"The fruit of bees is desired by all, and is equally sweet to kings and beggars and it is not only pleasing but profitable and healthful; it sweetens their mouths, cures their wounds, and conveys remedies to inward ulcers." - Saint Ambrose.

Honey is the Nature’s boon to the mankind. In Ayurveda it is described as Amrutha on the Earth. The use of natural honey as food and medicine by mankind has been in existence from times immemorial. In fact, records have it that raw honey is the most ancient sweetener, and was noted to have been in use throughout the world several million years ago. Natural honey (NH) is a sweet, flavorful liquid food of high nutritional value and immense health benefits.

Natural honey is produced by honey-bees as blossom honey by secreting nectars of flowers, and honeydew honey (forest honey) by secreting the exudates of plant sucking insects (Aphids). Natural honey is widely embraced by all ages, and its use transcends the barriers of culture and ethnicity. The use of honey is even advocated and embraced by all religious and cultural beliefs. This wonderfully rich golden liquid is the miraculous product of honey bees and a naturally delicious alternative to white sugar. Although it is available throughout the year, it is an exceptional treat in the Summer and Winter when it has just been harvested and is at its freshest.
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Approximately one half of the human diet is derived directly or indirectly from crops pollinated by bees. Today honey-bees are an essential part of a healthy agricultural economy. Honey is a sweet, sticky, yellowish fluid made by bees from nectar (Kindersley, 2007). Honey is an age-old food and medicine, dating back thousands of years. One would think that both believers in creation and believers in evolution would feel that honey is a symbiotic food and medicine.

Stone Age paintings in several locations, dating from 6000 BC or earlier, depict honey hunting, documenting human use of honey for at least 8000 years. References to honey as a medicine are found in ancient scrolls, tablets and books—Sumarian clay tablets estimated to be 6200 BC, Egyptian papyri dated from 1900-1250 BC, Veda (Hindu scripture) about 5000 years old (Jones et al., 2001) the Holy Koran, (Beck et al., 1997; McIntosh, 1995) the Talmud, both the Old and the New Testaments of the Bible, sacred books of India, China (Jones et al., 2001). Honey was ubiquitous and our ancestors used it for medicinal purposes universally.

There are more than 300 honey varieties—which also mean different flavours and compositions. Some have stronger tastes than others; some are milder and more delicate. In general, honey that is light in colour has a mild flavour and the ones with a darker colour usually have strong flavour. Experienced honey tasters can easily tell the differences between different honey varieties. The main reason for the large number of honey varieties is the different types of nectar source. Different honey varieties also mean different tastes and aroma. Bees visit many kinds of plants and flowers, accumulating different qualities of nectar from these flowers (Ransome, 1937).
Honey bees collect the nectar from various floral sources and store it as honey which serves as food for bees during winter. Honey bees make a journey of nearly 55,000 miles to gather nectar from approximately 2 million flowers for accumulating one pound of honey. In the bee-hive, three types of bees are found namely the queen, drone and worker bees. Among them, only worker bees collect and regurgitate the nectar a number of times in order to partially digest the nectar before storing in the honey comb.

Honey bees use their wings to fan the honey comb to evaporate most of the water from nectar thereby avoiding the fermentation of honey. The color of the honey collected by the bees varies according to the floral source and its mineral content, which usually ranges from water white to dark amber. It has been reported more than 300 unique varieties of honey depending upon the floral sources from United States alone (www.honey.com/consumers/kids/beefacts.asp, 2007; Todd et al., 1942).

Honey is the sweet and viscous carbohydrate rich food, which has occupied an important place in human nutrition since prehistoric times. Honey is considered not only as a sweetener but also as a healthy and wholesome food with curative properties. It acts as an antimicrobial agent against many bacteria. It has been used as a medicine in many cultures for a long time (Ransome, 1937; Champman et al., 1993; Majno, 1975; Quinn et al., 1994).

