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Pharmacological aspects & medicinal uses of *Trigonella foenum-graecum*: A Current Review

Review Article

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Abstract

Globally a large number of people are affected by acute and chronic diseases resulting in high morbidity and mortality rate. A huge amount of pharmaceutical drugs are being manufactured on a daily basis to combat these diseases. But due to their high cost and deleterious effects, it becomes critically important to state emphasis on finding an alternative way to manage these long term conditions. Medicinal herbs could provide a good source of dietary supplement combined with existing therapies. Many scientific studies have demonstrated that medicinal plants and herbs have the potential for the treatment of many serious infections and many disorders. Out of these herbs, Fenugreek is recognized as an oldest herb with great medicinal potential. Fenugreek harbors many essential macronutrients and micronutrients along with trace elements. Numerous chemical constituents present in fenugreek highlights a variety of pharmacological activity such as anti-glycemic activity, anti-oxidant capacity, anti-inflammatory effects, hypocholesterolemic activity and many more. This article explores the diverse active compounds and potential pharmacological applications of *Trigonella foenum-graecum* also known as fenugreek. It also focuses on the medicinal significance and health impact of taking fenugreek in our day to day nutrition.

Key Words: *Fenugreek, Trigonella foenum-graecum, Pharmacological activity, Phytoconstituents, Medicinal uses*.

Introduction

India is a land full of diverse flora and fauna collectively referred to as *Biota*. India has a huge diversity of flora owing to its vast range of topology, climatic conditions as well as habitat. Flora has been regarded as a source of medicine since ages. Around *8,000 species* in India have medicinal value. Out of these, Fenugreek is of great importance. Fenugreek is an annual aromatic plant grown throughout the Indian subcontinent (1) (2). The seeds and leaves of Fenugreek has anti-oxidant properties. Fenugreek is native to southern Europe and the Mediterranean region and India is regarded as largest exporter of Fenugreek throughout the world. In India, Rajasthan produces around 80% fenugreek of the country. Fenugreek is also globally known to be cultivated in specific parts of North Africa, Pakistan, Iran, Afghanistan, Russia, Australia, the USA, Argentina, Canada, Spain, Turkey, Nepal, Morocco and Lebanon (3) (4). It has been grown for centuries across the Indian subcontinent. The plant has its traditional roots in Ayurvedic medicines. The Binomial name of Fenugreek is *Trigonella foenum-graecum* belongining to family Fabaceae and subfamily Papilionaceae. The genus *Trigonella* is derived from Greek word meaning 'three angled' and the Latin word foenum-graecum meaning 'Greek hay'. Taxonomical classification is presented in table-1.

Traditionally, Fenugreek seeds have diverse uses such as antibacterial, anti-inflammatory, galactogauge, rejuvenating effects (5). Fenugreek is traditionally used for diabetes, painful menstruation, polycystic ovary syndrome and obesity. Various parts of fenugreek such as stem, leaves and seeds contain active constituents that are of great medicinal importance. Fenugreek seeds are aromatic seeds used as seasoning especially in curry. Many modern researches have established the role of fenugreek seeds and leaves in the treatment of several diseases comprising reduction of blood cholesterol and sugar levels in both clincal and non-clinical trials (6). In India, Fenugreek is popularly known as Methi. Many species of Fenugreek like *T. balansae, T. carniculata, T. spicata, T. occulta, T. polycerata, T. calliceras*, etc are all of great importance and cultivated globally (7,8).

As Thomas Edison quoted "*The doctor of the future will no longer treat the human frame with drugs, but rather will cure and prevent disease with nutrition*"; Fenugreek has been used worldwide as a part of our day to day life with respect to healthy nutrition.

