Chapter 2

REVIEW OF LITERATURE

2.0 Introduction

This Chapter presents an exhaustive review of literature in term of diabetes, nutrition, food habits and various indigenous foods (herbs) and its effect on type2 diabetes. The available literature has been presented to highlight the gaps in knowledge to supplement the primary objectives of the study.

According to Colagiuri et al., (2010), Type 2 diabetes (T2D) is a progressive, multifactorial metabolic disease caused by the interaction of hereditary (genotype) and environmental (obesity) factors. Kilpelainen et al., 2011 said that Diabetes is associated with a number of risk factors, such as age > 45, increased body weight, hypertension, dyslipidemia, and polycystic ovarian syndrome, a history of impaired glucose tolerance or impaired fasting glucose.

According to Prentki et al., (2006) Modern way of life, accompanied by excessive calorie intake and reduced physical activity resulted in a dramatic increase in rates of developing T2D. Campbell, (2009); Wild et al., (2004) estimated that by year 2030, 366 million people in the world will suffer from T2D. The prevalence of developing T2D shows significant ethnic and racial differences. T2D is less frequent in the countries of the East compared to the countries of the Western lifestyle.

Selvin et. al., (2011) said that the prevalence of the disease is higher in Hispanics, native Americans, African-Americans and Asians compared to non-Hispanic whites. T2D is characterized by hyperglycemia that occurs as a result of reduction in mass and function of beta cells, peripheral insulin resistance (IR), ie reduced insulin sensitivity and inadequate insulin secretion. According to many scientists (Dimitrova et. al., (2007), insulin resistance is the primary disorder in the development of T2D. It is believed that IR is caused by a reduced number or structural changes in insulin receptors, which results in a reduction in the capacity of insulin to stimulate cellular intake and glucose metabolism. According to the World Health Organization, up to
90% of the population in developing countries uses herbs and their extracts as traditional medicines.

According to Hermann, (1973) the development of metformin, an efficacious oral glucose-lowering agent was based on the use of a plant Galega officinalis to treat diabetes. Galega officinalis is rich in a hypoglycemic component – guanidine. Due to the fact that guanidine is too toxic for clinical use, the alkyl biguanides synthalin A and synthalin B were introduced as oral anti-diabetic agents in Europe in the 1920s. Bailey, 1988 prompted the development of metformin.

Rizvi et. al., (2013) reported about 800 plants for diabetes treatment. These include bitter melon, cinnamon, fenugreek and ginseng that appear to have anti-hyperglycemic effects. All of them have shown a certain degree of antidiabetic activity by different mechanisms of action.

2.1 Reviews related to “Indigenous food in treatment of diabetes”

India is the largest producer of medicinal herbs and is called as botanical garden of the world. The current review focuses on herbs used in the treatment of diabetes mellitus, a major crippling disease in the world leading to huge economic losses.

Herbs for Diabetes treatment are not new. Since ancient times, plants and plant extracts were used to combat diabetes. Many traditional medicines in use are derived from medicinal plants, minerals and organic matter. The World Health Organization (WHO) has listed 21,000 plants, which are used for medicinal purposes around the world. According to Zohary et. al., (2000) among these, out of which 150 species are used commercially on a fairly large scale.

Few medicinal herbs in India that have been confirmed by scientific investigation, which appear to be most effective, relatively non-toxic and have substantial documentation of efficiency are discussed here.

Tripathi, (1998), reported that the focus of research in diabetes includes discovering newer antidiabetic agents as well as isolating the active compounds from herbal sources that have been documented to have antidiabetic properties as have been
described in ancient texts. Tripathi, (1998) reported various types of herbal preparations such as decoctions (boiled extracts), Swaras (expressed juices), Asav-Arisht (fermented juices), and powders have been mentioned for the treatment of Madhumeha. These formulations are basically of plant origin but some inorganic compounds and animal products have also been used.

According to Pendse et. al., (1961) Alternative systems of medicine, such as Ayurveda and Unani, have been used widely in India. Ayurveda encompasses knowledge of life, known and unknown and is used to cure disease and preserve health. In Ayurveda diabetes falls under the term Madhumeha.

According to Shastri, (1994) mentioned in ancient texts such as the Charak Samhinta that a single herb exerts different actions on many diseases and that each herb may have one dominating effect and other comparatively subsidiary effects. It is also mentioned that an herbal drug can also have synergistic and antagonist effects in combination with other herbs.

2.2 Reviews related to MKK and its impact on blood glucose level of diabetic patients

2.2.1 Methi dana (Trigonella foenum-graecum) Fenugreek

(Trigonella foenum-graecum) Fenugreek in the Leguminoseae family is an annual herb, native to western Asia and southeastern Europe that is cultivated worldwide (e.g., the Mediterranean region, China, and northern India).

Kirtikar et al., (2000) reported several experimental and few human studies have demonstrated the hypoglycemic effect of T. foenum-graecum seeds. The leaves and seeds of the fenugreek plant are used as powders and extracts for medicine use. Fenugreek seeds contain 45-60% carbohydrates, most of which is a mucilaginous fiber which is 30% soluble and 20% insoluble fiber. It also contains about 20-30% proteins that are high in lysine and tryptophan, a small amount of oils (5-10%), a small amount of pyridine alkaloids (mostly trigonelline), and a few flavonoids, free amino acids, sapogenins, vitamins and volatile oils. Constituents in fenugreek that are thought to be responsible for its hypoglycemic effects include the testa and endosperm.
of the defatted seeds called the A sub fraction, the 4-hydroxyisoleucine and the fiber. It is also thought that the saponins in the seeds are transformed in the gastrointestinal tract into sapogenins and this is responsible for the lipid lowering effects.

Arti Gupta (2014) noted that Fenugreek has drawn much attention as a potential functional food and natural health product or ingredient therein. Medicinal properties attributed to fenugreek have been reported to be associated with its unique phytochemicals such as polysaccharides, complex carbohydrates, galactomannans, steroidal sapogenins, amino acids: 4-hydroxyisoleucine L-tryptophan, lysine; fibre, protein, fatty acids, vitamin C, niacin and potassium. It is rich source of calcium, iron, carotene and other vitamins. Researches show that fenugreek contains steroidal saponins, occurring mainly as furostanol 3,26-diglycosides such as trigonofoenosides A-G. On hydrolysis the saponins yield 0.6-1.7% of spirostanol, sapogenins consisting mainly (about 95%) of diosgenin and its 25β-epimeryamogenin in a 3:2 ratio, together with tigogenin and others. Steroidal saponin peptide esters such as fenugreekine are also present. Mucilage polysaccharide consisting mainly of galactomannan (25-45%) with a backbone of β-(1→4) linked manose residues, branches of α-(1→6) galactosyl residues and a small portions of xylose. Other constituents include: trigonelline (coffearine, the N-methyl betaine of nicotinic acid) protein (rich in tryptophan and lysine), saponin hydrolyzing enzymes, proteinase inhibitors which act on human trypsin and chymotrypsin, scopoletin and other coumarins, flavone glycosides, sterols (cholesterol, β-sitosterol), lecithin and choline. A small amount (<0.01%) of volatile oil is present, in which alkanes, terpenes, oxygenated and aromatic compounds have been identified. The dominant and characteristic aroma compound in fenugreek is 3-hydroxy-4-5-dimethyl-2(5H)-furanone (sotalone) of which 3-25mg/kg is present in the seeds.

The hypoglycemic effects of fenugreek have been reported that amino acid 4-hydroxyisoleucine in fenugreek seeds increased glucose induced insulin release in human. It was observed that 4-hydroxyisoleucine extracted from fenugreek seeds has insulin tropic activity. This amino acid appeared to act only on pancreatic beta cells and the levels of somatostatin and glucagon were not altered. In human studies, fenugreek reduced the area under the plasma glucose curve and increased the number
Review of Literature

of insulin receptors, although the mechanism for this effect is not very clear. Fenugreek seeds exert hypoglycemic effects by stimulating glucose dependent insulin secretion from pancreatic beta cells, as well as by inhibiting the activities of alpha-amylase. It is considered that the hypoglycemic effect of fenugreek is thought to be largely due to its high content of soluble fiber, which acts to decrease the rate of gastric emptying thereby delaying the absorption of glucose from the small intestine. The cases suggest fenugreek reduced post-prandial hyperglycemia in the case of diabetics, but less so in case of non-diabetics. It has proved that galactomannan blocks intestinal absorption of glucose. Water soluble fiber increases the viscosity inside the intestine and inhibits absorption of glucose.

Gupta et al., (2003) reported the results of a small randomized, controlled, double-blind trial to evaluate the effects of fenugreek seeds on glycemic control. Twenty-five patients with newly diagnosed type 2 diabetes received either 1 g daily of a hydroalcoholic extract of fenugreek seeds or “usual care” (dietary discretion and exercise). After two months, mean fasting blood glucose levels were reduced in both groups without significant differences between groups (148.3 mg/dL to 119.9 mg/dL in the fenugreek group versus 137.5 mg/dL to 113.0 mg/dL in the “usual care” group).

Raghuram et al., (2003) reported the results of a randomized, controlled, crossover trial of fenugreek seeds in 10 patients with type 2 diabetes. The doses of these patients’ antidiabetic drug, glibenclamide, ranged from 2.5-7.5 mg per day; both medication dose and dietary intake were stabilized prior to the actual study periods. The patients were given either 25 g powdered fenugreek seeds in two equal doses with meals or meals without fenugreek supplementation for 15 days. The fenugreek powder was added to the experimental diet in the form of dietary fiber, resulting in higher fiber content in the experimental diet than in the control diet. Five diabetic patients were randomized to receive fenugreek during the first 15-day period; the other five received it during the second period. Subjects were then crossed over an additional 15 days with no washout period. In the fenugreek-treated patients, statistically significant mean improvements were reported for glucose tolerance test
scores and serum-clearance rates of glucose (control group, 153 reduced by 11.92 mg/mL/min; fenugreek group, 136.4 reduced by 6.36 mg/mL/min).