The enzyme contents of fresh honey is one of the characteristics that make it beneficial to human health, but processing, heating and prolonged storage can lower enzyme activity (White, 1978). The medical profession has rediscovered the use of honey as a therapeutic substance and it is accepted as an antibacterial treatment of tropical infections resulting from burns and wounds (Abuharfeil et al., 1999; Allen et al., 1991; Linder, 1962; Mccarthy, 1995).
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The traditional use of honey in food preparations has been substituted in most cases by sugar and more recently by various sugar syrups derived from starches. Jaggery is a concentrated product of cane juice without separation of the molasses and crystals and can vary from golden brown to dark brown in colour.

**NUTRITIVE VALUE OF DIFFERENT SWEETENER**  
(Per 100gm quantity)

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Honey</th>
<th>Cane sugar</th>
<th>Jaggery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture (g)</td>
<td>20.6</td>
<td>0.4</td>
<td>3.9</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>0.3</td>
<td>0.1</td>
<td>0.4</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>-</td>
<td>-</td>
<td>0.1</td>
</tr>
<tr>
<td>Carbohydrate (g)</td>
<td>79.5</td>
<td>99.4</td>
<td>95.0</td>
</tr>
<tr>
<td>Energy (kcal)</td>
<td>319</td>
<td>398</td>
<td>383</td>
</tr>
</tbody>
</table>

Source: Gopalan et al., 2011

1.1.1 Physical Aspects of Honey

(i) **Sensitivity to heat:** The loss of antibacterial activity on exposure of honey to heat was of complete loss of inhibition by 17% honey after exposure of 50% honey to 100°C for 5 minutes, 80°C for 10 minutes, or 56°C for 30 minutes (Duo et al., 1937).

(ii) **Sensitivity to light:** Honey has been observed to lose its ability to inhibit bacterial growth (tested in a 17% solution) after exposing a thin film of it to sunlight and it is confirmed that exposure of honey in a layer 1-2 mm thick to sunlight for 15 minutes was found to result in complete loss of non-osmotic activity (White et al., 1964).
(iii) Storage effect: Enzymatic activity, antimicrobial properties, microbial quality, colour and chemical composition are all influenced by heat and storage (White, 1992).

Sources: Composition of honey by Gopalan et al., 2011

The medical and nutritional properties of honey depend on its chemical composition. The chemical composition of honey varies depending on the plant source, season, and production methods (Hatice et al., 2010). Honey mainly composes of sugars and water which account roughly 79.6% and 17.2%, respectively. Major sugars of honey are monosaccharides Viz., levulose and dextrose which constitute 38.19% and 31.28% correspondingly, remaining 1.3% and 7.3% are sucrose and maltose respectively. Besides, about 25 different sugars have been detected, which contain varieties of enzymes such as oxidase, invertase, amylase, catalase etc. (Doner, 1977; Siddiqui, 1970).

Minor constituents of honey include acids (0.57%), protein (0.266%), nitrogen (0.043%), amino acids (0.1%), a little amount of minerals (0.17%), and a number of other minute quantities of components like pigments, flavor and aroma substances, phenolic
compounds, colloids, sugar alcohols and vitamins which altogether accounts for the 2.1% of whole honey composition (www.honey.com/consumers/kids/beefacts.asp, 2007; Todd et al., 1942). The acid content of honey is relatively low but it is important for the honey taste. Most acids are added by the bees (Echigo et al., 1974).

The content of amino acids and proteins is relatively small, at the most 0.7% and has a small nutritive value. However, these components can be important for judging the honey quality. Honey contains almost all physiologically important amino acids (Cotte et al., 2004; Perez et al., 1989; Perez et al., 2007). The amino acid proline, which is added by bees, is a measure of honey ripeness (Von Der Ohe et al., 1991). The honey proteins are mainly enzymes (White, 1975). Honey contains varying amounts of mineral substances ranging from 0.02 to 1.03 g/100 g (White, 1975).

