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Trigonella foenum-graecum: A review on its traditional uses, phytochemistry and pharmacology

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Abstract

Fenugreek (*Trigonella foenum*-graecum) commonly known as Methi is an annual herb belonging to family Fabaceae. It is cultivated worldwide as a semiarid crop, and its seeds are a common ingredient in dishes from the Indian subcontinent. Its seeds are rich sources of protein dietary fiber, B vitamins, iron and several other dietary minerals. It has many potential medicinal applications in the health industry. It contains compounds which are bioactive such as galactomannan, diosgenin, 4-hydroxyisoleucene, 3-hydroxy-4, 5-dimethyl-2(5H) furanone (stolone), etc. Stolone is the flavor compound of fenugreek and it is now a day's commonly used in food industry for various purposes. Its shows antidiabetic, hypoglycemic, antiallergic and labor and lactation induction properties. It decreases the cholesterol level reduces the body weight by decreasing plasma triglycerides tri glycerides. Fenugreek is known to have hypocholesterolemic, antioxidant potency, digestive stimulant action, and hepatoprotective effect. It is anticarcinogenic, antioxidant, antibacterial agent, gastric stimulant, and anti-anorexia agent. Recent research revealed that fenugreek is a valuable medicinal plant of multipurpose uses and may be used for preparing various products such as steroidal hormones. This review presents the major medicinal and other beneficial uses of fenugreek discovered through last many years of research in animal and human subjects as well as in other experimental studies. In this review, we will summarize nutritional, nutraceutical, antioxidant and medicinal properties of fenugreek.

Keywords: Fenugreek, bioactive compounds, medicinal and nutraceutical effects.

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1. Introduction

Plant *Trigonella foenum-graecum* belongs to the family **Fabacea** and it is popularly known as Fenugreek [1]. It has been in use as a food and flavouring since time immemorial. It is native to the area from the Eastern Mediterranean to Central Asia and Ethiopia, and much cultivated in India and China [2]. Plant seeds and leaves are used not only as food but also as an ingredient in traditional medicines [3]. It has been mentioned in Ayurveda and Siddha that these plants are used to treat fever, dysentery and heart diseases, while in Unani system, this plant is used as an aphrodisiac, diuretic, emmenagogue and tonic [4].

Due to its strong flavor and aroma fenugreek in one of such plants whose leaves and seed are widely consumed in Indo-Pak subcontinent as well as in other oriental countries as a spice in food preparations, and as an ingredient in traditional medicine.[5]

A robust, erect, aromatic annual herb reaching up to 60 cm in height. The leaves are compound, up to 5 cm in length, with long pedicel. Leaflets are lanceolate or obovate, about 2.5 cm long, with slight toothed margins. The flowers are axillary, occurring singly or in pairs, sessile, yellow in colour. The fruits are typically leguminous pods 5-8 cm long, narrow and with a persistent 'bark', enclosing 10-20 golden yellow seeds, which possess a characteristic savoury aroma.[6]

1.1 Use in traditional medicine

Fenugreek (*Trigonella foenum-graecum* L. *Leguminosae*) is one of the oldest medicinal plants, originating in India and Northern Africa. More recent ethno pharmacological studies show and aromatic leaves are often eaten as a vegetable and the seeds are widely used as condiment in curries. A poultice made of the herb can be applied locally to relieve swelling and the leaves are also made into paste and applied over burns or to the scalp to prevent premature graying of the hair. [6]

Applications of fenugreek were documented in ancient Egypt, where it was used in incense and to embalm mummies. In modern Egypt, fenugreek is still used as a supplement in wheat and maize flour for bread-making [7]. In ancient Rome, fenugreek was purportedly used to aid labor and delivery. In traditional Chinese medicine, fenugreek seeds are used as a tonic, as well as a treatment for weakness and edema of the legs [8]. In India, fenugreek is commonly consumed as a condiment and used medicinally as a lactation stimulant [9].

Trigonella foenum-graecum is used in many parts of the world for the treatment of a number of diseases, e.g. urotoxicity, immunomodulatory, antiradical and antioxidant, chemopreventive, anticancer, antidiabetic, gastro protective, anti-inflammatory and antipyretic, regulation of hyperthyroidism, anthelmintic, antigenotoxic, anti-plasmodial, hepatotoxicity and nephrotoxicity, wound healing, hypocholesterolemic, nutritive, anti-plasmodial, allergenicity and antigenicity, antiseptic, aphrodisiac, astringent, bitter, demulcent, emollient, expectorant.

