Global Journal of Medicinal Plant Research, 1(2): 199-206, 2013
ISSN 2074-0883

Physiological and Pharmaceutical Effects of Fenugreek (*Trigonella foenum-graecum* L.) as a Multipurpose and Valuable Medicinal Plant

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ABSTRACT

Fenugreek (*Trigonella foenum-graecum* L.), plant is widely distributed throughout the world and which belongs to the family Fabacecae. The yields can be significant increase in quantity and quality through the suitable management of cultivation, irrigation and harvesting. The plant contains active constituents such as alkaloids, flavonoids, steroids, Saponins etc. It is an old medicinal plant. It has been commonly used as a traditional food and medicine. Fenugreek is known to have hypoglycemic, and hypocholesterolaemic, effects, Anti-inflammatory effects. Recent research has identified fenugreek as a valuable medicinal plant with potential for curing diseases and also as a source for preparing raw materials of pharmaceutical industry, like in steroidal hormones. Since fenugreek is a self-pollinated crop, a mutation breeding method can be used to generate mutants with a determinate growth habit. Irradiation and chemical mutagens can be used to produce point mutations in fenugreek.

Key words: Medicinal Plant, Fenugreek, Pharmaceutical Effects.

Introduction

In order to meet the ever increasing demand for medicinal plants, for the indigenous systems of medicine as well as for the pharmaceutical industry, many medicinal plants need to be cultivated commercially, but soil salinity and other forms of pollutions represent serious threats to plant production (Qureshi *et al*. 2005). In this context, fenugreek (*Trigonella foenum graecum* L.), an annual legume, is extensively cultivated in most regions of the world for its medicinal value (Petropoulos, 2002). Fenugreek leaves and seeds are consumed in different countries around the world for different purposes such as medicinal uses (anti-diabetic, lowering blood sugar and cholesterol level, anti-cancer, anti-microbial, etc.), making food (stew with rice in Iran, flavor cheese in Switzerland, syrup and bitter run in Germany, mixed seed powder with flour for making flat bread in Egypt, curries, dyes, young seedlings eaten as a vegetable, etc.), roasted grain as coffee-substitute (in Africa), controlling insects in grain storages, perfume industries, and etc. Fenugreek can be a very useful legume crop for incorporation into short-term rotation and for hay and silage for livestock feed, for fixation of nitrogen in soil and its fertility, and etc (Sadeghzadeh-Ahari *et al*., 2009). Fenugreek seeds have been known and valued as medicinal material from very early times. Fenugreek as a chemurgic crop has a wide use for industrial purposes. Its seeds are considered to be of commercial interest as a source of a steroid diosgenin, which is of importance to the pharmaceutical industry (Mehrafarin *et al*., 2010). Nowadays, fenugreek is widely cultivated as a drug plant. The mucilaginous seeds are reputed to have many medicinal virtues, as a tonic, emollient, carminative, demulcent, diuretic, astringent emmenagogue, expectorant, restorative, aphrodisiac and vermifugal properties and were used to cure mouth ulcers, chapped lips and stomach irritation Duke (1986). In Iranian traditional medicine the seeds are used as tonic and blood sugar lowering (Hajimehdipoor *et al*., 2010). The biological and pharmacological actions of fenugreek are attributed to the variety of its constituents, namely: steroids, N-compounds, polyphenolic substances, volatile constituents, amino acids, etc (Mehrafarin *et al*., 2010). Fenugreek seed contains 45-60% carbohydrates, mainly mucilaginous fiber (galactomannans), 20-30% proteins high in lysine and tryptophan, 5 - 10% fixed oils (lipids), pyridine alkaloids, mainly trigonelline (0.2 - 0.38%), choline (0.5%), gentianine and carpaine, the flavonoids apigenin, luteolin, orientin, quercetin, vitexin and isovitexin, free amino acids, such as 4-hydroxyisoleucine (0.09%), arginine, histidine and lysine, calcium and iron, saponins (0.6 - 1.7%), glycosides yielding steroidal sapogenins on hydrolysis (diosgenin, yamogenin, tigogenin, neotigogenin), cholesterol and sitosterol, vitamins A, B1, C and nicotinic acid and 0.015% volatile oils (n-alkanes and sesquiterpenes) (Mehrafarin *et al*., 2010). There are some possibilities for increasing the chemical constituents contained in the seed, either during the growing period by using different cultural techniques (Kozlowski *et al*., 1982; Mohamed, 1990), or during post harvest treatments by different techniques (enzymes, hormones, etc.) of germination with incubation (Hardman and Fazli, 1972), different conditions of incubation and fermentation (Elujoba and Hardman, 1985), by storage (Hardman and Fazli, 1972), by the use of tissue and cell culture (static or suspension) (Khanna and Jain, 1973; Trisonthi *et al*., 1980) and by biological

