Honey as Component of Diet: Importance and Scope

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Abstract

Natural honey (NH) is a highly nutritious substance and is considered as one of nature's wonders which has been used by all cultures, traditions and civilizations as a food and medicine. Natural honey (NH) is a by-product made by honeybees by using nectar of flowers and sugary non-floral deposits obtained from plants that is then converted into honey by a process of regurgitation and evaporation. Later the honeybees store honey as a primary source of food in wax honeycombs inside the beehive. Honey is classified on the basis of processing, physical, chemical, and nutritional properties. Honey also plays a part in symbolism and religion. The appearance, quality, sensory perception, and composition of NH vary greatly depending on the nectar source, environmental and climatic conditions. Honey's main constituents include carbohydrates, primarily fructose and glucose although it also contains various oligosaccharide sugars. Besides these NH, also contains minute quantities of amino acids, proteins, enzymes, trace elements, minerals, vitamins, aroma substances, and polyphenols. NH shows a vast range of health and nutritional properties. NH imparts antimicrobial, anti-inflammatory, antioxidant, immune boosting property, antiviral, antiparasitory,

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antimutagenic, and antitumor effects. Honey has also been well known for treatment of gastrointestinal disorders like peptic ulcers, gastroenteritis, and gastritis. Thus NH has proved a valuable nutritional food and medicinal entity.

Keywords

Natural honey (NH) · Composition · Scope · Nutritional and health effects

11.1 Introduction

The use of NH as a rich nutritive food and medicine has been done by mankind from the immemorial times. Honey is a sweet, viscous complex substance synthesized by honeybees (*Apis mellifera*) from nectar, a sugary liquid of flowers, or from exudation of plants or secretions of plant sucking insects living on plants, respectively. The honey bees gather, convert, and mix these plant parts in the comb with their own enzymes (diastase, invertase, and glucose oxidase), thereby storing and leaving this for ripening and developing (Can et al. 2015). In ancient times, the only natural food sweetener that was available to *Homo sapiens* was honey. Infact the relation between bees and man is very old and has started since the Stone Age (Crane 1983). The earlier people of ancient civilizations were prepared to sacrifice his life to get sweet honey. First instance of NH being used as medicine and emollient reflects back to a Sumerian tablet dating 2100–2000 BC (Crane 1975). For rich nutritious and medicinal value, NH has been used by most of the ancient civilizations (Crane 1975, 1999; Jones 2001; Allsop and Miller 1996). The utilization of NH by humans is believed to be 8000 years old as portrayed by the works of art of Stone Age (Bansal et al. 2005). The ancient Egyptians, Chinese, Assyrians, Greeks, and Romans used NH to treat wounds and gut diseases (Al-Jabri 2005). Natural honey is used by people of different ages as it overcomes all the barriers of culture and ethnicity. All religions all cultures advocate and embrace the use of NH. In our religion (Islam), an entire chapter is depicted in the Holy Qur'an, entitled "Surah al-Nahl," which means "Honey Bee" which advocates use of NH as food and medicine (The Holy Quran). Our Prophet Muhammad SAW has firmly mentioned the use of NH for healing and curative purposes as mentioned in the book of hadith (Al-Bukhari 1976). It is also mentioned in the Chap. 16 of the Holy Qur'an that NH is an essential nutritious and health boosting food) (An-Nahl 1990a, b). The well-known insight about honey being good for health has its origin from folklore. An important role in folklore has been played by myth. There are numerous written and oral records about the vitalizing honey's life-giving qualities. Avicenna, a great Iranian scientist and physician, has strongly recommended NH as best available remedy for tuberculosis treatment (Asadi-Pooya et al. 2003). To the mankind, NH has been considered as one of the most unique gifts of nature as described by Indian Ayurveda medicine. Ayurveda texts consider NH as a great medicine to treat disorders of skin

like burns and wounds, insomnia, cardiac pain, palpitation, anemia, teeth and gums, lung imbalances, weak digestion, irritating cough and eye ailments (Honey in History 2008). Honey is considered as highly valuable food by Veddas, Wild Men of Sri Lanka and Australian aboriginal tribes as they risk their lives to obtain it. The people of ancient Egypt considered NH as the most renowned medicine that was used in 900 remedies (Al-Jabri 2005). Most of the medicines used by Egyptians contained honey in combination with milk and wine. NH was used by ancient Egyptians and presented to their deities as a sacrifice (Zumla and Lulat 1989). Honey was also used as a topical ointment and antibacterial agent for healing wounds by ancient people of Egypt (Honey 2012). In ancient Greece, NH was used to treat several diseases. A beverage of ancient Greece was Oenomel that consists of unfermented juice of grapes and NH that was utilized to treat gout and various nervous disorders (Honey 2012). Hippocrates, prescribed a simple diet, which consisted of honey and other substances with honey being the main ingredient. He gave a mixture of honey and vinegar (oxymel) for pain, honey, and water (hydromel) for thirst and a combination of NH, water and other substituents for treating acute fevers (Zumla and Lulat 1989). Further NH was also used for treating baldness, cough, sore throat, wound healing, contraception, topical antisepsis, laxative action, eye diseases, prevention, and treatment of scars (Bansal et al. 2005). Thus NH was used by the folklore people as a great nutritious food and medicine for treating numerous diseases.

