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FENUGREEK: A TREASURE OF BIOACTIVE COMPOUNDS WITH PROMISING ANTIDIABETIC POTENTIAL

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ABSTRACT

Diabetes is a major health problem predisposing to markedly increased complications. Despite the numerous preventative strategies and armoires of medication, the management of diabetes remains grossly unsatisfactory. Diabetes is an oxidative stress related disorder and is emerging as a pandemic. The immediate need is to identify novel food based bioactive agents or drugs for curing or preventing diabetes, with comparatively fewer side effects. Plant secondary metabolites have long been known to have health benefits against various oxidative stress related diseases including diabetes. One of the most promising vegetable providing treasures of such secondary metabolites is fenugreek. This paper presents information on bioactive compounds of fenugreek and its strong anti-diabetic power. The herb have an enormous potential to prevent or cure diabetes more than other plant species especially due to the presence of unique chemical constituents including quercetin, diosgenin, trignolline, galactomanin and unusual amino acid 4 hydroxy isolucine. However, due to lack of enough scientific or clinical studies the use of fenugreek as hypoglycaemic official‘drug remains to be explored. It is proposed that a close attention be paid for preventive and curative properties of this potent herb against diabetes and its complications.

Key words: Fenugreek, Phenolic compounds, Alkaloids, Steroids, Antidiabetic potential.

INTRODUCTION

Fenugreek (*Trigonella foenum-gracum)* is an annual leguminous bean, and belongs to *Fabaceae* family (Figure 1). Its seeds and green leaves used as food posses medicinal applications, and is an old practice of human history (Thomas *et al*, 2011; Paridar *et al*, 2011; Vaidya *et al*, 2013). As shown in figure 2 in early times, it has been used for diverse medicinal benefits that include wound healing, aid in digestion, treatment of sinus and lung congestion, inflammation and infection, mitigation, hair treatment, breast enhancement and aphrodisiac effects (Kumar *et al*, 2013a). In India, it is extensively used as Ayurvedic medicine and in China as traditional medicine (Prasad *et al.*, 2014). Interestingly, in herbal medicine, it is used in the treatment of diabetes (Leela and Shafeekh, 2008).

Fenugreek is consumed in various parts of the world in different forms (Figure 3) and has been regarded as a treatment for many ailments known to man (Laila *et al*, 2013). Recent advances in nutraceutical and phytochemical research stimulated a renewed interest in fenugreek to be used as a functional food. The research has led to identification of specific health benefits of this novel crop through extensive research and clinical trials (Acharya *et al*, 2007). Latest research reports indicate fenugreek to posse's immunomodulatory, anti-carcinogenic, anthelmintic, anti-nociceptive, antioxidant, anti-microbial, anti-ulcer, gastro- and hepatoprotective, anti-obesity, anti-hyperglycemic, anti-diabetic and hypocholesterolemic effects (Kumar *et al*, 2013a). It has been shown to normalizes the blood circulation, thereby making the body active and energetic (Sudha and Mathangi, 2013).

Medicinally, the fenugreek seeds are the most important and useful part of fenugreek plant.These seeds are golden-yellow in colour, small in size, hard and have four-faced stone like structure. The biological and pharmacological actions of fenugreek seeds are mostly attributed to the variety of its bioactive chemical constituents that serve as raw materials for the manufacture of various hormonal and therapeutic drugs (Mehrafarin *et al*, 2010; Priya *et al*, 2011).