Sharma et al. (2003) conducted two randomized, controlled, crossover studies in patients with type 2 diabetes. The doses of 15 patients antidiabetic drug, glibenclamide/glipizide/metformin, were reduced by 20 percent and both medication dose and dietary intake were stabilized for one week prior to the actual study periods. In the first study, subjects ate meals with or without 100 g of defatted fenugreek seed powder, divided into two equal doses, for 10 days. Patients were then crossed over an additional 10 days. Seven of the 15 patients received the fenugreek diet first; there was no washout period. The second study had a similar study design, except the duration of the study was 20 days and the total subject number was five (three patients received the fenugreek diet first). Significant mean improvements in fasting blood glucose levels and glucose-tolerance test results were described in the fenugreek-treated patients. The reduction in fasting blood glucose ranged from 179 reduced to 137 reduced in the first study and from 157 reduced to 116 reduced in the second study. The fenugreek-treated patient group also reported subjective improvements in polydipsia and polyuria.

Neeraja et al. (2003) presented a complex case series including six men with type 2 diabetes and six without diabetes. The cases suggest fenugreek reduced postprandial hyperglycemia primarily in subjects with diabetes, but less so in subjects without diabetes. This effect might be more pronounced if raw seeds rather than boiled seeds had been used. Results from several additional case series also suggest fenugreek seeds may improve glycemic control in type 2 diabetes. As with all case series, however, the lack of controls increases the possibility the results obtained were due to confounding from other interventions.

Ravikumar et al. (1999) reported that administration of fenugreek seeds improved glucose metabolism and normalized creatinine kinase activity in heart, skeletal muscle and liver of diabetic rats. It also reduced hepatic and renal glucose-6-phosphatase and fructose 1,6-biphosphatase activity. This plant also shows antioxidant activity (Dixit et al., 2005; Stanely et al., 2003). Recently the antidiabetic activity of Fenugreek seeds were investigated clinically (Ismail, 2009).
Ajbnoor et al., (1988) observed the hypoglycemic effect of a decoction and an ethanol extract of *T. foenum-graecum* seed on the serum glucose levels of normal and alloxan-induced diabetic mice. A significant reduction was observed in the mice’s fasting blood glucose as a result of administering the decoction and the ethanol extract. This effect was comparable to that observed with tolbutamide.

In another study by Raju et al., (2001) a significant reduction was observed in diabetic rats’ fasting blood glucose by approximately 300 mg% after administering the seed powder for 21 days.

Vats et al., (2002) studied the hypoglycemic effect of *T. foenum-graecum* along with other herbs and observed a significant reduction in fasting blood glucose level by approximately 15 mg% in normal and in diabetic rats by approximately 80 mg%.

Sharma et al., (1990) studied the antidiabetic properties of *T. foenum-graecum* seeds in 10 patients with type 1 diabetes. Patients were put on a fixed dose of insulin throughout the study and randomly assigned to an isocaloric diet, with or without *T. foenum-graecum* defatted seed powder twice per day in chapatti. The patients’ mean fasting blood glucose was reduced significantly from baseline by approximately 76 mg% .Statistically significant decreases of serum total cholesterol, triglycerides, and LDL was also reported.

Genet et al., (1999) reported that there was a significant improvement in the activity of creatine kinase caused by sodium orthovanadate and *T. foenum-graecum* seed powder. This reversal was effective in tissues such as muscles and livers, which are insulin-dependent for the metabolism of glucose. The researchers hypothesized that this might be the result of the insulin-mimetic effect of sodium orthovanadate and explained further that this combination restored the energy level to control levels by inhibiting adenosine triphosphatase (ATPase) thereby increasing the levels of adenosine triphosphate (ATP) and controlling phosphorylation and dephosphorylation of regulatory cytosolic and mitochondrial enzymes involved in utilization and generation of ATP. Ravikumar et al., 1999 reported *T. foenum-graecum* also reduced lipid peroxidation and increased levels of GSH and β-carotene, showing a potential to reduce complications of diabetes.
Nazila Kassaian et al., (2004) reported in a study on 24 adults with type 2 diabetes were treated for eight weeks with 10 g powdered fenugreek seeds mixed in yoghurt or soaked in hot water. In an analysis of the 18 individuals who completed the study, significant reductions in fasting blood sugar were observed in subjects treated with fenugreek seeds soaked in hot water, but not among subjects treated with fenugreek seeds mixed with yoghurt.

Abha Saxena et al., (2004) In a double blind, placebo-controlled, cross-over clinical trial, a wheat bread incorporating fenugreek was tested for metabolic effects and taste acceptability in eight individuals with lifestyle-controlled type 2 diabetes. Subjects were randomized to receive 56 g bread with 5% fenugreek or regular wheat bread baked at the same bakery. Postprandial blood glucose and insulin were measured periodically over a 4-hour period after consumption. Blood insulin area under the curve was significantly reduced following consumption of fenugreek-containing bread, and this bread was indistinguishable from the whole-wheat control in terms of flavor and appearance. These findings suggest that fenugreek may represent an effective food-based means of reducing plasma insulin among individuals with type 2 diabetes.

Mona Boaz et al., (2004) Clinical trials of fenugreek for diabetes endpoints have been conducted in humans. In a study of fenugreek treatment efficacy, 60 adults with type 2 diabetes were treated with 25 g fenugreek seed powder for 24 weeks, leading to improved measures of glucose homeostasis, including reduced urinary glucose, glycosylated hemoglobin, and area under the curve for both glucose and insulin. However, the lack of a parallel control group or placebo intervention restricted the generalization of results or determination of causality.

Nithya Neelakantan, et al., (2013) reviewed clinical trials of the effect of fenugreek intake on markers of glucose homeostasis for trials of at least 1 week duration comparing intake of fenugreek seeds with a control intervention. Data on change in fasting blood glucose, 2 hour postload glucose, and HbA1c were pooled using random-effects models. A total of 10 trials were identified. Fenugreek significantly changed fasting blood glucose by -0.96 mmol/l (95% CI: -1.52, -0.40; $I^2=80\%$; 10 trials), 2 hour postload glucose by -2.19 mmol/l (95% CI: -3.19, -1.19; $I^2=71\%$; 7
trials) and HbA1c by -0.85% (95% CI: -1.49%, -0.22%; I² = 0%; 3 trials) as compared with control interventions. The considerable heterogeneity in study results was partly explained by diabetes status and dose: significant effects on fasting and 2 hr glucose were only found for studies that administered medium or high doses of fenugreek in persons with diabetes. Most of the trials were of low methodological quality. Results from clinical trials support beneficial effects of fenugreek seeds on glycemic control in persons with diabetes. However, trials with higher methodology quality using a well characterized fenugreek preparation of sufficient dose are needed to provide more conclusive evidence.

Studies on different experimental models have proved that fenugreek has strong antidiabetic properties (Kumar et al., 2012). The therapeutic potential of fenugreek is primarily due to the presence of saponins (Petit et al., 1995), 4-hydroxyisoleucine (Sauvaire et al., 1998), the alkaloid trigonelline (Raghuram et al., 1994) and high fiber content (Ali et al., 1995). The most studied active principle is 4-hydroxyisoleucine, which increases pancreatic insulin secretion and inhibits sucrose D-glucosidase and amylase (Sauvaire et al., 1998; Singh et al., 2010). The antihyperglycemic effect has been correlated with decline in somatostatin and high Intl. J. Trad. (Ribes et al., 1986).

Yadav et al., (2005) reported that fenugreek seeds also have a lipid-lowering effect, thereby lowering serum triglycerides, total cholesterol and low-density lipoprotein cholesterol. These effects may be due to sapogenins, which increase biliary cholesterol excretion in liver, leading to lowered serum cholesterol levels. However, the lipid-lowering effect of fenugreek might also be attributed to its oestrogenic constituent.

2.2.2 Kale Til (Black sesame seeds)

For thousands of years, sesame seeds have been a source of food and oil. Sesame has one of the highest oil content of any seed, some varietals exceeding 50 per cent oil content compared to soybean's 20 per cent. Sesame oil is one of the most stable vegetable oils, with long shelf life, because of the high level of natural antioxidants (sesamin, sesamolin, and sesamol). Oil from the seed is used in cooking, as salad oils
and margarine, and contains about 47 per cent oleic and 39 per cent linoleic acid. Sesame seed oil, like sunflower seed oil, is rich in Omega 6 fatty acids, but lacks Omega 3 fatty acids. Sesame seed is also rich in protein, at 25 per cent by weight. The flour that remains after oil extraction is between 35 to 50 per cent protein, has good effective carbohydrates, and contains water-soluble antioxidants (sesaminol glucosides) that provide added shelf-life to many products. This flour, also called sesame meal, is an excellent high-protein feed for poultry and livestock. The addition of sesame to high lysine meal of soybean produces a well balanced animal feed. Source: Internet article: Black sesame seeds – Source to prolong youth beauty.

Sesame seeds a very good source of manganese and copper, but they are also a good source of calcium, magnesium, iron, phosphorus, vitamin B1, zinc and dietary fibre. In addition to these important nutrients, sesame seeds contain two unique substances: sesamin and sesamolin. Both of these substances belong to a group of special beneficial fibres called lignans, and have been shown to have a cholesterol-lowering effect in humans, and to prevent high blood pressure and increase vitamin E supplies in animals. Sesamin has also been found to protect the liver from oxidative damage.