11.2 Classification of Honey

The honey is classified into various classes and the major forms that are available after the process of packaging are raw, pasteurized, strained, granulated, ultrafiltered, chunk, ultrasonicated, comb, whipped, and dried as enlisted in Table 11.1 (Crane 1975; Ustunol and Gandhi 2001; Decaix 1976).

11.3 Chemical Composition of Natural Honey

NH possesses all the essential components that are required for a healthy balanced diet. NH is an energy rich source of food and is readily digestible. More than 200 compounds are present in NH, a major portion of which are carbohydrates and water accounting for about 95% of honey's dry weight and the remaining part includes amino acids, proteins, enzymes, vitamins, organic acids, polyphenols, and aroma substances (White 1979). NH's nutritional and chemical constituents are strongly affected by the plants or botanical sources on which the honey bees feed (Persano and Piro 2004). The importance of honey with regard to its nutritional aspect lies in its manifold physiological effects irrespective of the recommended daily intake being required is small.

Table 11.1 Natural honey and its types

Class	Description
Raw honey	Raw honey exists in the beehive in its original form and is obtained by various processes such as extraction, settling, straining, etc. The production of raw honey requires minimal processing and no heat treatment
Pasteurized honey	Pasteurized honey is obtained during the process of pasteurization in which the honey is heated to a high temperature of about 161 °F (71.7 °C). The pasteurization cycle kills the cells of yeast, and also causes micro-crystal liquefaction in NH, thus preventing start of visual crystallization
Strained honey	Strained honey is obtained after the honey passes over a mesh medium to extract suspended matter like propolis, wax, and dirt without the removal of minerals, enzymes, and pollens
Granulated honey	Granulated honey or crystallized honey is typically made when glucose levels in NH has slowly crystallized in monohydrate form from a solution (Bogdanov 2015). This form of honey returns to liquid form when it is placed in a vessel with lukewarm water which is at a temperature of 120 °F (49 °C)
Ultrafiltered honey	Ultrafiltered honey is obtained when the honey is heated at a temperature of 150–170 °F (65–77 °C) under high pressure. The honey is then filtered through fine filters in order to extract all pollen grains and extraneous solids (Bogdanov 2015)
Chunk honey	In chunk honey at least one or more portions of comb honey are soaked in collected liquid honey and placed in big mouth containers
Ultrasonicated honey	This type of honey is retrieved through a nonthermal process which, along with inhibition of crystal formation, destroys the yeast cells
Comb honey	Comb honey is what usually exists in the honeybees' wax comb, which is typically collected from honey supers by using standard wooden frames where the comb is cut in chunks before being packed
Whipped or creamed honey	Whipped honey contains small crystals that are present in large numbers and the honey produced in this process is smooth with a ubiquitous constancy
Dried honey	In dried honey, moisture content is removed from the liquified form honey in order to make complete solid, nonsticky granules. Drying and anticaking agents are usually used during this process

11.4 Carbohydrates

The key constituents in NH are the carbohydrates that includes fructose which is a monosaccharide accounting for 32.56–38.2% and glucose, also a monosaccharide that accounts about 28.54–31.3%, thereby constituting about 85–95% of total sugars (Moundoi et al. 2001; Ezz El-Arab et al. 2006). In NH the only monosaccharides present are glucose and fructose. There are about 25 different complex oligosaccharide sugars found in natural honey (Doner 1977; Siddiqui 1970). In blossom honey, the principal oligosaccharides are primarily the disaccharides such as sucrose, maltose, isomaltose, melibiose, turanose, panose, nigerose, palatinose, maltotriose, 1-kestose, 6-kestose, and (Bogdanov 2015; Ezz El-Arab et al. 2006; Yun 1996; Chow 2002). Honeydew honey, on the other hand, contains higher levels