Figure 1 Fenugreek grown under field conditions

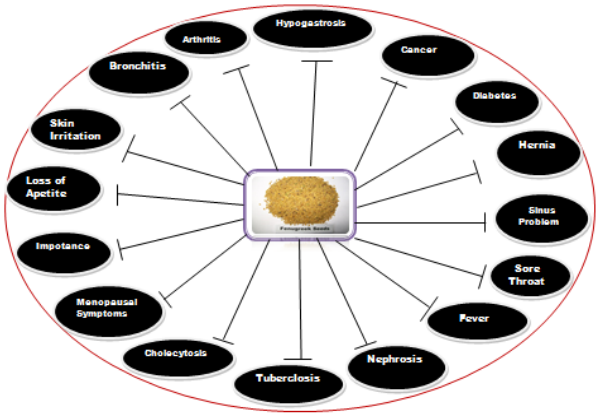

Figure 2 Multifarious therapeutic potential of fenugreek seeds

Figure 3 various forms of fenugreek

BIOACTIVE COMPOUNDS IN FENUGREEK

Among the plethora of bioactive compounds found in fenugreek, the major chemical constituents, Polyphenolic compounds, galactomannan (fiber), diosgenin (saponin) , quercetin (flavonoid), trigonelline (alkaloid) and 4-hydroxyisoleucine (unusual amino acid) have, by far superseded the rest due to their numerous health promoting activities especially their hypoglycaemic nature (Mehrafarin *et al*, 2010; Rizvi and Mishra, 2013, Nazni and dharmalingam, 2013).

POLYPHENOLIC COMPOUNDS

Till date more than 8000 polyphenolic compounds, including phenolic acids,flavonoids, stilbenes, lignans and polymeric lignans have been identified from whole plant foods.These compounds are actually secondary metabolites of the plants that act as a defense against ultraviolet radiation, oxidants and pathogens (Bahadoran *et al*, 2013). Phenolic compounds possess anti-oxidative attributes, which may prevent some forms of chronic diseases (Huang *et al*, 2010). Epidemiological studies have repeatedly shown an inverse association between the risk of chronic human diseases and the consumption of polyphenolic rich diets. It has been seen that polyphenol rich diets provide significant protection against the development and progression of cancer, diabetes, cardio-vascular problems and aging (Pandey and Rizvi, 2009). Many reports have shown that fenugreek is generally rich in polyphenols (>100 mg g-1)**)** and polyphenolic extract of fenugreek exhibit cytoprotective function during alcohol-induced liver damage under *in vitro* and *in vivo* conditions (Naidu *et al.*, 2011). Aqueous extract of *Trigonella* has also been investigated to offer a significant protection against ethanol toxicity in wistar rats by enhancement of the antioxidant potential and prevention of enzymatic leakage and the rise in lipid peroxidation (Lu *et al*, 2012).In addition to this, the protective action of fenugreek seed polyphenols has also been reported to exert gastroprotective effect on gastric ulcer **(**Helmy, 2011). As shown in figure 4, biogenetically, phenolic compounds arise from two primary metabolic pathways: the shikimic acid pathway where, mainly, phenylpropanoids are formed and the acetic acid pathway, in which the main products are the simple phenol (Maria de Lourdes Reis -Giada, 2013). The combination of the above mentioned pathways lead to the formation of flavonoids, the most plentiful group of phenolic compounds in nature.

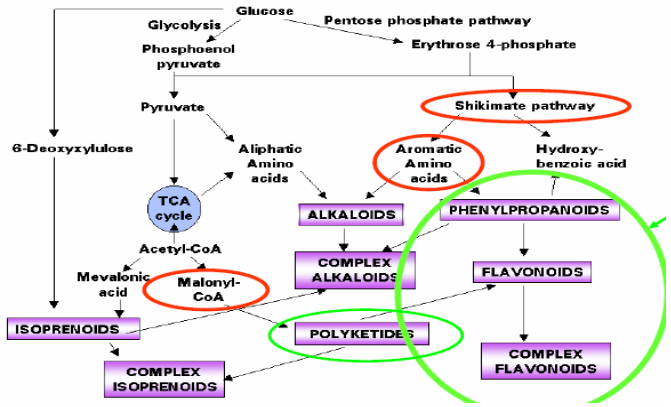

Figure 4-Biosynthesis of Phenols (Source: Lepiniec et al., 2006)