Several investigations have shown that the trace element content of honey depends mainly on the botanical origin of honey, light blossom honeys have a lower content than dark honeys, e.g. honeydew, chestnut and heather (Feller-Demalsy et al., 1989; Gonzalez-Miret et al., 2005; Sevlimli et al., 1992). It was possible to differentiate among different unifloral honeys by determination of different trace elements by measuring Mg, Ca, Al, Fe, Mn, Zn, B, Cu, Co, Cr, Ni, Cd and P (Bogdanov et al., 2007; Nozal Nalda et al., 2005).
1.1.2 Benefits of Honey

The use of honey for its medicinal properties is widespread and has been well documented in literature. The indications for its medicinal uses are several; the uses reported in literature include wound healing (Blaser et al., 2007), oral ulcers (Worthington et al., 2007), recurrent herpes simplex infection (Telles et al., 2007), gastrointestinal and ophthalmologic conditions (Khan et al., 2007). There are reports indicating its beneficial use in burns and post-operative wound healing (Khan et al., 2007).

It has been used as a wound barrier against tumor implantation in laparoscopic oncological surgery (Khan et al., 2007). This shows the potential benefits of honey in modern day surgical procedures. It has been found to be therapeutically useful in patients suffering from anal fissures (Al-Waili et al., 2006). Honey has also been reported to be effective in gastrointestinal disorders (Haffeejee et al., 1985; Ladas et al., 1995), as an antimicrobial agent (Ladas et al., 1995; Ali, 1991) and to provide gastric protection against acute and chronic gastric lesions (Ali et al., 1991; Mobarok, 1995). The therapeutic
potential of honey is gradually growing and scientific evidences for the effectiveness of honey in several experimental and clinical conditions are beginning to emerge.

Honey is considered as a valuable medicinal food in Indian system of medicine and is found to be useful in management of diabetes (Agrawal et al., 2007). The major dietary component responsible for fluctuations in blood glucose levels is carbohydrate (Jenkins et al., 1981; Gannon et al., 1989). Both the amount and the source of carbohydrate appear to have profound influence on postprandial glucose levels (Brand et al., 1985). Honey is a concentrated solution of different carbohydrates with glucose and fructose as the major ones. Honey is also shown to contain minerals like selenium, magnesium, chromium, potassium, zinc and copper (Bogdanov et al., 2007). Zinc appears to lower plasma glucose levels via improvement of insulin sensitivity (Song et al., 2003).

The presence of free radicals and reactive oxygen species (ROS) is culpable in the processes of cellular dysfunction, pathogenesis of metabolic and cardiovascular diseases (CVDs) as well as aging. The consumption of foods and substances rich in antioxidants can protect against these pathological changes and consequently prevent the pathogenesis of these and other chronic ailments. Researches indicate that natural honey contains several important compounds, and these include antioxidants (Al-Wailly, 2003; Schramm et al., 2003). The qualitative and quantitative composition of honey (including the antioxidants constituent and the other phytochemical substances) is a reflection of the floral source as well as the variety of the particular honey. The colour of honey also influences its antioxidant content, as darker honeys are known to have higher amount than lighter honeys (Frankel et al., 1998).
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Besides these health benefits honey is also reported to have low glyvemic index. A study, reported that honey had a lower GI when compared with sucrose in patients with type 1 diabetes mellitus (Abdulrhman et al., 2011). Further, in a small clinical study (Samanta et al., 1985) plasma glucose levels were significantly lower after 1-3 hour in diabetic patients who had consumed honey (20-75 g) than in those who had consumed equivalent amounts of glucose, sucrose or fructose.

1.2 Glycemic Index

There are some possible explanations why honey, although having a high carbohydrate content, has a low or moderate-low glycaemic index: (1) the glucose component of honey might be poorly absorbed from the gut (Agrawal et al., 2007). (2) Palatinose or isomaltulose, a sugar present in honey, exhibits characteristics of delayed digestion and absorption (Dahlquist et al., 1963; Lina et al., 2002) and (3) small quantity of fructose shows an increase in hepatic glucose uptake and glycogen storage, as well as reducing peripheral glycaemia (Watford, 2002). Furthermore, the unique physiochemical composition of honey contains other known and unknown substances that may play a role. For example, in-vitro studies with other honeys have shown some samples to have an insulin-mimetic effect (Heffetz et al., 1990).