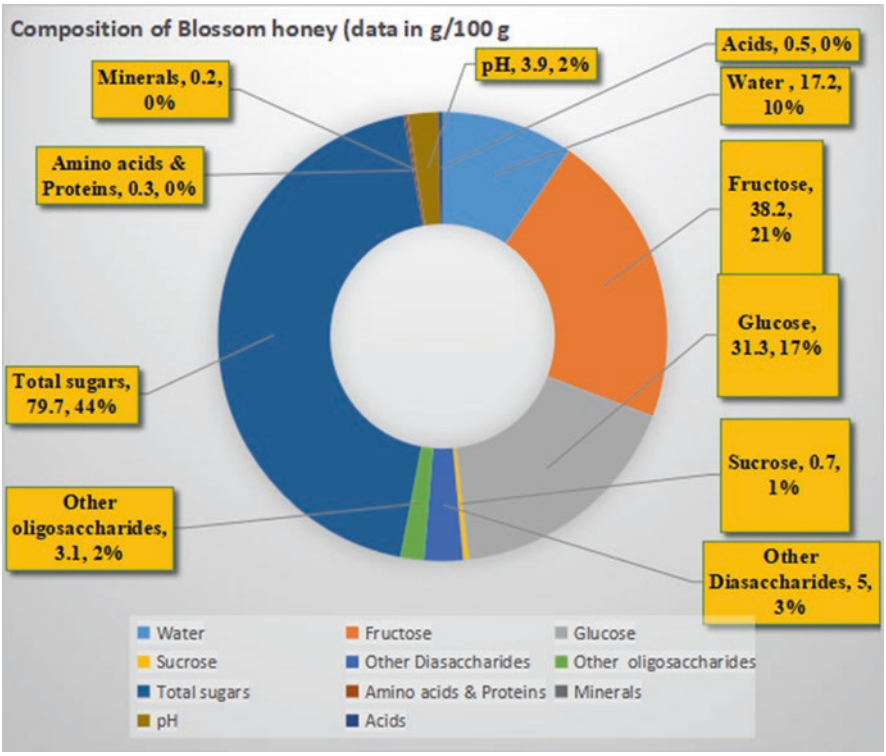

Fig. 11.1 Pie chart depicting composition of blossom honey (data in g/100 g)

of oligosaccharides such as melezitose and raffinose relative to blossom honey. It was also found that 4–5% fructo-oligosaccharides present in natural honey serve act as probiotics (Ezz El-Arab et al. 2006; Chow 2002). The second most essential constituent of NH is water, averaging for about 17.2%. After the intake of honey the principal carbohydrates that are present in human body during the process of digestion are fructose and glucose which can readily serve as energy sources to meet the requisite requirements. The average amount carbohydrates present in blossom honey and honeydew honey is shown in Figs. 11.1 and 11.2 as represented separately by pie charts (1 and 2).

11.5 Proteins, Enzymes, and Amino Acids

Proteins are present in NH only in minute amounts that make up about 0.5% and mostly exist as free amino acids and enzymes. A recent report demonstrated that according to the origin of honeybee the quantities of specific protein were different (Jenkins and Cooper 2012). Natural honey contains a variety of enzymes, however invertase (saccharase), diastase (amylase), and glucose oxidase are key enzyme

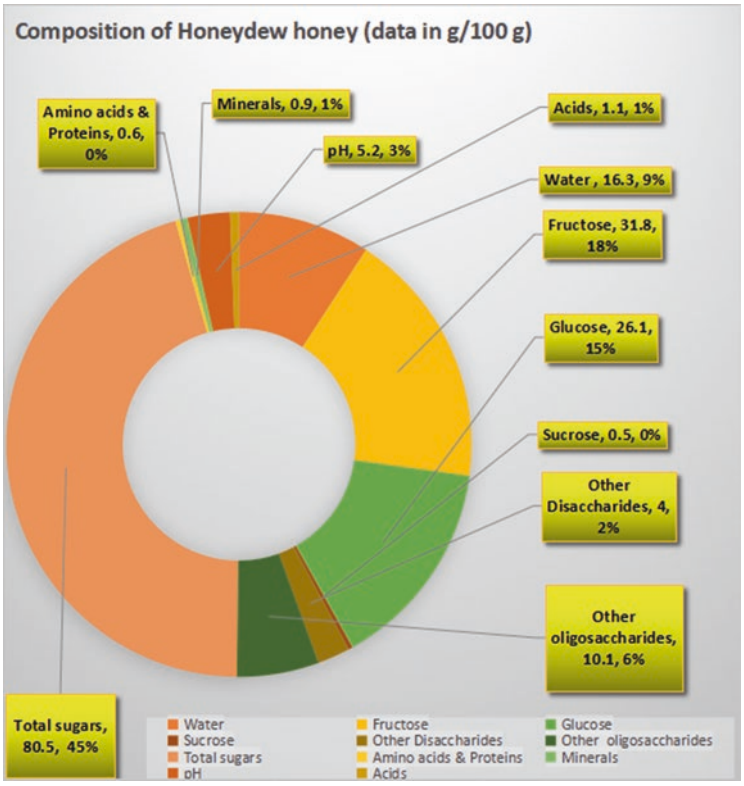

Fig. 11.2 Pie chart depicting composition of honeydew honey (data in g/100 g)

molecules involved in the production of NH (Olaitan et al. 2007). The enzyme invertase found in honey converts sucrose into invert sugars (dextrose and levulose). The enzyme glucose oxidase acts on the glucose molecule to produce hydrogen peroxide (H_2O_2) and gluconic acid, the former provides antimicrobial property and the later helps in calcium absorption. The enzyme amylase acts on the long chains of starch to produce dextrin and maltose. The average amount of amino acids and proteins that are found in blossom and honeydew honey are shown in Figs. 11.1 and 11.2 as represented separately by pie charts (1 and 2).

11.6 Organic Acids

Natural honey contains various organic acids which constitute 0.57% of dry weight and largely contribute primarily to its complex flavor. An essential organic acid found in NH is gluconic acid, which is the by-product of glucose digestion produced by the glucose oxidase enzyme (White 1979). Other acids that are present in NH are acetic acid, malic acid, butyric acid, citric acid, lactic acid, formic acid,

pyroglutamic acid, succinic acid, and inorganic acids like hydrochloric acid and phosphoric. The acidic nature of NH is due to the organic acids which largely render to its great sweetness. Average amount of organic acids present in blossom honey and honeydew honey is shown in Figs. 11.1 and 11.2 as represented separately by pie charts (1 and 2).

