The quality of life in terms of income, spending and lifestyle has improved globally with economic development. However, it has also thrown up a major challenge in the form of ‘lifestyle diseases’. The first victim of this lifestyle change has been food habits. Consumption of processed foods has increased manifold, which has led to a number of non communicable diseases like cardiovascular diseases, diabetes, hypertension and cancer of various sites. Nutraceuticals can play an important role in controlling these non communicable diseases. No wonder more and more people are turning to nutraceuticals (Pandey et al, 2010). The term nutraceutical was coined from nutrition and pharmaceutical in 1989 by Stephen Defelice, founder and chairman of Foundation for Innovation in Medicine, an American organization which encourages medical health (Defelice, 1995). According to him “a nutraceutical is any substance that is a food or a part of food and provides medical or health benefits, including the prevention and treatment of diseases”. Such products may range from isolated nutrients, non nutrient compounds, dietary supplements and specific diets to genetically engineered designer foods and herbal products (Rishi, 2006).

Nutraceuticals can be broadly classified into three categories. The first category includes grouping of nutraceutical based upon relatively concentrated foods. This model is more appropriate when there is interest in a particular nutraceutical compound or related compounds, or when there is interest in a specific food for agricultural/geographic reasons or functional food-development purposes. There are several nutraceutical substances that are found in higher concentrations in specific foods or food families. These include capsaicinoids, which are found primarily in pepper fruit, and allyl sulfur (organosulfur) compounds, which are particularly concentrated in onions and garlic (Keservani et al, 2010). The second category classifies the nutraceutical based on their mechanism of action. This system groups nutraceutical factors together, regardless of food source, based upon their proven or purported physiological properties. Among the classes would be antioxidant, antibacterial, antihypertensive, antihypercholesterolemic, antiaggregate, antiinflammatory, anticarcinogenic, osteoprotective, and so on. These include soy proteins, α tocopherol, lycopene, quercetin, β carotene, polyphenols etc. The third category includes grouping the nutraceutical based upon their chemical nature. This approach allows nutraceuticals to be categorized under molecular elemental groups.
such as isoprenoid derivatives, phenolic substances, fatty acids and structural lipids, microbes, minerals etc (Keservani et al, 2010).

Antioxidative nutraceuticals can inhibit or slow the formation of free alkyl radicals in the initiation step and interrupt the free-radical chain reactions in the propagation step during lipid oxidation. Antioxidative nutraceuticals can be antioxidative enzymes, hydrogen donating compounds, metal chelators, and singlet oxygen quenchers (Lee, 2004).

Antioxidants are known to defuse free radicals leading to limited risk of oxidative stress and associated disorders. At cellular and molecular levels they inactivate Reactive Oxygen Species (ROS) and under specific low concentration inhibit or delay oxidative processes by interrupting the radical chain reaction of lipid peroxidation. Phytochemicals with antioxidant capacity naturally present in food are of great interest due to their beneficial effects on human health as they offer protection against oxidative deterioration. The natural antioxidant system is mainly classified into two categories namely *in vitro* and *in vivo* antioxidants. On the basis of function they can be further divided into following four categories. First line of defense comprises of preventive antioxidants such as glutathione peroxidase, glutathione reductase, Super Oxide Dismutase (SOD), catalase, selenoprotein, transferrin, ferritin, lactoferrin and non-enzymatic proteins etc., which suppress the formation of free radicals. They act by quenching of [O$_2$]$^-$, decomposition of hydrogen peroxide and sequestrations of metal-ions. Second line of defense include the radical scavenging antioxidants mainly glutathione (GSH) and antioxidant phytochemicals. They act as free radical scavengers by suppressing chain initiation or breaking chain propagation. Third line of defense are complex group of enzymes required for the repair of damaged proteins, DNA, oxidized lipids and these enzymes can stop chain propagation of peroxyl lipid radicals. Fourth line of defense is an adaptation where signal for the production and reactions of free radicals and transport of the appropriate antioxidant to the right site at the tail end of disease where immunology plays an important role (Prakash and Gupta, 2009).