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Table 1: Taxonomic hierarchy of Fenugreek

Kingdom	Plantae
Division	Eudicots
Class	Rosids
Order	Fabales
Family	Fabaceae
Sub-family	Papilionaceae
Genus	Trigonella
Species	T. foenum-graecum

Relevance of Phytochemicals present in Fenugreek

Fenugreek is a major source of diverse active chemical constituents such as Flavonoids, Alkaloids (0.36%), Saponins along with steroidal saponins (0.1 – 2.2%) , Unsaturated fatty acids (6-10%), fiber (20% insoluble fiber & 30% soluble fiber) (9), amino acids, vitamins (A, B1, C), mucilage (28%), lipids, proteins (22-25%), and minerals (10). It also contains carbohydrates (45-60%), calcium and iron. On hydrolysis, glycosides content yields steroidal sapogenins like diosgenin, neotigogenin, tigogenin, and yamogenin. Due to the presence of iron content, Fenugreek is considered good for iron-deficient patients (11). The seeds and leaves of Fenugreek also has an established role in reducing the cholesterol and blood glucose levels. Fenugreek seeds contain large amount of polyphenols, as suggested by many studies (12), which are naturally occurring phytoconstituents in plant kingdom that possess strong anti-oxidant properties. Also fenugreek seeds polyphenols prevented oxidative hydrolysis and lipid peroxidation caused by H2O2 in vitro in human erthrocytes (13).The major phytoconstituents of fenugreek are presented in table-2.

Table 2: Phytochemical present in fenugreek

Phytochemicals	**Chemical constituents**
Alkaloids	Trigonelline, Choline, Gentianine, Carpaine, Trimethylamine, Neurin
Saponins	Graecunins, fenugrin B, fenugreekine (14) , Yamogenin, diosgenin, sarsasapogenin, neotigogenin, protodioscin
Flavonoids	Quercetin, rutin, vitexin, isovitexin
Amino acids	Isoleucine, 4-Hydroxyisoleucine, aspartic acid, leucine, arginine, proline, glutamic acid, lysine
Fibres	Neutral detergent fiber, gum
Lipids	Monoacylglycerols, diacylglycerols, triacylglycerols, free fatty acids
Coumarins	Scopoletin, cinnamic acid (15)
Others	Vitamin A, folic acid, minerals, mucilage, nicotonic acid, proteins, lenoleic acid

Fenugreek contains different proportion of active constituents in parts such as leaves and seeds. The leaves contain a variety of compounds including seven saponins (graecunins). Leaves also contain 86.1% moisture, fats, proteins and carbohydrates along with minerals and vitamins such as zinc, calcium, riboflavin, carotene, niacin, iron, phosphorous, vitamin C, etc (16). The fresh leaves of fenugreek contain ascorbic acid and b-caroten in definite proportions (17). The seeds of fenugreek contain compounds like alkaloids (trigonelline, gentianine) flavonoids, saponins (diosgenin), proteins and even small amount of fixed oils and volatile oils (18). Polyphenolic compounds constituted major active components of the fenugreek seeds. Endosperm part contains the highest content of saponin and protein. Diverse active constituents along with various pharmacological activities of fenugreek are highlighted in the table-3.

Table 3: Importance of various chemical constituents of fenugreek

Active constituents	**Pharmacological activity**
Trigonelline	Hypoglycemic, decrease diabetic auditory neuropathy
Gentianine	Anti-inflammatory, anti-diabetic activity
Carpaine	Exhibit cardiovascular effect
4-Hydroxyisoleucine	Reduces insulin resistance and body weight
Graecunins	Anti-lipidemic activity
Yamogenin	Alters lipid accumulation
Diosgenin	Hypolipidemic, hypoglycaemic, antioxidant capacity
Sarsasapogenin	Anti-tumor activity
Protodioscin	Antiproliferative activity
Flavonoids (such as quercetin & rutin)	Antioxidant capacity to combat free radicals
Soluble fibres	Controls blood sugar, lowers inflammation
Sotolone	Volatile constituent that adds flavour
Folic acid	Treats anemia

Pharmacological activity of Fenugreek

Due to the presence of various phytoconstituents in different parts, fenugreek exhibit many pharmacological activities which are summarized in the table -4.