11.7 Minerals

Natural honey also contains minerals with composition that ranges from 0.1 to 1.0%. The major mineral found in honey are potassium (K), followed by calcium (Ca), magnesium (Mg), sodium (Na), sulphur (S), and phosphorus (P). In NH, the trace elements found are iron (Fe), copper (Cu), fluorine (F), zinc (Zn), iodine (I), manganese (Mn), and selenium (Se) (Yun 1996; Chow 2002; White 1975). In human nutrition, other elements that be can be important are boron, sulphur, fluorine, cobalt, silicon, iodine and molybdenum. The amount of minerals varies in different unifloral honeys (Bengsch 1992a, b). The daily requirement of minerals is too low which makes its requirement marginal in daily diet. The average amount of minerals present in blossom honey and honeydew honey are shown in Figs. 11.1 and 11.2 as represented separately by pie charts (1 and 2).

The amount of choline present in NH is 0.3–25 mg/kg whereas acetylcholine accounts for 0.06–5 mg/kg (Heitkamp 1984). Choline plays a vital role in cellular membrane composition, repair, brain function and cardiovascular activities, while as acetylcholine mainly functions as a neurotransmitter.

According to the studies carried out by White (1975), Bogdanov et al. (2003) the composition of constituents in blossom honey (pie chart 1) and honeydew honey (pie chart 2) varies and is depicted in Figs. 11.1 and 11.2, respectively:

11.8 Vitamins

Natural honey also contains vitamins which includes vitamin C, & B (thiamine (B_1), riboflavin (B_2), niacin (B_3), pyridoxine ($B_{6,}$ pantothenic acid (B5), and folic acid (B_9) (Olaitan et al. 2007). The amount of vitamins required is so small and that their recommended daily intake (RDI) is marginal. NH contains vitamins in minute amounts as depicted in Tables 11.2 and 11.3.

Table 11.2 Amount of vitamins in 100 g honey

Vitamins	mg/Kg
Thiamine (B_1)	0.00–0.01
Riboflavin (B_2)	0.01–0.02
Pyridoxine (B_6)	0.01–0.32
Niacin (B_3)	0.10–0.20
Pantothenic acid (B_5)	0.02–0.11
Folic acid (B_9)	0.002
Ascorbic acid (C)	2.2–2.5
Phyllochinon (K)	0.025

Table 11.3 Honey nutrients values in 100 g (White 1975; Conti 2000; Terrab et al. 2004; Iskander 1995; Rodriguez-Otero et al. 1994; Golob et al. 2005; Yilmaz and Yavuz 1999; Bengsch 1992a, b; Bogdanov and Matzke 2003)

Ingredient	Amount in 100 g
Energy (kcal)	
Carbohydrates (kcal)	300
Fats (g)	0
Proteins (g)	0.5
Minerals (mg)	
Sodium (Na)	1.6–17
Calcium (Ca)	3–31
Potassium (K)	40–3500
Magnesium (Mg)	0.7–13
Phosphorus (P)	2–15
Zinc (Zn)	0.05–2
Copper (Cu)	0.02–0.6
Iron (Fe)	0.03–4
Manganese (Mn)	0.02–2
Chromium (Cr)	0.01–0.3
Selenium (Se)	0.002–0.01

11.9 Aroma Compounds and Polyphenols

Depending on the origin, a wide range of honey exists which have different tastes and colors (Crane et al. 1984). However sugars are the main compounds that make up the taste. Natural honey that has higher amount of fructose (e.g., acacia) is sweeter than those which have a high glucose concentration (e.g., rape).The quantitative and qualitative proportion of amino acids and organic acids within NH determines its aroma. Numerous studies for detection of aroma substances in different types of natural honey have been put forth and they have identified about 500 different volatile compounds. Different forms of NH have varied aroma composition which ultimately depends on their botanical origin (Bogdanov et al. 2007). The flavor of honey is an important factor that determines its quality for being used in food industry and other areas.

Based on appearance and functional characteristics of NH, an important group of compounds that have been discovered are the polyphenols. In different types of honey total polyphenols that have been found account for 56–500 mg/kg, respectively (Al-Mamary et al. 2002; Gheldof and Engeseth 2002). The main polyphenols present in NH are flavonoids such as keampferol, quecertin, apigenin, luteolin, galangin, chrysin), phenolic acids and derivatives of phenolic acid (Tomas-Barberan et al. 2001). An important characteristic feature of these compounds is their antioxidant properties. As flavonoids, are the main polyphenols, their concentration ranges from 60 to 460 μg/100 g of honey and various studies have reported that samples produced higher amounts of flavonoids during a dry season with high temperatures (Kenjeric et al. 2007).

11.10 Physical Properties of Natural Honey

In addition to taste and composition, NH is a viscous liquid with various essential properties. The water content and composition of NH varies because viscosity of honey is dependent on a number of factors. Another property of NH is hygroscopicity that describes its capacity to absorb and retain moisture from the surrounding environment. Natural honey has a water content of 18.8% or less, which additionally has the property of extracting moisture from air at a relative humidity greater than 60%. NH shows variation in surface tension which is totally dependent on the biological origin and the nature of different colloidal substances present. The foaming characteristics of NH are due to high viscosity along with presence of these substances (Olaitan et al. 2007). NH has a pH of 3.2–4.5 and this relative acidic pH levels prevents many bacteria from growing. Further there also exists variation in color of liquid honey which usually is transparent and colorless (as water) to dark amber or black. Also the color of NH varies on the basis of botanical origin, storage conditions, age, etc., however the amount of particulate matter such as pollens also determines the transparency or clarity of natural honey (Olaitan et al. 2007). The least known colors of NH that are available are bright yellow (sunflower), reddish undertones (chest nut), grayish (eucalyptus), and greenish (honeydew). The light color of honey after crystallization is due to the white glucose crystals. The production of monohydrate crystals of glucose causes crystallization of honey which varies with number, shape, dimension, quality, composition, and storage conditions (Olaitan et al. 2007). Further the process of crystallization is faster if the water content is lower and the glucose content is higher in honey (Olaitan et al. 2007).