The insulin regulating benefits of consuming a low GI diet for individuals with established diabetes are well known (www.diabetes.org.nz, 2008); however, there are also strong links emerging between a high GI diet and coronary heart disease (www.hsph.harvard.edu/nutritionsource, 2012). The global financial costs of managing these co-morbidities are in excess of hundreds of billions of dollars annually (www.who.int/en, 2012; www.who.int/en, 2011) suggesting that urgent action is required.
The possible use of alternative, lower GI sweeteners, including honeys, is therefore one way in which this may be addressed.

Glycemic index is an important tool used in treating people with diabetes. Low glycemic index foods, by virtue of the slow digestion and absorption of their carbohydrates, produce a more gradual rise in blood sugar and insulin levels and are increasingly associated with health benefits. Low glycemic index foods have thus been shown to improve the glucose tolerance in diabetic subjects. Glycemic index is a classification of the blood glucose-raising potential of the carbohydrate portion of foods. It is defined as the incremental blood glucose area under the curve following a test food, expressed as the percentage of the corresponding area following a carbohydrate equivalent load of a reference food (Bjorek et al., 2000).

The glycemic index concept was developed in human nutrition in an attempt to characterize foods according to their postprandial glycemic response rather than their chemical composition (Jenkins et al., 1981). The glycemic effect of a food in human beings is influenced by the nature of the carbohydrates, the type of carbohydrates, the physical form of the food and processing (Wolever, 1990).

The glycemic response to a food is a measure of the impact of a food on blood sugar. Foods with rapidly (broken down) hydrolyzed and absorbed carbohydrates generally have a fast and high impact on blood sugar, resulting in the highest glycemic index (www.foodproductdesign.com, 2006). Slowly or incompletely digested carbohydrates have low glycemic index. In these cases, glucose is released gradually into the blood, and the blood sugar response is slow and steady (www.foodproductdesign.com, 2006). Foods with a high glycemic index value tend to raise your blood sugar faster and higher than foods with
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a lower value (www.mayoclinic.com, 2010). Foods with low GI (GI= 55% or less), foods with medium GI (GI= 55-69%) and foods with high GI (GI=70% or more) are the categories of glycemic index.

Sources: Classified by Foster et al., 2002

There is currently much scientific and popular interest in the role of low Glycemic index (GI) foods in the management of weight and metabolic disease risk. The Glycemic Index (GI) concept was proposed for the first time by Jenkins et al., (1981). The regular consumption of food exhibiting a high GI is associated with the development of some diseases such as type 2 diabetes (Augustin et al., 2002) and certain forms of cancer (Augustin et al., 2001) and to an increased risk of cardiovascular diseases and obesity (McCrory et al., 2000; Ludwig, 2000).

1.3 Impaired Glucose Tolerance (IGT)

Impaired glucose tolerance (IGT) is a pre-diabetic state of hyperglycemia that is associated with insulin resistance and increased risk of cardiovascular pathology. IGT may precede type 2 diabetes mellitus by many years. IGT is linked with an increased risk of cardiovascular events and some analyses have demonstrated an increased mortality risk compared with patients having normal glucose tolerance. IGT is also associated with other features of insulin resistance, including dyslipidaemia, hypertension, abdominal obesity, microalbuminuria, endothelial dysfunction, and markers of inflammation and
hypercoagulability traits collectively referred to as the metabolic syndrome. Analyses of combinations of these components have also been associated with progression to T2DM, cardiovascular disease and increased mortality (Petersen et al., 2005).

1.4 Diabetes

Diabetes mellitus (DM) is a global health problem and one of the major causes of morbidity and mortality. The total number of people with DM is projected to rise to 552 million in 2030 (Unwin et al., 2011). The incidence of the disease is high worldwide and varies among the people because of differences in genetic susceptibility and other modifiable risk factors. Diabetes mellitus is a metabolic disease, characterized by hyperglycaemia (increased concentration of blood glucose) and disturbance of glucose metabolism, as a result of reduced secretion or insulin resistance or both (Quaseem et al., 2007; Hjelm et al., 2003).