Table 1: Ethnomedical uses of *Trigonella foenum-graecum*

Place, country	Part (s) used	Ethno medical uses	Preparation(s)	Reference(s)
Pakistan	Seeds	Antioxidant	Methanol, ethanol, dichloromethane, acetone, hexane and ethyl acetate extra	Syeda Birjees Bukhari *et al*. [10]
China	Seeds	Blood glucose, blood lipid, hemorheology	Decoction or thick paste	Xue *et al*[11]
Iran	Leaves	Anti-inflammatory, and antipyretic		Ahmadian *et al*[12]
India	Seeds	Antidiabetic	Ethanolic extract	Renuka C. *et al*. [13]
India	Seeds	Anthelmintic	Alcoholic extract	Khadse *et al*[14]
India	Seeds	Antifertility	Chloroform extract	Sharma *et al*. [15]
Spain	Seeds	Antigenotoxic	Infusion	Mezzoug *et al*. [16]
India	Leaves	Anti-plasmodial	Ethanol extract	Palaniswamy, M *et al[17]*
India	Seeds	Antioxident	Methanol extract	Kaviarasan *et al*. [18]
India	Seeds	Anticancer	Methanol extract	Verma *et al*. [19]
India	Leaves	Urotoxicity	Aqueous extract	Bhatia, K. *et al*. [20]
India	Leaves	Immunomodulater	Chloroform extract	Bin-Hafeez B *et al [21]*
India	Seeds	Analgesic and anti-inflammatory	Extract	Vyas Savita *et al*[22]
India	Seeds	Anti-inflammatory	Aqueous extract	Malviya *et al* [23]
India	Seeds	Antimicrobial activity	Ethanolic extract	Khanra. R *et al* [24]
India	Seeds	Antifungal and antibacterial	Oil	Wagh *et al* [25]
India	Seeds	Diuretic	Various extract	Rohini *et al*. [26]
India	Seeds	Antidiabetic	Methanol extract	Abou El-Soud *et al*.[27]
India	Seeds	Anti-inflammatory	Alcoholic extract	Datta Debranjan *et al* [28]
India	Seeds	Antiradical and antioxidant activities	Methanol extract	Kaviarasan *et al* [29]
India	Seeds	Estrogenic	Chloroform extract	Sreeja *et al.* [30]
India	Seeds	Gastric ulcer	Chloroform extract	Pandian *et al* [31]
India	Seeds	Anti-hyperglycemic	Aqueous extract	Moodrthy *et al*. [32]
India	Seeds	Antifertility	Ethanol : water (70:30) extract	Aaswer *et al* [33]
China	Seeds	Hypoglycaemic and hypercolesterolamic effect	Extract	Xue *et al*. [34]
Iran	Leaves	Anti-inflammatory and antipyretic	Extract	Ahmadiani *et al*. [35]
Arab	Seeds	Chemopreventiv activity against breast cancer	Extract	Amin *et al.* [36]

2. Phytochemistry

2.1. Seeds:

The endosperm of the seed is rich in galactomannan, young seeds mainly contain carbohydrates and sugar. Mature seeds content amino acid, fatty acid, vitamins, and saponins. The seeds of fenugreek contain a large quantity of folic acid (84mg/100g). It also contents disogenin, gitogenin, neogitogenin, homorientin saponaretin, neogigogenin, and trigogenin. The main chemical constituents of *T.foenum-graecum* are fibers, flavonoids, polysaccharides, saponins, flavonoids and polysaccharides fixed oils and some identified alkaloids viz., trigonelline and choline. (The Wealth of India &Compendium of Indian Medicinal Plants)

Neutral and polar lipids of fenugreek were investigated. Triacylglycerol and phosphatidylethanolamine were the major molecular species identified in the neutral and polar lipid fractions, respectively. The seeds raised from treated plants showed increased level of kaempferol, luteolin, quercetin, and vitexin.

2.2. Leaves:

Young fenugreek leaves yield: total lipids (dry wt), 1.50%; neutral lipids, 0.98; glycolipids, 0.38; and phospholipids, 0.14%. The leaf lipid is a rich source of essential fatty acids, viz. linolenic and linolenic acid. The leaves also contain: α-tocopherol, 0.87; and β-tocopherol, 0.37 mg/g (dry weight)

3. Biological activity

3.1 Medicinal and Pharmacological activities

3.1.1 Antidiabetic activity:

The aqueous and alcoholic extracts of *Trigonella foenum-graecum* leaf were tested for hypoglycaemic activity in normal and alloxan-diabetic rats. The results suggest that the aqueous extract of *Trigonella foenum-graecum* leaves given both orally and intraperitoneally possesses a hypoglycaemic effect in normoglycaemic and alloxan induced hyperglycaemic rats [37].

The hyperglycemic activity of the seeds and various extracts was studied in experimental rabbits and the glucose tolerance test showed a significant hypoglycemic activity in the alkaloid-rich fraction [38]. *Trigonella foenum-graecum* (fenugreek) seeds have previously been shown to have hypoglycemic and hypocholesterolemic effects on type 1 and type 2 diabetes mellitus patients and experimental diabetic animals [39]. In a controlled clinical trial, the effect of three preparations of the seeds (raw, boiled and germinated) was seen in six healty and six diabetic patients taking raw and germinated seeds. Raw and germinated seeds significantly reduced postprandial glucose levels in all subjects; however, boiled seeds did not produce any such effects [40]. Administrations of the ethanolic extract of *Trigonella foenum-graecum* seed powder decreased blood glucose, serum cholesterol, serum glutamate oxaloacetate transaminase (SGOT) and serum glutamate pyruvate transaminase (SGPT) levels [41]. The aqueous extract of *Trigonella foenum- graecum* leaves given both orally and intraperitoneally possesses a hypoglycaemic effect in normoglycaemic and alloxan induced hyperglycaemic rats [42]

3.1. Immunomodulatory effect:

Trigonella foenum graecum L.showed a stimulatory effect on immune functions in mice. Immunomodulatory activity of aqueous extract of *Trigonella foenum graecum* L. was evaluated in male mice [43].

3.1.3 Antioxidant

A freeze- dried extract of fenugreek was reported to be antioxidant in a carotene and linoleic acid emulsion, with an activity comparable to standard commercial antioxidents**.** The fenugreek extracts (methanol, ethanol, dichloromethane, acetone, hexane and ethyl acetate) act as potent source of antioxidants [44]. Flavonoids of fenugreek extract have been observed to possess anti-oxidant activity [45]. Fenugreek seeds have been reported to raise the anti-oxidant levels and lower the lipid peroxidation in liver of ethanol intoxicated and diabetic rats [46]. The free radical scavenging potential of the seeds of (*Trigonella foenum-graecum*) ethanolic extract at 500µg/ml showed maximum scavenging of the radical cation. An aqueous methanolic extract of fenugreek seeds having antiradical and *in vitro* antioxidant activity [47].

3.1.4 Chemopreventive activity

Trigonella foenum-graecum (Fenugreek) seeds showed potential protective effect against 7, 12-dimethylbenz (a) anthracene (DMBA)-induced breast cancer in rats at 200 mg/kg body wt [36]. The methanolic extract of *Trigonella foenum graecum* L was proved to have maximum growth inhibition against 502713 and HT-29 human cancer cell lines [48].