11.11 Beneficial Effects of Honey in Physiological Processes

The constituents of NH include bioactive compounds that are necessary for metabolism and physiological processes. Regular use of natural honey encourages physiological processes such as development and strengthens physical activities such as exercise and other sporting events (Kreider et al. 2002). Honey is considered a complete meal, as it includes essential constituents of a balanced diet, particularly micronutrients which support digestion and its main dietary components promote healthy growth (Kreider et al. 2002). Studies have reported increased gain in body weight in rats fed that were with fed with honey blossom honey. Calcium as a constituent element of honey is believed to contribute to enhanced bone growth and mineralization in rodents from this study. Some of the important beneficial properties that are provided by natural honey are shown graphically in Fig. 11.3, however the general description is given below:

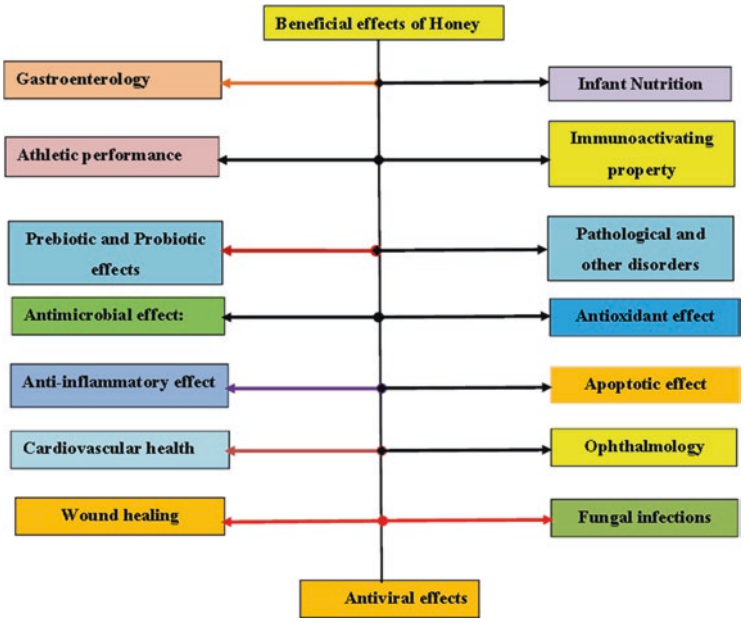

Fig. 11.3 A general overview of beneficial properties of natural honey

11.12 Gastroenterology

Natural honey (NH) has been used to treat various gastrointestinal disorders. Different studies have supported the growth stimulating property of honey, as it was involved in enhanced gastrointestinal function (Ajibola 2013). One of the Hadith mentioned in Sahih Al-Bukhari by our Prophet Muhammad (SAW) have recommended the use of honey against diarrhea (Potschinkova 1992; Cherbuliez and Domerego 2003; Khotkina 1955; Ludyanskii 1994; Menshikov and Feidman 1949; Mladenov 1978; Slobodianiuk and Slobodianiuk 1969) and Arab countries (Salem 1981), NH has been used to prevent and treat gastrointestinal disorders including gastritis, peptic ulcers, and gastroenteritis. It has been reported that NH inhibits Helicobacter pylori that is responsible for causing gastritis and peptic ulcers (Al Somal et al. 1994; Ali et al. 1991; Osato et al. 1999). In experimental rats, NH acted against gastric ulcers which was induced by indomethacin, alcohol, ammonia, and aspirin (Ali 1995a, b; Gharzouli et al. 2001, 2002). Two possible mechanisms have been suggested that provide NH these protective properties. The first one is the antioxidant property of honey and the second mechanism suggests that NH stimulates sensory nerves of the stomach, which then show response to capsaicin (Ali 1995a; Nasuti et al. 2006). The use of NH in indomethacin-induced gastritis rat models showed decreased stomach ulcer index, myelperoxidase and microvascular permeability activities (Ali 1995a). Further NH also maintains the amount of non-protein sulfhydryl compounds (e.g., glutathione) in gastric tissues (Al Swayeh and Ali 1998; Ali 1995b, 1997).