In the past, foods were primarily recognized for their essential nutrients for normal body activity and function. During the past two decades, however, consumers
have switched from an emphasis on satisfying hunger to an emphasis on the promising use of foods to promote well-being and to help reduce the risk of disease (Niva, 2007). Today, there is a consensus that eating the right foods extends life expectancy and improves the quality of life. A number of factors are responsible for changing consumer attitudes toward foods and reshaping food supply trends. These include an aging population, increased health care costs; consumers desire to enhance personal health, change in consumer awareness and expectations, advancing scientific evidence that diet can alter disease prevalence and progression, advances in food science and technology, and changes in food regulations. Following the trends observed in consumer demand, the food industry introduced a new category of products named functional foods—“foods that bring science and high-technology into everyday life by promising certain health benefits” (Niva, 2007). This interest has been fuelled by increased media attention and an increasing number of consumers determined to take greater responsibility for their own health (L'Abbé et al, 2008).

Nutraceuticals slightly differ from functional foods. When food is being cooked or prepared using "scientific intelligence" with or without knowledge of how or why it is being used, the food is called Functional food. Thus, functional food provides the body with the required amount of vitamins, fats, proteins, carbohydrates, etc. needed for its healthy survival (Tank et al, 2010). When functional food aids in the prevention and/or treatment of disease(s) and/or disorder(s) other than anemia, it is called a Nutraceutical. (Since most of the functional foods act in some way or the other as antianemic, the exception to anemia is considered so as to have a clear distinction between the two terms, functional food and nutraceutical.) Examples of nutraceuticals include fortified dairy products (e.g. milk) and citrus fruits (e.g. orange juice) (Kalra, 2003).

Honey has been used as a food and medical product since the earliest times. It is a natural substance produced by honeybees, Apis mellifera, from the nectar of blossoms or from exudates of trees and plants giving nectar honeys or honeydews, respectively. As the only available natural sweetener, honey was an important food for Homo sapiens from his very beginnings. Indeed, the relationship between bees and man started as early as the Stone Age (Crane, 1983). The first written reference to honey, on a Sumerian tablet dating back to 2100–2000 BC, mentions the use of honey
as a drug and an ointment. In most ancient cultures honey was used for both
nutritional and medical purposes. According to the bible, King Solomon said: “Eat
honey my son, because it is good” (Old Testament, proverb 24:13). The belief, that
honey is a nutrient, drug and an ointment has been carried into our days. For a long
time in human history it was the only known sweetener, until industrial sugar
production began to replace it after 1800 (Crane, 1975). On an estimate, about 80% of
honey is used directly in medicines and 10% is used in Ayurvedic and pharmaceutical
production. Five species of honey bees are found all over the world, namely Apis
florea, A. cerana, A. dorsata, A. mellifera and Trigona iridipennis. However, A.
cerana and A. mellifera are reared in hives in India (Singh, 2007).

China is the world leading producer as well as exporter of honey. Annual
production in China is estimated to be around 300,000 tonnes out of which nearly
50% is exported across the world. In comparison, production in India is less than a
quarter to that in China and so is its share in exports market. India produces around
70,000 tonnes of honey annually out of which 25,000-27,000 tonnes is exported to
more than 42 countries including the European Union, Middle East and the United
States (2002–03). The major honey-producing states are Punjab, Haryana, Uttar
Pradesh, Bihar and West Bengal (Anon, 2006). Developing countries as China,
Argentina, India, Brazil and Egypt consume 0.1 to 0.2 kg per capita. Rich developed
countries consume generally higher amount. However the per capita consumption
does not follow the richness of the countries, but there are also cultural influences. In
the European Union, the biggest honey consumer is Greece with 1.8 kg, followed by
Germany with 1.5 kg; other EU countries like Italy, Spain, France and Hungary are in
the intermediate range with 0.6-0.9 kg, while the UK is on the lowest end with 0.4 kg
(www.bee-hexagon.net).