Table 4: Different pharmacological activities of fenugreek

S.No.	Pharmacological activity	Parts of fenugreek used	References
1	Anti-diabetic activity	Seeds	Sharma et al., 1990, Morani et al., 2012, Xue et al., 2007, Gupta et al., 2001
2	Anti-oxidant activity	Leaves and seeds	Kaviarasan et al., 2007, Annida et al., 2008, Xue et al., 2011, Tripathi and Chandra 2009
3	Anti-carcinogenic activity	Leaves and seeds	Hibasami et al., 2003, Sebastian and Thompan 2007, Prabhu and Krishnamoorthy 2010, Monalic et al., 2001
4	Anti-inflammatory activity	Seeds and leaves	Kawabata et al., 2011, Sumanth et al., 2006, Vyas et al., 2009
5	Anti-lipidemic activity	Leaves and seeds	Bordia et al., 1997, Abdel-Barry et al., 2000, Sowmya and Rajyalakshmi 1999
6	Antimicrobial activity	Seeds	Omolosa and Vagi 2001, Randhir et al., 2004, Olli and Kirti 2006, Zia et al., 2001
7	Gastroprotective effect	Leaves and seeds	Pandian et al 2002, Al-dalain et al., 2008, Helmy et al., 2011
8	Hepatoprotective effect	Leaves and seeds	Kaviarasan et al., 2006, Raju and Bird 2006, Meera et al., 2009
9	Anti-cataract activity	Seeds	Gupta SK et al., 2009
10	Effect of Fenugreek on weight of the body	Seeds	Chevassus et al., 2010, Kumar et al., 2014
11	Anti-asthamatic activity	Seeds	Schroeter et al., 2002

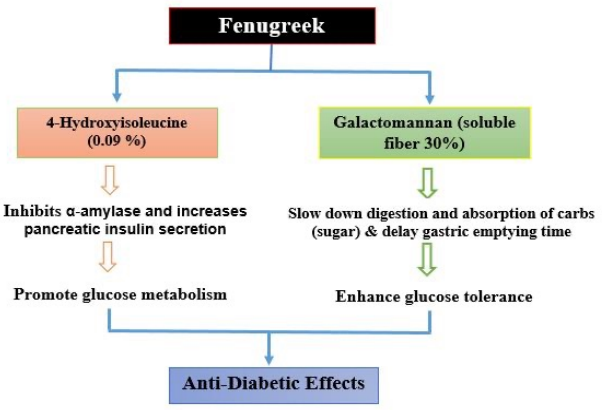
Anti-diabetic activity

Diabetes mellitus is a clinical condition disorder that is characterized by persistent rise in blood glucose levels (hyperglycemia). In diabetes, the beta cells of pancreas do not produce sufficient amount of insulin or the body cells are not able to respond to the produced insulin because of insulin resistance. The problem related to diabetes has become a global burden. Polydipsia, Polyuria and Polyphagia are considered hallmarks of diabetes mellitus. Diabetes Mellitus was initially outlined in the Egyptian manuscript 3000 years back (19). Osteoporosis has a strong relevance with diabetes mellitus. During diabetes, there is an abnormal metabolism of carbohydrates leading to increased levels of glucose in the blood.

The use of fenugreek seeds, leaves and extracts has been well established. In many countries such as Saudi Arabia (20), Fenugreek herb was used most commonly to treat diabetes. Various animal and human studies observed the hypoglycemic effects of fenugreek extracts (21) (22). One such study was performed by Sharma et al., on 10 patients having type 1 diabetes. The subjects were given food containing fenugreek seeds powder (100 g) during lunch and dinner wthin a period of 10 days. At the end of the study there was a great improvement noted in the patients with fenugreek meals including reduction in urine glucose level and reduction of serum glucose levels in fasting conditions (23).

A study conducted by Morani et al., showed ameliorative effects of fenugreek extracts in peripheral neuropathy of rats. IND01 was the fenugreek derived fraction as named by the authors that was standardized and purified by HPLC (high performance liquid chromatography) method. The dose was administered in rats daily over a period of time (particularly 15 days). The motor nerve conduction velocity was restored in rats with sciatic nerve crush injury SNCI. The end results concluded fenugreek extract has neuroprotective activity in painful peripheral neuropathy that is very common in diabetes (24). Another research study by Xue et al., documented the effects of aqueous seed extract of Fenugreek in rats that have STZ-induced diabetes. It was seen that fenugreek treated mice has gained weight as compared to only STZ treated mice. Also there was a great reduction in the blood glucose levels in group that received fenugreek extract as compared to the other one (25). Due to the presence of amino acid (***4-hydroxyisoleucine***), fenugreek exhibits insulinotropic effect considerably (26). In another clinical study conducted by Gupta et al., on twenty five newly diagnosed type 2 diabetes patients, group I (where n = 12) received hydroalcoholic extract of fenugreek seeds while group II (where n = 13) received normal care (diet and exercise) along with placebo capsule for a period of two months. It was noted that there was hardly any difference between two groups in terms of values of mean glucose tolerance test except enhancement in insulin sensitivity. It was inferred that adding fenugreek seeds in the diet enhanced blood glucose control as well as reduced insulin resistance in subjects with mild level of type 2 diabetes .(27)