3.1.5 Antimicrobial activity:

The fatty oil and unsaponifiable matter of fenugreek seeds were evaluated against six bacterial and six fungal strains and the study concluded that the unsaponifiable matter was more active than the oil. *Trigonella foenum-graecum* was screened against 26 common pathogens and demonstrated a broad-spectrum antibacterial activity. The ethanolic extract of seeds of *Trigonella foenum-graecum was* evaluated for antimicrobial activity against eight bacterial stains the result revealed that the ethanolic extract is potent in inhibiting bacteria growth of both gram-negative and gram-positive bacteria [24].

3.1.6 Anticancer activity:

Apoptosis is a type of cell death, and agents with the ability to induce apoptosis in tumors have the potential to be used for antitumor therapy. Flavonoids produce several biological effects, and the apoptosis inducing activities of flavonoids have been identified in several previous studies [49]. Flavonoids and catechins were first shown to be apoptotic in human carcinoma cells [50]. Similar observation has since been extended to lung tumor cell lines [51], *Trigonella foenum graecum* has also been shown to have stimulatory effects on macrophages. Phagocytosis and killing of invading microorganisms by macrophages constitute body's primary line of defense against infections [52]. On the bases of published studies, flavonoids seem to be most likely candidates eliciting anti-tumorigenic effect.

3.1.7 Gastroprotective effect

The aqueous extract and a gel fraction isolated from the seeds showed significant ulcer protective effects [31].

3.1.8 Anti-inflammatory

The anti-inflammatory activity was exhibited by all three (ether, alcohol and aqueous) extracts but the ether extract was the most potent and comparable to sodium salicylate. The methanolic extract obtained from *Trigonella foenum-graecum* seeds produced marked acute anti-inflammatory activity in rats [22]. Anti– inflammatory effects of the *Trigonella foenum-graecum* leaves significantly reduced formalin-induced edema in single dose [23]. The alcoholic extract of *Trigonella-foneum-graecum* exhibited anti-inflammatory effect on carrageenan induced paw oedema in rats at dosage of both at 100mg & 200mg/kg b. wt. This low dose of fenugreek was more significant than Indomethacin. The alcoholic and petroleum ether extracts of fenugreek seeds can be used safely as anti inflammatory agent [28].

3.1.9 Antipyretic activity

The *Trigonella foenum-graecum* leaves extract (1000 mg/kg) significantly reduced hyperthermia induced by brewer's yeast in 1 and 2 hours after administration. The antipyretic effects in this extract suggest a NSAID-like mechanism [35].

3.1.10 Analgesic activity:

The aqueous and ethanol extracts of *Trigonella foenum – graecum* (TFG) seeds having analgesic potential in rats [23]. The methanolic extract obtained from *Trigonella foenum-graecum* seeds was found to be a potent analgesic activity [22].

3.1.11 Neuropharmacological Activity

The *Trigonella foenum-graecum* seeds of total alcoholic extract, total aqueous extract, total alkaloidal extract, petroleum ether extract, total glycosidal extract, fenugreek oil, diosgenin and trigonelline were assessed for their neuropharmacological activity. All the extracts and active principles except total aqueous extract showed significant central nervous system (CNS) stimulant activity, while total aqueous extract alone showed significant CNS depressant activity [53]

3.1.12 Anthelmintic activity:

The alcoholic extracts of seeds of *Trigonella Foenum-graecum* has shown a potent anthelmintic activity, which was compared with albendazole as reference drug [54].

3.1.13 Anti-plasmodial activity:

The *Trigonella foenum-graecum* leaves extracts (ethanol, butanol, chloroform, ethyl acetate, chloroform and ethyl acetate and water extract) are shown the most interesting anti-plasmodial activity. The ethanol and butanol extracts having significant anti-plasmodial activity, chloroform and ethyl acetate shows moderate activity, and the other two extracts, hexane and water appeared to be inactive against *Plasmodium falciparum* [55].

3.1.14 Hepatoprotective and nephroprotective activity:

The protective effect of aqueous extract of germinated fenugreek seeds against Cypermethrin induced hepatic and renal toxicity [56].

3.1.15 Wound healing activity:

The aqueous suspension and extract of the seed of *Trigonella foenum graecum* was investigated for wound healing properties in excision, incision and dead space wound models in rats. Results indicated that the suspension and extract promoted significant wound Healing activity [57]. Traditionally the crushed seeds are in use for application on the wound [58].

3.1.16 Hypocholesterolemic activity:

Fenugreek seeds have been shown to prevent the elevation of cholesterol in rat when given with a hypocholesterolemic diet. Steroidal saponins isolated from fenugreek seeds administered to rats with food significantly reduced plasma cholesterol in both normal and diabetic rats. Fenugreek seeds showed some hypocholesterolemic activity. Fenugreek seeds contain both the galactomannans and the saponins. Galactomannans decrease the uptake of bile acids, lower blood and liver concentration of cholesterol and decrease hepatic cholesterol synthesis; Saponins were also shown to interact with bile salts in the GIT [59].

3.1.17 Nutritive activity

In one presently preferred embodiment of the present invention, the bio-active compounds are extracted from fenugreek seeds. A method for extracting a composition of bio-active compounds from fenugreek seeds is also disclosed, wherein the method comprises the steps of: (1) providing a plurality of fenugreek seeds; (2)

preparing the fenugreek seeds; and (3) extracting a composition of bio-active compounds from the fenugreek seeds, wherein the bio-active compounds comprise 4-hydroxyisoleucine and one or more amino acids selected from the group consisting of arginine, aspartate, threonine, serine, glutamate, proline, glycine, alanine, cysteine, valine, methionine, isoleucine, leucine, tryptophan, phenylalanine, ornithine, lysine, histidine and gamma-amino butyrate. The composition of bio-active compounds and methods for extraction of same preferably include between about 10% and 70% of 4-hydroxyisoleucine and between about 20% and 40% of the amino acids.