The composition of honey is rather variable and primarily depends on the floral
source; however, certain external factors also play a role, such as seasonal and
environmental factors and processing. Honey contains at least 181 substances (Chow,
2002); it is a supersaturated solution of sugars, mainly composed of fructose (38%)
and glucose (31%), containing also minerals, proteins, free amino acids, enzymes and
vitamins (Pérez, 2002 and Terrab et al, 2003). A wide range of minor constituents is
also present in honey, many of which are known to have antioxidant properties. These
Honey is mainly made up of carbohydrates, which constitute about 95% of its dry weight (Jose et al., 2009). Main sugars are the monosaccharides fructose and glucose. Beyond the two monosaccharides, about 25 different oligosaccharides have been detected, between them nutrition relevant ones such as panose, 1kestose, palatinose (Doner, 1977). The principal oligosaccharides in blossom honey are the disaccharides sucrose, maltose, trehalose and turanose. Honeydew honey compared to blossom honey contains higher amounts of oligosaccharides, and also trisaccharides such as melezitose and raffinose. During digestion the principal carbohydrates fructose and glucose are quickly transported into the blood and can be utilized for energy requirements of the human body. A daily dose of 20 g honey will cover about 3% of the required daily energy (Bogdanov et al., 2008).

Antioxidant activity, or simply antioxidant capacity, is the ability and potential of honey to reduce oxidative reactions within the human health and food systems. Notably, these oxidative reactions can cause deleterious reactions in food products (e.g., lipid oxidation in meat, and enzymic browning in fruits and vegetables) and adverse health effects, such as chronic diseases and cancers (Gheldof, 2002). The antioxidants that naturally occur in honey contribute to its antioxidant capacity. These compounds are flavonoids, phenolic acids and some enzymes (e.g., glucose oxidase, catalase), ascorbic acid, carotenoid-like substances, organic acids, maillard reaction products, amino acids and proteins. Gheldof et al. (2002 & 2003) found that while phenolic compounds contribute significantly to the antioxidant capacity of honey, they are not solely responsible for it. However, the antioxidant capacity varies greatly depending on the honey floral source, possibly due to the differences in the content of plant secondary metabolites and enzyme activity.

Polyphenols are another important group of compounds regarding the appearance and the functional properties of honey. Although studies on honeys, honeybees and the basic composition of honeys started a hundred years ago, interest in honey phenolic compounds has only recently increased. This is because of their
potential role as biochemical markers for authenticating the geographical and antioxidant properties. Many authors have studied the phenolic and flavonoid contents of honey to determine if a correlation with floral origins exists. The distribution of three main phenolic families (benzoic acids, cinnamic acids and flavonoids) shows different profiles in honey from different floral origins, with flavonoids being the most common in floral honeys. Therefore, a characteristic distribution pattern of phenolic compounds should be found in unifloral honeys sourced from the corresponding plant sources. The flavonoids in honey and propolis have been identified as flavanones and flavanones/flavanols. In general, the flavonoid concentration in honey is approximately 20 mg/kg. Polyphenols in honey are mainly flavonoids (e.g., quercetin, luteolin, kaempferol, apigenin, chrysin, galangin), phenolic acids and phenolic acid derivatives (Jose et al, 2009).

The factors responsible for the antimicrobial activity of honey are high osmolarity, acidity and particularly hydrogen peroxide (Bogdanov, 1997), which is formed from the oxidation of glucose by the enzyme glucose oxidase, during the period when honey is ripening (Weston et al, 1999). Glucose oxidase originates from the hypo pharyngeal glands of honeybees (Taormina et al, 2001). When hydrogen peroxide is removed by adding catalase, some honeys still show significant antibacterial activity (Allen et al, 1991) and this activity is referred to as non-peroxide antibacterial activity. The non-peroxide factors of honeys include lysozyme, phenolic acids and flavonoids (Taormina et al, 2001). Bogdanov (1997) suggested that the main part of the non-peroxide antibacterial activity might be of honeybee origin, while part may be of plant origin. Wahdan (1998) also suggested that flavonoids and phenolic acids might be a part of the antibacterial activities of honey.

It has also been shown that honey reduces skin inflammation, edema and exudation, promotes wound healing, diminishes scar size and stimulates tissue regeneration (Molan, 2001). Honey contains an array of chemicals endowed with antiradical/anti-inflammatory activity, i.e., phenolic derivates, which can play an important role, alone or in combination, in their antitumor, anti-inflammatory effects (Facino, 2001).