Sesame (Sesamum indicum L.), otherwise known as sesamum or benniseed, member of the family Pedaliaceae, is one of the most ancient oilseeds crop. The seed is rich in protein and the protein has disable amino acid profile with good nutritional value similar to soybean (NAERLS, 2010). The chemical composition of sesame shows that the seed is an important source of oil (44-58%), protein (18-25%), carbohydrate (~13.5%) and ash (~5%) (Borchani et al., 2010). Sesame seed is approximately 50 percent oil (out of which 35% is monounsaturated fatty acids and 44% polyunsaturated fatty acids) and 45 percent meal (out of which 20% is protein) (Ghandi, 2009; Hansen, 2011). It can affect the endocrine system by lowering blood sugar levels, thus reducing the concentration of glucose (sugar) in the bloodstream. This makes it a beneficial dietary inclusion for persons living with diabetes, in conjunction with other lifestyle adjustments geared toward lowering blood glucose. Two grams of black seed a day resulted in reduced fasting glucose, decreased insulin resistance, increased beta-cell function, and reduced glycosylated hemoglobin (HbA1c) in human subjects.
Kamal-Eldin et al. (2011) have reviewed patent literature claiming beneficial effects of sesame seed. They note that these health claims are based on the very high levels (up to 2.5%) of furofuran lignans with beneficial physiological activities, mainly sesamin, sesamolin, and sesaminol glucosides. Among edible oils from six plants, sesame oil had the highest Ferric Reducing/Antioxidant Power (FRAP) value, which means the herbs and additives are better preserved in sesame oil. To the extent these herbs have health benefits; the study proposes that it may be possible that ingestion of these herbs preserved in sesame oil could increase resistance of polyunsaturated fatty acids of cell membranes and lipoproteins to oxidation within the body.

Black sesame seeds extracts help inhibit the absorption of glucose in the intestines and improve glucose tolerance in laboratory animals, according to a study published in the January 2009 issue of the “Journal of Ethnopharmacology.” Another study in a 2009 issue of the “Bangladesh Journal of Pharmacology” reveals that crude Nigella sativa extracts reduce damage to beta cells in the pancreas, which are responsible for the production of insulin. This might lower the risk of type 1 diabetes, the study says.

An article in the April 2011 issue of the “Journal of Endocrinology and Metabolism” reaffirms that thymoquinone found in black seeds can prevent the development of type 1 diabetes and increase the insulin sensitivity of liver cells, which helps prevent type 2 diabetes. Black seed extracts also possess significant antioxidant activity and might protect the pancreatic cells against the harmful effects of free-radicals.

As revealed by healthimpactnews.com. A study published in 2011 in the Clinical Journal of Nutrition showed that sesame oil improved the effectiveness of the oral ant diabetic drug glibenclamide in type 2 diabetic patients. Another study published in 2006 in the Journal of Medicinal Foods showed that the substitution of sesame seed oil as the sole edible oil lowers blood pressure and glucose in hypertensive diabetics.

2.2.3 Kaliziri (Centratherum anthelminticum) Black cumin

It is highly reputed in Hindu medicine as remedy for leucoderma and other skin diseases. The seeds have a hot sharp taste, acrid, astringent to the bowels, anthelmintic and cure ulcers. The seeds are used as purgative, for asthma, kidney
troubles and hiccough, applied in inflammatory swelling, remove blood from liver, good for sores and itching of the eyes. In Punjab, it is considered as antipyretic. The seeds are also credited with tonic, stomachic, and diuretic properties. Different organic solvent and aqueous extracts of these seeds were scientifically evaluated for antifilarial, antibacterial, larvicidal, antiviral, antifungal, anticancer, analgesic, antipyretic, anti-inflammatory, diuretic, wound healing activities.

Shah, J. G. et al. (2008) carried out to study the effect of Centratherum anthelminticum wild. kuntze (Asteaceae) on blood glucose level and antioxidant enzymes level in streptozotocin induced diabetic rats. Streptozotocin (STZ 50 mg/kg, i.p) induced diabetic rats were treated with methanolic extract of Centratherum anthelminticum (100 mg/kg; p.o.) for 28 days. Methanolic extract of Centratherum anthelminticum wild. Kuntze significantly prevented loss of body weight, decrease food and water intake. It showed significant prevention in elevation of glucose and significantly increased insulin level and showed prevention in increase in the cholesterol, triglyceride, LDL cholesterol, VLDL cholesterol levels in serum of diabetic rats. The treatment with methanolic extract of Centratherum anthelminticum also significantly prevented decrease in the HDL-cholesterol level and increase in urea and creatinine levels in diabetic rats compared to that of diabetic control. The chronic treatments with methanolic extract of CA significantly prevented the increase of malondialdehyde and prevent reduction of superoxide dismutase, catalase, and reduced glutathione levels. Histopathological study revealed that Centratherum anthelminticum extract provided significant protection against STZ induced degeneration in liver and kidney. This confirms the antidiabetic and antioxidant activity of Centratherum anthelminticum wild. kuntze in streptozotocin induced diabetic rats.

Aditya Arya et al. (2012) aimed to ascertain the potential of Centratherum anthelminticum seeds methanolic fraction (CAMFs) for the management of type 2 diabetes and its associated complications. CAMFs was initially tested on β-TC6 cells for H₂O₂-induced nuclear factor-κB (NF-κB) translocation effects. The result displayed that CAMFs significantly inhibited NF-κB translocation from cytoplasm
into the nucleus, dose-dependently. Furthermore, a 12-week sub-chronic CAMFs study was carried out on streptozotocin (STZ)-nicotinamide–induced type 2 diabetic rat model to evaluate glycemia, essential biochemical parameters, lipid levels, oxidative stress markers, and pro-inflammatory cytokines level. Our study result showed that CAMFs reduced hyperglycemia by increasing serum insulin, C-peptide, total protein, and albumin levels, significantly. Whereas, elevated blood glucose, glycated hemoglobin, lipids and enzyme activities were restored to near normal. CAMFs confirmed antioxidant potential by elevating glutathione (GSH) and reducing malondialdehyde (MDA) levels in diabetic rats. Interestingly, CAMFs downregulated elevated tumor necrosis factor α (TNF-α), interleukin (IL)-1β and IL-6 in the tissues and serum of the diabetic rats. We conclude that CAMFs exerted apparent antidiabetic effects and demonstrated as a valuable candidate nutraceutical for insulin-resistant type 2 diabetes and its associated complications such as dyslipidemia, oxidative stress, and inflammation.

Ani et al., (2008), studied the effects of C.anthelminticum Kuntze extract containing mixture ofpolyphenolic compounds, against rat intestinal α-glucosidases, human salivary α-amylase activity and postprandial hyperglycemia in rats. The polyphenolic components of C. anthelminticum seed extracts, inhibited rat intestinal disaccharidases in a dose dependent manner. IC50 values observed for intestinal sucrase, maltase and p-nitrophenyl α-D glucopyranoside (PNP-glycoside), were found to be 34.1 ± 3.8, 62.2 ± 4.5 and 500.5 ± 11.9 μg of extract, respectively. The study suggested that the C. anthelminticum exhibit antihyperglycemic effect by reducing postprandial glucose in rats through the modulation of α-amylase and glucosidases (sucrase and maltase) activity and thus may be valuable in the management of diabetes mellitus3.

The seeds are brownish in color, with a hot sharp taste and astringent properties (Rastogi et al., 1995; Mehta 2004; Bhatia, 2008a; Ani et al.,2011). It is widely used as folk medicine for diabetes in Rayalaseema, India and a popular ingredient in Ayurvedic medicine. In other places, C anthelminticum has been traditionally applied as anthelmintic, stomachic, digestive, diuretic, tonic, alterative, anti-phlegmatic, anti-asthmatic, anti-phlegmatic treatment, as well as a therapeutic agent for cough,
Review of Literature

diarrhea, helminth, skin diseases, ulcers, leucoderma and fevers (et al., 1955; Chopra et al., 1956; Kirtikar et al., 1987; Nagaraju et al., 1989; Amir et al., 2011; Arya et al., 2012a). Experimental investigations on the extracts or pure compounds isolated from the plant indicated a vast variety of pharmacological effects, including anti-inflammation/anti-pyretic (Purnima et al., 2009; Ashok et al., 2010), anti-helminthic (Iqbal et al., 2006), anti-viral (Bhakuni et al., 1969), insecticidal (Verma et al., 1982), anti-microbial (Sharma et al., 1991), anti-filarial (Singhal et al., 1992; Nisha et al., 2007), anti-cancer (Arya et al., 2012a), anti-diabetic (Ani et al., 2008; Fatima et al., 2010; Arya et al., 2012b), diuretic (Koti et al., 2008), melanogenesis (Zhou et al., 2012) and wound healing activities (Sahoo et al., 2012).

Daksh Bhatia et al., 2008 In a study on “anti-diabetic activity of centratherum anthelminticum kuntze on alloxan induced diabetic rats” reported that The antidiabetic activity of Centratherum anthelminticum Kuntze (Compositae) was investigated in a model of Alloxan-induced diabetic rats. Extracts were administered daily at the doses 200 mg/kg and 500 mg/kg p.o., 14 days after alloxan administration (150 mg/kg). The aqueous extract of the drug showed significant dose dependent percentage blood glucose reduction in diabetic rats (35.61% at 200 mg/kg dose, 40.1% at 500 mg/kg dose). The antidiabetic effect of C.anthelminticum was compared with the reference standard drug Glibenclamide (5 mg/kg bodyweight) which showed 48.65% decrease in blood glucose level after the study of one week. The drug was found promosing in management of diabetes and in overcoming the secondary effects of diabetes like fatigue and thirst.

2.2.4 Other Indigenous food and their impact on type2 diabetes

Acacia Arabica (Babbul): Yasir et al., (2010). The plant extract acts as an antidiabetic agent by acting as secretagouge to release insulin. It induces hypoglycemia .Powdered seeds of Acacia arabica induced hypoglycemic effect by initiating release of insulin from pancreatic beta cells (Wadood et al., 1989). Oral administration of cold water extract of Acacia arabica bark to diabetic and normal rats at a dose of 400 mg kg\(^{-1}\) b.wt. resulted in significant reduction of blood glucose, cholesterol and triglycerides
Aegle marmelos (Bengal Quince, Bel or Bilva): Karunanayake et al. (1984) Administration of aqueous extract of leaves improves digestion and reduces blood sugar and urea, serum cholesterol. Along with exhibiting hypoglycemic activity, this extract also prevented peak rise in blood sugar at 1 h in oral glucose tolerance test.

