



Overview on physical properties and biochemical composition of honey

Sabra Ambreen¹, Zahid Mehmood¹, Khalid Mehmood¹, Sabeena Rizwan², Farida Behlil^{2*}, Uzma Jabeen², Ayesha Mushtaq², Farrukh Bashir²

¹*Institute of Biochemistry, University of Balochistan Quetta, Pakistan*

²*Department of Chemistry Sardar Bahadur Khan Women's University Quetta, Pakistan*

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Abstract

Honey is a sweet and viscous liquid, made by honey bees. The biochemical nature of honey depends on different organic and inorganic compounds. The honey is commonly acidic which prevents it from adulteration and inhibits the growth of microbes. The low water content of honey also inhibits the growth of bacteria and fungi. The sweet taste of honey is due to the presence of carbohydrates i.e. different monosaccharides and disaccharides. Besides the presence of different sugars honey contains a low amount of fat, vitamins, minerals, organic acids, polyphenols, flavonoids and antioxidants. Presents review describes the research work of different authors from the world, working on the biochemical nature of different honey samples. They described the acidic nature, ash content, moisture content, total sugars, flavonoids, polyphenols, antioxidants, vitamins and mineral contents of honey from different regions of the world.

* **Corresponding Author:** Farida Behlil ✉ faridabehlil@yahoo.com

Introduction

Honey is a substance, sweet in taste, produced naturally by honey bees. The bees collect the sugary secretion of the plants called nectar. According to Pearson (1976), the definition of honey is: 'Honey is the saccharine product gathered by the bees from the nectar of flowers. This definition is in agreement with the regulations issued by the Economic Community of Europe and the United Kingdom. Honey is used in many countries as a nutritional source and due to its healing properties, it has also been used as a medicinal substance (Khalil *et al.*, 2011). Although various analysis are done on honey, but only few of these are published. This review highlights the physiochemical and biochemical analysis of natural honey.

Religious significance of honey

In Islam, Prophet Mohammad (PBUH) suggested honey for the therapy of various diseases and the Qur'an also prefers honey as a healthy and nourishing food for human beings, a whole chapter (surah) named An-Nahl (the bees) is present in the Qur'an. The Holy Qur'an and Hadith suggested that honey is a therapy for different diseases.

And thy Lord taught the bee to build its cells in hills, on trees and in (men's) habitations. There issues from within their bodies a drink of varying colors, wherein is healing for mankind. Verily in this is a sign for those who give thought' (Translation of Quran 16:68-69).

The prophet (PBUH) said: Honey is a remedy for every illness and the Qur'an is a remedy for all illness of the mind, therefore I recommend to your remedies, the Qur'an and the honey (Bukhari).

Honey has importance in different religions; in Buddh religion the people of Bangladesh and India commemorate a celebration known as 'Madhu Purnima' (honey full-moon). In this celebration, they give the natural honey to monks to commemorate the presentation of honey to Buddha by a monkey (Wikimedia Foundation, Inc., Honey.28 Jan 2010).

The honey is one of the five liquids of ever-living (Panchamruta) for Hindus. Over the statues of deities, the natural honey is poured in a ritual known as 'Madhu Abhisheka'. Honey is an identification of New Year in Jewish tradition; they celebrate the function of 'Rosh Hashana'. To lead a sweet new year, traditionally the apple slices are dipped in honey and then eaten (Wikimedia Foundation, Inc., Honey.15 Feb 2010). In the New Testament of Christianity, Matthew 3:4, John the Baptist said to live in a wilderness for a long period on a diet consisting of locusts and natural honey.

History of honey

From how long natural honey has been in existence, it is very difficult to say. 7000BC in Spain, the Cave paintings show the initial records of beekeeping. About 150 million years ago, the honey bees' fossils date back. Near Cairo when the sun temple was erected in 2400BC, the earliest record of beekeeping in hives was found. The ancient Egyptians give natural honey gifts to their gods, as a natural sweetening agent and preservative for different solutions. The Egyptians baked the cakes of honey and used these cakes as an offering to conciliate the gods. The people of Greeks also baked cakes of honey and offered these cakes to their gods. They consider honey is an important nutritious food and a therapeutic agent of medicines. The Greek books of recipes are full of cakes and sweetmeats which are made from honey. To make cheesecakes, Cheeses are mixed in honey. In the entire Roman Empire, Beekeeping flourished. The people of Romania extensively used honey in cooking and they also give honey gifts to their gods. During the establishment of Christianity, to get the demand for candles for the church, the use of beeswax and honey production increased greatly. The significance of Honey continued inside Europe until revival when sugar has arrived from other sources and thus the use of honey decreased. In the seventeenth century, the use of honey (as a regular sweetener) was decreased and sugar was replaced as a regular sweetening agent. They thought the bees have special powers; so these were used as different symbols. During the First

Dynasty (3,200BC) the bee was the sign of the king of Lower Egypt. Napoleon's robe was embroidered with bees and his flag also carried a single line of bees in flight. In the Greek city of Ephesus, the bee was the symbol used on coins in the third century BC. The honey bee was also the emblem of the Artemis (Greek goddess), and Eros/cupid (Crane, 1980).