11.13 Infant Nutrition

In infant nutrition, a general recommendation that has been used since the last century is the use of honey in diet and there are some interesting observations that have been reported. Honey has found applications in infant nutrition as well and studies have reported that the blood formation was better along with regular weight gain in infants fed on honey-containing diet as compared to honey-free diet. It has been found that babies have a higher weight gain and also a higher hemoglobin content, better skin tone when fed with honey instead of sucrose and studies have shown less throw up than controls on sucrose. Besides better weight increase in infants exposed to honey, they were least vulnerable to diseases than infants who were usually fed with blood building agents. Some other studies have reported increased calcium intake into the blood, leading to lighter and thinner feces in infants fed with honey (Bianchi 1977; Ajibola 2015a). In infant diet, the positive results of honey are due to its direct role in the digestion process. Several studies have reported well-established oligosaccharide effect on *B. bifidus* (Rivero-Urgell and Santamaria-Orleans 2001). In one study, babies were given a mixture of milk and honey and the results of which showed a regular weight gain with rich acidophilic microorganism like *B. bifidus* (Hubner 1958). Other study in infants that were fed with honey and milk were found to have improved hematological profile, less frequent diarrhea, increased uptake of calcium in blood leading to lighter and thinner feces (Hubner 1958).

11.14 Athletic Performance

Besides enhancing growth, the results provided by Sports Nutrition and Exercise Laboratory has shown that natural honey can provide constant energy as compared to commercially available glucose during vigorous physical exercises. Consumption of natural honey during some form of physical activity raises heart rate and maintains a relatively steady level of glucose in blood, thus making it a better substitute for glucose and an efficient source of carbohydrates (Ajibola 2013, 2015b). The fasted athletes did not show any physical or psychological signs of hypoglycemia (Leutholz and Kreider 2001), as they had consumed NH before during training (Earnest et al. 2000).

11.15 Immuno-activating Property

Honey also exhibits immuno-activating properties in humans as daily use of honey for 2 weeks of 1.2 g/kg body weight, observable were found: iron in serum increased by 20 and ferritin in plasma decreased by 11%, monocyte increased by 50%, lymphocyte and eosinophilic percentages rise marginally (Al-Waili 2003; Bogdanov et al. 2008). Further in serum reduction of immunoglobulin E (34%), lactate dehydrogenase (41%), AST (aspartate transaminase) (22%), ALT (alanine transaminase) (18%), CK (creatine kinase), and fasting sugar (5%) (Bogdanov et al. 2008; Al-Waili

2003). Lastly, an increase in levels of blood copper (33%) and a minor increase in magnesium, zinc, hemoglobin and packed cell volume was also observed (Bogdanov et al. 2008; Al-Waili 2003).

11.16 Prebiotic and Probiotic Effects

Oligosaccharides in honey, mostly panose, are believed to contribute to its prebiotic effect thereby causing an increase of lactobacilli and bifidobacteria. Increase in the apex of lactobacillus plantarum and lactobacillus acidophilus has been observed in intestines (small and large) of honey fed rats where as in vitro sucrose failed to produce any such effect (Yun 1996; Ajibola 2015b). Other studies have shown probiotic effect only of fresh honey for about 2–3 months only that contained *Bifidus* and *Lactobacilus* bacteria. In addition, NH shows laxative effect on individual's digestive system. However, in some cases fructose malabsorption or insufficient absorption, ingestion of fairly large quantities of natural honey (70–95 g) can only show a mild laxative effect (Ladas et al. 1995). The supply of calcium is other nutraceutical property of NH. Honey consumption provides calcium which is an essential mineral and is easily absorbed in the body which further enhances bone mass growth. As a consequence of this, there occurs a reduction in chances of developing osteoporosis or low bone mass in the elderly population. Studies in animal models has shown that calcium absorption was increased with regular intake of honey (Bogdanov et al. 2008; Olofsson and Vasquez 2008; Chepulis and Starkey 2008).

11.17 Pathological and Other Disorders

The importance of natural products for medicine and well-being has been enormous throughout our evolution and has often been regarded as the primary means of treating diseases and injuries. In recent years, an alternate branch of medicine, known as apitherapy or bee products therapy, has been developed that offers treatment mainly focused on using natural honey and various bee products (Bansal et al. 2005). Honey plays a vital part as antioxidant, antibacterial agent, anti-inflammatory molecule, increases skin graft adherence and healing of wounds. Scientific literature has recognized the importance of honey and a strong evidence has evolved supporting its antibacterial and antioxidant existence, that helps in treatment of cough, fertility problems and healing of wounds (Alvarez-Suarez et al. 2010a, b). NH has found its uses in a wide array of pathological conditions (acute and chronic infections) in humans which particularly includes gastrointestinal ailments, dental infections, neonatal conditions ophthalmological diseases, metabolic diseases, urinary tract infections and neoplastic diseases (Bogdanov et al. 2008; English et al. 2004). Among the various health claims, the most widely investigated property of NH is its potent healing ability that has been utilized in the therapeutic and surgical management of wounds (Havsteen 2002; Ames et al. 1993; Abubakar et al. 2012).