Infections of the intestinal tract are common throughout the world, affecting people of all ages. Infectious diarrhea exacerbates nutritional deficiencies in various
ways, but as in any infection, the calorific demand is increased. Pure honey has bactericidal activity against many enteropathogenic organisms, including those of the *Salmonella* and *Shigella* species, and enteropathogenic *E. coli* (Jeddar, 1985). The application of honey in infant nutrition used to be a common recommendation during the last centuries and there are some interesting observations reported. Infants on a diet containing honey had better blood building and a higher weight increase compared to a diet without honey. Honey was better tolerated by babies than sucrose and compared to a water based placebo significantly reduced crying phases of infants. Infants have a higher weight increase when fed by honey than by sucrose, and showed less throw up than the sucrose controls (Bogdanov et al, 2008).

Other important effects of honey on human digestion have been linked to oligosaccharides. These honey constituents have prebiotic effects, similar to that of fructooligosaccharides (Sanz et al, 2005). The oligosaccharide panose is the most active oligosaccharide. The oligosaccharides cause an increase of bifidobacteria and lactobacilli and exert the prebiotic effect in a synergistic mode of action (Yun, 1996). According to an *in vitro* study on five bifidobacteria strains, honey has a growth-promoting effect similar to that of fructose and glucose oligosaccharides (Kajiwara et al, 2002).

It has been found that honey ameliorates cardiovascular risk factors in healthy individuals and in patients with elevated risk factors. Consumption of natural honey reduces cardiovascular risk factors, particularly in subjects with elevated risk factors, and it does not increase body weight in overweight or obese subjects (Yaghoobi et al, 2008).

The impact of carbohydrates on human health is discussed controversially especially the understanding of how the carbohydrate content of a given food affects blood glucose levels. Carbohydrates having a low Glycemic Index (GI) induce a small increase of glucose in blood, while those with high GI induce a high blood glucose level. Fructose, besides glucose the main honey sugar has a GI of 19, that of sucrose 68. It seems that honeys containing predominantly fructose have a lower GI than glucose-predominant honeys (Swellam et al, 2003). Thus, theoretically high fructose honeys like acacia, tupelo, chestnut, thyme, calluna honeys should have a relatively
lower GI. It has been established that Acacia honey (*Robinia pseudoacacia*) has the lowest GI, lying between 43 and 49. It is the unifloral honey of choice for nutritional menu of people with diabetes type 2 or with glucose intolerance. Other fructose rich honey as chestnut, thyme, calluna and tupelo are also good alternatives. One German honeydew honey was found to have a relatively high GI (Berg, 2008).

A small number of studies (Swellam et al., 2003, and Orsolic et al., 2005) have investigated the anti-cancer properties of honey in recent years, with interesting results. Honey (1–25%) significantly inhibited the growth of bladder cancer cell lines when tested *in vitro* (Swellam et al., 2003). Honey causes both an enhancement of the immune response and an immunosupression. The immunoactivating effects are in line with the common belief that honey improves human reaction to viral infections. Honey may be also trigger immunoactivating activity by its stimulatory effects on lymphocytes and also by its probiotic effects. On the other hand the immunosuppressive activity of honey is probably due to its anti-inflammatory effect. These effects are in line with the belief that honey ingestion will decrease allergic reactions like hay fever (Bogdanov, 2010).

Due to its various favorable properties honey is used as an additive to a variety of food and beverages. The application of honey as a food additive is based on its manifold properties. The antibacterial effect of honey part counteracts microbial spoilage of food, e.g. of meat (Nagai et al., 2006). The antioxidant effect of honey prevents oxidation of food during storage. Honey acts against lipid oxidation of meat and is thus an efficient meat additive for preventing oxidation spoilage, e.g. to poultry or to meat and muscle of unspecified origin. Effects of honey against enzymatic browning of fruits and vegetables, soft drinks light raisin, apple slices have been reported. Honey enzymes have a clearing effect in fruit juices and fruit drinks manufacturing. Other physical and sensory properties make honey a good candidate for an additive to a wide variety of food: good sensory and rheological properties, superior microwave reactivity than synthetic sugars etc (Bogdanov, 2010).

