Quim. Nova.*, 26: 90-96.
- Blasa M, Candracci M, Accorsi A, Piacentini MP, Albertini MC, Piatti E (2006). Raw millefiori honey is packed full of antioxidants. *Food Chem.*, 97: 217-222.
- Bogdanov S, Jurendic T, Sieber R, Gallmann P (2008). Honey for nutrition and health: a review. *Am. J. Coll. Nutr.*, 27: 677-689.
- Brown KL (2000). Control of bacterial spores. *Br. Med. Bull.*, 56(1): 158-171.
- Cooper RA, Molan PC, Harding KG (2002). The sensitivity to honey of Gram -positive cocci of clinical significance isolated from wounds. *J. Appl. Microbiol.*, 93: 857-863.
- Conti ME (2000). Lazio region (central Italy) honeys: a survey of mineral content and typical quality parameters. *Food Control.*, 11: 459-463.
- Dhalla NS, Temah RM, Netticadan T (2001). Role of oxidative stress in cardiovascular diseases. *J. Hypertens.*, 18: 655.
- Dastouri MR, Fakhimzadeh K, Shayeg J, Dolgari-sharaf J, Valilou MR, Maheri-sis N (2008). Evaluating antibacterial activity of the Iranian honey through MIC Method on some dermal and intestinal pathogenic Bacteria. *J. Anim. Vet. Adv.*, 7: 409-412.
- Davis C (2005). The use of Australian honey moist wound management. In: Rural industries research and development corporation report, pp. 1-18.
- Dunford C, Cooper RA, White RJ, Molan PC (2000). The use of honey in wound management. *Nurs. Stand.*, 15: 63-68.
- Escrive I, Visquert M, Juan-Borras M, Fito P (2009). Influence of simulated industrial thermal treatments on the volatile fractions of different varieties of honey. *Food Chem.*, 112: 329-338.
- Fahey JW, Stephenson KK (2002). Pinostrobin from honey and Thai ginger (*Boesenbergia pandurata*): potent flavonoid inducers of mammalian phase 2 chemo protective and antioxidant enzymes. *J. Agric. Food Chem.*, 50: 7472-7476.
- French VM, Cooper RA, Molan PC (2005). Antibacterial activity of honey

- against coagulase-negative staphylococci. *J. Antimicrob. Chemother.*, 56(1): 228-231.
- George NM, Cutting KF (2007). Antibacterial honey (Medihoney™): *in vitro* activity against clinical isolates of MRSA, VRE and other multi-resistant Gram-negative organisms including *Pseudomonas aeruginosa*. *Wounds.*, 19: 231.
- Gheldof N, Wang XH, Engeseth NJ (2002). Identification and quantification of antioxidant components of honeys from various floral sources. *J. Agric. Food Chem.*, 50: 5870-5877.
- Gheldof N, Wang XH, Engeseth NJ (2003). Buckwheat honey increases serum antioxidant capacity in humans. *J. Agric. Food Chem.*, 51: 1500-1505.
- Ghosh S, Playford RJ (2003). Bioactive natural compounds for the treatment of gastrointestinal disorders. *Clin. Sci.*, 104: 547-556.
- Henriques A, Jackson S, Cooper R, Burton N (2006). Free radical production and quenching in honeys with wound healing potential. *J. Antimicrob. Chemother.*, 58: 773-777.
- Iglesias MT, De Lorenzo C, Polo M, Martín-Alvares PJ, Pueyo E (2004). Usefulness of amino acid composition to discriminate between honeydew and floral honeys. Application to honeys from a small geographic area. *J. Agric. Food Chem.*, 52: 84-89.
- Irish J, Carter DA, Shokohi T, Blair SE (2006). Honey has an antifungal effect against *Candida* species. *Med. Mycol.*, 44: 289-291.
- Iurlina MO, Fritz R (2005). Characterization of micro-organisms in Argentinean honeys from different sources. *Int. J. Food Microbiol.*, 105: 297-304.
- Jones KP, Blair S, Tonks A, Price A, Cooper R (2000). Honey and the stimulation of inflammatory cytokine release from a monocytic cell line. *First World Wound Healing Congress: Melbourne, Australia.*
- Kleerebezem M, Vaughan EE (2009). Probiotic and gut lactobacilli and Bifidobacteria: Molecular approaches to study diversity and activity, 63: 269-290.