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manipulation of yield (Mehrafarin *et al*., 2010; Hardman and Fazli, 1972; Petropoulos, 2002). When fenugreek grown under modern production techniques, resulted in an increased yielding ability. The yield potential of fenugreek can be defined as the total biomass produced or agricultural important part of the crop. The total biomass is a result of the integration of metabolic reactions in the plant. Consequently, any factor influencing the metabolic activity of the plant at any period of its growth can affect the yield (Ahmed *et al*., 2010). Metabolic processes of fenugreek plants are greatly governed by both internal, i.e. genetic make up of the plant and external conditions which involve two main factors namely climatic and edaphic environmental factors. The yield potential of fenugreek could be regulated through alternation of genetical make up and reconstitution of genetical structure through breeding programs and/or by modifications of environment through cultural treatments (Ahmed *et al*., 2010; Basu *et al*., 2009).

General Description:

It is an erect hairy annual of the bean family, reaching 30-60 cm. The plant grows to a height of about three feet, has three part leaves, the long slender stems bear tripartite, toothed, grey-green obovate leaves, 20-25 mm (3/4-1 in) long. *Trigonella foenum-graecum* has long stalked leaves up to 5 cm long stipules triangular, lanceolate, leaflets about 2.5 cms long, obovate to obanceolate. The root is a mass of fingery structures. The sissile axillary flowers are white or pale yellow. The thin, sword-shaped pods are 10-15 cm (4-6 in), with a curved beak-like tip, each carrying 10-20 seeds. The plant radiates a spicy odour which persists on the hands after touching. Wild and cultivated varieties exist. Flowers are 1-2, axillary, sessile, racemed, whitish or lemon yellow that bloom from June to July. Pod 5.7 cm long with a persistent beak, hairy with 10-20 seeds. Mild Mediterranean climates are most suitable. Plants mature in about four months. The flowering season for the herb fenugreek is generally midsummer. Fenugreek seeds are small (5 mm. long), hard, and brownish yellow the colour may varies. They are flattened and have a very characteristic rhomboidal outline. Nearly in the centre of one of the long, narrow sides is a small depression in which hilum and micropyle are situated, the former being distinctly visible as a whitish point; this depression is continued in the form of a furrow running diagonally across part of each of the adjoining sides, thus dividing the seed into two unequal lobes. If the seed is cut in a direction transverse to the side in which the hilum lies, so as to pass through both lobes of the seed, it will be found that the larger lobe contains two accumbent cotyledons - the smaller, the radical. Both are yellowish in colour, and surrounded by a darker, horny, translucent endosperm, which separates the radicle from the cotyledons. When it is soaked in water the endosperm swells and yields mucilage to the surrounding liquid. Entire seeds macerated in warm water burst their seed-coats by the swelling of the mucilage, and disclose the structure of the seed.

Fig. 1: Images of Fenugreek (*Trigonella foenum-graecum* L.)