Types of honey bees

Honey bees serve as good pollinators of the world vegetable and fruit crops with the estimation of commercial value approximately ranging from \$200-\$300 billion (US)/annually. Researchers found that vegetables, fruits and seeds of 87 leading world food crops depend on pollination done by the animals (Klein *et al.*, 2007). Honey was formed by three families of honey bees such as Apidae, Bombidae, and Meliponidae.

The family Apidae of honey bees is found in Europe, Africa and Asia. The family Bombidae of honey bees is found in temperate climates, these bees have small nests found often in the grounds and they have less commercial importance except these bees can serve as pollinators of certain plants (FAO, 1986; Crane, 1990). Nine species of honey bees are found worldwide, which includes as *Apis andreniformis*, *Apis cerana*, *Apis cerana indica*, *Apis dorsata*, *Apis dorsata binghami*, *Apis florea*, *Apis laboriosa*, *Apis mellifera*, and *Apis vechti*.

Most important and main species of the economic importance are *A. cerana/indica*, *A. dorsata*, *A. florea* and *A. mellifera*. Honey is a non-allergic substance used as nutritional food and energy provider (Rehman *et al.*, 2010). *Apis cerana* is a species present in southern and southeastern Asia, which includes Pakistan, China, India, Japan, Nepal, Korea, Bangladesh, Malaysia, and Australia. The Diet of these bees consists of pollen grains and nectar of flowers or honey. *A. cerana* has eight subspecies. *A. cerana cerana Fabricius* also called Chinese honey bees found in Pakistan, Afghanistan, northern India, Taiwan, China and northern Vietnam. *A. cerana heimifeng Engel* also known as black Chinese bees. *A.*

cerana indica Fabricius also known as Indian bees found in Sri Lanka, Southern India, Bangladesh, Malaysia, Burma, Philippines and Indonesia. *A. cerana japonica Fabricius* known as Japanese bees are present in Japan. *A. cerana javana Enderlein* also called Javan bee. *A. cerana johni Skorikov* known as Sumatran bee. *A. cerana nuluensis Tingek*, Koeniger and also called Bornean bee. *A. cerana skorikovi Engel* known as Himalayan bees found in eastern and central Himalayan Mountains.

In India two species of honey bees are used for apiculture and are predominant; *A. c. cerana* and *A. c. indica*. Both the species have resembled *A. mellifera*, some exceptions are found in color. *A. c. indica* has black abdominal bands present on its abdomen. These bees live near the hill stations and are also found sometimes in plain areas. *A. c. cerana* species has yellow abdominal bands on its abdomen and found near plain areas of India. *Apis mellifera* is recognized from *A. cerana* by its slightly large size (Engel, 1999).

Honey manufacturing process

The different flowers attract bees which contain high protein pollen and sugary nectar. Honey bees mostly like blackberry, apple, clover, dandelion, lavender, goldenrod, lime trees, ivy, rosemary and many more. The bees use their proboscis (long tongue) for the collection of nectar from the flowers. The proboscis is used like straw and slides down it into the flower to suck their nectar out. The nectar is then collected inside the honey stomach. The nectar can't be digested inside the honey stomach as it is present before to the digestive system of the honey bee and only serves as a carrying purse. It can store about 0.07 g of nectar. The tiny hairs present on the bodies of the honey bees allow the pollens to stick to their bodies. So while flying these bees also carries both pollen and nectar. The honey is not the vomit of the bees, it is a myth. The worker bees fly plant to plant and collect the nectar from different flowers. To pull out the water from the nectar the honey stomach begins to mix the nectar with enzymes. To get ready for summer dearth when there are little pollination