Aegle marmelose, a member of the Rutaceae family, is a perennial tree of 7.62–9.14 m height that is native to India but also grows in several areas of southeast Asia. Leaf extract in form of expressed juice and fruit of A. marmelose has been used since ancient times (Sharma, 1996). The leaf extract of A. marmelose has been shown to have a hypoglycemic activity similar to that of insulin. It decreased blood glucose levels near to controls and increased the glucose tolerance. On the other hand, leaf extract also decreased serum cholesterol by approximately 93 mg% and brought back body weight to control levels, which were decreased in diabetic rats (Ponnachan et al., 1993).

Alchemilla mollis (Lady's mantle): Some modern herbalists recommend lady's mantle as a treatment for diabetes, it may help to prevent circulatory problems in diabetics (Ahad et al., 2010).

Allium cepa (onion): Various ether soluble fractions as well as insoluble fractions of dried onion powder show anti-hyperglycemic activity in diabetic rabbits. Allium cepa is also known to have antioxidant and hypolipidaemic activity. (Roman-Ramos et al., 1995; Kumari et al., 1995). When diabetic patients were given single oral dose of 50 g of onion juice, it significantly controlled post-prandial glucose levels (Mathew et al., 1975).

Allium sativum (garlic): This is a perennial herb cultivated throughout India. Allicin, a sulfur-containing compound is responsible for its pungent odour and it has been shown to have significant hypoglycemic activity (Sheela et al., 1992). This effect is thought to be due to increased hepatic metabolism, increased insulin release from pancreatic beta cells and/or insulin sparing effect (Bever et al., 1979).

Aloe vera and Aloe barbadensis: Aloe, a popular houseplant, has a long history as a multipurpose folk remedy. The plant can be separated into two basic products: gel and
latex. Aloe vera gel is the leaf pulp or mucilage, aloe latex, commonly referred to as aloe juice, is a bitter yellow exudate from the pericyclic tubules just beneath the outer skin of the leaves. Extracts of aloe gum effectively increases glucose tolerance in both normal and diabetic rats (Farida et al., 1987).

Aloe vera (PAG). lowered blood glucose level by decreasing insulin resistance. The administration of PAG also lowered triacylglyceride levels in liver and plasma. Histological examinations of periepididymal fat pad showed that PAG reduced the average size of adipocytes (Kim et al., 2009; Joseph et al., 2010a).

**Althaea officinalis (Marsh Mallow):** Most of the therapeutic ability comes from the large concentration of mucilage and pectin. Pectin is a soluble fiber that keeps the gastrointestinal system running smoothly and helps tame blood sugar (Ahad et al., 2010).

**Arctium lappa (Burdock roots):** Fresh burdock roots contain phytochemicals called polyacetylenes, which destroy certain bacteria and fungi. Studies revealed that the root extract was found to reduce blood sugar in rats. An extract made from burdock has shown prolonged blood-sugar-lowering effects in animal tests. It works by filling the intestines with fiber, which prevents the absorption of sugars. Burdock's chromium content also helps regulate blood-sugar levels (Ahad et al., 2010).

**Azadirachta indica (Neem):** Hydro alcoholic extracts of this plant showed antihyperglycemic activity in streptozotocin treated rats and this effect is because of increase in glucose uptake and glycogen deposition in isolated rat hemidiaphragm (Chattopadhyay et al., 1987a, b). Apart from having anti-diabetic activity, this plant also has anti-bacterial, antimalarial, antifertility, hepatoprotective and antioxidant effects (Biswa et al., 2002)

The Margosa tree, a member of the Meliaceae family, is indigenous to India, Sri Lanka, and also found in other tropical regions including Indonesia and Australia. Seed oil, expressed juice of leaves, and the bark of this plant, along with other herbs have been used as hypoglycemic agents since ancient times (Kirtikar, et al., 2000).
**Berberis lyceum (Indian Barberry):** Berberis lyceum (Berberidaceae) is an important traditional shrub, native to Pakistan and India but also found in other parts of the world. Inhabitants of these areas have been using Berberis lyceum for the treatment of diabetes, wounds, broken bones, ulcers and sore eyes. Roots are yellowish in color, rich in alkaloids (berberine, etc.) and other phytochemicals (Bailey et al., 1989; Leng et al., 2004).

Gulfraz et al. (2007) investigated the antihyperglycemic effects of aqueous and ethanol extracts of Berberis lyceum in alloxan induced diabetic and normal rats and concluded that the root extract reduced serum glucose level in normal and diabetic rats, however, the effects of 100 mg kg\(^{-1}\) ethanol extracts were more pronounced in alloxan diabetic rats. Furthermore, due to the presence of antihyperglycemic phytochemicals (berberine, etc.) the roots of Berberis lyceum have a potential to provide raw materials for pharmaceutical industries (Gulfraz et al., 2007).

**Caesalpinia bonducella (Bonduc):** Caesalpinia bonducella is widely distributed throughout the coastal region of India and used ethnically by the tribal people of India for controlling blood sugar. Both the aqueous and ethanolic extracts showed potent hypoglycemic activity in chronic type II diabetic models. These extracts also increased glycogenesis thereby increasing liver glycogen content (Chakrabarti et al., 2003). Two fractions BM 169 and BM 170 B could increase secretion of insulin from isolated islets. The aqueous and 50% ethanolic extracts of Caesalpinia bonducella seeds showed antihyperglycemic and hypolipidemic activities in streptozotocin (STZ)-diabetic rats (Sharma et al., 1997). The antihyperglycemic action of the seed extracts may be due to the blocking of glucose absorption. The drug has the potential to act as antidiabetic as well as antihyperlipidemic (Kannur et al., 2006).

**Cinnamomum zeylanicum (Cinnamon):** It has Insulin-like properties, which able to decrease blood glucose levels as well as triglycerides and cholesterol, all of which are important especially for type II diabetes patients. Just half a teaspoon of Cinnamon into the daily diet of a diabetic can significantly reduce blood glucose levels. (Mukul et al., 2008).
Review of Literature

Both common cinnamon (Cinnamomum verum and C. zeylanicum) and cassia (C. aromaticum) have been used for thousands of years to treat diabetes and other conditions. The aqueous extract of cinnamon appears to activate the insulin receptor by multiple mechanisms, and also increases glycogen synthase activity (Imparl-Radosievich et al., 1998; Jarvill-Taylor et al., 2001; Qin et al., 2003; Cao et al., 2007; Nahas et al., 2009). Cinnamon phenolics were proposed to be the active compounds in modulation of insulin signaling (Subash Babu et al., 2007; Qin et al., 2012). Moreover, cinnamaldehyde, a compound of cinnamon extract is thought of as a potential antidiabetic agent (Subash Babu et al., 2007).

*Coccinia indica* (*Coccinia*): Dried extracts of *Coccinia indica* (C. indica) (500 mg kg⁻¹ b.wt.) were administered to diabetic patients for 6 weeks. These extracts restored the activities of enzyme lipoprotein lipase (LPL) that was reduced and glucose-6-phosphatase and lactate dehydrogenase, which were raised in untreated diabetics (Kamble et al., 1998).

*Ivy guard* (*Coccinia indica*), a member of the Cucurbitaceae family, is perennial tree, native to India and distributed to Sri Lanka, Malaysia, and tropical Africa. The leaves and thick taproot of this plant has been used since ancient times by Ayurvedic physicians as an adjunct to metallic preparations in treatment of diabetes (Sharma, 1996). In a double-blinded controlled trial, the leaves of *C. indica* also improved glucose tolerance in patients with uncontrolled type 2 diabetes. Ten (10) out of 16 patients in the treated group showed significant improvement in blood glucose level (Azad Khan et al., 1979).

*Costus pictus* (D.Don) belongs to the family Costaceae and it is called as Insulin plant in English, Keu-Hindi, Kottam-Tamil, and Kemuka - Sanskrit. It is a vulnerable species, slow growing, and perennial herb of tropical and subtropical regions. It is a potent antidiabetic plant and used in folk, ayurvedic and homeopathic systems of medicine (Joshi, 2000). It also used asthma, eye complaints and snake bite and 18 chemical analyzed and identified from leaves of Costus pictus (George et al., 2007).

*Curcuma longa* (*Tumeric*), a member of the Zingiberaceae family, is a perennial herb, native to southern Asia, extensively cultivated in India, China, and other tropical
countries. Traditionally rhizome of \textit{C. longa} has been used in form of expressed Juice along with fruit of Embilica officinale (Awala), for treating diabetes (Sharma, 1996). In Ayurveda, \textit{C. longa} is advocated extensively for the treatment of diabetes but few scientific studies are available in the modern literature. Curcumin, an active ingredient isolated from \textit{C. longa}, has been shown to have hypoglycemic, hypolipidemic, and antioxidants effect in experimental studies. Recently, it was reported that curcumin decreases blood glucose.

\textbf{Curcumin}, a dietary polyphenol in turmeric, has been shown to exert an anti-hipogenic function in both human and murine preadipocytes, particularly in the early stages of adipocyte differentiation. A dose-dependent decrease in leptin and lipopolysaccharide-induced IL-6 secretion was observed in dipocytes incubated with curcumin. Downregulation of other inflammatory cytokines such as resistin and upregulation of adiponectin have also been observed. Through its interaction with several signal transduction pathways, curcumin can reverse insulin resistance, hyperglycemia, and other inflammatory symptoms associated with obesity and metabolic diseases. Curcumin has been shown to inhibit fatty acid synthase, repressing lipid accumulation, down-regulating mRNA levels of peroxisome proliferators-activated receptor [PPAR]{\gamma}, inhibiting lipid accumulation.