3.1.18 Antifertility Activity:

The *Trigonella foenum graecum* seeds extract exerts antiestrogenic and antifertility activity in female rats [15].

3.1.19 Urotoxicity activity:

Cyclophosphamide is a commonly used anti-cancer drug which causes toxicity. Pre-treatment of *Trigonella foenum-graecum* L. extract restored activities of all the enzymes and thus showed an overall protective effect in urinary bladder [22].

3.1.20 Diuretic activity:

The *Trigonella foenum-graecum* Linn. (fenugreek) seeds extract at 150 and 350 mg/kg body weight showed a dose dependent increase in volume of urine [26].

3.1.21 Effect on enzyme activity:

Fenugreek seeds powder reduces the activities of glucose-6-phosphatase and fructose-1, 6-biphosphatase in liver and kidneys of diabetic rats [50].

3.1.22 Effect on ovaries and liver tissues:

Fenugreek oil has stimulating effect on the ovarian activity of mice. Administration of fenugreek oil showed that the total number and quality of cumulus-oocyte complexes increased and the oil stimulated the oocytes to progress in meiosis, but the levels of nucleic acid contents were unaffected [60].

3.1.23 Nematicidal activity:

The aqueous, methanol and chloroform extract of fenugreek seeds cause significant mortality of *Melodogyne javanica* larvae [61]. Aqueous leaf extract of fenugreek leaves shows nematicidal activity against J2 of *M. incognita.*

3.2 Miscellaneous effects

3.2.1 Regulation of Hyperthyroidism:

The combined effects of *T. foenum graecum* and *Allium sativum* extracts were evaluated for their ameliorative potential in the L-thyroxine-induced hyperthyroidic rat model to contribute to an understanding of interaction between the two extracts. The investigation was carried out using two different doses. A comparison was made with the response of individual plant extracts at the previously studied effective dose in adult Wistar rats rendered hyperthyroidic by daily injections of L-thyroxine (300 µg/kg body wt., *s.c.*). Propylthiouracil, an antithyroid drug, was used as a reference compound. Alterations in serum triiodothyronine, thyroxine, glucose, hepatic glucose-6-phosphatase and oxygen consumption were studied as end parameters. Superoxide dismutase, catalase activities, lipid peroxidation and reduced glutathione were examined to reveal any toxic effects of the drugs. The combined effects of *Trigonella* and *Allium* at 200 and 500 mg/kg body wt. respectively, were equipotent as compared to the individual extracts in lowering the serum concentrations of triiodothyronine and thyroxine hyperthyroidic rats. Our findings reveal that some plant extracts in combination may not always prove to be synergistic. It is therefore suggested that *T. foenum-graecum* and *Allium sativum* extracts may be used individually and not together in the regulation of hyperthyroidism.

3.2.2 Larvicidal effect:

The combined effects of extracts of *Trigonella foenum* and *Nerium oleander* against mosquito were evaluated for their larvicidal potential and to test their activity in combination with each other. Mosquito, the primary vector for malaria, dengue and other severe infectious diseases are the major problem in Vellore city. The larvicidal activity of *Trigonella foenum* and *Nerium oleander* leaf extracts on the different mosquito larvae were studied. The results showed that, there are four genera of mosquitoes present in Vellore city and the leaf extract of both the above plants contains larvicidal activity, and the combination of the extracts, increased the activity considerably to a high percent. From the obtained data the *Nerium oleander* has a less larvicidal activity than the nutritional plant, fenugreek. **[62]**

3.2.3 Toxicology:

This toxicologic study was conducted using dry leaves and seeds of *Trigonella foenum-graecum* L. An acute intraperitoneal and oral toxicity study of the glycosidic extract of fenugreek leaves concluded that the extract was considered to be safe and have a minimal adverse effect. The interperitoneal study was aimed at four target organ, e.g. liver, kidney, stomach, small and large intestine, and found that the liver was the only organs affected, where early degenration with infiltration of mononuclear and mild hepatitis was found in some animals treated with toxic doses of the glycosidic extract administrated twice a week for 4 weeks, at dosages of 1.0, 1.5 and 2.0g/kg of body weight, exhibited a necrotic effect on liver and kidney tissues of male albino wister rats. Spermatogenesis was observed in the testes at dosage levels of 1.5g/kg and 2.0g/kg of extract. Fenugreek powder does not produce any significant acute and cumulative toxicity in

mice and rats up to 10% level [53]. Fenugreek seeds are used to treat dysentery, diarrhea, dyspepsia, cough, enlargement of liver and spleen, rickets and gout. No renal or hepatic toxicity was observed in patients ingesting an experimental diet containing fenugreek seeds powder (25g/day), even after 24 weeks [15].

4. Clinical trials:

4.1 Hypoglycaemic activity:

A study on cyclists showed that a fenugreek extracts increases insulin concentration and glycogen resynthesis after exercise. Various clinical trials of fenugreek showed improvement in glucose tolerance in healthy volunteers as well as in type 2 and type 1 diabetic patient [26]. However, all these studies were considered as methodologically weak and classified as preliminary.

4.2 Hypocholesterolemic activity:

A clinical trial on hyperlipidemic non-diabetic patients whom diet was supplemented in defatted fenugreek showed significant reduction of serum total cholesterol, LDL and VLDL cholesterol and triglyceride levels, while HDL cholesterol levels were unchanged. In another trial, fenugreek seed powder did not affect the blood profile in healthy subjects, but significantly reduced the total cholesterol and triglyceride without affecting the HDL-cholesterol in patients with coronary artery disease [63]. Similar results were obtained with germinated seeds, which are less bitter. Long lasting hypo-cholesterolemic activity was also demonstrated in diabetic subjects. Altogether, the methodology of these studies was considered as poor [64].

4.3 Galactogogue activity:

One study involving ten women indicated that fenugreek seeds would increase milk production. However a stronger methodology would be required before this claim could be endorsed.