More than 5000 different flavonoids reported till date in addition to be involved in providing flavour and colour to fruits and vegetables, have been found to have biological activities, including inhibitory effects on enzymes, modulatory effect on some cell types, protection against allergies, antibacterial, antifungal, antiviral, anti-malarial, antioxidant, anti-inflammatory and anticarcinogenic properties (Tanwar and Modgil, 2012; Priya *et al*, 2011, Dharmalingam and Nazni, 2013). Recent reports indicate that fenugreek seeds contains five different types of flavonoids namely, vitexin, tricin, naringenin, quercetin, and tricin-7-O-β-D-glucopyranoside (Nanjundan *et al.*, 2009). Amoung them quercetin and kaempferol are flavonols; luteolin is a flavone; naringenin is a flavanone while vitexin occurs as a glycosylated flavone.Isoflavanoid phytoalexins are also reported to occur in fenugreek in the form of the pterocarpans, medicarpin and maackiaian (Quintans-Junior *et al*, 2014). A recent report by Patil and Jain (2014) show the common phenolic compounds isolated from fenugreek to be scopoletin, coumarin, chlorogenic, caffeic p-coumaric acids and quercetin**.**

Among these flavonoids present in fenugreek, quercetin being a strong antioxidant has been reported to possess anti-inflammatory, anti-oxidant, anti-tumor, immunomodulatory, anti-ulcer, anti-cancer, antioxidant, anti-diabetic, anti-angiogenic, anti-inflammatory activities and many other properties including the improvement of mental and physical performance (Stochmaova *et al*, 2013; Mahmoud *et al*, 2013; Phani *et al*, 2010). Recently, quercetin (Figure 5) has been reported to possess beneficial antidiabetic effects under *in vitro* as well as under *in vitro* conditions (Abdelmoaty *et al*, 2010). The antidiabetic

mechanism of quercetin has been reported to involve reduction of intestinal glucose absorption at the level of glucose transporters (GLUT), blockage of tyrosine kinase activity of β-subunit of insulin receptor, increase insulin secreation from pancreatic β-cells, inhibit11-β-hydroxysteriod dehydrogenase type 1 enzyme, increase glucokinase activity, prevention degeneration of β-cells, increase α-glucosidase inhibition, decrease insulin resistance, and increase adiponectin expression (Aguirre *et al*, 2011). Recent studies indicate that quercetin effectively ameriolates postprandial hyperglycemia in STZ-induced diabetic rats and these effects were mediated through α-glucosidase inhibition with an IC50 of 0.48-0.71 mM (Hussain *et al*, 2012; Jo *et al*, 2009). Further, it has also been reported to improve hyperglycemia, hypertriglyceridemia, and antioxidant status of STZ-induced diabetic rats (Jeong *et al*, 2012).

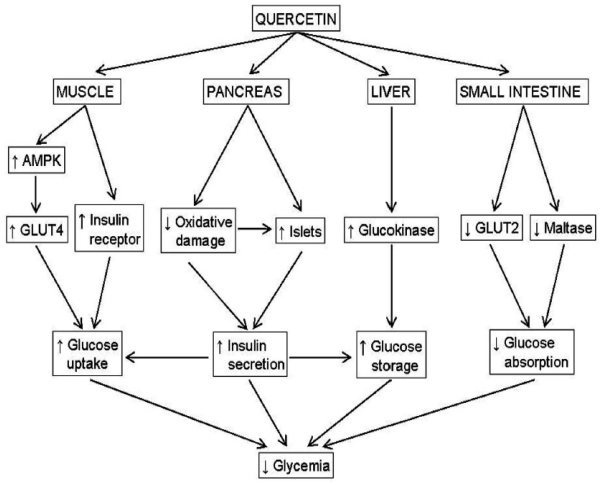

Figure 5 Antidiabetic effects of quercetin (Source: Aguirre *et al.*,2011.)