Growing period of fenugreek:

The time of germination in soil usually varies from 3-10 days. Six to ten days after the fenugreek germination the seedlings produce the first leaf, which is usually simple; there is still no noticeable epicotyl as the first trifoliate leaf is formed after a further 5–8 days (Figure 2) (Petropoulos, 2002). Growth is slower under cooler and wetter conditions, and long periods of these conditions may cause a failure of plants to mature for seed harvest. The growth rate of fenugreek is slow at the beginning of the growing season, and leaf development is temperature-dependent (McCormick *et al*., 2006). Dawidar and Fayez (1972) studied the sapogenin make up of the plant at various stages of growth along with the different parts of the seeds and they revealed that the

seedlings have the highest diosgenin (and other steroid sapogenin) content compared to all other stages of growth (Petropoulos, 2002).

Fig. 2: Image of Fenugreek (*Trigonella foenum-graecum* L.)

Ecology:

Although the main area cultivated with fenugreek is concentrated in some countries of Asia and Africa, however it has been distributed in many countries throughout the world under different environments. This wide distribution of its cultivation in the world is characteristic of its adaptation to variable climatic conditions and growing environments (Petropoulos, 2002, 1973). Duke (1986) reports that fenugreek, ranging from cool temperate steppe to wet through tropical very dry forest life zone, is reported to tolerate an annual precipitation of 3.8–15.3 dm and an annual mean temperature of 7.8 – 27.5°C. There are indications of the possible benefit of colder nights on the sapogenin content of the seed (Fazli *et al*., 1968). Depending on the geographical source of the seed its sapogenin content, calculated as diosgenin, varied from 0.8–2.2 percent expressed on a moisture free basis (Fazli *et al*., 1968). The highest sapogenin content was found in an Ethiopian sample and the lowest in a sample from Palestine (Petropoulos, 2002). As a legume crop, it can condition the soil by fixing nitrogen from the atmosphere and can reduce the need for nitrogen fertilizer for subsequent crops. Because fenugreek is a nitrogen-fixing legume, seeds must be inoculated with appropriate *Rhizobium* species for optimal growth (Petropoulos, 2002; Basu, 2006; Basu *et al*., 2008). As a dry-land crop, its water requirements are low; use of fenugreek can reduce the cost of irrigation, save water and reduce eutrophication of surface water and limit contamination of ground water source. These properties also make fenugreek a useful legume crop for incorporation into short term rotations (Basu, 2006; Acharya *et al*., 2008).

Traditional Uses:

The nourishing seeds are given during convalescence and to encourage weight gain, especially in anorexia. Helpful in lowering fever, it is compared to quinine by some authorities. The seeds' soothing effect makes them of value in treating gastritis and gastric ulcers. The seeds freshen bad breath and help restore a dulled sense of taste. The oil in the seeds is used as a skin softener and emollient. In China, the fenugreek seeds are used as a pessary to treat cervical cancer. In the Middle East and the Balkans, the aerial parts of plant are a folk remedy for abdominal cramps associated with both menstrual pain and diarrhea or gastroenteritis. They are also used to ease labour pains (Indian food, Fenugreek). Traditional Chinese herbalists used plant for kidney problems and conditions affecting the male reproductive tract. The seeds also function as a preservative and are added to pickles, chutneys and other similar products (Vortex health, Fenugreek). In modern food practice, the seeds or the extract are used in bakery products, frozen dairy products, meat products, relish, condiments, candy, gravy sauces, gelatin puddings and in alcoholic and non-alcoholic beverages. Fenugreek has a beneficial action on cleansing the blood. As a diaphoretic it is able to bring on a sweat and to help detox the body. This takes place through the pores of the skin. The pungent aroma of fenugreek may be smelt on the skin and in under-arm