5. Interactions

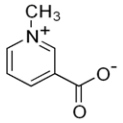
5.1 Interaction with drugs

- Potential interaction with antiplatelet/anticoagulant drugs (incl. NSAIDs): the presence of coumarin in fenugreek may theoretically increase the risk of haemorrhage (speculative) (65, 66)
- Potential interaction with exogenous insulin in diabetic patients who do not adjust insulin dosage: could lead to hypoglycaemia (speculative).
- Potential interaction with oral hypoglycaemic drugs sulfonylurea, biguanides, or both: could lead to hypoglycaemia (speculative).
- Potential enhancement of the activity of cholesterol-lowering agents due to additive effects (speculative).

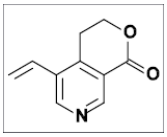
5.2 Interactions with Other Herbs / Herbal Constituents

Fenugreek seeds extract and garlic extract are less effective in the regulation of hyperthyroidism in rats than administrated independently.

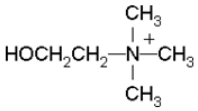
Constituents of *Trigonella foenum graecum*



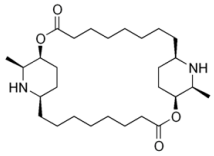
Trigonelline



Gentianine

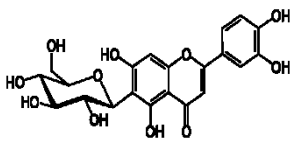


Choline

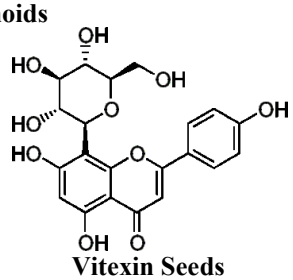


Carpaine

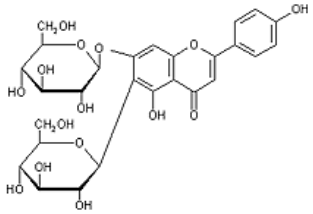
Flavonoids



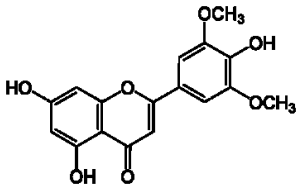
Homoorientin



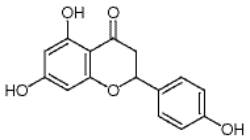
Vitexin Seeds



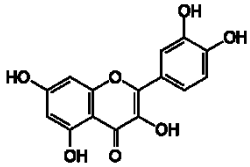
Saponaretin (Isovitexin),



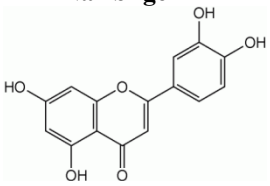
Tricin



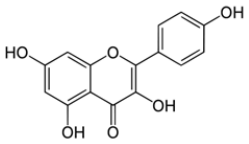
Naribngenin



Quercetin

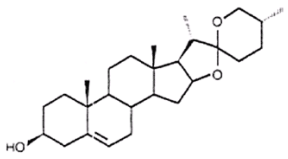


Luteolin

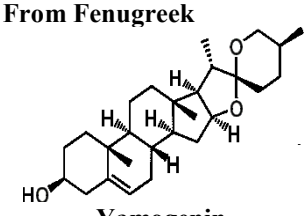


Kaempferol

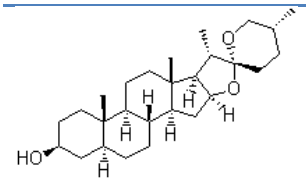
Steroid Saponins From Fenugreek



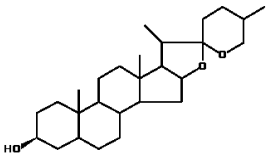
Diosgenin



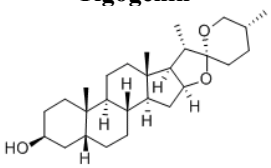
Yamogenin



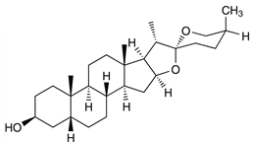
Tigogenin



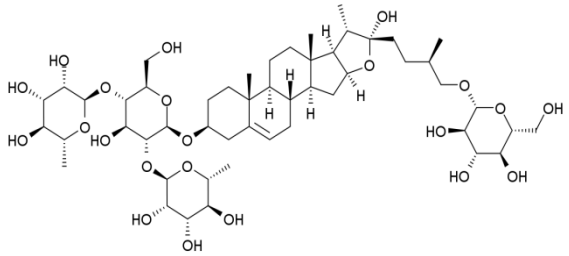
Neotigogenin



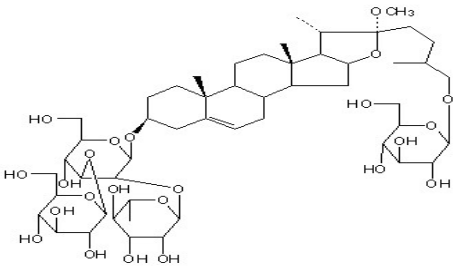
Smilagenin



Sarsasapogenin

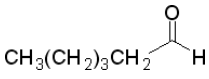


Protodioscin

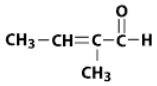


Methyl Protodioscin

Volatiles from Sicilian fenugreek
Carbonyl compounds

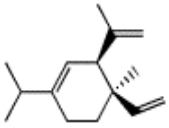


Hexanal

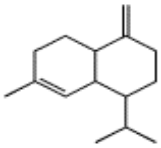


2-Methyl-2-Butenal

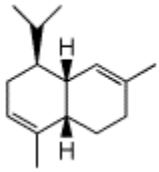
Sesquiterpene hydrocarbons



δ –Elemene

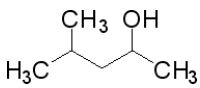


γ –Cadinene

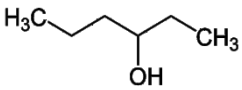


α-Muurolene

Alcohols



Pentanol



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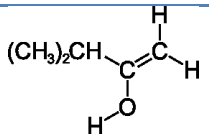
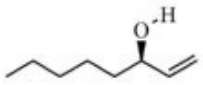
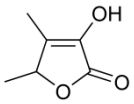