\textbf{Emblica officinalis (Amla)}: It is rich in Vitamin C. Amla stimulates the Pancreas to secrete Insulin (Ahad \textit{et al.}, 2010). The aqueous extract of Emblica officinalis seeds was investigated for its anti-diabetic activity in Streptozotocin induced type 2 diabetes animal models. The dose of 300 mg kg\textsuperscript{-1} of aqueous seed extract in sub- and mild-diabetic animals produced a maximum fall of glucose level in the blood (Shikha \textit{et al.}, 2009).

\textbf{Eugenia jambolana (Indian gooseberry, jamun)}: In India decoction of kernels of Eugenia jambolana is used as household remedy for diabetes. This also forms a major constituent of many herbal formulations for diabetes. Antihyperglycemic effect of aqueous and alcoholic extract as well as lyophilized powder shows reduction in blood glucose level. This varies with different level of diabetes. In mild diabetes (plasma sugar >180 mg dL\textsuperscript{-1}) it shows 73.51\% reduction, whereas in moderate (plasma sugar...
>280 mg dL\(^{-1}\)) and severe diabetes (plasma sugar >400 mg dL\(^{-1}\)) it is reduced to 55.62 and 17.72%, respectively (Sheela and Augusti, 1992).

The extract of jamun pulp showed the hypoglycemic activity in streptozotocin induced diabetic mice within 30 min of administration while the seed of the same fruit required 24 h. The oral administration of the extract resulted in increase in serum insulin levels in diabetic rats.

Insulin secretion was found to be stimulated on incubation of plant extract with isolated islets of Langerhans from normal as well as diabetic animals. These extracts also inhibited insulinase activity from liver and kidney (Achrekar et al., 1991).

Administration of the ethanolic extract of kernel of E. jambolana at a concentration of 100 mg kg\(^{-1}\) of b.wt. significantly decreased the levels of blood glucose, blood urea, and cholesterol, increased glucose tolerance and levels of total proteins and liver glycogen, and decreased the activities of glutamate oxaloacetate transaminase and glutamate pyruvate transaminase in experimental diabetic rats (Ravi et al., 2004).

**Ficus racemosa (Cluster Fig.Tree):** Ficus racemosa Linn (Moraceae) is an evergreen, moderate to large sized spreading, lactiferous, deciduous tree, without much prominent aerial roots found throughout greater part of India in moist localities and is often cultivated in Indian villages for its edible fruit (Joseph et al., 2010b).

The ethanol extract (250 mg/kg/day) lowered blood glucose level within 2 weeks in the alloxan diabetic albino rats confirming its hypoglycemic activity (Kar et al., 2003; Joseph et al., 2010c). β-sitosterol isolated from the stem bark was found to posses potent hypoglycemic activity when compared to other isolated compound (Swain et al., 1990; Joseph et al., 2010b).

**Ginkgo biloba (Gingo):** Long used in traditional Chinese medicine, a species that has survived in China for more than 200 million years and now grows throughout the world (Taylor et al., 1993). The extract may prove useful for prevention and treatment of early-stage diabetic neuropathy. It has been shown to prevent diabetic retinopathy. Dosage of the extract standardized to contain 24% ginkgo flavoglycosides is 40-80 mg three times per day (Ahad et al., 2010).
**Gymnema sylvestre**: The indigenous medicinal herb, Gymnema sylvestre R. Br. (Family: Asclepiadaceae) is a potential natural alternative to chemical means of blood sugar regulation (Siddiqui *et al.*, 2000). The word Gymnema is derived from a Hindu word Gurmar meaning destroyer of sugar and it is believed that it might neutralize the excess of sugar present in the body in Diabetes mellitus (*et al.*, 1990).

The plant is reported to be useful in ethno botanical surveys conducted by ethno botanists. It has been documented that the Jungle Irulas inhabitants of Nagari Hills of the North Arcot District, Bombay and Gujarat from India have the habit of chewing a few green leaves of *G. sylvestre* in the morning in order to keep their urine clear and to reduce glycosuria.

Bourgeois classes of Bombay and Gujarat also chew fresh leaves for the same effect. In Bombay and Madras, Vaids are known to recommend the leaves in the treatment of furunculosis and madhumeha. The juice obtained from root is used to treat vomiting and in dysentery and plant paste is applied with mother milk to treat mouth ulcer (Kritikar and Basu, 1998; Ekka and Dixit, 2007). Gymnemic acids have antidiabetic, antisweetener and anti-inflammatory activities.

Gymnema, also known as periploca of woods in the Asclepediaceae family is a large woody highly branched climber, native to southern India, that is distributed in Sri Lanka and tropical Africa. Leaves of *G. sylvestre* in the form of powder are used as an antidiabetic agent (Sharma, 1996).

Many experimental and clinical studies have documented the hypoglycemic action of this plant. In an animal study, it was observed that an aqueous extract (GS4) of this plant improved glucose tolerance when administered in rats with experimentally induced diabetes (Okbayashi *et al.*, 1990). In vitro studies reported that the GS4 extract stimulates insulin release from beta cell lines and from pancreatic islets in the absence of any other stimuli, suggesting that it releases insulin by increasing beta cell permeability rather then stimulated exocytosis by regulating pathways (Persaud *et al.*, 1999). *G. sylvestre* also increases the activities of the enzymes involved in glucose utilization by insulin-dependent pathways thereby correcting the metabolic...
derangements in liver, kidney, and muscles of diabetic rabbits (Shanmugasundaram et al., 1983).

**Helichrysum italicum:** It has been known that by eating ten fully green leaves for every morning for at least three months will prevent diabetes of heredity related (Arulselvan et al., 2006).

**Lagerstroemia speciosa (Banaba):** Banaba possesses the powerful compound corosolic acid and tannins, including lagerstroemin that lends itself to the treatment of diabetes (Burgess, 1987). These ingredients are thought to stimulate glucose uptake and have Insulin-like activity. The latter activity is thought to be secondary to activation of the Insulin receptor tyrosine kinase or the inhibition of tyrosine phosphatase. It is a natural plant Insulin, can be taken orally.

**Mangifera indica (Mango):** The leaves of this plant are used as an antidiabetic agent in Nigerian folk medicine, although when aqueous extract given orally did not alter blood glucose level in either normoglycemic or streptozotocin induced diabetic rats. However, antidiabetic activity was seen when the extract and glucose were administered simultaneously and also when the extract was given to the rats 60 min before the glucose. The results indicate that aqueous extract of Mangifera indica possess hypoglycemic activity. This may be due to an intestinal reduction of the absorption of glucose (Aderibigbe et al., 1999). The ethanol extracts of stem-barks reduced glucose absorption gradually during the whole perfusion period in type 2 diabetic rats (Bhowmilk et al., 2009).

**Momordica charantia (bitter gourd):** Momordica charantia (bitter gourd) is one of the many plants considered to have a hypoglycemic effect and many diabetic subjects consume it because of its hypoglycemic effect (Karunanayake et al., 1984).

Extracts of fruit pulp, seed, leaves and whole plant was shown to have hypoglycemic effect in various animal models. Polypeptide p, isolated from fruit, seeds and tissues of M. charantia showed significant hypoglycemic effect when administered subcutaneously to langurs and humans (Khanna et al., 1981). Momordicin is an active compound present in the leaf extract of M. charantia.
The ethanolic extract of M. charantia (200 mg kg\(^{-1}\)) showed an antihyperglycemic and also hypoglycemic effect in normal and STZ diabetic rats. This may be because of inhibition of glucose-6-phosphatase besides fructose-1, 6- biphosphatase in the liver and stimulation of hepatic glucose- 6-phosphate dehydrogenase activities (Shibib et al., 1993). The alcoholic extract of M. charantia was quite effective in lowering blood sugar levels and islet histopathology also showed improvement.

Recently Vikrant et al. (2001) investigated the effect of M. charantia along with Eugenia jambolana on insulin resistance in fructosefed diabetic rats. The water extract of these plants in a dose of 400 mg/d reduced hyperglycemia and also reduced insulin levels.

**Bitter Melon (Momordica charantia)** It is widely cultivated in Asia, Africa, and South America and has been used extensively in folk medicines as a remedy for diabetes. In an animal study, alcohol-extracted charantin from Momordica charantia was even found to be more potent than the oralhypoglycemic agent tolbutamide (Sarkar et al., 1996). Momordica charantia contains several active ingredients, such as charantin, vicine and polypeptidep. These active ingredients are believed to stimulate insulin secretion (Baldwa et al., 1977; Basch et al., 2003) and to alter hepatic metabolism (Welihinda et al., 1986; Shibib et al., 1993; Yeh et al., 2003). Momorcharin and momordicin, also isolated from Momordica charantia and its fruit, act to lower bloodglucose likely because they possess insulin-like chemical structures (Singh et al., 2011).

Bitter melon in the Cucurbitaceae family is a slender-stemmed tendril climber, cultivated in tropical areas including India, Asia, and South America. Swaras of fruit has been used as a hypoglycemic agent in Ayurveda (Sharma, 1996). *M. charantia* fruit has been evaluated in many animal studies; however, relatively few reports are available on its activity in humans. Significant reduction of blood glucose level and increased concentration of plasma insulin has been observed in rats with diabetes who were treated with fruit juice of *M. charantia*. This is probably the result of an increase in the number of beta cells in treated animals compared to untreat ones (Ahmed et al., 1999a).
A clinical study comprising 100 patients with type 2 diabetes, conducted for 2 days, showed that, on the first day the patients’ pretreatment mean fasting blood glucose was 152 mg% and after an oral glucose tolerance test (OGTT), their mean 2-hour postprandial glucose level was 257 mg%. On the second day, an M. charantia extract was given 1 hour prior to blood testing. The patients’ mean fasting glucose level was 131 mg%, which was significantly different from that of the previous day ($p$, 0.001). Similarly, after 75 g OGTT was taken, OGTT, patients’ mean 2-hour blood glucose was reduced to 222 mg% in 86 patients. Although this study was conducted with a larger sample size the study ran for a short duration (Ahmad et al., 1999b).

Another study in which the fruit juice was administered before the OGTT to 18 patients with type 2 diabetes, a significant improvement in glucose tolerance was observed in 13 patients, while 5 patients experienced no significant improvement (Welihinda et al., 1986b).