and growth, the bees will forage heavily in the spring. When the bee needs the energy while flying then the nectar is digested and when it doesn't need energy, the nectar takes the second pathway inside the honey stomach where it is not digested. The digested nectar cannot be used to create honey. The nectar is made of a sugary fluid, trace substances and aromatic oils that give the flower its scent (Perfect Bee LLC., 2019). When the worker bee flies back to the hive, the small bee called the house bee is waiting for the nectar. Her job is to suck the nectar from the honey stomach of the forager. When the nectar is transferred from the worker bee to the house bee, it will chew the nectar for about 30 minutes, she add some enzymes to break the nectar and forms a simple syrup. This enzyme also helps to reduce the content of water from the nectar, making it easily digestible and safe to be attacked by the bacteria during storage in the hexagonal cells that make up the hive. This dehydration process is continued by fanning the filled cells of the hive by their wings to bring the content of water below 18% and then the cell is capped with wax. The abdominal gland of the bee secretes wax; this content is now considered honey. The nectar of the flowers is composed of about 70% of water but honey is only about 18% of water. The honey is now a stable product which remains unspoiled and unfermented for years (luriegarden.org. 14 Oct 2016). A study was reported on the novel quality control methods in conjunction with chemometrics (multivariate analysis) for detecting honey authenticity. The author described that a very important authenticity issue of honey is its adulteration. The adulteration process is getting important for producers, regulatory authorities and consumers. It is significant to know about the chemical characteristics as a major natural health-promoting product in terms of the protection of honey against adulteration (Arvanitoyannis *et al.*, 2005).

The use of honey in the food industry and non-food products

Physical and chemical properties make honey an excellent and important element in many food compositions and also as a self-sustained product.

The main part of honey depends on carbohydrates; it is mainly used as a sweetening agent in different drinks and foods. The relative values of sweetness for different carbohydrates in honey are; sucrose (sweetness value of 1.0), glucose (0.7), fructose (1.5). The honey is rich in fructose so it is considered approximately 20% sweet than sucrose, therefore; less honey is used to bring about the same taste response in beverages and foods. Honey is humectants (the ability to hold moisture) that's why it is an important ingredient in baked. Honey is used as a natural food preserving agent. The preservative property of honey is due to its greater carbohydrate content; it affords water binding by the lowering of water activity, its low pH (~3.9). Antimicrobial agents are present but not limited to bacteriocins and hydrogen peroxide produced by enzyme glucose oxidase. honey is also used as an ingredient in food manufacturing include as a flavoring agent in sauces and dressings; coloring agent in puddings, bakery products and yogurt; as a source of carbohydrate for the production of an alcoholic beverage; and in salad dressings as an agent to modify viscosity. In non-food products; it is commonly used in cosmetics and pharmaceuticals. Honey is mainly used in ointments for its softening effect on the skin. The commercial products contain honey on large scale which includes hand creams, facial masks, lotions and soaps (Burlando and Comara, 2013). The shampoos and conditioners also contain honey. In medicines honey is used as a base and in ointments; in general pharmaceuticals e.g. cough syrups, it is used as a palatability agent. For wound dressing, it is also used which is based on its antimicrobial and antioxidant properties and also used in the treatment of respiratory infections (Wilson and Crane, 1979). From ancient past honey has been used as a sweetening agent and medicinal substance. The flavor and the physicochemical characteristics of the honey vary with the source of plant flowers, environmental climatic conditions and regional beekeeping practices. Melissopalynology is a method used most frequently in the analysis of pollens to find the plant source of honey (Puusepp, 2014). The external factors like weather conditions, harvesting conditions, vegetation

sources and preservation can influence honey's chemical composition (Crane, 1980).

The use of Honey as a therapeutic agent

Honey is used as a therapeutic agent for different diseases like throat infections, tuberculosis, bronchial asthma, eye diseases, thirst, hiccups, dizziness, hepatitis, fatigue, constipation, worm infestation, piles, wounds healing, eczema and different types of ulcers. For weak people, honey serves as nourishing, healthy and easily digestible food. Honey improves mental health and is used to treat diarrhea, vomiting, rheumatoid arthritis, diabetes mellitus, obesity. It is used as a preservative for fruits and meat. Honey is used for cosmetic purposes, for preparing facial washes, hair conditioners, skin moisturizers and it is also an important part of cosmetic treatments like pimples treatment. It is one of the best products of nature having a large range of beneficial uses (Ediriweera *et al.*, 2012). A study reported on the Bangladeshi honey of uni floral origin. The authors analyzed the biochemical composition of different brands of honey in Bangladesh. They determine the pH, moisture content, vitamins, sugar, proteins and antimicrobial properties of the honey of the Northern region of Bangladesh. The result of this study was that the chemical composition of uni floral honey changes with the source. This chemical change determines the nutritive and medicinal values and specifies the therapeutic values (Khalil *et al.*, 2001).