2-methyl-2buten-1-ol

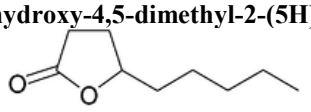


Octen-3-ol

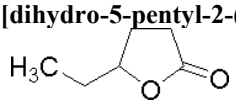
Hetrocyclics



Sotolon [3-hydroxy-4,5-dimethyl-2-(5H)-furanone]

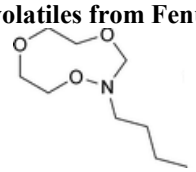


***Γ*-nonalactone [dihydro-5-pentyl-2-(5H)- furanone**

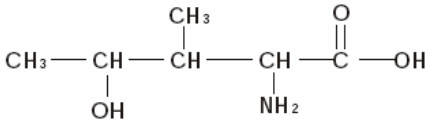


***Γ* -caprolactone[dihydro-5-ethyl-2-(3H)-furanon**

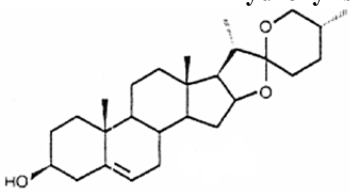
Non volatiles from Fenugreek



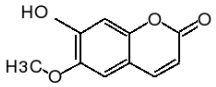
Trigoxazonane



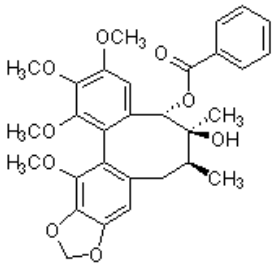
4-Hydroxy Isolucine



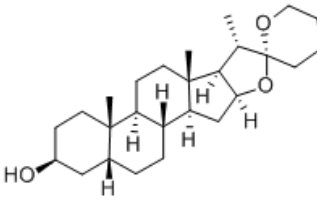
Scopoletin



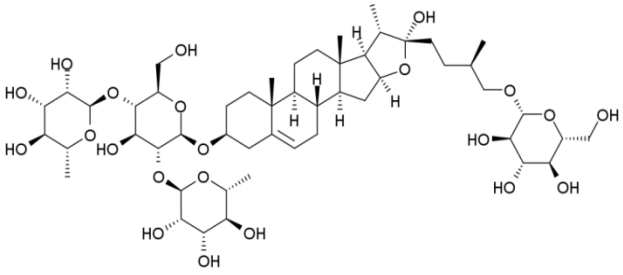
Diosgenin



***γ* –Schizandrin**

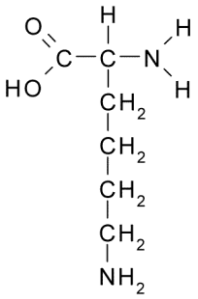


Smilagenin

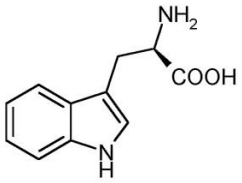


Protodiscin

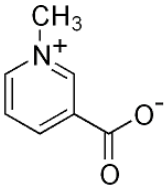
Protein



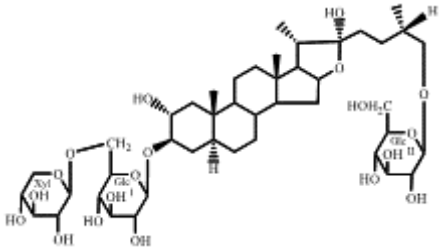
Lysine



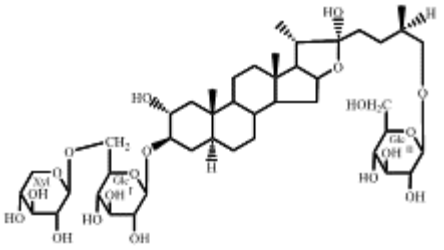
Tryptophan



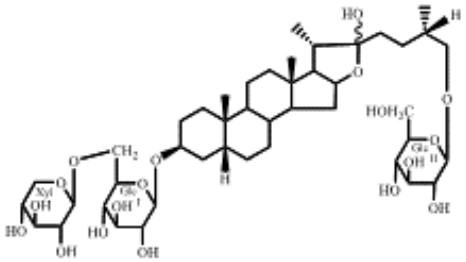
Trigonelline



Trigoneoside 1a



Trigoneoside lb



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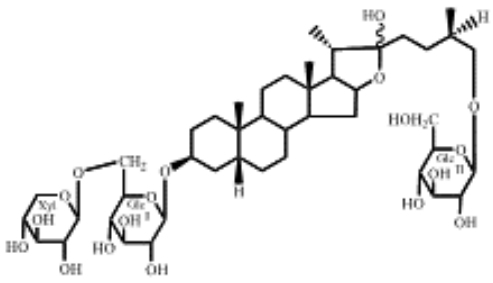
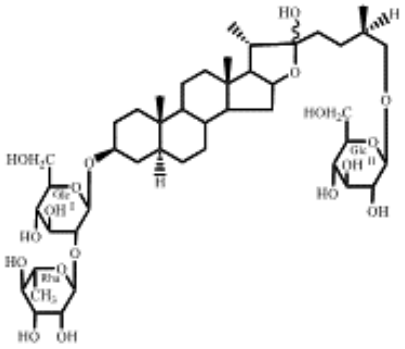
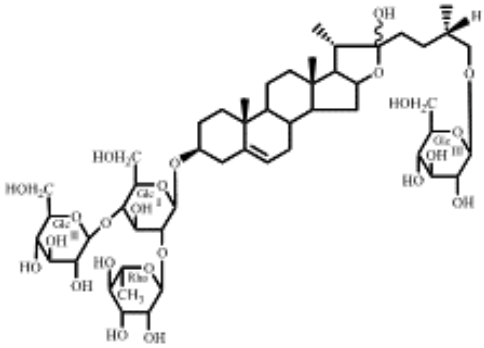