*Murraya koenigii (Curry leaves):* The curry tree (Murraya koenigii) is a tropical to sub-tropical tree in the family Rutaceae, which is native to India. It is commonly known as Curry Patta (Hindi) is widely used as a spice and condiment in India and other tropical countries.

Various parts of Murraya koenigii have been used in traditional or folk medicine for the treatment of rheumatism, traumatic injury and snake bite and it has been reported to have antioxidant, anti-diabetic and anti-dysenteric activities (Kong et al., 1986; Keasri et al., 2007). Murraya koenigii leaves are used traditionally in Indian Ayurvedic system to treat diabetes (Dineshkumar et al., 2010).

Mahanimbine is a carbazole alkaloid and present in leaves, stem bark and root of Murraya koenigii. Most of the carbazole alkaloids have been isolated from taxanonomically related plants of the genus Murraya, Glycosmic and Clausena from the family Rutaceae (Knolker et al., 2002).

The Murraya species has richest source of carbazole alkaloids. Further, Carbazole alkaloids has been reported for their various pharmacological activities such as anti-tumor, anti-viral, anti-inflammatory, anti-convulsant, diuretic and anti-oxidant
Review of Literature

activities (Knolker et al., 2008). Dineshkumar et al. (2010) suggested that the mahanimbine has beneficial effect in the management of diabetes associated with abnormal lipid profile and related cardiovascular complications.

The fresh leaves as well as aqueous and methanol extract of Murraya koenigii have also found to be hypoglycemic in nature (Khan et al., 1995; Rupashree, 1999; Bhat, 1995). The hypoglycaemic effect of curry leaves has been studied in animal models and noninsulin dependent diabetes mellitus (NIDDM) patients (Mani and Iyer, 1990; Grover et al., 2003). Oral administration of ethanolic extract of M. koenigii at a dose of 200 mg/kg/b.w./day for a period of 30 days significantly decreased the levels of blood glucose, glycosylated hemoglobin, urea, uric acid and creatinine in diabetic treated group of animals (Arulselvan et al., 2006).

**Ocimum sanctum (Holy basil):** It is commonly known as Tulsi. Since ancient times, this plant is known for its medicinal properties. The aqueous extract of leaves of Ocimum sanctum showed the significant reduction in blood sugar level in both normal and alloxan induced diabetic rats (Vats et al., 2002).

**Olive leaf:** Olive leaves, particularly Olea europaea L., are rich in phenolic compounds including flavones, flavonols, catechin, and substituted phenols. The most abundant polyphenol in olive leaves is oleuropein, which accounts for approximately 20% of phenolic compounds in the olive leaf, which has been shown to suppress improved insulin secretion in H$_2$O$_2$-exposed cells. Olive leaf phenolic compounds have been shown to have both antioxidant and anti-inflammatory properties.

Used in traditional medicine to treat hyperglycemia and diabetes, olive leaf extract has been shown to improve beta cell viability and protect against cell death after cytokine exposure through suppression of caspase 3/7 activity, protecting insulin secretion, and reducing reactive oxygen species production post exposure. It has been proposed that olive leaf extract potentiates glucose-induced insulin release and increases peripheral glucose uptake.

The efficacy of olive leaf extract on metabolic, hemodynamic and anthropometric measures was studied in a clinical trial in borderline hypertensive monozygotic twins.
A significant reduction in both systolic and diastolic blood pressure was observed, however, differences in glucose were not detected.

In a randomized, double blind clinical trial, 79 adults with type 2 diabetes [T2DM] were randomized to treatment with 500 mg of olive leaf extract tablets, taken orally once daily or matching the placebo. Subjects treated with olive leaf extract exhibited significantly lower HbA1c, and fasting plasma insulin levels; however, post prandial plasma insulin levels did not differ significantly by treatment group.

**Panax ginseng (Ginseng):** It has been shown to enhance the release of Insulin from the pancreas and to increase the number of Insulin receptors. It also has a direct blood sugar-lowering effect.

Ginseng has attracted considerable attention since the double-blind study by Sotaniemi et al(Sotaniemi *et al.*, 1995). The mentioned study examined the efficacy of Panax ginseng, given in a dosage of 100 or 200 mg per day for 8 weeks in newly diagnosed type 2 diabetics. Compared to the placebo group, the 200 mg ginseng group experienced elevated mood, improved physical performance, and reduced fasting blood glucose. A second study (Tetsuani *et al.*, 2000) demonstrated that 24 months of treatment with 3 to 4.5 g of a Korean red ginseng extract decreased HbA1c by an unspecified magnitude. Vuksan *et al.* (Vuksan *et al.*, 2000) showed that 8 weeks of supplementation with an American ginseng extract at the dose of 1 g (prandial agent 40 min before each meal) similarly improved FBG and HbA1c.

A 2005 double-blind, crossover RCT examined the effects of Panax ginseng on blood glucose levels and cognitive performance during sustained mental activity (Reay *et al.*, 2009). Healthy volunteers ingested either the G115 (Ginseng product). The 200-mg and 400-mg G115 doses reduced blood glucose levels significantly and improvement was also noted in the ability to complete the serial sevens subtraction task after taking 200 mg G115. In a recently conducted clinical trial by Reeds *et al.* (Reeds *et al.*, 2011), fifteen overweight or obese adults were included. The participants were randomly assigned to 4 week treatment with either: placebo capsule, Korean Red Ginseng extract (3 g/d for 2 week and 8 g/d for 2 week) or ginsenoside Re (250 mg/d for 2 week, followed by 500 mg/d for 2 week). The results showed no evidence that oral ginseng or ginsenoside Re therapy improves β-cell function or insulin sensitivity in overweight
or obese subjects with impaired glucose tolerance or newly diagnosed type 2 diabetes. A double-blind, 12-week RCT examined the effect of red Panax ginseng on HbA1c levels in 19 subjects with well-controlled type 2 diabetes (Vuksan et al., 2008). Study participants received 2 g ginseng or placebo three times daily before meals. Although no change was seen in HbA1c levels with ginseng, the participants maintained good glycemic control and improved plasma glucose and plasma insulin regulation.

**Phaseolus vulgaris (Kidney Bean):** In addition to lowering cholesterol, kidney bean’s high fiber content prevents blood sugar levels from rising too rapidly after a meal, making these beans an especially good choice for individuals with diabetes, Insulin resistance or hypoglycemia. It seems that Phaseolus preparations should not be considered the first choice in phyto pharmaceutical treatment of diabetes or lead structure research. To be effective, fairly high doses of aqueous extracts need to be given. Because of their fiber content and an α-amylase inhibitory effect, beans might be more useful as food components in preventing or ameliorating type 2 diabetes (Helmstadter, 2010).

**Phyllanthus amarus (bhuiawala):** It is a herb of height up to 60 cm, from family Euphorbiaceae. It is commonly known as Bhuiamala. It is scattered throughout the hotter parts of India, mainly Deccan, Konkan and south Indian states. Traditionally it is used in diabetes therapeutics. Methanolic extract of Phyllanthus amarus was found to have potent antioxidant activity. This extract also reduced the blood sugar in alloxanized diabetic rats (Raphael et al., 2002). The plant also shows antiinflammatory, antimutagenic, anticarcinogenic, antidiarrhoeal activity.

**Punica granatum,** Pomegranate a member of the Punicaceae family is a shrub or small tree, probably originated in Asia, and is widespread in the Mediterranean region as far as the southern Tyrol, near east Africa, South Africa, and China. The seeds of *P. granatum* have been used for the treatment of diabetes in various formulations indicated in Ayurveda literature. The flowering part of this plant has also been recommended as treatment of diabetes in Unani literature (Kirtikar et al., 2000).
**Review of Literature**

*Plantago ovata (Ispaghula):* It can be taken in the form of seeds/husk (Freitas et al., 2002). In case of diabetics, it controls blood sugar by inhibiting the excessive absorption of sugar from the intestine.

*Prunus dulcis (Almond):* The fixed Oil of Almonds is extracted from both Bitter and Sweet Almonds (Singh, 2002). They have a special dietary value (containing about 20% of proteins); they contain practically no starch, and are therefore often made into flour for cakes and biscuits for patients suffering from diabetes.

*Pterocarpus marsupium (Indian Kino):* It is a deciduous moderate to large tree found in India mainly in hilly region. Pterostilbene, a constituent derived from wood of this plant caused hypoglycemia in dogs (Haranath et al., 1958; Joglekar et al., 1959) showed that the hypoglycemic activity of this extract is because of presence of tannates in the extract. Flavonoid fraction from Pterocarpus marsupium has been shown to cause pancreatic beta cell regranulation (Chakravarty et al., 1980).

The Indian kino tree (Pterocarpus marsupium) in the Leguminaceae family is a large deciduous tree, native to southern India, is distributed in the country’s west peninsula and in Sri Lanka. A water extract of the wood of this plant has been used for treating diabetes mellitus since ancient time (Sharma, 1996). In a clinical study, 10 patients were given water stored in a heartwood container of this plant for a period of 1 month. Blood glucose levels decreased from the second week of treatment and were maintained at a normal level until the treatment was withdrawn (Keder and Chakrabarti, 1981).

Another flexible-dose open trial evaluated the efficacy of this plant for treating newly diagnosed or untreated patients with type 2 diabetes. A plant extract was given to patients for total period of 12 weeks. Initially, 2 g of herb extract was given to the patients for 4 weeks. The dose was increased up to 4 g if no significant effect was observed. Among 93 patients who completed the study, both fasting and postprandial blood glucose levels decreased significantly ($p$, 0.001) by 32 mg% and 45 mg% 12 weeks after the initial mean values of 151 mg% and 216 mg%, respectively (Indian Council of Medical Research [ICMR], 1998).
An active principle (2) epicatechin isolated from the bark of *P. marsupium* has been found to have protective and restorative effects on beta cells in diabetic subjects. Possibly, (2)epicatechin acts by regenerating the beta cells and may produce actions similar to the effects of insulin (Ahmad *et al.*., 1989; Chakraverty *et al.*, 1981).