Antibacterial activity of honey

In past, the honey as a therapeutic agent in medicine was as a dressing for inflammations and wounds but now in folk medicine, its uses are largely confined. Besides this, it was thought that milk can be a carrier of some diseases, and honey can also be such a carrier. These ideas were examined some years ago by the addition of nine disease-causing bacteria to the honey samples. It was observed that within a few hours and days all the disease-causing bacteria have died. There are two reasons which indicate that honey can't serve as a good medium for the survival of bacteria; the first reason is that due to its acidic nature and its large amount of sugar content. The

ability of a solution to kill the bacteria by a large amount of sugar is termed an osmotic effect. Its function is too drying out the bacteria, while few bacteria can survive in the spores' forms, which cannot grow inside the honey. The second property of honey to serve as an antibacterial medium is the presence of antibacterial agent inhibine. In 1940, many laboratories confirmed and reported that honey has antibacterial properties. The antibacterial activity of protein inside the honey was named inhibin by Dold (discoverer). It is very sensitive to light and heat. The amount of inhibine in a honey solution depends on its floral origin, age, and heating (White *et al.*, 1978). A study reported on the indicator microorganisms' value with primary impurities of honey. The authors described that the microbes found in honey are mostly the spores of forming bacteria and yeast. The presence of these microbes indicates the commercial quality of honey. Under certain conditions, these microbes present in honey could cause human illness. The digestive system of honey bees, earth, dust nectar and pollens are considered as the primary sources of contamination done by microbes inside honey. These primary impurities are hard to control. Various other sources like air, cross-contamination, handlers of food, buildings and equipment are the secondary microbial contaminations sources. The authors reported that by good manufacturing practices the secondary sources of microbial contamination can be controlled (Kacsniova *et al.*, 2009). A study described the supersaturated solution of sugars found in honey samples. The author described that the strong interaction between these molecules of sugars will give few molecules of water available for the development of microbes. Gluconic acid is the main dominant acid present in honey. This acid is produced from the activity of the enzyme glucose oxidase. This enzyme also produces hydrogen peroxide molecules, having antimicrobial activity (Malika *et al.*, 2005).

Antioxidant property of honey

Honey has antioxidant properties; it is a potent anti-inflammatory agent for the treatment of

inflammation. The good healing activities of honey are achieved by the availability of natural honey impregnated dressing. The studies show that the dressing of honey keeps the ulcer clean and also prevents it from different infections. The insulin-mimetic effect of honey is found to stimulate diabetic ulcer healing (Molan, 2004). The chemical property and phytochemical property of honey vary from plant to plant. Researchers found that honey stimulates the release of different types of cytokines which include tumor necrosis factor, it is a protein that is found to minimize the inflammation of tissue and activates white blood cells, which is very important for healing (Molan, 1998). A study determined the antioxidant capacity and amino acid composition of 53 Spanish samples of honey. The samples consist of 39 floral, 9 blend honey and 5 honeydew honey. They analyze the physicochemical characteristics, amino acid composition, and polyphenolic content and estimate the radical scavenging capacity against the stable free radical DPPH. Results of the study showed that the total absorbance, pH, electrical conductivity, acidity, and net phenolic content had a high correlation with radical scavenging capacity (Pérez *et al.*, 2007).

Physical and Biochemical composition of honey

Honey contains very important complementary elements which are very easily digestible. Over 300 substances are present in honey, which have good effects on the metabolic processes in the body. Honey contains a wide range of saccharides, amino acids, organic acids, minerals, coloring agents, aromatic substances and a very small amount of lipids (Redtke and Hadtke 1998; Bogdanov *et al.*, 1998). Honey carries very unstable but valuable components like vitamins, hormonal characters substances, enzymes and few trace elements. Different groups of honey differ in color, taste and aroma. Researchers reported about some variations in the chemical composition of different honey groups, it reflects in different physicochemical characteristics, such as pH, ash content, and enzyme activity, the spectrum of saccharides, optical rotation and electrical conductivity (Bogdanov *et al.*, 1987, 1999; Goloband and Plestenjak, 1999; Sanjuan *et al.*, 1997). The