TRIGONILLINE (ALKALOID)

Fenugreek seed predominatly contains simple alkaloids consisting mainly of trigonelline (up to 0.13%), choline (0.05%), gentianine, and carpaine; much of the trigonelline is degraded during roasting to nicotinic acid and other pyridines and pyrroles, which probably account for much of the flavour of roasted fenugreek (Talobi *et al*,2013). As shown in Figure 6, Trigonelline a methylbetaine derivative of nicotinic acid is one of the major alkaloids found in fenugreek seeds. Trigonelline, or N-methylnicotinic acid, first isolated from *Trigonella foenum-graecum* is a secondary metabolite derived from pyridine nucleotides trigonilline and has now found in many plant species including pea, hemp, coffee, soybean and potatoes (Mehrafarin *et al*, 2010). Many legumes produce trigonelline as a secondary metabolite derived from NAD (nicotinamide dinucleotide (Xin-qiang Zheng1, 2005). Nicotinic acid formed from NAD via nicotinamide may be preferentially utilized for NAD formation, and the remainder may be reserved for future needs as a form of trigonelline. Trigonelline is synthesized by S-adenosyl-L-methionine (SAM) dependent nicotinate N-methyltransferase, which has been found in crude extracts of the pea (Sridevi and Giridhar, 2013). Trigonelline accumulated in seeds is converted to nicotinic acid during germination, and is used for the NAD synthesis. In this way, trigonelline acts as a reservoir of nicotinic acid in plants (Mehrafarin *et al*., 2010).

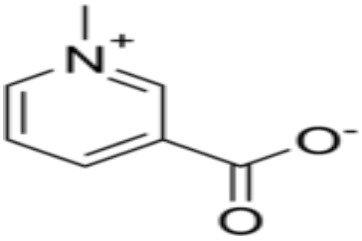

Figure 6 Structure of Trigonelline

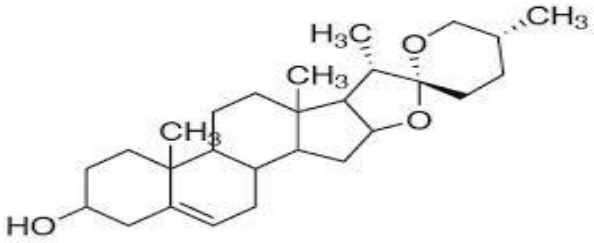

Figure 7 Chemical structure of diosgenin

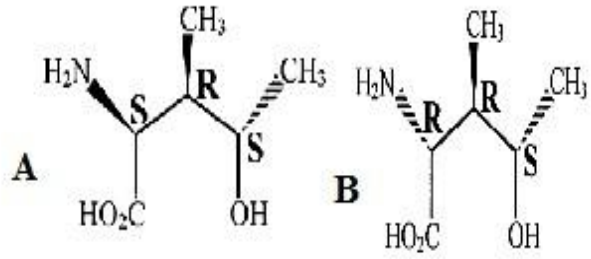

Figure 8 Isomers of 4-hydroxyisoleucine; major isomer (2S, 3R, 4S) (A) and minor isomer (2R, 3R. 4S) (B)

Various clinical and animal studies conducted using fenugreek have identified numerous potential health benefits for consumption of fenugreek, and have drawn much attention to fenugreek as a potential functional food and natural health product due to various bioactive agents. Trigonelline, isolated from fenugreek seeds have been shown to be useful in diabetes (Raheleh *et al*, 2010). It is a hormone found naturally in plant products, a vitamin B6 derivative and has been more thoroughly evaluated than fenugreek's other components, especially with regard to diabetes and central nervous system disease (Monago *et al*, 2010). It has been reported to exibit hypocholesterolemic, antitumor, antimigraine, antiseptic, hypoglycemic, neuroprotective, sedative, memory-improving, antibacterial, antiviral, and anti-tumor activities. Recently, trigonelline has been suggested to exert hypoglycemic effects in healthy patients without diabetes (Monago *et al*, 2010).

A recent study demonstrated that the administration of trigonelline to diabetic rats can make it a potentially strong candidate for industrial application as a pharmacological agent for the treatment of hyperglycemia,

hyperlipidemia, and liver-kidney dysfunctions (Hamden *et al*, 2013).The mechanism of action of this bioactive constituent includes decreased degeneration of pancreas β-cells , inhibition of intestinal α-amylase and maltase,inhibition of lipase activity, significant decrease in the serum aspartate transaminase (AST), alanine transaminase (ALT), gamma-glutamyl transpeptidase (GGT), and lactate dehydrogenase (LDH) activities andcreatinine, albumin, and urea rates (Hamden, *et al* 2013). However, further study of its pharmacological activities and exact mechanism is warranted, along with application of this knowledge to its clinical usage.