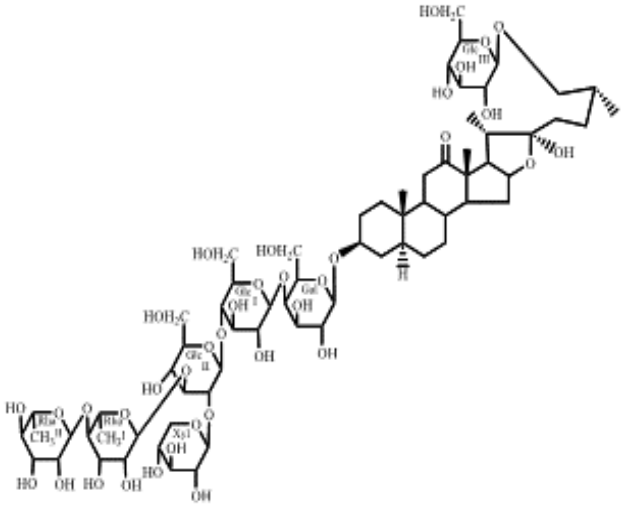
Trigoneoside IIb



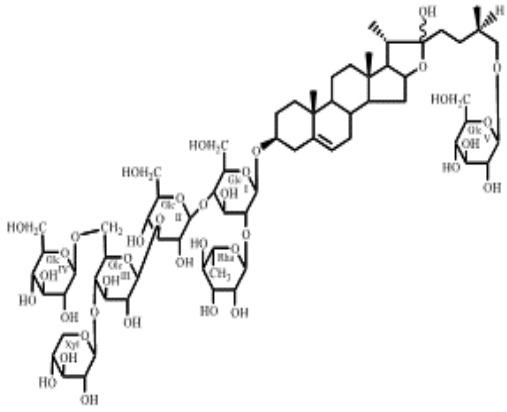
Trigoneoside IIIb



Trigoneoside IVa



Trigoneoside Va



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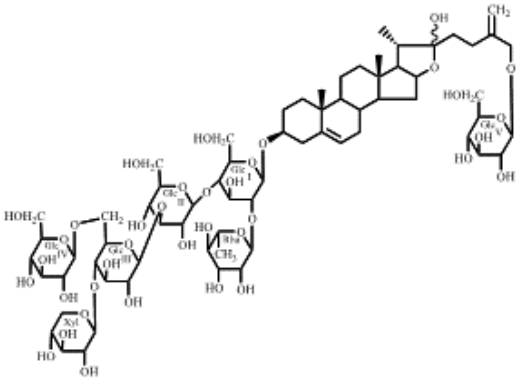

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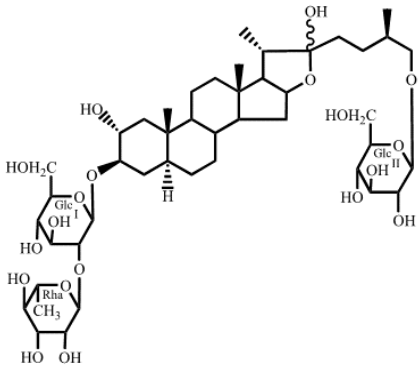

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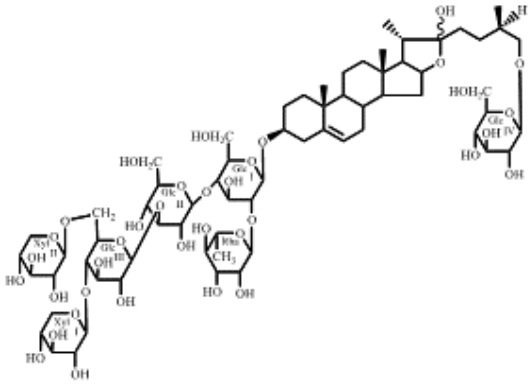

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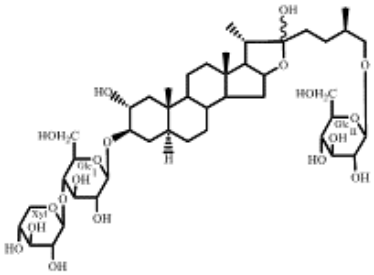

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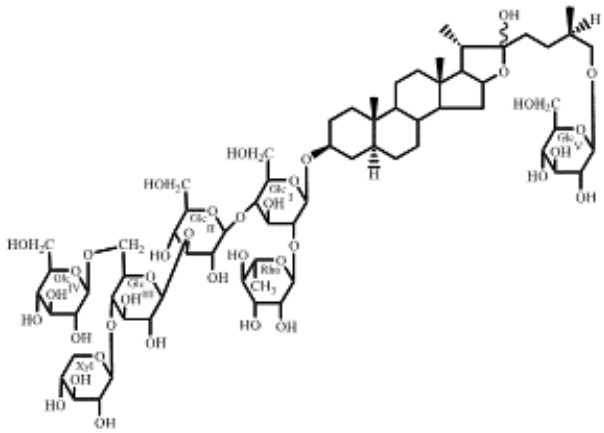

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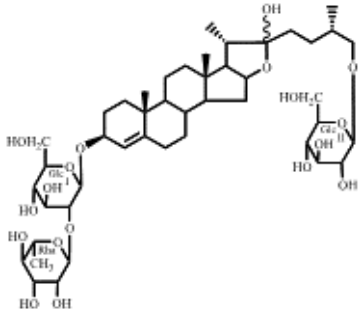
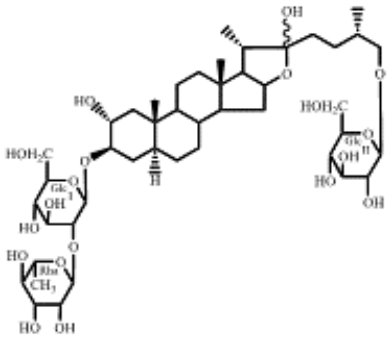