concentration of mercury in different groups of honey is the indicator of contamination of weather by this metal. The researchers have not discovered a new antibiotic for the last 30 years. The bacteria are developing resistance to antibiotics which results in deadly diseases that were treated by these antibiotics. The researchers estimated that two million people are infected with antibiotic-resistant bacterial diseases. Honey bees not only producing sweet honey for humans but these bees also pollinate our food, roughly one-third of the world's supply. Researchers recently suggested that honey bees create an antimicrobial compound that could be helpful for the development of new antibiotics. By creating antibacterial proteins and peptides the organisms present in nature can resist bacterial infections (the University of Illinois at Chicago, 2017). The fragrance, consistency and taste distinguish high quality of the honey. At 20 °C (68 °F) the high-quality honey flows in a straight line without breaking in to separate drops from containers (Bogdanov *et al.*, 2008). It should form a bead after falling and forms small temporary layers which disappear after a few minutes when poured. It shows the high viscosity of honey. Honey with high water content (over 20%) is not considered as good quality, pure honey and also is not suitable for long time preservation (Allan *et al.*, 2001). Honey is the very concentrated liquid of water and carbohydrates like dextrose, levulose and at least 22 other complex sugars. Honey mainly consists of other organic and inorganic substances but carbohydrate is the main component of the honey. The presence of different sugars identifies the principal physical characteristics and behavior of honey. The difference among the different honey types are identified by the presence of minor compounds such as pigments, flavoring materials, acids, minerals and trace elements (White *et al.*, 1980). Honey is hygroscopic; this is the characteristic of honey to absorb and retain moisture from the surroundings. Due to the excess content of water, the hygroscopic nature of the honey becomes problematic which causes difficulty in storage and preservation. The ripped honey with a water content of about 18% or less can absorb the water from above 60% humid

air. The colors of the honey depend on its botanical source, storage conditions and age, but the suspended particles like pollens are responsible for its clarity and transparency. So the basic honey colors found clear to colorless like water and from dark amber and nearly black. These colors are variations of yellow, amber concentration of caramelized carbohydrates, and used as a standard of color. Honey turned lighter in color after crystallization due to the formation of white glucose crystals. The higher glucose content of honey and lower water content in honey causes faster crystallization. Honey crystallization results in the formation of crystals of monohydrate glucose, the variation in numbers, shapes, quality and dimensions are dependent on the composition of honey and its storage conditions (Olaitan *et al.*, 2007). A study conducted several United States regions on multi-floral honey typically contains; as fructose (38.2%), glucose (31.3%), maltose (7.1%), sucrose (1.3%), water (17.2%), higher sugars (1.5%), ash (0.2%) and other trace elements (3.2%) (White *et al.*, 1980).

Another study on 20 different honey samples from Germany by NMR spectroscopy found that the sugar contents of honey consist of fructose as 28% to 41% and glucose as 22% to 35%.

The method of NMR spectroscopy did not quantify other sugars like galactose, maltose and other sugars present in small amounts as compared to glucose and fructose. The average fructose and glucose ratio was 56% and 44% respectively, but the ratio of fructose and glucose differs in individual samples (Ohmenhaeuser *et al.*, 2013). The composition of honey mainly depends on different types of sugars, consisting of 95 % of the dry weight of honey. The monosaccharide hexose, glucose, fructose, the hydrolysis products of the disaccharide sucrose are the main sugars inside honey. Besides these researchers said that about 25 different types of carbohydrates are detected in different samples of honey (De La Fuente *et al.*, 2007). The bees add acids to the honey while the acid content is very low in honey. The acid is important to develop the taste of honey (Echigo *et al.*, 1974). The main acid is gluconic

acid and the following acids have been found in minor quantities: acetic acid, formic acid, citric acid, lactic acid, succinic acid, malic acid, maleic acid, oxalic acid and pyroglutamic acid (Mato *et al.*, 2003). Honey contains all types of physiologically important proteins and amino acids in a small amount, a maximum of 0.7%. The main amino acid found in honey is proline. It is a measurement of the ripening of honey. Normal honey contains about 200 mg/kg of proline content while the values less than 180 mg/kg means that the honey is blended with other sugars (Perez, 2007). The proteins found in honey are mainly enzymes. Different types of enzymes are added by bees to break the nectar during the ripening process of honey. The heat-stable enzyme diastase (amylase) is added for the digestion of starch to maltose. Two enzymes catalase and glucose oxidase regulates the formation of H₂O₂ (antibacterial factors of the honey), invertase is the enzyme that converts sucrose to glucose and fructose, it may take part in the conversion of many other sugars. Invertase and diastase enzymes play a very important part in the judgment of the quality of honey and serve as indicators of honey freshness. That's why their activity decreases upon storage and heat (Bogdanov, 2009). In early times the quality of honey was determined by mineral content, while nowadays; this procedure is replaced by the process of electrical conductivity. The mineral content of blossom honey lies between 0.1to 0.3%, the mineral content of honeydew honey ranges to 1% of the total amount. Different amounts of mineral substances are present in honey which ranges from 0.02 to 1.03 g/100g. The main mineral component of honey is potassium. The mineral contents largely depend on the botanical origin of honey. It is possible to separate different uni floral and multi-floral origins of the honey by determining their mineral content. So the light blossom honey have low mineral content than dark-colored kinds of honey (Bogdanov *et al.*, 2007). Hydroxymethylfurfuraldehyde or HMF is present in a very small amount in honey. It is a decomposition product of fructose. The concentrations of HMF increase with prolonging the heating of honey and storage. Its production depends upon the acidity of