Figure 1: Principle effect of 4-Hydroxyisoleucine and Galactomannan present in fenugreek



Anti-oxidant activity

Free radicals are generated during catabolism and metabolism in the human body. Free radicals contain one or more unpaired electrons in outermost shell that makes it extremely unstable or highly reactive. Due to this, they take electrons from other compounds in order to become stable. This makes the attacked molecule to become free radical that finally destroys the living cells (28). The ROS and RNS contribute to cellular damage of the molecules. Free radicals are responsible for fatal diseases like diabetes, cancer, Alzheimer's, etc and may result in tissue damage, inflammation and diseases. To tackle these harmful free radicals, the human body produces naturally occurring products termed as antioxidants. These naturally occurring antioxidants counteract the surplus of free radicals to shield cells and tissues against their deleterious effects. Examples of antioxidants include catalase (CAT), superoxide dismutase (SOD), vitamin A, E and C as well as glutathione reductase (GR) (29) (30).

The phenolic conpounds present in the fenugreek seeds are mainly responsible for anti-oxidant activity (31) (32).Various pharmacological experiments have been conducted by researchers to elucidate the anti-oxidant effect of Fenugreek. Kaviarasan et al., demonstrated the anti-oxidant activity of fenugreek seeds on rat liver and concluded that methanolic extract of fenugreek seeds was able to scavenge the free radicals (33). In another study it is indicated that phenolic compound showed the protective effect of fenugreek seeds. Ethanol was given to induce toxicity in rat liver. The rat liver was treated with the fenugreek seed polyphenol extract (200 mg/Kg/day). This caused a notable reduction in protein carbonyl content and lipid peroxidation levels. The activities of antioxidant enzymes were increased and thiol groups were restored (34). Annida et al., demonstrated that in STZ induced diabetic rats, oxidative stress was notably reduced due to supplementations of fenugreek leaves. It was also concluded that admiration of Fenugreek leaf powder to diabetic rats lowered lipid peroxidation at the same time elevated the antioxidant system (35).

Xue et al., observed the antioxidant potential of aqueous extract of Fenugreek seeds in reinstating kidney function of diabetic rats. When the diabetic rats were treated with Fenugreek extract, there was an elevation in the activities of SOD and catalase and reduction in the concentration of malondialdehyde (MDA) in serum and diabetic rats kidney. Also, noted was a decrease in the levels of 8-hydroxy-2'-deoxyguanosine in urine (an indicator of increased oxidative stress). These investigations elucidated the protective action of Fenugreek extract by remarkably increasing the antioxidant enzyme activities in kidney of diabetic rats (36). Tripathi and Chandra conducted a similar study that concluded Fenugreek significantly improved Thiobarbituric acid reactive substances (TBARS) levels and antioxidant enzyme activities in various tissues such as kidney, liver or heart enunciating antioxidant effect of fenugreek in diabetes induced oxidative stress (37).

Anti-carcinogenic activity / Chemopreventive Activity

Cancer is an uncontrolled growth of cells resulting in the formation of tumors in body. Cancer is not a single disease but a group of many distinctive lethal diseases with high mortality rate. Many in vitro and in vivo studies were conducted to highlight the anti-carcinogenic potential of Fenugreek seeds in experimental animals. Phytoestrogens and saponins are the chief phytoconstituents of fenugreek responsible for anti-carcinogenic activity (38). Constituents like Diosgenin, Protodioscin and trigonellene (alkaloids) have been revealed to have anti-cancer activity.