11.18 Antimicrobial Effect

Honey's healing ability is because of its strong antibacterial properties, high viscosity and moisture content that helps to protect against infections by providing a protection barrier (Bogdanov et al. 2008). The unique antibacterial property of honey is due to large amounts of sugar molecules, strong acids, low water activity, hydrogen peroxide (White et al. 1963), flavonoids (Cushnie and Lamb 2005), and phenolic acids (Weston et al. 1999), bee defensin-1 and methylglyoxal. However, manuka honey still shows significant antibacterial non-peroxide activity even though when hydrogen peroxide activity is blocked. Some studies have reported that non-peroxide parameters like lysozyme, flavonoids and phenolic acids may be involved, however it is believed that lower honey pH and high levels of sugar (high osmolarity) may also hinder the microbial growth (Bogdanov et al. 2008; Yatsunami and Echigo 1984). Both Gram positive bacteria and Gram negative bacteria show response to honey therapy, for instance, *Bacillus subtilis*, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, and *E. coli*. Other microbial pathogens that have found to respond to honey treatment include Rubella virus, *Candida albicans*, *Trichophyton mentagrophytes*, and *Leishmania* parasites (Molan 1992a, b, 1997; Bogdanov 1997).

11.19 Antioxidant Effect

NH also possesses strong antioxidant properties in addition to the antibacterial activity. It boosts natural mechanism against diseases by serving as natural dietary antioxidant. Antioxidants scavenge free radicals to protect the body from oxidative stress responsible for cellular dysfunction, metabolic and cardiovascular diseases (CVD's) pathogenesis as well as ageing (Ames et al. 1993). The production of free radicals by oxidative reaction may destroy cells, tissues and finally the physiological functions (Al-Mamary et al. 2002). The redox properties of NH are due to its chemical constituents like phenolic compounds, flavonoids, vitamins, proteins, amino acids, and organic acids. There occurs a tremendous variation in the antioxidant potential of NH which largely is dependent on floral source. These characteristic properties may be due to the variations in the constituents of secondary metabolites of plants and enzyme activity. Some studies have shown that the antioxidant property positively correlates with the dark color and water content of the natural honey (Beretta et al. 2005; D'Arcy 2005; Gheldof et al. 2002; Aljadi and Kamaruddin 2004; Inoue et al. 2005; Fahey and Stephenson 2002; Blasa et al. 2006; Nagai et al. 2006; Perez et al. 2007; Frankel et al. 1998).

11.20 Anti-inflammatory Effect

In animal models, cell cultures, and human clinical trials, the anti-inflammatory potential of NH has been studied by various studies (Al-Waili and Boni 2003; Candiracci et al. 2012). In humans after intake of 70 g of NH, the mean plasma

levels of thromboxane B(2) decreased by 7%, 34%, and 35% whereas levels of PGE(2) were reduced to 14%, 10%, 19% at 1, 2 and 3 h respectively. After further intake of NH, the concentration of PGF (2α) was reduced to 31% after 2 h and by 14% at 3 h. The concentration of thromboxane B(2), PGE(2), PGF (2α) in plasma after 15 days of NH intake were decreased to 48%, 63%, and 50%, respectively (Bilsel et al. 2002). In NH, the flavonoid and phenolic compounds possess significant properties that suppress the pro-inflammatory activities of cyclooxygenase-2 (COX-2) and/or inducible nitric oxidase synthase (iNOS) (Al-Waili and Boni 2003; Viuda-Martos et al. 2008).

11.21 Apoptotic Effect

Honey acts as potent anticancer agent by exerting apoptotic effect either by upregulating and modulating proapoptotic proteins including p53, caspase 3, caspase 9, Bax or by downregulating antiapoptotic protein Bcl-2. Earlier research has related honey's chemopreventive action to its hydrogen peroxide-releasing property, but recent studies have implicated the role of phytochemical antioxidants in induction of cell apoptosis. Since honey contains phenolic derivatives, which exhibit antitumor, anti-inflammatory effects (Bang et al. 2003; Lopez-Lazaro 2006). It has been observed that either oral administration of honey or intravenous injection mediates its apoptotic effect by activating various proapoptotic proteins and by downregulating antiapoptotic proteins. Honey's apoptotic properties thus render it a potential natural product as an anticancer agent (Facino 2001; Bogdanov et al. 2008).

11.22 Cardiovascular Health

In the developed countries of the world, more deaths and disability are caused by ischemic heart disease (IHD) (Selwyn and Braunwald 2004). Among them the serious manifestations of IHD are arrhythmias and myocardial infarctions. Antiarrhythmic drugs are commonly used for the management of such conditions. However, in some patients the use of anti-arrhythmic medications poses serious health hazards like lethal arrhythmias, it is therefore important to use such drugs that will produce fewer side effects and will have more efficacy (Hume and Grant 2007). From ancient times, NH was used due to its medicinal aspect but most of the previous studies that have been reported in animals have particularly focused on various risk factors of cardiovascular disease like hyperlipidemia and generation of free radical species (Schramm et al. 2003; Chepulis 2007; Bahrami et al. 2008; Yaghoobi et al. 2008). The flavonoids and phenolic compounds that are present in NH have proved effective for treating cardiovascular diseases. These phenolic compounds possess protective effects which primarily include antithrombotic, antiischemic, antioxidant, and vasorelaxant. A study has reported that flavonoids perform three functions i.e., improves coronary vasodilation, decrease ability of platelets to form clot, and prevents oxidizing of LDL's in order to decrease the risk

of CHD (Khalil and Sulaiman 2010). It has also been found that NH decreases venous blood pressure which might be important for diminishing the congestion in the venous system (Rakha et al. 2008).