It is genetically and clinically heterogeneous group of disorders of glucose tolerance, associated with the disturbances of carbohydrate, fats and protein metabolism due to the absolute and relative deficiency in insulin secretion and/or action (Mani et al., 1990). It is also defined as a group of disorders characterized by deficient insulin secretion on peripheral insulin resistance resulting in hyperglycemia and developing life threatening complications such as atherosclerosis, nephropathy, neuropathy and retinopathy (Clark et al., 1994). Diabetes has long been viewed as a disorder of carbohydrate metabolism due to its hallmark feature of hyperglycemia.

Hyperglycemia is the cause of the acute symptoms associated with diabetes such as polydypsia, polyuria and polyphagia. The log-term complications (retinopathy, nephropathy and neuropathy) associated with diabetes are also believed to result from chronically elevated blood glucose levels. In addition, hyperglycemia may contribute to the development of macro
vascular disease which is associated with the development of coronary artery disease, the leading cause of death in individuals. Based on World Health Organization recommendations, diabetes mellitus is classified into three major subtypes: insulin dependent diabetes mellitus (Type1, IDDM), non-insulin dependent diabetes mellitus (Type2, NIDDM) and gestational diabetes.

Type1 diabetes mellitus results from cell mediated autoimmune destruction of the β-cells of pancreas (Yazdanparast et al., 2005), which is responsible for secretion of insulin. These patients, therefore, have to depend upon insulin (provided externally) for their survival. Insulin dependent diabetes mellitus has its onset most often in childhood and adolescence; however, it can also occur at any age.

Type2 diabetes is characterized by defective insulin secretion in pancreatic β-cells in response to glucose and by deficiencies in insulin action on its target tissues. Indeed, the relative importance of β-cell dysfunction has been reported in clinical studies (Weyer et al., 1999; Stumvoll et al., 2005; Ferrannini et al., 2003). In a state of IR, normal pancreatic β-cells can compensate for insulin insensitivity by up-regulating insulin secretion; however, insufficient secretion by β-cells can induce the onset of abnormalities in glucose metabolism, i.e. impaired glucose regulation (IGR) (Stumvoll et al., 2005).

Once hyperglycemia becomes evident, the function of pancreatic β-cells deteriorates progressively due to ‘glucose toxicity’, which leads to severe impairment of glucose-stimulated insulin secretion, apparent degranulation of β-cells and decreased β-cell number, resulting in the aggravation of IR. This vicious circle finally results in the clinical manifestation of diabetes (Gorogawa et al., 2002; Schinner et al., 2005). Obviously, the
natural progression of diabetes occurs after a prolonged pre-diabetic period, during which IGR forms an important intermediate and reversible stage.

This abnormal metabolic state between normal glucose tolerance (NGT) and diabetes consists of two distinct disorders: impaired fasting glucose (IFG) and impaired glucose tolerance (IGT). Compared with subjects with NGT, patients with IFG or IGT, unless treated, have a considerably higher risk of developing diabetes and cardiovascular disease (Unwin et al., 2002; Baron, 2001) and thus, can be used as a significant target group for the primary prevention of Type 2 diabetes. However, the question as to whether the onset of Type 2 diabetes in patients with IGR can be prevented or delayed has been poorly addressed over the last few years. Non-insulin dependent diabetes mellitus usually begins at the middle age or after 40 years.

1.4.1 Screening of Diabetes

A screening test for diabetes involves estimating an individual's plasma glucose level after he consumes 75 g of glucose dissolved in 300 ml water. Currently, a person is diagnosed with diabetes if his plasma glucose level is 200 mg/dl or higher two hours after ingesting the glucose. Those with plasma glucose level less than 200 mg/dl but greater than or equal to 140 mg/dl are diagnosed with a condition called impaired glucose tolerance. Those with plasma glucose level less than 140 mg/dl are diagnosed with a condition called impaired fasting glucose. People with this condition have trouble in metabolizing glucose, but the problem is not considered severe enough to classify them as diabetic. Individuals with impaired glucose tolerance are at a slightly elevated risk for developing high blood pressure, blood lipid disorders, and Type 2 diabetes WHO, (2006).
The OGGT is considered to be gold-standard status for the diagnosis of diabetes because of its longstanding use in many studies, not because of its qualities as a test. The ADA recommends sequential testing to make the diagnosis of type 2 diabetes without the measurement of haemoglobin A1c level. The investigators suggested that in patients with fasting plasma glucose values (100 to 126 mg/dl), the next step should be to measure the haemoglobin A1c level rather than to obtain a second measurement of the fasting plasma glucose level (WHO, 2006; Newman et al., 1994).