honey, in more acidic honey-like blossom honey it is built at a higher concentration. Beekeeping organizations of some countries, e.g. Italy, Germany, Switzerland and Finland have set 15 mg/kg maximum for specially labeled “quality” of honey (Thrasylvoulou, 1997). Apart from the sugars, acids and water honey also contain polyphenols, proteins, free amino acids, phytonutrients and trace elements with vitamins. Honeydew honey and blossom honey have slightly different compositions. Blossom honey has a mineral content from 0.1 to 0.3%, the mineral content of honeydew honey is 1% of the whole composition. Honey carries a different amount of minerals ranging from 0.02 to 1.03 g/100g. The main important mineral is potassium, with an average of one-third of the total concentration of minerals present inside the honey and the other two-third parts include a wide range of different trace elements. To differentiate between the uni floral and multi-floral origin of honey, the different trace elements present in the various honey samples is determined because the amount of trace elements present in the honey largely depends on the plant source from which the nectar is derived (Bogdanov *et al.*, 2008). The studies show that potassium is found most abundantly about 73% of the total mineral content. Calcium is present in a large concentration than other minerals, 82.9 mg/kg in nectar honey, and 34.9 mg/kg in honeydew honey, with an average of 64.9 mg/kg (Lachman *et al.*, 2007). Besides these minerals Aluminium, Arsen, Barium, Boron, Chlorine, Florin, Iodine, Bromine, Cobalt, Sulfur, Silicium, Strontium, Nickel, Rubidium, Zirkonium and other elements are also present in trace amounts. Heavy metals e.g zinc (Zn), lead (Pb) and cadmium (Cd) found in the monofloral type of honey samples were very low. The study on the samples of New Zealand honey was conducted to understand the heavy metal content present inside the honey. This study shows that the presence of heavy metals on the samples was, zinc 1.18mg/kg, cadmium 0.149 mg/kg, and lead 0.017 mg/kg respectively (Przybylowski and Wilczynska, 2001). Due to chemicals and different digestive processes the breakdown of proteins occurs, the resultant compounds obtained are the amino

acids. Amino acids are the “building blocks” of proteins. The essential amino acids can't be synthesized by the body and must be taken in the food. The free amino acids are present in very small quantities and have no benefits. The separation and analysis techniques for very small quantities of samples (chromatographic techniques) have identified the different types of honey samples having 11 to 21 free amino acids. leucine, glutamic acid, phenylalanine, Proline, alanine, tyrosine, and isoleucine are the commonly found amino acids in honey samples, in which proline predominates. To form yellow or brown products, Amino acids always slowly react or more quickly when the heat is provided with sugars. Part of the dark coloration of honey by heating and age could be due to this (White *et al.*, 1978). A study conducted on biochemical properties, antibacterial and cellular antioxidant activities of buckwheat honey compared with manuka honey. Authors found that buckwheat honey has larger sugar, phenol and protein content as compared to manuka honey. Manuka honey contains higher methylglyoxal content than buckwheat honey. They further described that buckwheat honey has a large amount of minerals like Fe, Mn, and Zn and phenolic compounds like p-hydroxybenzoic acid, p-coumaric acid and chlorogenic acid. They also found that buckwheat honey exhibit antibacterial activity against *Staphylococcus aureus* and *Pseudomonas aeruginosa*, the cellular antioxidant activity of buckwheat honey when compared with monuka honey, buckwheat honey found higher cellular antioxidant activity than monuka honey. They suggested that buckwheat honey has a higher commercial and nutritional potentials than monuka honey (Deng *et al.*, 2018). Another study was conducted on the biochemical, physiochemical, mineral content analysis and antioxidant potential of national and international honey in Pakistan. The authors reported that the total phenolic content of monofloral honey of Yemen and Saudi Arabia are similar to jujube honey of Pakistan and acacia honey of Germany, respectively. The content of minerals inside honey samples was compared with honey samples from Romania and Brazil. They reported that