Honey enhances the growth of dairy starter cultures in milk and milk products. Especially species with week growth rates in milk such as bifidobacteria are usually fortified by growth enhancers or by honey. The growth rate of two bifidobacteria Bf-1 and Bf-6 in milk can be stimulated by the addition of honey to
milk (Ustunol, 2001). The effect of honey was more pronounced than the one caused by common growth enhancers based on other oligosaccharides. Thus, honey can be used as a prebiotic additive to probiotic milk products. Honey added to non fat dry milk has a favorable influence on some other “good bacteria” (Chick et al, 2001). The milk was incubated with *Streptococcus thermophilus*, *Lactobacillus acidophilus*, *Lactobacillus delbrueckii* subsp. *bulgaricus*, or *Bifidobacterium bifidum*. Honey supported the growth of all strains. The authors conclude that various oligosaccharides found in honey may be responsible for the enhanced lactic acid production by bifidobacteria (Bogdanov, 2010).

The impact of heat on the antioxidant capacity of clover and buckwheat honey during storage was analysed by Wang et al (2004). Processing clover honey did not impact significantly antioxidant capacity. Storage during 6 months reduced the antioxidant capacity of honeys by about 30%, with no impact of storage temperature or container type detected at the end point of the storage period. Antioxidant capacity of processed and raw honeys was similar after storage. In another study both antioxidant activity and brown pigment formation increased with heat treatment and time (Turkmen et al, 2006). These results suggest that not only flavonoids, but also other substances formed under heating could be responsible for the honey antioxidant effect.

There is a significant correlation between the antioxidant activity, the phenolic content of honey and the inhibition of the *in vitro* lipoprotein oxidation of human serum. It was found that honey intake caused a higher antioxidative effect in blood than the intake of black tea, although it’s *in vitro* effect measured as Oxygen Radical Scavenging Activity (ORAC) was five times smaller than that of black tea (Gribel and Pashinskii, 1990). Generally, the darker the honey, the higher its phenolic content and its antioxidative power (Bertoncelj et al, 2007). Further, in a lipid peroxidation model system buckwheat honey showed a similar antioxidant activity as 1 mM α-tocopherol (Nagai et al, 2006). Also, the influences of honey ingestion on the antioxidative capacity of plasma was also tested (Al-Waili, 2003). In the first study the trial persons were given maize syrup or buckwheat honeys with a different antioxidant capacity in a dose of 1.5 g/kg body weight. In comparison to the sugar control honey caused an increase of both the antioxidant and the reducing serum capacity (Schramm et al,
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2003). In the second study humans received a diet supplemented with a daily honey consumption of 1.2 g/kg body weight. Honey increased the body antioxidant agents: blood vitamin C concentration by 47%, β-carotene by 3% and uric acid by 12% and glutathione reductase by 7% (Al-Waili, 2003).

From the literature reviewed, it is concluded that honey contains non nutritive bioactive compounds which have a beneficial effect in the prevention of non communicable diseases. Although in India honey is produced and consumed in large scale, there is a lack of information on the comparative biochemical properties of commercial and forest honey samples from different geographical regions with respect to their antioxidant levels, use in food product formulations etc.

**To explore honey as a nutraceutical ingredient in functional foods in India the present investigation is planned with the following objectives:**

1. To study the non nutritive antioxidants, total antioxidant capacity, moisture, sugar and color index of selected commercial brands of honey as well as honey procured from four different regions/ forest of Gujarat.
2. To investigate the effect of storage of honey on its non nutritive antioxidants and total antioxidant capacity.
3. To study the synergic antioxidant effect of pure antioxidant (Vitamin E, β-carotene and Vitamin C) with honey.
4. To study the possible replacement of sugar in glucose biscuit formulation.
5. To formulate milk based probiotic product using honey as a source of oligosaccharides.
6. To evaluate the efficiency of honey to increase the plasma antioxidant capacity using human model.