In a study by Hibasami et al., protodioscin (a furostanol saponin derived from fenugreek) exhibited death in leukemic cell line (HL-60) in account for apoptotic alterations (39). Sebastian and Thompan, in an investigation, demonstrated that ethanolic extract of Fenugreek decreased cell viability (functioning) and cause apoptotic changes like decrease in mitochondrial membrane potential as well as inversion of phosphatidylserine. Also it is observed that DNA were degraded into multiple fragments. Further, cell cycle was observed to be arrested at G2/M phase and showed a sub-G1 apoptotic population in cells treated with Fenugreek extract suggesting apoptosis induced by Fenugreek repressing anticancer potential (40). Prabhu and Krishnamoorthy, in one of the investigation, injected Swiss albino mice with EAC to illustrate anticancer activity of Trigonella leaf ethanolic extract. The mice showed enhanced lifespan when compared with tumor control indicating anticancer potential of fenugreek extract in animal models (41). Monalic et al., demonstrated the repressing effect of diosgenin on human osteosarcoma cell line (1547 cell line). This was attributed due to the halt of cell cycle at G1 and initiation of apoptosis process (42).

Anti-inflammatory activity

Inflammation is defensive mechanism of our body. There are five hallmark cardinal signs of inflammation such as calor (heat), tumor (swelling), rubor (redness), dolar (pain) and functio laesa (loss of function). Fenugreek seeds contain alkaloids (43), saponins and flavonoids (44) that play a pivotal role as an anti-inflammatory agent.

Many experiments have been conducted to elucidate the anti-inflammatory potential of fenugreek seeds. Kawabata et al., studied anti-inflammatory potential of fenugreek seeds in human monocytic cell line (THP-1). 12-o-tetradecanoylphorbol-13-acetate was used to induce inflammatory cytokines such as IL-1, IL-6 and TNF-a. The methanolic extract of Fenugreek caused repression in production of TNF-a. This extract was further examined for isolation and segregation of functionalized compounds like saponins and related compounds that caused inhibition of other cytokines like IL-1 and IL-6 as well as TNF-a (45). Sumanth et al., reported anti-inflammatory potential of Trigonella against ulcer production.To induce ulcers in rats, Indomethacin and immersion stress was used. Anti-ulcer effect was exhibited by aqueous extract of

fenugreek determined by the ulcer index (46). The protective effect of the extract against ulcer was allocated to the anti-oxidants present in them. The leaves also exhibit antipyretic and anti-inflammatory activity (47). Vyas et al., reported the analgesic and anti-inflammatory activity of purified fraction of fenugreek seed extract. The pain was induced both by acetic acid and hot plate in a mouse model. When the experimental data was compared with control group, the group treated with fenugreek extract showed notable dose dependent analgesic activity (48).

Anti-lipidemic activity / Hypocholesterolemic activity

Cholesterol is a type of lipid molecule that mainly constitutes the animal cell membranes. Atherosclerosis is a serious condition resulting from cholesterol plaques in the walls of the arteries. This causes arteries to become narrow resulting in reduced blood flow through arteries and causing serious cardiovascular diseases. Oxidative alteration of low density lipoprotein (LDL) is considered a critical incident in the pathogenesis of atherosclerosis (49). The prevalence of high levels of cholesterol in blood plasma increase risk for atherosclerotic heart disease. It is very important to manage cholesterol levels to prevent cardiovascular diseases by hampering the increasing atherosclerosis in hyperlipidemic individuals. It is assumed that if lipid levels (triglycerides and LDL-cholesterol) are managed, it results in preventing chronic inflammatory diseases.