DIOSGENIN (SAPONIN)

Saponins, widely distributed in the plant kingdom, include a diverse group of compounds characterized by their structure containing a steroidal or triterpenoid aglycone and one or more sugar chains. Their structural diversity is reflected in their physicochemical and biological properties, which are exploited in a number of traditional and industrial applications (Arivalagan *et al.*, 2013). Fenugreek seeds contain 4.8% saponins in the form of diosgenin, yamogenin, tigogenin, neotigogenin, yuccagenin, lilagenin, gitogenin, neogitogenin, sarsapogenin and smilagenin. Amoung them diosgenin (Δ5, 25α-spirostan-3β -ol) represent the principal steroidal saponin (Mullaicharam *et al*., 2013). As shown in figure 7, structurally, diosgenin [(25R)-spirost-5-en-3b-ol] is a spirostanol saponin consisting of a hydrophilic sugar moiety linked to a hydrophobic steroid aglycone and is similar to cholesterol and other steroids. Since its discovery, diosgenin a major sapogenins found in fenugreek seed is the single main precursor used in the manufacture of synthetic steroids in the pharmaceutical industry (Raju and Rao, 2012). It occurs naturally as a glycosylated compound in fenugreek, and can be liberated by acid hydrolysis (which removes three carbohydrate residues) of the steroidal saponin, dioscin .It is synthesized as part of the melavonate pathway in the biosynthesis of steroids (C18-C30). Steroidal diosgenin is formed by modification of the side chain of cholesterol, in which a spiroketal structure is formed at C-22, yielding a non-polar compound with 6 carbon rings (Mehrafarin *et al*., 2010).

The diosgenyl saponins, that are steroidal glycosides and bear diosgenin as aglycone are often found as the major components in the traditional oriental medicines as an antihypercholesterolemic, antihypertriacylglycerolemic, anti-diabetic and antihyperglycemic agent (Manivannan *et al.*, 2013). Additionally, there is considerable commercial interest in growing fenugreek for its high sapogenin content.Saponins is reported to display hypocholesterolemic as well as antidiabetic activity (Wani *et al.*, 2012). These diosgenyl saponins that are steroidal glycosides and bear diosgenin as aglycone are often found as the major components in the traditional oriental medicines as an antihypercholesterolemia, antihypertriacylglycerolemia, anti-diabetes and antihyperglycemia agent (Manivannan *et al.*, 2013)**.** Depending upon biogeographic origins, genotypes and environmental factors, reported diosgenin contents in fenugreek seeds varies in between 0.1% and 0.9% (Snehlata and Payal, 2012). This naturally occurring steroidal saponin, present in fenugreek, has been shown to have favorable effects on glucose lowering, antioxidant activity, lipid metabolism and myocardial infarction (Al-Matubsi *et al.*, 2011).This compound has been found to mitigate diabetes induced oxidative stress and dyslipidemia in type 2 diabetic rats which is crucial in cardio-metabolic risks by modulating the PPARs (Sangeetha *et al.*, 2013). Recently, fenugreek has been reported to ameliorated diabetes in type 2 diabetic obese KK-Ay mice, by promoting adipocyte differentiation and inhibiting inflammation in adipose tissues, and effects were reported to be mediated by diosgenin (Uemura *et al.*, 2010). Thus, the best documented medical use of fenugreek seeds is to control blood sugar in both type 1 and type 2 diabetes. It is well known that diosgenin lowers plasma cholesterol by increasing faecal cholesterol excretion Therefore, the hypocholesterolemic effect of dietary diosgenin by increasing of faecal cholesterol excretion is primarily attributable to its impact on hepatic cholesterol metabolism rather than intestina cholesterol absorption (Al-Matsubi *et al.*, 2011). Diosgenin has also been found to exert anti-carcinogenic properties, such as inhibiting proliferation and inducing apoptosis in a variety of tumor cells .In a recent study, it has been reported to inhibit migration and invasion of PC-3 cells by reducing MMPs expression, inhibition of ERK, JNK and PI3K/Akt signalling pathways as well as NF-*κ*B activity, and thus suggests a new therapeutic potential for diosgenin in anti-metastatic therapy (Chen *et al.*, 2011). Recently, diosgenin from fenugreek has been reported to ameliorate diabetes in type 2 diabetic obese by promoting adipocyte differentiation and inhibiting inflammation in adipose tissues (Uemara *et al.*, 2010).