perspiration. After using the sprouts for a while, this fenugreek body aroma, does not seem to be so apparent, maybe, the sprouts have done a pretty good cleanse. Fenugreek also has the reputation as a lymphatic cleansing herb. The lymphatic system is the vacuum cleaner of the body. It has the vital role to irrigate the cells with nutrients and to remove toxic wastes, dead cells and trapped proteins. The fluid is cleaned through the lymph nodes, before the body's 13 litres of filtered lymph fluid recycles again, via the subclavian vein near the heart. A blocked lymphatic system can mean poor circulation, fluid retention, pain, loss of energy and disease, anywhere in the body. Fenugreek is a practical herb for all mucus conditions of the body, particularly the lungs, by helping to clear congestion. It is a powerful antioxidant and it acts as a mucus solvent and throat cleanser, which also eases the urge to cough. Even drinking the water that seeds have soaked in and been rinsed with, helps to soften and dissolve, accumulated and hardened masses of cellular debris. Use fenugreek for head colds, influenza, catarrh, constipation, bronchial complaints, asthma, emphysema, pneumonia, pleurisy, tuberculosis, sore throat, laryngitis, hay fever and sinusitis (Home remedies guide). Fenugreek has been used to treat peptic ulcers and inflamed conditions of the stomach and bowel, it absorb toxic material and eliminate it. The healing and soothing action creates a protective coating, like a lubricant, over inflamed areas. The slightly bitter properties of the seed are beneficial for digestion. Fenugreek has a powerful demulcent action, as it is rich in mucilage and it can soothe irritated or inflamed tissue. For relief from the agonizing symptoms of irritable bowel syndrome, colitis and diverticulitis, the 'soak-and-rinse water' is drunk and the sprouts blended to a liquid. It has been called the herb for 'every ailment under the sun (Vortex health, Fenugreek). The Fenugreek herb has been known to help reduce fever when taken with lemon and honey, since it nourishes the body during an illness. Some health food stores also sell herbal Fenugreek teas, which can be used instead of the green tea. Fenugreek is often used in many teas and other products that help balance women's hormones and/or enlarge the breasts. Remedy to Ease Child Birth for Pregnant Women: Fenugreek stimulates uterine contractions and can be helpful to induce childbirth. However, pregnant women should only use Fenugreek for inducing labor after consulting with their doctor (Global herbal supplies). Lactation Aid: Fenugreek seeds contain hormone precursors that increase milk supply. Some scientists believe it is possible because breasts are modified sweat glands, and fenugreek stimulates sweat production. It has been found that fenugreek can increase a nursing mother's milk supply within 24 to 72 hours after first taking the herb. Immunological Activity: An Immunomodulatory effect of fenugreek extract in mice has been investigated. Overall, Fenugreek showed a stimulatory effect on immune functions in mice. As it is used for a variety of medicinal purposes, its immunostimulatory effect, as reported in this study, strengthens the rationale of its use in several Unani and Ayurvedic drugs. For the removal of Kidney Stones, a study was undertaken to investigate the effect of Fenugreek (*Trigonella foenum-graecum*) seed on experimentally-induced kidney stones in rats. Oxalate urolithiasis in male rats was produced by the addition of 3% glycolic acid to their diet. After 4 weeks, highly significant deposition in the kidneys was noticed and changes in water intake and body weight recorded. Daily oral treatment with *T. foenum-graecum* significantly decreased the quantity of calcium oxalate deposited in the kidneys thus supporting its use in Saudi folk medicine (Indian food, Fenugreek).

Clinical Studies:

Antimicrobial Effects: The seeds of the fenugreek herb possess toxic oils, and other constituents of the fenugreek leaf have been shown to be toxic to bacteria, parasites and fungi. A 2007 issue of Current Science journal noted the antifungal properties of fenugreek. The research attempted to clone the substance defensins which are native to plants such as fenugreek to test their effects in the petri dish. The defensins protect the plant from fungi which was extracted from leaf tissue. As an antiparasitic agent, fenugreek was pitted in a 2008 Oxford Journals article against the malaria-causing organism Plasmodium. In vitro studies found that fenugreek extracts were effective against resistant species of Plasmodium. The 2004 Asia Pacific Journal of Clinical Nutrition article also noted that germination or sprouting of fenugreek seeds increased their antioxidant profile and antimicrobial activity against *H-pylori*. Finally, a 2006 African Journal of Biotechnology article compared the effectiveness of fenugreek against two common pathogenic bacteria. Fenugreek was found to strongly inhibit the growth of *Staphylococcus aureaus* and *Pseudomonus aeruginosa* in a petri dish (Basu *et al*., 2009). Animal Studies have clearly demonstrated the cholesterol-lowering activity of fenugreek in animals. In a typical study, fractions of fenugreek seeds were added to the diets of diabetic hypercholesterolemic and normal dogs. The defatted fraction, which contains about 54% fiber and about 5% steroidal saponins, lowered plasma cholesterol, blood glucose, and plasma glucagon levels from pretreatment values in both groups of dogs. The hypocholesterolemic effect has been reproduced in rats. Administration of the fiber-rich fraction of fenugreek to diabetic rats lowered total cholesterol, triglycerides, and low density lipoprotein (LDL). The level of high density lipoprotein (HDL) was increased. In the Clinical study Serum triglycerides were reduced from baseline in patients with newly-diagnosed, mild, type-2 diabetes mellitus who received a hydroalcoholic extract of fenugreek seeds 1 g/day. Total cholesterol and proportions of LDL and HDL fractions were not altered by treatment. A systematic review identified 5 other randomized clinical trials (N=140) investigating the