There is enough data to suggest that fenugreek decreases serum cholesterol. Various pharmacological experiments have been performed on animal models. The animal experimentation is not just restricted to rats and mice but is also performed on different species of rabbits and dogs as well. Bordia et al., conducted a study involving coronary artery disease (CAD) either with or without type - 2 diabetes. Fenugreek was given twice a day for around three months at a dose 2.5 g to both the individuals (groups). While healthy individuals revealed no specific effect on lipid profile, the CAD patients remarkably had decrease in blood lipids, total cholesterol and triglycerides with no estimated effect on HDL-cholesterol (50). Abdel-Barry et al., conducted a study on 20 healthy male volunteers. A single dose of aqueous extract of fenugreek leaves (40 mg/kg) was given. A dilute coffee extract was used as placebo. There was a reduction of 9.2 % in total serum cholesterol as compared to reduction of 2.8 % of placebo group (51). Sowmya and Rajyalakshmi conducted a study on 20 adults having hypercholesterolemia. These adults received a dose of 12.5 - 18.0 gm of powdered fenugreek seeds for a duration of one month. It was seen that there was a significant decrement in both total cholesterol and low density lipoprotein cholesterol (LDL-C) (52). A compound termed GII isolated from fenugreek seed extract with water was found to show changes in serum lipid levels in diabetes induced rabbits. The compound showed incredible effect by reducing total cholesterol (triacylglycerols, phospholipids and free fatty acids) while increasing HDL cholesterol (53). It is also indicated that diosgenin (a steroidal saponin present in fenugreek) reduces hypercholesterolemia in monkeys. Diosgenin has a wonderful effect on cholesterol metabolism leading to lower cholesterol concentration in plasma. In general, the plant protein content present in fenugreek is 26 % that has cholesterol lowering capacity (54). The hypocholesterolemic activity of fenugreek may be accounted to its estrogenic constituent (55), saponins (diosgenin) and fiber. The proposed mechanism through which saponins act is by enhancing biliary cholesterol excretion resulting in lower cholesterol serum levels (56) (57).

Antimicrobial activity

Micro-organism include bacteria, viruses, fungi, algae and protozoa. These tiny organisms are present all over the world and even within our human body. Herbs have been used globally for their antimicrobial activity. Plant systems like *Curcuma longa*, *Citrus lemon* and many more are studied by researchers that showed intense microbial activities. The antibacterial activity of various plant extracts may be partially attributed to different phytoconstituents present in fenugreek such as phenolic compounds, alkaloids, flavonoids, tannins, steroids, saponins, etc.

Various studies have highlighted the anti-bacterial as well as antifungal activities of fenugreek seeds. Many studies were conducted that showed various parts of fenugreek plant like leaves, roots and stem exhibited antifungal potential against fungal strains such as *Rhizoctonia solani, Fusarium graminearum*, *Botrytis cinerea* and *Alternaria* sp, (58). In a study documented by Omolosa and Vagi, Fenugreek has shown intense microbial activity against 26 bacterial pathogens (59). Fenugreek has also shown high antimicrobial activity against Helicobacter pylori as documented by Randhir et al., Fenugreek sprout extract was used that contains free phenolic content showing more antimicrobial activity (60). In a study by Olli and Kirti, small cycsteine rich peptides named Tfgd1 was successfully cloned having antifungal effect. The expressed protein recombinant in E.coli showed great antifungal activity against wide range of fungi like *Phaeoiusariopsis personata* and *R. solani* (61). Zia et al demonstrated nematicidal effect of Fenugreek methanol fraction extract on *Meloidogyne javanica* larvae accounting for death of the larvae (62). Antimycotic activity of fatty oil of fenugreek against *Aspergillus fumigates* and *Aspergillus niger* was also reported (63).

Gastroprotective effect

Gastric ulcers occur when there is damage to the inner lining of the stomach or small intestine. A bacterium like H. pylori present in digestive tract is a common cause of gastric ulcer. Fenugreek was traditionally used in the management of gastric ulcer. The fenugreek seed oil extract exhibit pharmacological activities that have been studied by the scientists globally. In one such research, it is indicated that fenugreek exhibits ulcer protective activity against ethanol induced gastric ulcer in rats. The activity of

fenugreek was compared with that of omeprazole. Aqueous extract of fenugreek showed great ulcer protectiveness when compared to omeprazole. The erosion of mucosal layer caused by ethanol due to the lipid peroxidation is prevented by fenugreek seeds. This is due to increasing antioxidant capacity of gastric mucosa resulting in minimal injury to mucosal layer (64). In another study performed on Albino rats, aspirin (400 mg/kg) was given to induce ulcer. Then aqueous extracts of Trigonella foenum graecum L (fenugreek) and Hordeum vulgare L (barley grains) was given to the same group. The end result showed that rats treated with aqueous extract showed great decrease in ulcer severity which is calculated by curative ratio and ulcer index and confirmed histopathologically (65). In a similar study performed on rats, Aspegic was given to induce gastric mucosal ulcer. Fenugreek was administred that showed great anti-ulcer potential in rats (66). This action may be due to the presence of flavonoids content in fenugreek that prevents necrotic agents to form ulcerative lesions (67) (68). Chemical constituents like trigonelline, phytic acid and saponins are responsible for lessening gastric ulcer (69).