GALACTOMANNAN (POLYSACCHARIDE)

Galactomannan represents the major polysaccharide found in fenugreek seeds and accounts for approximately 17 – 50 % of the dry seed weight (Rathore, 2013). It is an integral component of the cell wall which is found concentrated around the seed coat. Galactomannan polysaccharides are structurally composed of a 1,4-β-D-mannosyl backbone substituted by a single galactose unit α-linked at the C-6 oxygen. It is simply mucilage with antidiabetic potetntial present in plants, and due to high viscosity and neutral ionic properties is finding wider applications in the food, pharmaceutical, cosmetics, paint and paper industries also (K.Nandhini 2010, 28-39).

Fenugreek galactomannans contain a galactose to mannose ratio of 1:1.This high degree of galactose substitution renders the molecule relatively more soluble compared to galactomannans from guar or locust bean, which has a galactose to mannose ratio of 1:2 and 1:4, respectively (Quintans-Junior *et al*, 2013; Dionisio and Grenha, 2012). Presence of galactomannan in fenugreek seed is recognized as the principal source of soluble dietary fibre (SDF) in the plant.The soluble nature of galactomannan fiber from fenugreek has been linked to numerous human health benefits, mainly in the reduction of plasma glucose levels and thus possess an antidiabetic effect (Arti Gupta, 2014). It is also known to be hepatoprotective and have the potential to reduce risk of cardiovascular disease, and to protect against some cancers

through the reduction of low-density lipoprotein (LDL), total cholesterol, and considerably decrease aspartate and alanine transaminases (AST and ALT) and lactate deshydrogenase (LDH) contents in the serum of diabetic rats (Hamden *et al.*, 2010). A study conducted by Hannan *et al* (2007) demonstrated that the soluble dietary fiber (SDF) portion of fenugreek can significantly improve glucose homeostasis in type 1 and type 2 diabetes by delaying carbohydrate digestion and absorption. They have also suggested that the SDF fraction may enhance insulin action in type 2 diabetes as indicated by the improvement of oral glucose tolerance in these test subjects.

4-HYDROXYISOLEUCINE (UNUSUAL AMINO ACID)

4-Hydroxyisoleucine is a branch amino acid and is uniquely found in the seeds of fenugreek (Sridevi *et al*;2014). A recent report by Hajimehdipoor *et al* (2010) determined the content of 4-hydroxyisoleucine to be 0.4% in Iranian fenugreek seeds. Earlier reports fronm India have shown its content to be 015% in fenugreek seeds (Narender *et al.*, 2006).The Research studies have confirmed the presence of 4-hydroxyisoleucine in fenugreek seeds in two diastroisomers: the major one being the 2S, 3R, 4S configuration, representing about 90% of the total content of 4-hydroxyisoleucine, and the minor one being the 2R, 3R, 4S. The major isomer is presently being viewed as a point of focus due to its ability to stimulate glucose-induced insulin secretion in micromolar concentrations (Sauvaire *et al;* 1998.). This natural non-proteinogenic amino acid possessing insulinotropic biological activity is reported to be responsible for antidiabetic activity of this plan (Jetté *et.al.*, 2009)

It increases glucose-induced release of insulin and is strictly dependent on the glucose concentration due to which it avoids undesirable side-effects such as hypoglycemia in the therapy of type II diabetes **(**Patil and Jain, 2014). Thus, this unusual amino acid of fenugreek seems to be promising dietary supplement in the treatment and prevention of chronic diseases

ANTIDIABETIC POTENTIAL OF FENUGREEK

As shown in Figure 9, the antidiabetic activity of fenugreek has been demonstrated in various *in vitro* experiments followed by confirmation under *in vivo* conditions using different animal models.