For the diagnosis of diabetes, the patient must have a haemoglobin A1c more than 7mmol. Glycated haemoglobin (glycosylated haemoglobin, haemoglobin A1c, HbA1c, A1c, or Hb1c; sometimes also HbA1c) is a form of haemoglobin used primarily to identify the average plasma glucose concentration over prolonged periods of time. It is formed in a non-enzymatic pathway by haemoglobin's normal exposure to high plasma levels of glucose (Larsen et al., 1990). The measurement of glycosylated haemoglobin (GHb) is one of the
well established means of monitoring glycemic control in patients with diabetes mellitus (Diabetes Control and Complications Trial Research Group, 1993). The use of haemoglobin A1c for monitoring the degree of control of glucose metabolism in diabetic patients was first proposed in 1976 (Koenig et al., 1976).

Measurement of glycated haemoglobin is recommended for both (a) checking blood sugar control in people who might be pre-diabetic and (b) monitoring blood sugar control in patients with more elevated levels. According to the American Diabetes Association guidelines the glycosylated haemoglobin test can be performed at least two times a year in patients who are meeting treatment goals (and who have stable glycemic control) and quarterly in patients whose therapy has been changed or who are not meeting glycemic goals (ADA, 2006).

1.4.2 Non–Pharmacological Approaches in the Treatment of Diabetes

➢ Lifestyle Management

➢ Dietary Management.

Lifestyle therapies are the cornerstone of diabetes treatment. Advice on lifestyle change should take account of factors such as the person’s ability and willingness to change, willingness to accept possible adverse effects on quality of life, their beliefs concerning their diabetes, psychosocial circumstances and depression. An unhealthy lifestyle featuring a lack of physical activities and excessive eating initiates and propagates the majority of type 2 diabetes.


Introduction

Different approaches have been used to reduce the incidence rate of diabetes and to cure it. The most popular approaches are the drug therapy, dietary therapy and recently the spices and natural products therapy. Drug therapy is the most common approach but is costly and has side effects. Medical nutrition therapy (MNT) is important in preventing diabetes, managing existing diabetes, and preventing, or at least slowing, the rate of development of diabetes complications. It is, therefore, important at all levels of diabetes-prevention. MNT is also an integral component of diabetes self-management education (or training) (Bantle et al., 2008).

The dietary therapy is the most natural, economical and more feasible. Several plant foods are reported to have nutraceutical functions and proper dietary intake can stop the incidence of disease and even can reduce the severity of existing cases. The food quality and diabetes mellitus have close association with each other.

Dietary modification has long been thought to play an important role in the prevention of type 2 diabetes. Dietary intervention, weight management, physical activity and smoking cessation are critical parts of diabetes health care as they are important for good glycemic control and the prevention of both microvascular and macrovascular complications.

There is a need for sweeteners in the diabetic diet (Kiovisto, 1978) to improve overall dietary compliance of diabetic people. It is equally important to use foods that produce the least postprandial blood glucose variation (Cudworth et al., 1982). GI of honey is reported to be lower than glucose or sucrose as it produces lesser postprandial hyperglycemia than glucose and sucrose. Thus honey may possibly be beneficial as sugar substitute for subjects with impaired glucose tolerance.
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The explanations and evidences on use of honey indicate that consumption of honey in the management of impaired glucose tolerance or other health problems associated with poor blood glucose control appears to be beneficial, provided that genuine and natural honey is administered at appropriate therapeutic doses. Therefore, the present study entitled “Evaluation of Therapeutic Potential of Honey and Incorporation of Honey in Food Products” was undertaken and honeys from different floral sources available in local area were evaluated for GI and validation of therapeutic potential.