Hepatoprotective effect

Hepatotoxicity or toxic hepatitis refers to damage to the liver that may be attributed to many factors including drug-induced injury. Damage to liver may affect people of all ages. Alcohol addiction and long term alcoholism is the leading cause linked with liver diseases and fibrosis (70) (71). Many medicines and drugs could also contribute to hepatic damage. That is why it becomes very essential to have a proper knowledge of herbs and extract many properties including hepatoprotective activity of plant based medicines (72). Kaviarasan et al., conducted a study in human Chang liver cells. The cells were exposed to ethanol. This induced cytotoxicity, mitochondrial dysfunction, concentration of GSSG (oxidized glutathione) and reduced growth of Chang liver cells. There was also decrease in GSH level when compared to normal cells. Polyphenolic content present in the extract of fenugreek was used along with ethanol. Cells were incubated with this aqueous extract that resulted in increased cell viability. It also decreased TBARS formation, lactate dehydrogenase leakage and GSH/ GSSH ratio was normalized. Silymarin (a hepatoprotective substance) and effects of FPEt are comparable (73). Raju and Bird performed a study on Ob rats. The rats were given fenugreek diet. The end result showed reduction in triglyceride and soluble or bound forms of TNF-a when compared to control group. This highlights that there was a decrease in triglyceride accumulation in liver after fenugreek administration (74). Meera et al., in a study demonstrated on goat model demonstrated the hepatoprotective effect and antilipid peroxidation effect of ethanol fenugreek extract. H2O2 and CCl4 was used to induce liver damage in goat model. Hepatoprotective effect was observed as there was seen reduced levels of enzymatic as well as non-enzymatic antioxidant enzymes (75).

Anti-cataract activity

Cataract is a serious medical issue that affects the vision of the eye resulting in cloudy lens. Cataract decreases the normal vision of a person. It can result from either aging or trauma. Around 90 % of the people by the age of sixty five are affected by this condition. Factors such as obesity, smoking, steroids, high B.P., nitric oxide, etc could account for the growth of cataract (76). Various experimental studies were performed to highlight the anti-cataract effect of Fenugreek seeds. One such study was performed in selenite induced cataract. In an organ culture that has Dulbecco's modified Eagles medium (DMEM) and 100 uM selenite as standard and control group, rat enucleated lenses were kept. In case of the test group, selenite and Fenugreek aqueous extract was served in medium and lens was incubated at a temperature of 37oC for 24 hour. Then reduced glutathione (GSH), anti-oxidant enzyme and lipid peroxidation product (malondialdehyde) was estimated. A rise in malondialdehyde and reduction in GSH in control when compared to standard lenses was observed. Fenugreek extract greatly reinstated glutathione and reduced the malondialdehyde levels. In Fenugreek supplemented group, effects of various antioxidant enzymes like superoxide dismutase, glutathione peroxide and catalase were restored. The anti-cataract effect was attributed to antioxidant activity of aqueous Fenugreek extract. It was also observed that GSH levels were decreased in selenite presence as well as anti-oxidant enzymes were also reduced (77).

Effect of Fenugreek on weight of the body

Obesity is a common problem worldwide. With increasing population there is increasing demand of food all over the world. This increasing demand of food comes under two categories, i.e., healthy nutrition and unhealthy nutrition. Too much craving of unhealthy food and nutrition could result in increased body weight and obesity. According to WHO, the individuals having Body Mass Index (BMI) equal to or greater than 25 is considered to be obese. Many studies concluded that extract of Fenugreek as supplement reduced the body weight and adipose tissue weight (78) (79). One such randomized placebo controlled trial study was conducted for 6 weeks on 39 overweight healthy male subjects given a fixed dose of extract of fenugreek seeds. It was noted that frequent administration of the extract resulted in reduced dietary fat consumption in the given subjects (80). The possible mechanism through which fenugreek acts is twofold. Firstly, fenugreek expels the carbohydrate contents from the body just before it can enter the blood stream causing loss of weight, furthermore fenugreek has a significant amount of soluble fiber (around 40%) that basically slows down the digestion and absorption of carbohydrates from the intestine thus indirectly suppressing hunger and encouraging weight loss (81). The amino acid named 4-hydroxyisoleucine (0.015 % - 0.4 %) present in fenugreek reduces plasma triglyceride gain resulting in weight loss and prevention of obesity (82). In one of the experiments, it was observed that

aqueous extract of fenugreek given to rats on high fat diet showed decrease in body weight and also in body mass index. Also a sudden reduction in biochemical parameters including serum lipid profile and cardiac elements were noted. The level of leptin was also reduced in adipose tissue by fenugreek (83).