Ahmed *et al.* (1991(b)) observed that epicatechin increases the cyclic adenosine monophosphate (cAMP) content in pancreatic islets, which in turn, are associated with the increase in insulin release, conversion of proinsulin to insulin, and cathepsin-B activity in mature (12 months old) and immature (1 month old) rats pancreatic islets in vitro. The effect was more pronounced in immature rats. In another in vitro study epicatechin was observed to elicit a protective effect on the osmotic fragility of human erythrocytes similar to the effect of insulin (Rizvi *et al.*, 1995)

**Stevia rebaudiana (Stevia):** Steviosides, the principle sugar molecule of Stevia, which is 400 times sweeter than Sucrose, neither absorbed nor metabolized in digestive processes (Parsons *et al.*, 2001). As a result, the Steviosides, molecules pass unchanged through the human gastrointestinal tract and are not absorbed into the blood, producing no calories.

**Syzygium jambolanum (Jambul Seeds):** Practitioners of ayurvedic medicine report that jambul fruit pulp lowers blood-sugar levels in approximately thirty minutes, while jambul seed lowers blood-sugar levels (Matsui *et al.*, 1996) in about twenty-four hours. The maximum hypoglycemic effect of the herb requires ten days of treatment. This Ayurvedic herb has long been used to reduce the level of sugar in the blood and urine. Over a period of several weeks it can diminish the thirst associated with diabetes and decrease the quantity of urine output, and in some cases can lower the need for medical Insulin.

**Tinospora cordifolia (Guduchi):** It is a large, glabrous, deciduous climbing shrub belonging to the family Menispermaceae. It is widely distributed throughout India and commonly known as Guduchi. Oral administration of the extract of Tinospora cordifolia (T. cordifolia) roots for 6 weeks resulted in a significant reduction in blood and urine glucose and in lipids in serum and tissues in alloxan diabetic rats. The extract also prevented a decrease in body weight (Prince *et al.*, 2001).
T. cordifolia is widely used in Indian ayurvedic medicine for treating diabetes mellitus (Prince et al., 1999; Mathew et al., 1997). Oral administration of an aqueous T. cordifolia root extract to alloxan diabetic rats caused a significant reduction in blood glucose and brain lipids. Though the aqueous extract at a dose of 400 mg kg\(^{-1}\) could elicit significant antihyperglycemic effect in different animal models, its effect was equivalent to only one unit/kg of insulin (Khosla et al., 1995). It is reported that the daily administration of either alcoholic or aqueous extract of T. cordifolia decreases the blood glucose level and increases glucose tolerance in rodents. Oral administration of an aqueous T. cordifolia root extract and various extracts (hexane, ethyl acetate and methanol) of stem to alloxan and streptozotocin induced diabetic rats caused a significant reduction in blood glucose level (Stanely et al., 2000; Rajalakshmi et al., 2009).

Tinospora, is a member of the Menispermaceae family is large glabrous climber, indigenous to India and is also found in Myanmar and Sri Lanka. Traditionally, stem and root plant parts have been used in form of decoction and swaras, in diabetic patients (Sharma, 1996). The use of T. cordifolia in a few animal studies has shown hypoglycemic, hypolipidemic, and antioxidant effect. The possible mechanism by which root of this plant brings about its hypoglycemic action may be by increasing the secretion of insulin from beta cells. It may also have action on activity of hexokinase and may decrease the activity of hepatic glucose-6-phosphatase in diabetic rats (Stanely et al., 2000).

**Vaccinium myrtillus (Blue Berry):** Blue berry is a natural source of lowering blood sugar levels (Zohary a et al., 2000). Results have shown the leaves have an active ingredient with a remarkable ability to get rid the body of excessive sugar in the blood.

**Other principal Anti-diabetic herbs in common use:** Cashew leaves (Anacardium occidentale), Madagascar periwinkle leaves (Catharanthus roseus), Cumin seed (Cuminum cyminum), Goat’s Rue seeds (Galega officinalis), Gymnema leaves (Gymnema sylvestre), Olive leaves (Olea europaea), Devil’s Club root bark (Oplopanaxhorridum), Prickly Pear stems and fruit (Opuntia sps), Dandelion plant (Taraxacum officinale), Stinging Nettle plant (Urtica dioica), Bilberry leaves
(Vaccinium myrtillus), Celery seed (Apium graveolens), Bupleurum (Bupleurum falcatum), Gotu kola (Centella asiatica), Rosemary (Rosmarinus officinalis) (Ahad et al., 2010).

Major hindrance in amalgamation of herbal medicine in modern medical practices is lack of scientific and clinical data proving their efficacy and safety. Here is a need for conducting clinical research in herbal drugs, developing simple bioassays for biological standardization, pharmacological and toxicological evaluation and developing various animal models for toxicity and safety evaluation. It is also important to establish the active components from these plant extracts.

2.3 Reviews Related To Body Weight and Diabetes

The medical management; of type 2 diabetes requires a 3- Pronged approach involving nutrition therapy, physical activity, and medication when necessary. Each is designed to compensate for metabolic abnormalities in three modulations of glucose control.

According to Ruderman N et.al, (1980, somewhere between 80-90% of people with type 2 diabetes is overweight. Evidence is unequivocal that weight loss improves blood glucose control by improving insulin action to enhance glucose uptake (i.e., decrease insulin resistance) and by reducing; hepatic glucose output (HGO).

According to Wing RR et.al, 1994, Blood glucose levels and insulin sensitivity continue to improve as weight loss progress on a calorie- restricted constant diet. But this blood glucose levels are maintained or can be kept under control only when the diet and weight is kept under check. As rightly stated by Henry RR et.al, (1985), Improvement in metabolic control diminishes and returns to baseline levels when calorie intake resumes and weight is regained.

According to Haffner SM 1998 et.al, hyperlipidemia is as much a hallmark of type 2 diabetes as is elevated fasting blood glucose. Increased triglycerides and decreased HDL cholesterol levels are the most common lipid abnormalities present in type II diabetes and appear in men. Lipid levels can be related to glycemia and glycemic control improves hypertriglyceridemia regardless of how the improved glycemc
control is achieved. According to Consensus Development Panel (1987), because of the effect of obesity on insulin resistance, weight loss may be the single most important therapeutic objective for individuals with type 2 diabetes.

In the Dixon and O’Brien 2012 study, no one with impaired fasting glucose progressed to develop diabetes during follow-up. Weight loss reduced the incidence of a new diagnosis of type II diabetes from 19% to only 3.6% at 8 years. In patients with impaired glucose tolerance (IGT), the incidence of type II diabetes occurred in only 1% after 7.6 years. In addition, impaired fasting glucose resolved in 89% of patients at 1 year and 100% at 2 years.

Markovic et al., 1990 emphasize that in the short-term, small amounts of weight loss may improve insulin resistance and glycemic but because of the difficulty in maintaining weight loss long term. It is unknown whether this benefit continues. Short-term studies lasting 6 months or less demonstrate that modest amount of weight loss improve metabolic abnormalities in many persons with type II diabetes.

Kelley et al. 1993; stated that An energy restricted diet, however, can have an important regulatory effect on glucose control in person with type II diabetes, independent of any effects from weight loss. When energy intake is restricted, hyperglycemia improves more rapidly than with weight loss. Furthermore, when calories are increased after weight reduction, glucose level increase despite no regain of weight. This suggests that energy intake is more important than weight loss.

Studies done by Wing RR et al., 1994 have evaluated blood glucose control during weight loss have demonstrated that metallic changes responsible for improved control occur with a 10 – 20 kg. Weight loss According to Ebeling P (1997) and Fineberg SE (1997), the dosage of lipro is regulated by assessing 2 hours post parandial glucose level, and premeal glucose value i.e. fasting and pre evening meal levels, are used for the adjustment of background insulin.

Henry R R et al., (1986) said that not everyone who lose weight sees an important in glycemic control, several studies like – U.S. dependent of agriculture (1992) have demonstrated that subjects with the highest fasting plasma glucose levels within the
first 2 weeks of restriction are most likely to gain glucose control through to weight loss efforts.

Redmon et al. 2005 reports in this issue of Diabetes care the 2 years outcome of a combination of weight loss therapies in type 2 diabetic patients. The end result was a weight loss of 4.6 sustained over 2 years, which less to a decrease of Hb A1C of 0.5%.

According to a study by Chourasiya (2009) the effectiveness of fenugreek for weight loss is the low calorie content versus the high levels of fiber. In this study patients were given this herb just prior to a meal. Participants consumed fewer calories during this meal, though they did not eat fewer calories during later meals. This implies that the fiber in the fenugreek keeps a person satisfied for longer periods of time.

N. Patel et. al., (2009) in his study involved giving 10 gm powdered fenugreek to 20 patients during their breakfast. The fullness and satisfaction level of each patient was then measured every half hour for three and half hours. The weight reduction was found to be 5-10% after two months.

Several studies have proven the effectiveness of fenugreek in balancing glucose levels and insulin resistance. It is often used by diabetic people as a supplementary medicinal aid. Many dietary experts believe that having balanced glucose levels helps with weight loss.

2.4 Reviews related to “Food habits and nutrients intake of diabetic patient”

In Franz MJ et.al., (1994), research studies comparing sucrose to starch demonstrated that sucrose did not adversely affect glycemia. Medical management of type 2 diabetes comprises nutrition therapy, increased physical activity, and medications when necessary. The goals of nutrition therapy are to achieve near normal metabolic control- blood glucose blood lipids and blood pressure and to prevent the acute and chronic complications of diabetes (ADA-2002).
Snow don (1985) found vegetarians had a substantially lower risk of type II diabetes than non-vegetarians. The link between meat consumption and incidence of diabetes remained after contributory factors such as weight, physical activity and other dietary factors were accounted for. Dietary recommendations for diabetics encourage a high intake of complex carbohydrates and fibers and low consumption of total and saturated fat (British Diabetic Association, 1982). Vegetarian diets tend to match these recommendations more closely.