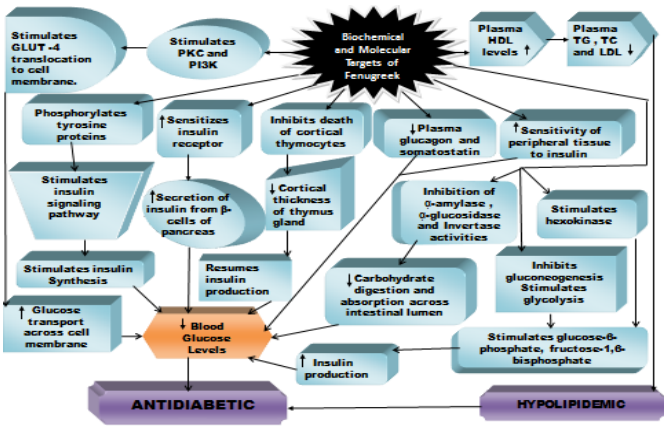

Figure 9 Antidiabetic and hypolipidemic mechanisms of fenugreek (*Trigonellafoenum-graecum)*

IN VITRO STUDIES

Numerous *in vitro* studies have examined and proved the hypoglycemic and andiabetic effects of both fenugreek seeds and leaves. A recent study of ethyl acetate and water extracts of *T. foenum-graecum* leaves demonstrated its hypoglycemic activity to be mediated through its dose dependent inhibitory activity on carbohydrate hydrolysing enzymes viz.,α-amylase and α-glucosidase (Ganeshpurkar *et al,* 2013). Similary, fenugreek seeds have been found to were able to inhibit α-amylase and sucrase activity in dose-dependent manner under *in vitro* conditions and this inhibition was reversed by increasing substrate concentration in a pattern which complies well with the effect of competitive inhibitor i.e. fenugreek (Gad *et al;* 2006)). Futher, Mukherjee and Sengupta (2013) reported that fenugreek seeds were also able to inhibit α-glucosidase (maltase and sucrase activity) under *in vitro*conditions with an IC50 (Mg/ml) of 112±8.0, 98±5.0 for maltase and 65±6.5 52±, 4.5 for sucrase in their aqueous and methanolic extracts, respectively. In another study**,** Randhir and Shetty (2007) investigated the enrichment of fenugreek (*Trigonella foenum graceum*) seed substrate with phenolic antioxidants and L-DOPA revealed a direct association between higher phenolic contents , and antioxidant activity that improved the *in vitro* porcine α-amylase inhibition activity by 75 %. The high α-amylase inhibitory activity also coincided with high L-DOPA content. Thus, these *in vitro* based studies have implications for diet-based management of diabetes and its associated complications.

ANIMAL STUDIES

Numerous reports have authenticated the beneficial hypoglycemic effects of fenugreek seeds in various animal model systems (Gad *et al;* 2006)**.** Animal studies have shown that fenugreek seed extracts have the potential to slow enzymatic digestion of carbohydrates, reduce gastrointestinal absorption of glucose, and thus reduce post-prandial glucose levels. In addition to this, fenugreek stimulate glucose uptake in peripheral tissues and had insulinotropic properties in isolated rat pancreatic cells (Neelakantan1 *et al;* 2014,). Several mechanisms found to explain this hypoglycemic action of fenugreek include modulation of insulin secreation, insulinomimictic effects and inhibition of intestinal glucosidase activity (Basch *et al.*, 2003; Mitra and Bhattacharya, 2006; Gad *et al.*, 2006; Neelakantan *et al.*, 2014; Marzouk *et al.*, 2013; Abd-El-Rahman, 2014). In diabetic rat, loaded with glucose, fenugreek has been shown to posses a dose-dependent hypoglycemic action via its potential to increase glucose transport rates as reflected by increased induction of glucose transporter GLUT-4 translocation, enhancing muscle, liver, and adipose cell glucose uptake (Hanan S El-Abhar, 2014). Fenugreek has also been associated with alterations in enzymes associated with carbohydrate metabolism. In diabetic rat models treated with fenugreek, key hepatic enzymes associated with glycolysis get increased, while hepatic enzymes associated with

gluconeogenesis are decreased (Boaz *et al.,* 2011; Ali *et al.,* 2013).