cholesterol-lowering effects of fenugreek seeds. Reductions (15% to 33%) of serum cholesterol from baseline were reported in all the trials identified. Total serum cholesterol and LDL cholesterol were reduced, while HDL cholesterol remained unchanged. The galactomannan-rich soluble fiber fraction of fenugreek may be responsible for the antidiabetic activity of the seeds. An Animal study evaluated the hypoglycemic effects of the seeds in dogs. The defatted fraction of the seeds lowered blood glucose levels, plasma glucagons and somatostatin levels; carbohydrate-induced hyperglycemia also was reduced. Clinical data shows that Glycemic control was improved in a small study of patients with mild type-2 diabetes mellitus. A reduction in glycosylated hemoglobin (HbA 1c) levels and increased insulin sensitivity were observed in fenugreek recipients. An anti-inflammatory effect was observed in an Animal study which shows that when rats treated with a single dose of fenugreek extract (100 or 200 mg/kg). Inhibition of inflammatory swelling was 45% and 62% in the lower and higher dose groups, respectively, compared with 100% in untreated animals. In 2007 Laroubi *et al* studied the Prophylaxis effect of *Trigonella foenum graecum* L. seeds on renal stone formation in rats. The inhibitory effect of the aqueous extract of fenugreek seeds was examined on the formation of calcium oxalate renal stones induced by ethylene glycol (EG) with ammonium chloride. At the end of the experiment all kidneys were removed and examined microscopically for possible crystal/stone locations and the total calcium amount in the renal tissue was evaluated. The blood was recovered to determine the levels of calcium, phosphorus, creatinine and urea. The results showed that the amount of calcification in the kidneys and the total calcium amount of the renal tissue in rats treated with fenugreek was significantly reduced compared with the untreated group. The fenugreek can be used in the treatment of patients with calcic urolithiasis (Laroubi *et al*., 2007). In 2010 Chauhan *et al* reported an anti-inflammatory potential of fenugreek (Chauhan *et al*., 2010).

Effects Fenugreek on Sugar Decreasing and Diabetes:

Fenugreek seed powder in the diet reduces blood sugar and urine sugar with concomitant improvement in glucose tolerance and diabetic symptoms in type 2 diabetic patients (Analava and Debaprasad, 2004), Too studies (Madar et al., 1988; Jain et al., 1995; Sharma et al., 1996), showed hypoglycemic effects of fenugreek seeds type 2 diabetics and (Sharma *et al*., 1990) conducted a randomized, controlled, crossover trial in 10 patients with type1 diabetes. The hypoglycemic effects of fenugreek have been attributed to several mechanisms. Sauvaire *et al*. (1998) demonstrated in vitro the amino acid 4-hydroxyisolcucine in fenugreek seeds increased glucose-induced insulin release in human and rat pancreatic islet cells, It was observed that 4-hydroxyisoleucine extracted from fenugreek seeds has insulin tropic activity (Sauvaire *et al*., 1998). Sauvaire et al. (1998) show This amino acid appeared to act only on pancreatic beta cells, since 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 of insulin receptors, although the mechanism for this effect is unclear (Raghuram *et al*., 1994). In humans, 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 and 203ignali, two intestinal enzymes involved in carbohydrate metabolism. According report of Tim (1998) 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 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. Fenugreek may aid with insulin secretion, as suggested by animal studies, since typically these patients have little or no endogenous insulin production (Ethan *et al*., 2003). Animal tests have proved that galactomannan blocks intestinal absorption of glucose. Water soluble fiber increases the viscosity inside the intestine and then inhibit absorption of glucose.