According to Milne RM et.al, (1994), The nutrition prescription must be based on the assessment of what individuals are currently doing, what needs to be changed to improve glycemic control or for a healthier lifestyle, and what the individual is willing and able to do. Normally the traditional dietary advice, which is being given to diabetic patients, is to avoid sugar and lose weight. However, individuals with diabetes usually have found this advice difficult, if not impossible, to follow and have therefore abandoned all attempts at making lifestyle changes.

According to Mehtab S Bamji (1996), complex carbohydrates present in cereals and pulses are better than simple carbohydrates present in jam, jellies, sugar, jiggery and sweets etc. Complex carbohydrates should account for approximately two-thirds of total carbohydrate in the diet. Though some claims have been made that excess carbohydrate leads to hyper triglyceridemia and increases the risk for coronary heart disease, several studies have shown that generous supply of carbohydrates (6-65% of calories) in diabetic diet, when given with high fiber diet, has no adverse effect. In fact, it has been shown to improve glucose tolerance as a result of improved insulin sensitivity. In addition, generally low carbohydrate western diets are rich in fat and such diets are likely to increase the serum lipids and also risk of coronary heart disease and certain types of cancer.

According to Wolever TMS et.al., (1994) and Foster-powell K et.al., (1995), the glycemic index represents the blood glucose are above the fasting glucose concentration following the ingestion of 50 gms carbohydrate portions of foods compared with the blood glucose area obtained with a 50 gms. A carbohydrate portion of white bread as an index food is considered to be 100%. The response to other foods is given as a percentage of that obtained with the index food. Normal subjects have
been studies most extensively. However, nearly 600 foods have now been studied in people with diabetes receiving a variety of treatments and with varying degree of insulin insufficiency.

According to Osei K et al., (1987), In a mixed meal, the blood sugar rise is not very different whether wheat, potato starch, or sucrose (household sugar) is eaten. The form (powdered or as granules) and also whether the food is well chewed or not, makes a difference to the glycemic index. Well-chewed food increases the glycemic index. The mode of preparation of food also determines its absorption: cooked whole rice gives a lower blood sugar rise when compared to rice flour. Fructose produces lower rise of blood sugar than glucose.

According to Wadden TA et al., (1986), very low calorie diet therapy consisting of 400-800 kcal/day is a calorie restriction technique that has enjoyed success in obese individual with type 2 diabetes. Whereas according to Hollenback CB et al., (1991) have shown that high carbohydrate diet have been implicated in worsening blood glucose control in type 2 diabetes.

Henry RR et al., (1985) have indicated that glycemic control improves within 24 hours of calorie restriction, before any weight loss occurs. According to Wing RR et al., (1994), only 10 days of a calorie- restricted diet are required to see 87% of the eventual drop in blood glucose. What is not clear is the role that caloric restriction plays in improved glycemic control independent of weight loss, when obese individual with type 2 diabetes lost the same amount of weight (11% or 11kg) by consuming either a 400 kcal (1,674kj) or a 1,000 kcal (4,185 kj) diet, those on the 400 K cal plan had greater improvements in insulin sensitivity and fasting plasma glucose.

Franz MJ et al., (1994) found that, “Traditionally it was taught that refined sucrose (table sugar) should be eliminated from the diets of people with diabetes. The scientific rationale for this was never defined. More recently evidence has been developed indicating that amounts of sucrose typically found in the American diet are not likely to be harmful or to affect blood glucose control adversely.”
According to Major JH et. al., (1988), Fiber rich foods slow stomach emptying and delay intestinal transit, and so reduce the rate of glucose absorption, lower blood sugar rise, and decrease urinary glucose excretion. As reported in Am J Dietetic association (1989), Fiber also contributes to satiety; and the consequent decreased food intake helps reduce weight. Thus fiber containing foods such as pulses, rice, bread, chapattis and apple etc. will produce fewer rises in blood sugar and less excretion of urinary sugar than an equivalent amount of carbohydrate taken as sugar in tea. The inclusion of high fiber foods in diets has improved control of both blood glucose and lipids. Diabetes should therefore eat more fibers (35-40 gms.)

According to studies by Garg A (1988) and Coulston AM (1989), when saturated fat intake was kept low but a portion of the carbohydrate in the diet was replaced by mono saturated fat, diabetic subjects experienced reductions in glycemia, insulinemia, and triglyceridemia. There was no difference between high monounsaturated fat diets and high carbohydrate diets in fasting total LDL cholesterol because both diets were low in saturated fats. These studies suggest that diets relatively high in monounsaturated fat and low in carbohydrate may have metabolic benefits for people with type 2 diabetes.

Coulston and colleagues (1989) questioned the restriction of total fat to < 30% of total daily caloric intake in patients with diabetes in two studies comparing lipids glucose, and insulin levels in subjects with diabetes treated in a random crossover design with either a low-fat, high-carbohydrate diet (20% fat, 60% carbohydrate) or a high-fat diet (40% fat, although restricted in saturated fat, with P/S ratio > 1.0; 40% carbohydrate). Both studies were designed to maintain weight stability throughout (is caloric diets), and at the end of each dietary intervention, both studies demonstrated no difference in fasting levels of glucose, insulin, total cholesterol, and LDL cholesterol between the two diets. Triglycerides levels VLDL cholesterol, and postprandial excursions of glucose and insulin were higher and HDL cholesterol were lower, however, when the subjects consumed the low-fat, high carbohydrate diet compared with when they consumed the high fat, low saturated fat diet.
According to Mehtab S. Bamji (1996) since the blood glucose depends mainly on the intake of carbohydrates, it should be distributed in accordance with our daily needs. One third (33%) of the diet is served during lunch and another one third (33%) during dinner. The remaining one third is served during breakfast (25%) and during evening tea or at bedtime (9%). For individuals with type I diabetes, it is important to establish a regular meal pattern with consistent day-to-day calories and carbohydrate intake. In addition the distribution of carbohydrate should match with the duration of action and type of insulin used. In some IDDM patients, it may be necessary to give additional carbohydrate in the form of snack before the patient goes to sleep to prevent hypoglycemia, particularly when the patient is on slow acting insulin.

In conflict with this idea are several recent studies that suggest that a high carbohydrate may not be optimal for people with type 2 diabetes. According to studies by Garg A (1988) and Coulston AM (1989), when saturated fat intake was kept low but a portion of the carbohydrate in the diet was replaced by mono saturated fat, diabetic subjects experienced reductions in glycemia, insulinemia, and triglyceridemia. There was no difference between high monounsaturated fat diets and high carbohydrate diets in fasting total LDL cholesterol because both diets were low in saturated fats. These studies suggest that diets relatively high in monounsaturated fat and low in carbohydrate may have metabolic benefits for people with type 2 diabetes.

However, according to Lissner L et al., (1987), high fat diet increase energy intake and may thereby cause weight gain. Therefore, it has not been established whether a high carbohydrate diet or a high-monounsaturated fat diet is preferable for patients with type 2 diabetes. If weight loss is the primary issue, a diet low in fat may be preferable, whereas if hyperglycemia and hyper triglyceridemia are the issues, a diet high in monounsaturated fat may be a preferable.

According to American Diabetes Associations nutrition recommendation 1998 and Franz MJ et al., (1994) current nutrition recommendations to achieve and maintain glucose, lipid and blood pressure goals for individuals with type 2 diabetes are simple
in their brevity lose weight if overweight, restrict saturated fat, and spread nutrient intake throughout the day.

According to Willett W C (1994), an increase in carbohydrate intake would result in a decrease in fat intake, since the protein content of the diet is relatively constant. Thus the high-carbohydrate recommendation is being driven by the concern that dietary fat is path genetically important in the development of atherosclerosis and in turn the development of coronary heart disease in most people. The amount of saturated fatty acids is of particular concern. In the non diabetic population there are epidemiological data to support this hypothesis, but it has been difficult to demonstrate in prospective studies. Whether the high carbohydrate, low fat diet is actually beneficial for diabetic patient is not confirmed or certain.

Hence it has been suggested by Strachan MWJ (1998) that for meal with a high fat content, administration of rapid acting insulin after the meal may be preferable to administration of rapid acting insulin before the meal. Here fiber also plays a major role, as human kind is not capable of digesting fibres through the intestine. It also plays a role in adjustments to insulin administration. In an effort to reduce intake of saturated fat and cholesterol, it has been recommended by Garg A (1988, 1994) and Coulston AM (1989), that the diet contains 30% or fewer calories from total fat. Such a diet necessarily derives 50 or 60% of calories from carbohydrate. Here fiber also plays a major role, as human kind is not capable of digesting fibers through the intestine. It also plays a major role in adjustments to insulin administration.

According to Christiansen et al., (2001), the primary risk factor for type 2 diabetes or non-insulin dependent (NIDDM) has been reported to be excess body fat resulting from an imbalance between resulting from an imbalance between energy intake and physical activity. Dietary fats probably also influence the onset of NIDDM but the long-term effects of specific types of dietary fatty acids on insulin resistance and risk of type 2 diabetes remain unclear. Accordingly a team of researchers from the Harvard school of public health examined the relation between dietary fat intake and the risk of type 2 diabetes, utilizing food consumption data collected from over 84,000 women in the Nurses Health study. At entry into the study in 1980, the women had no diabetes, Coronary Heart Disease (CHD), or cancer. During 14 yrs. Of
follow – up, 2507 incident cases of type 2 diabetes were documented. The data indicated that total fat, saturated fatty acids (SFA), and monounsaturated fatty acids (MUFA) intakes are not associated with risk of type 2 diabetes in women. In contrast, Trans Fatty Acids (TFA) increase whereas poly saturated fatty acids (PUFA) reduces the risk. This adverse influence of TFA is consistent with an earlier report, which documented the negative impact of TFA on insulin sensitivity.