- Koc AN, Silici S, Ercal BD, Kasap F, Hörmet -öz HT, Mavus-Buldu H (2009). Antifungal activity of Turkish honey against *Candida* spp. and *Trichosporon* spp: an *in vitro* evaluation. *Med. Mycol.*, 47(7): 707-712.
- Lusby PE, Coombes A, Wilkinson JM (2002). Honey: A potent agent for wound healing? *J. Wound Ostomy. Continence Nurs.*, 29: 295-300.
- Makawi SZA, Gadkariem EA, Ajoub SMH (2009). Determination of antioxidant flavonoids in Sudanese honey samples by solid phase extraction and High Performance liquid Chromatography. *Eur. J. Chem.*, 6(S1): S429-S437.
- Malika N, Mohammed F, Chakib EA (2004). Antimicrobial activity of natural honey from aromatic and medicinal plants on antibiotic resistant strains of bacteria. *Int. J. Agric. Biol.*, 6(2): 289-293.
- Manyi-Loh CE, Clarke AM, Mkwetshana NF, Ndip RN (2010a). Treatment of *Helicobacter pylori* infections: Mitigating factors and prospective natural remedies. *Afr. J. Biotechnol.*, 9: 2032-2042.
- Manyi-Loh CE, Clarke AM, Munzhelele T, Green E, Mkwetshana NF, Ndip RN (2010b). Selected South African honeys and their extracts possess *in vitro* anti-*Helicobacter pylori* activity. *Arch. Med. Res.*, 41: 324-331.
- Meda A, Lamien CE, Millogo J, Romito M, Nacoulma OG (2004). Therapeutic uses of honey and honeybee larvae in Central Burkina Faso. *J. Ethnopharmacol.*, 95(1): 103-107.
- Molan PC (2001). Why honey is effective as a medicine 2. The scientific explanation of its effects. *Bee World.*, 82: 22-40.
- Molan PC (2002). Re-introducing honey in the management of wounds and ulcers-theory and practice. *Ostomy. Wound Manage.*, 48: 28-40.
- Molan PC, Betts JA (2004). Clinical usage of honey as a wound dressing. *Wound Care.*, 13: 353-356.
- Molan PC (2006). The evidence supporting the use of honey as a wound dressing. *Int. J. Low Extrem. Wounds.*, 5: 40-54.
- Mulu A, Tessema B, Derbie F (2004). *In vitro* assessment of the antimicrobial potential of honey on common human pathogens. *Eur. J. Health Dev.*, 18: 107-111.
- Namias N (2003). Honey in the management of infections. *Surg. Infect.*, 4: 219-226.
- National Honey Board (2003). *Honey-Health and Therapeutic Qualities*, National honey Board, Longmont, Co.
- Ndip R, Malange Takang AE, Echakachi CM, Malongue A, Akoachere J-FTK, Ndip LM, Luma HN (2007). *In vitro* antimicrobial activity of selected honeys on clinical isolates of *Helicobacter pylori*. *Afr. Health Sci.*, 7: 228-231.
- Nzeako BC, Al-Namaani F (2006). The antibacterial activity of honey on *Helicobacter pylori*. *Sultan Qaboos Univ. Med. J.*, 6(2): 71-76.
- Okhiria O, Henriques A, Burton N, Peters A, Cooper RA (2004). The potential of Manuka honey for the disruption of biofilms produced by strains of *Pseudomonas aeruginosa* isolated from wounds. Poster presentation at the 155<sup>th</sup> Meeting of the Society for General Microbiology. Dublin, Ireland. September 6-9.
- Oyeleke SB, Dauda BEN, Jimoh T, Musa SO (2010). Nutritional analysis and antibacterial effect of honey on bacterial wound pathogens. *J. Appl. Sci. Res.*, 6(11): 1561-1565.
- Ramírez R, Montenegro YG (2004). Certificación del origen botánico y polen corbicular perteneciente a la comuna de Litueche, VI Región de Chile. *Cien. Inv. Agric.*, 31: 197-211.
- Rendel M, Mayer C, Weninger W, Tshachler E (2001). Topically applied lactic acid increases spontaneous secretion of vascular endothelial growth factor by human constructed epidermis. *Br. J. Dermatol.*, 145: 3-9.
- Rozaini MZ, Zuki ABZ, Noordin M, Norimah Y, Nazrul-Hakim A (2004). The effects of different types of honey on tensile strength evaluation of burn wound tissue healing. *Int. J. Appl. Res. Vet. Med.*, 2(4): 290-296.