Effect in treatment of Asthma

Asthma is a respiratory disorder that affects the bronchi of lungs resulting in spasm and causing difficulty in inhalation and exhalation process. Asthma causes inflammation of the bronchial tubes resulting in narrowing of the pathway. Many studies were performed to check the extent to which fenugreek extract helps provided as supplement. In various studies, the present of flavonoids content in fenugreek can limit the lipid peroxidation as well as protect the respiratory tract from unnecessary oxidative stress (84). The mechanism of action against asthma is very little known but flavonoids in fenugreek up to certain extent can limit the stimulation of basophile cells and mast cells (85). Fenugreek's antioxidant capacity as well as the occurrence of flavonoids (quercetin) can prevent the emergence of crystals of Charcot-Leyden which are the characteristics in asthmatic patients. Fenugreek also has the capacity to reduce the stress caused by oxidative mediators (86). It has also been well established that fenugreek seeds have diverse effect as an anti-inflammatory agent (87). Fenugreek seeds have high content of mucilage around 28 % due to the presence of which there is comfort in the secretions of lungs. This could also account for mechanism of action. In one experimental study where one group was given fenugreek and other group was given honey as intervention, it was found that the efficacy of fenugreek was much high. Even clinical studies were conducted to demonstrate the effect of fenugreek seeds on asthma (88). It is very clear that fenugreek is highly effective in treatment of mild asthma without producing any side effects. Also fenugreek helps to improve the functions of respiratory tract as well as lungs.

Medicinal uses

Fenugreek is considered a multipurpose crop. From maintaining the blood glucose level to having anti-bacterial and anti-fungal effects, fenugreek is critically important for keeping a healthy digestive system. Fenugreek had diverse ethno-historical uses. Traditionally, fenugreek was used as a potent aphrodisiac to increase sexual desire and performance. Fenugreek was also used by Egyptian women to lessen menstrual pain and stomach problems (89). Fenugreek seeds were considered as a hypoglycemic agent in Egyptian folk medicine. In Chinese medicine system, fenugreek was used as a tonic and to treat leg frailty and edema (90). Fenugreek was recognized as a main component for treating dysmenorrheal and postmenopausal symptoms. In folk medicines, fenugreek was used for the treatment of tuberculosis and boils. The seeds of fenugreek were also used as a herbal remedy for constipation and diarrhea (91) (92). The alcoholic extract of fenugreek was used to expel unwanted harmful material or poisons from the human body (93).

Presently, fenugreek is used for diverse purposes across the globe such as for preparing flavor cleanse in Switzerland, spice in Iran, as vegetables in India and Pakistan and seed powder along with flour for making flat bread in Egypt (94). Fenugreek have well established role in treating various animal and human disorders (95). For instance the seed of fenugreek was used to enhance milk production (96) and lower serum cholesterol level (97) in animals. Fenugreek is also used as food preservative in pickles as well as sauces. A well-known advantage of fenugreek is that it enhances blood hemoglobin level through natural means. This could help manage anemia and lead a long and healthy life (98). The seeds of fenugreek is used as a tonic and carminative as well as in several conditions like to treat dyspepsia, to cure skin conditions (wounds, psoriasis, rashes), treatment of reproductive disorders, gout, chronic cough, heavy metal toxicity and in rheumatism (99) (100).

Figure 2: Health Impact of Fenugreek

Summary

In this review, promising pharmacological aspects and properties of fenugreek and its parts such as seeds and leaves are highlighted. Ethno-historical uses and modern medicinal value of fenugreek are also covered. Diverse bioactive constituents such as alkaloids, flavonoids, saponins, dietary fibres and many more are of great pharmacological importance. This review would help world researchers to find concise information regarding fenugreek as a future scope for nutrition and good health.

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