11.23 Ophthalmology

Natural honey has been used around the globe to cure several ophthalmological diseases like conjunctivitis, keratitis, blepharitis, corneal injury, chemical and thermal burns to eyes (Meda et al. 2004; Shenoy et al. 2009). A study in which NH was used as an ointment was conducted in 102 persons with nonresponsive disorders of eye, the results of which demonstrated that the condition improved in 85% patients while as in remaining 15% cases the disease did not progress at all. The use of NH in infectious conjunctivitis decreased redness, pus discharge, swelling, and eradicated bacteria (Bansal et al. 2005; Obaseiki and Afonya 1984; Al-Waili 2004).

11.24 Wound Healing

The use of NH that has been mostly studied and found to be most effective is in healing of wounds (Medhi et al. 2008). During the World War I, NH was used by the Russians to treat wound infection and to accelerate healing of wounds. The ancient Germans used a mixture of NH and cod liver oil for curing boils, burns, ulcers, and fistulas (Bansal et al. 2005). Natural therapy using honey has found to be most effective against all kinds of wounds such as abrasion, abscess, bed sores, amputation, burns, ulcers, burst abdominal wound, varicose & sickle cell ulcers, diabetic wound, septic wounds, leprosy, surgical wounds or wounds of abdominal wall and perineum, etc. In wound dressing the healing process is quickly stimulated by the use of NH besides clearing the infection. NH has been found to reduce inflammation, cleaning wounds and stimulate regenerate tissue. During tissue dressing, the pads impregnated with honey acts as nonadhesive (Bansal et al. 2005; Efem 1988; Al-Waili 2005). However, the elucidation of exact process of wound healing using honey is still not known.

11.25 Fungal Infections

Natural honey is capable of inhibiting the growth of fungi whereas diluted honey functions to inhibit the production of toxins (Al-Waili and Haq 2004). It has been found that NH possesses antifungal properties against yeast and species of Penicillium and Aspergillus (Sampath Kumar et al. 2010; Brady et al. 1997), *Candida albicans*, which causes Candidiasis also responds to honey therapy (Obaseiki and Afonya 1984; Bansal et al. 2005). It has also been reported that mycoses such as the ringworm and athletes foot respond to honey therapy (Bansal et al. 2005). Some research data studies have suggested that topical honey was quite successful to treat seborrheic dermatitis and dandruff (Al-Waili 2001, 2005).

11.26 Antiviral Effects

Natural honey has been found to have antiviral property in addition to the antibacterial and antifungal qualities. In one study conducted by Al-Waili (2004) in which he compared the effects of topical NH and acyclovir cream in treating genital herpes and recurrent labial lesions and found that NH was quite effective and safe in managing the signs and symptoms (Al-Waili 2004). It has also been found that NH inhibits the activity of rubella virus (Al-Waili and Haq 2004).

11.27 Scope of Use of Honey

Honey produced all over the world is well known for its nutritional and therapeutic properties. NH has been used in various ways as an artificial sweetening and flavoring agent. NH has found application as food additive based on its antibacterial and antioxidant activity (Nagai et al. 2006). In probiotic products of milk, NH can be used as a prebiotic additive based on its oligosaccharide content which acts as growth enhancer. There are sufficient evidences in support of use of honey for beneficial physiological effects in adults as well as infants older than 1 year (Ajibola 2015a; Yun 1996; Ladas et al. 1995). The health claims for honey include physiological processes like growth, physical performance and fitness, bone health, mental state and regulation of body weight. However, there is enough evidence that supports the use of NH in managing various disease conditions like diet-related cardiovascular disease, cancer, osteoporosis, etc. (Kreider et al. 2002; Ajibola 2013; Al-Bukhaari 1994). Research studies have found that natural honey may have a medicinal effect because of its antibacterial, anti-inflammatory, apoptotic, and antioxidant qualities. Antioxidant property of natural honey confers gastroprotective role such that it can help to prevent, cure, and treat some GIT disorders that includes gastritis, ulcers, and gastroenteritis (Ajibola 2015b). Moreover, NH is a folklore topical medicine to treat various ailments including eye diseases, wounds, dental plaque, gingivitis, periodontics. The only possible explanation for this behavior is its antibacterial properties, which prevent the bacteria from growing. Overall, the use of NH in diet reduces the pathogenesis as compared to other conventional antibacterial agents (Bansal et al. 2005; Ajibola et al. 2012). However, there are some research studies which have tested the effectiveness of honey for medicinal applications, however further research studies are required to validate all these aspects of natural honey. The primary issue about the therapeutic use of honey in present medicinal field is its variability in its constitution and inadequate clinical trials. Apicultural activities should be promoted worldwide in order to increase the production and availability of natural honey as it has the potential to replace refined sugars and traditional medicines. Moreover, it would also promote the use of NH as a reasonably inexpensive source of energy and an alternate cost-effective medication for most disorders.

11.28 Conclusion

Most countries of the world produce NH and it has been used in Ayurvedic as well as Yunani medicines for centuries. Generally NH is regarded as a rich nutritional and medicinal diet mainly due to the presence of various sugar molecules, water and also various vitamins, particularly B complex and vitamin C. There occurs a tremendous variation in composition as well as their medicinal uses among honeys of different floral origin. Natural honey contains various bioactive compounds and possesses various nutritional and biological effects. The presence of numerous substances present in natural honey has rendered it of utmost importance as a nutritional food and as a promising therapeutic agent.

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