- Sanz ML, Polemis N, Morales V, Corzo N, Drakoularakou A, Gibson GR, Rastall RA (2005). *In vitro* investigation into the potential prebiotic activity of honey oligosaccharides. *J. Agric. Food Chem.*, 53: 2914-2921.
- Sato T, Miyata, G (2000). The Nutraceutical Benefit, Part 111: Honey. *Nutrition.*, 16: 468-469.
- Simon A, Traynor K, Santos K, Blaser G, Bode U, Molan P (2009). Medical honey for wound care-Still the "latest resort"? *Evid. Based Complement. Alternat. Med.*, 6: 165-173.
- Snow MJ, Harris MM (2004). On the nature of non-peroxide antibacterial activity in New Zealand manuka honey. *Food Chem.*, 84: 145-147.
- Subrahmanyam M, Sahapure AG, Nagane NS (2003). Free radical control-the main mechanism of the action of honey in burns. *Ann. Burns Fire Disasters.*, 16: 135-138.
- Subrahmanyam M (2007). Topical application of honey for burn wound treatment-an overview. *Ann. Burns Fire Disasters.* 20: 3.
- Tan HT, Rahman RA, Gan SH, Halim AS, Hassan SA, Sulaiman SA, Kirnpal-Kaur BS (2009). The antibacterial properties of Malaysian tualang honey against wound and enteric microorganisms in comparison to manuka honey. *BMC Complement. Altern. Med.* 9:34doi:10.1186/1472-6882-9-34.
- Tanah NF, Dube C, Green E, Mkwetshana N, Clarke AM, Ndip LM, Ndip RN (2009). An African perspective on *Helicobacter pylori*: prevalence of human infection, drug resistance, and alternative approaches to treatment. *Ann. Trop. Med. Parasitol.*, 103: 189-204.
- Taormina PJ, Niemira BA, Beuchat LR (2001). Inhibitory activity of honey against food-borne pathogens as influenced by the presence of hydrogen peroxide and level of antioxidant power. *Int. J. Food Microbiol.*, 69: 217-225.
- Temaru E, Shimura S, Amano K, Karasawa (2007). Antibacterial activity of honey from stingless honeybees (Hymenoptera; Apidae; Meliponinae). *Polish J. Microbiol.*, 56: 281-285.
- Tonks AJ, Cooper RA, Jones KP, Blair S, Parton J, Tonks A (2003). Honey stimulates inflammatory cytokine production from monocytes. *Cytokine.*, 21: 242-247.
- Tonks AJ, Dudley E, Porter NG, Parton J, Brazier J, Smith EL, Tonks A (2007). A 5.8kDa component of manuka honey stimulates immune cells via TLR4. *J. Leukoc. Biol.*, 82: 1147-1155.
- Van den Berg AJ, van den Worm E, Van Ufford HC, Halkes SB, Hoekstra MJ, Beukelman CJ (2008). An *in vitro* examination of the antioxidant and anti-inflammatory properties of buckwheat honey., 17(4): 172-174, 176-178. *J. WoundCare.*
- Vela L, Lorenzo C, Pérez RA (2007). Antioxidant capacity of Spanish honeys and its correlation with polyphenol content and other physicochemical properties. *J. Sci. Food Agric.*, 87: 1069-1075.
- Weston R (2000). The contribution of catalase and other natural products to the antibacterial activity of honey: a review. *Food Chem.*, 71: 235-239.
- Williams ET, Jeffrey J, Barminas JT, Toma I (2009). Studies on the



- effects of the honey of two floral types (*Ziziphus* spp. and *Acelia* spp.) on organism associated with burn wound infections. *Afr. J. Pure Appl. Chem.*, 3: 98-101.
- World Health Organization (2002). Reduced Osmolarity Oral Rehydration Salts (ORS) Formulation. World Health Organization, Geneva.
- Zaghloul AA, El-Shattaw HH, Kassem AA, Ibrahim EA, Reddy IK, Khan MA (2001). Honey, a prospective antibiotic: extraction, formulation, and stability. *Pharmazie.*, 56: 643-647.
- Zhou Q, Wintersteen CL, Cadwallader RW (2002). Identification and quantification of aroma-active components that contribute to the distinct malty flavor of buckwheat honey. *J. Agric. Food Chem.*, 50: 2016-2021.