dark color honey contains larger phenolic content than light color honey and has higher oxidation potential (Ahmed *et al.*, 2016). A study investigated the relationship of biochemical (enzymes) and nutritional components in honey samples from Malaysia. The study was conducted on tropical areas with heavy rainfall. The study was important to estimate the quality of different samples of honey. The results of this study indicated that the peroxide activity was negatively correlated with carbohydrate content and positively correlated with moisture content in honey. The results of free amino acid profiles and chromatographic sugar indicated, that based on maturity and types the different honey samples could be clustered (Chua *et al.*, 2014). Another study determined on antioxidant and biochemical properties of Bangladeshi honey. The authors determined the ash, mineral, moisture content, vitamins, antioxidant contents, proteins, sugar, pH level and antimicrobial properties in honey samples. This study covers the use of natural honey in human diseases. They compare the Bangladeshi honey samples with the samples of many parts of the world and found that the honey from Bangladesh also falls within the limits of international standards (Asaduzzaman *et al.*, 2015). The natural forests and different types of flowering plants are present in the bale region of Ethiopia. It has large and unique fauna and flora. A study was conducted on 30 samples of different agro-ecological of bale nature flora in 3 districts. The results of this study show no significant differences between the thirty samples for free acidity, reducing sugar and ash contents (Tefaye *et al.*, 2016). An article reported on the biochemical, physicochemical and antibacterial properties of honey from India. The authors collect 15 honey samples from Kerala, India and classified these honey samples into three categories: raw/wild samples, marked samples and industrial samples. They used the following parameters for the analysis of samples: physiochemical characters, biochemical properties, organoleptic features and microbiological state. The values they found from the analysis of honey were compared with the standard values. They reported that no honey ideally conformed to the entire

parameter standard. The results of this study indicated that honey contains a significant amount of phenols and effective antimicrobial properties. Honey samples showed microbial growth upon dilution which shows important links between yeast count and moisture content and highlights the necessity of proper storage conditions (Kavapurayil *et al.*, 2014). A study was conducted on the North-East Nigerian honey. The authors analyzed the biochemical composition of different honey samples. Nigeria mainly consists of a humid climate with different types of vegetation and varying agricultural activities. The chemical composition, physicochemical properties of honey is influenced by these agricultural activities and difference in vegetation. To check the quality of Nigerian honey, they collected 18 samples from various regions of Nigeria. They compared the honey samples with the samples of various regions of the world and the results showed that the Nigerian honey falls within the limits of international standards (Buba *et al.*, 2013). A study determined the chemical markers of unifloral honey. The study was done to analyze the compositional data of volatile compounds, flavonoids, phenolic acids, amino acids, carbohydrates, and other components of the honey samples. They reported that the composition of phenolic acids, saccharides, volatile compounds and other compounds have been related to the botanical origin of honey. They reported that other extrinsic and intrinsic factors can affect the composition of honey; floral phytochemical markers had investigated not completely reliable indicators for authentication of honey by investigating its geographic origin and floral source. The collected data studied on the floral markers which suggest that good classification of different honey samples can be done by the use of different groups of components like carbohydrates, volatile components, phenolic compounds, and amino acids, include some supplementary parameters like color, electrical conductivity, and activity of enzymes (Kaškonienė *et al.*, 2010). Another study reported on the Evaluation of the floral origin of Estonian uni floral and poly floral honey by amino acid content activity. The author determined the activity of enzymes. The enzymes are biochemical components

that are related closely to the freshness of honey and nutritional content. Enzymes are present in minute quantity in the honey and having an essential role in the quality of honey. Enzymes have an important effect on the profile of free-amino acid, protein content and honey's acidity. Most of the enzymes are secreted in bees' salivary glands present in the honey samples. These enzymes are oxidases, amylases and catalases. The complex sugars will be broken down into simple sugars by these enzymes and simple sugars will be turned into acetic acid and alcohol under the right temperature condition and an appropriate amount of moisture content because of fermentation. The enzyme activity may alter the aroma and flavor after fermentation of honey, besides affecting the pH values. Proline is reported in the abundance of all the amino acids (Rebane *et al.*, 2008). A study describes the several significant qualities in addition to taste and composition. The author describes that the honey's ability to hold and absorb the water from the outer environment is a property called Hygroscopicity. The hygroscopicity of honey could be problematic during processing and storage. The presence of excess content of water can cause difficulties in storage and preservation. The color of liquid honey changes from colorless to clear, from dark amber and black. The different colors of the samples are different shades of yellow, amber and various concentrations or dilutions of caramelized sugar and used for a color standard traditionally. The author further described that the normal honey with 18.8% or less water content will absorb water from the environment with relative moisture of above 60%. The author said that the color of honey varies with its age and botanical origin. Its color also depends on the conditions of storage but the clarity and the transparent color of honey depend on the concentration of suspended particles like pollens. After crystallization, the color of honey turns lighter because the crystals of glucose are white. The formation of monohydrate glucose crystals results in the crystallization of honey. These crystals vary in number, dimension, shape and quality depends on honey's composition and storage conditions. The more glucose content and the lower the moisture