Fenugreek shows potential to ameliorate symptoms of diabetes during progressive deterioration and improved glycemic functions in neonatal streptozotocin-induced diabetic rats (n-STZ).In a recent study, Kulkarni *et al* (2012) demonstrated the antidiabetic activity of standardized extract of *Trigonella foenum-graecum* seeds in n-STZ model of diabetes mellitus (DM). It was observed that fenugreek extract (100 mg/kg, oral) treatment showed significant reversal of n-STZ-induced changes (rise in blood glucose, decline in body weight and rise in HBA1c) and increased number and size of pancreatic islet β-cells. In another study, Abdelateif *et al* (2012) demonstrated the antidiabetic and insulin mimtic effects of fenugreek seeds in rabbits. The supplementation with fenugreek resulted in a slight increase in body weight and profound decrease in cholesterol levels of diabetic rabbits.Likewise, fenugreek leaves are also reported to improve body weight, liver glycogen and show significant effect on key ezymes involved in carbohydrate metabolism and the results are quite comparable to that of standard antidiabetic drug, glibenclamide (Devi *et al*, 2003; Rathore *et al*, 2013).

HUMAN-STUDIES

Clinical trials of fenugreek for diabetes endpoints have been conducted in humans and found to exert hypoglycemic effects by stimulating glucose-dependent insulin secretion from pancreatic β-cells as well as by inhibiting the activities of α-amylase andsucrase (Boaz *et al*, 2011).In a recent meta-analysis of 10 clinical trials, the intake of hydro-alcoholic extracts of fenugreek seeds resulted in a significant reduction in fasting blood glucose, 2 hour glucose and HbA1c (Neelakantan *et al*, 2014). Bawadi *et al.,* (2009) and Nazni and Ravinder Singh, (2014) demonstrated that fenugreek seeds have a significant hypoglycemic activity in type 2 diabetic patients. Another study assessed the effect of fenugreek seeds at a dosage of 5 g/day in patients with type 1 diabetes for a period of 16 weeks. Some studies show significant reduction of postprandial blood glucose level in diabetic patients treated with fenugreek (5g/day) in comparison to standard drug control (Yaheya and Ismail, 2009). Losso *et al* (2009) demonstrated blood insulin area under the curve significantly reduced in type 2 diabetic patients, on consumption of fenugreek-containing bread. These findings suggest that fenugreek may represent an effective food-based means of reducing plasma insulin among individuals with type 2 diabetes. Fenugreek seed extract has also been shown to reduce spontaneous fat consumption, leading to a marginal reduction of total energy consumption in healthy male volunteers (Chevassus *et al*, 2009). Similarly, in healthy overweight individuals, fenugreek seed extract significantly reduced dietary fat intake and decreased the insulin/glucose ratio, (Chevassus *et al*, 2010). From clinical trials, beneficial effects of fenugreek seeds on glycemic control in diabetic persons are clear (Kassaian *et al;* 2009).

CONCLUSION

The incidence of type 2 diabetes is increasing dramatically worldwide, resulting in large measure from the increasing prevalence of obesity. These patients already manifest abnormalities of glucose handling and could benefit from a low-risk; inexpensive, food-based intervention aimed at normalizing their metabolic milieu.Fenugreek is a dietary supplement that may hold promise in this regard. The herb have an enormous potential to prevent or cure diabetes more than other plant species especially due to the presence of unique chemical constituents including quercetin, diosgenin, trignolline, galactomanin and unusual amino acid 4 hydroxy isolucine. However, trials with higher methodology quality using a well characterized fenugreek preparation of sufficient dose are needed to provide more conclusive evidence for its preventive and curative properties.

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