Chemical Composition:

Fenugreek is a natural source of iron, silicon, sodium and thiamine. Fenugreek contains mucilagins which are known for soothing and relaxing inflamed tisuues. Fenugreek seeds contain alkaloids, including trigonelline, gentianine and carpine compounds. the seeds also contain fibre, 4-hydroyisoleucine and fenugreekine, a component that may have hypoglycemic activity. The mechanism is thought to delay gastric emptying, slow carbohydrate absorption and inhibit glucose transport. Fenugreek may also increase the number of insulin receptors in red blood cells and improve glucose utilization in peripheral tissues, thus demonstrating potential anti-diabetec effects both on the pancreas and other sites. The amino acid 4-hydroxyisoleucine, contained in the seeds, may also directly stimulate insulin secretion.

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Medicinal Properties:

Methika is pungent in both taste and post digestive effect. It possesses light and unctous attributes. It augments the appetite, relieves fever , alleviates swelling and reduces body fats but vitiates Pitta. Fenugreek seeds and leaves are anticholesterolemic, anti-inflammatory, antitumor, carminative, demulcent, deobstruent, emollient, expectorant, febrifuge, galactogogue, hypoglycaemic, laxative, parasiticide, restorative and uterine tonic, and useful in burning sensation.

Medicinal Uses:

Helps treat Diabetes & Reduce Cholesterol:

It has been proven to be an excellent remedy for reducing level of bad Cholesterol levels from our body. It is also used to reduce blood glucose levels in the blood.

Aids Digestion:

It purifies blood and helps in flushing out the harmful toxins. It helps in dissolving excess mucus, thereby making the digestive organ refreshed and clean. Also fenugreek seeds are useful in improving memory power too.

Prevent hair loss:

The Fenugreek seeds being high source of Protein are very useful in hairfall, so it helps in treating baldness, thinning of hair and hair fall. It also has Lecithin, a natural emollient which helps in strengthening and moisturisation of hair. It also keeps the dandruff away and keeps the hair free of lices.

Helps In Losing Weight:

The fiber in fenugreek fills the stomach, even when consumed in a little amount. Soak a few fenugreek seeds in water and chew them in the morning, on an empty stomach.

Antidote For Skin Problems:

Fenugreek seeds prove to be an excellent beauty product. They help prevent wrinkles, blackheads, pimples, dryness and rashes.

Good For Beauty & Health:

Fenugreek helps attain hormonal balance in women and therefore, helps in enlargement of breasts. It helps increase the lactation in breast feeding women.

Prevents Dandruff & Strengthens Hair:

Not only does fenugreek help prevent hair loss, but also keeps the dandruff away. It also keeps the hair lice free.

Conclusion:

In conclusion this plant is effective on blood lipids and sugar and on some bacterial strains, antioxidant activity of fenugreek causing protective of organs and inhibition of entrance diseases to body, too decrease body fats and is effective on obesity. Fenugreek (Trigonella foenum-graecum L.), plant is widely distributed throughout the world and which belongs to the family Fabacecae. The yields can be significant increase in quantity and quality through the suitable management of cultivation, irrigation and harvesting. The plant contains active constituents such as alkaloids, flavonoids, steroids, Saponins etc. It is an old medicinal plant. It has been commonly used as a traditional food and medicine. Fenugreek is known to have hypoglycemic, and hypocholesterolaemic, effects, Anti-inflammatory effects.

Acknowledgments

The authors are grateful to Mrs Dr. Somayeh Sadeghi for Suggested writing manuscript about medicinal plants and his useful kindly help. The authors also would like to have a special thanks to Mrs, Fariba Ashrafzadeh for criticism reading and editing of this manuscript.

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