content of honey, the process of crystallization will be faster (Olaitan *et al.*, 2007).

The use of honey in medicines

A study was conducted on honey and its role in relieving multiple facets of atherosclerosis. The authors said that honey is a natural sweetener that is used all over the world. They determine that the biochemical composition of honey changes according to the environment, geographical and botanical origin. It is a mixture of sugars and non-sugar constituents; glucose and fructose are the main dominant carbohydrates. They reported that the non-sugar part consists of enzymes, vitamins, amino acids, minerals and a phenolic compound that contributes to the nutritional components of honey. This paper summarized and discussed the honey's composition, its protective effects and different possible mode of action on risk factors of the disease atherosclerosis. Atherosclerosis is a very damaging chronic disease present all over the world. They reported that the phenolic compounds, antioxidant system and enzymes present in honey can protect from the disease condition (Nguyen *et al.*, 2019). Pearce wrote a book on the composition, geographical and botanical origin, history and therapeutic use of honey in modern and traditional medicines. The name of the book is Review of honey in traditional and modern medicine. In this book, the author determines the history of honey, the biochemical and physicochemical properties of honey. He also determines the healing properties of honey and its sources. The author discussed in this book the health-promoting properties of honey (Pearce, 2015). A study on Argentinean honey was conducted to investigate the development of reliable fingerprints from elemental and isotopic signatures to assess the geographical provenance of Argentinean honey. They collected the samples of soil, honey and water from three regions (Buenos Aires, Córdoba, and Entre Ríos). The multi-element composition was reported by using various techniques. The result of the study shows the 91.5 % consensus among the samples of honey, soil and water, in addition to clear differences among the three study areas (Baroni *et al.*, 2015).

Another study reported about Honey and its Anti-Inflammatory, Anti-Bacterial and Anti-Oxidant Properties. The authors described about the biochemical composition of honey that large part of honey depends on sugar and water. They said that honey also contains different vitamins like vitamin B complex, vitamin C, niacin, riboflavin and pantothenic acid.

They reported that honey contains minerals like calcium, iron, copper, magnesium, phosphorus, magnesium, zinc, potassium and manganese. The author described the healing, antibacterial, nutritional and therapeutic properties of honey from ancient times. The honey shows antibacterial properties against multi-drug resistant bacteria like *Pseudomonas aeruginosa*, *Acinetobacterbaumanni* and *Staphylococcus aureus*. The authors also reported the anti-inflammatory and antioxidant properties of honey. These properties of honey can give help for the cure of different long-term inflammatory disorders e.g. atherosclerosis, cardiovascular disease and diabetes mellitus (Vallianou *et al.*, 2014).

Conclusion

It is concluded from this overview that honey is a natural sweet substance found all over the world for nutrition. Honey is made by the honey bees from nectar of the plants. Honey has religious importance as well and was found to be used from ancient past. The fossils of honey bees were date back 150 years ago. Three families of honey bees are found all over the world which includes Apidae, Bombidae and Meliponidae. The family Apidae is found in Europe, Africa and Asia, having nine species. Among all those species *A. cereana*, *A. dorsata*, *A. florum* and *A. mellifera* are of prime importance. Honey is manufactured inside the bodies of honey bees; the bees collect the nectar from the plants and collect it inside the honey stomach. Where by the help of some enzymes and substances this nectar is changed into honey syrup and then ripened in hives to reduce moisture. This overview is based on physical properties and biochemical composition of honey. The composition of honey mainly depends on

carbohydrates, about 17 to 20% of water and small amount of minerals, organic acids, vitamins, antioxidants, polyphenols and very little amount of lipids. The pH of honey is 3.9 which prevent it from contamination. Honey is used in food and non-food products, it is mainly used in baking cakes, as base in cosmetics, as therapeutic agent, as antibacterial agent and also used in medicines. Over 300 substances are reported to be present in honey which is very much important for metabolic process.

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