Trigoneoside XIIa



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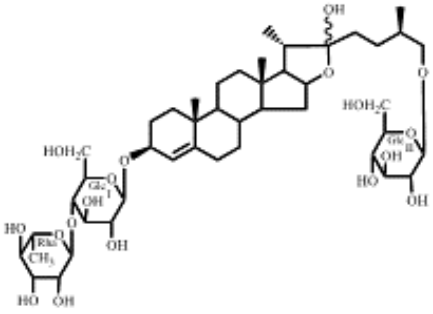
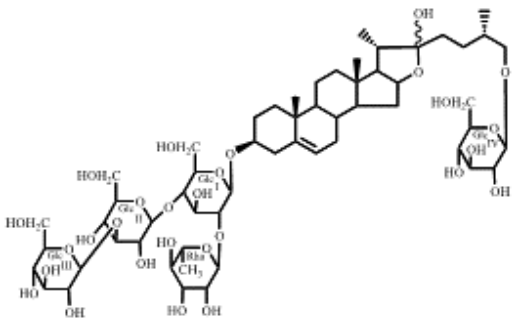


Trigoneoside XIIb



Trigoneoside XIIIa

References

[1]. Warrior, P.K, Nambiar, V.P.K. Indian Medicinal Plants, Orient Longman, 1995, pp.131.

[2]. Morton J.F. Mucilaginous plants and their uses in medicine. *J.Ethnopharm*.1990; 29: 215 – 266.

[3]. Wallis, T.E. Text book of Pharmacognosy, CBS Publication and Distributor New Delhi, 2005, pp. 224-225.

[4]. Nadkarni, A.K., Indian Materia Medica, Popular Praka-shan pvt. Ltd., Bombay, 1982, pp. 1240-1243.

[5]. Sharma R. D, Sarkar A, Hazra D. K, Misra B, Singh J. B., Maheshwari B. B. Toxicological Evaluation of Fenugreek Seeds: a Long Term Feeding Experiment in Diabetic Patients" *Phytotherapy Research* 1996; 10: 519–520.

[6]. Major herbs of Ayurveda. Elizabeth M. Williamson, Elsevier Science, Churchill Liv-ingstone, China, 2002; 315-320.

[7]. Morcos SR, Elhawary Z, Gabrial GN. Protein rich food mixtures for feeding the young in Egypt. 1. Formulation. *Z Ernahrungswiss,* 1981; 20: 275-282.

[8]. Yoshikawa M, Murakami T, Komatsu H, *et al*. Medicinal foodstuffs. IV. Fenugreek seed. (1): structures of trigoneosides Ia, Ib, IIa, IIb, IIIa, and IIIb, new furostanol saponins from the seeds of Indian Trigonella foenum-graecum L. *Chem Pharm Bull* (Tokyo), 1997; 45: 81-87.

[9]. Patil SP, Niphadkar PV, Bapat MM. Allergy to fenugreek (*Trigonella foenum graecum*), *Ann Allergy Asthma Immunol* 1997; 78: 297-300.

[10]. Syeda Birjees Bukhari, Muhammad Iqbal Bhanger and Shahabuddin Memon, Antioxidative Activity of Extracts from Fenugreek Seeds *Trigonella foenum-graecum, Pak. J. Anal. Environ. Chem*. 2008; 9 (2) 78-83.

[11]. Wan-Li Xue, Xuan-She Li, Jian Zhang, Yong-Hui Liu, Zhi-Lun Wang and Rui-Juan Zhang, Effect of *Trigonella foenum-graecum* (fenugreek) extract on blood glucose, blood lipid and hemorheological properties in streptozotocin-induced diabetic rats, *Asia Pac J Clin Nutr* 2007; 16 (Suppl 1): 422-426.

[12]. Ahmadiani A., Javan M., Semnanian, S., Barat, E. and Kamalinejad, M., Anti-inflammatory and antipyretic effects of *Trigonella foenum-graecum* leaves extract in the rat, *Journal of Ethnopharmacology* 2001: 75(2-3): 283-286.

[13]. Renuka C, Ramesh N. and Saravanan K. Evaluation of the antidiabetic effect of *Trigonella foenum-graecum* seed powder on alloxan induced diabetic albino rats, *International Journal of PharmTech Research*, 2009; 1 (4): 1580-1584.

[14]. Chandrashekhar D. Khadse, Rajendra B. Kakde, *In vitro* anthelmintic activity of Fenugreek seeds extract against *Pheritima posthuma, Int. J. Res. Pharm. Sci.* 2010; 1(3): 267-269.

[15]. Sharma, J.D. and Bhinda, Anjula, Antifertility Activity of Steroidal Extract of *Trigonella foenum-graecum* (seeds) in Female Rats, *Asian J. Exp. Sci.*, 2005; 19 (1): 115-120.

[16]. Nadya Mezzoug, Jamal Abrini, Andres Munoz Serano, Angeles Alonso-Moraga and Mohamed Idaomar, Study on antigenotoxic effects of moroccan medicinal plants and spices using the white/white+ somatic assay in drosophila, *Afr. J. Trad. CAM*, 2006, 3 (3): 22 – 31.

[17]. M. Palaniswamy, B. V. Pradeep, R. Sathya and J. Angayarkanni, In vitro anti-plasmodial activity of *Trigonella foenum–graecum* L., *eCAM* 2008, pp. 1 - 5.

[18]. S. Kaviarasan, G.H. Naik, R. Gangabhagirathi, C.V. Anuradha, K.I. Priyadarsini, In vitro studies on antiradical and antioxidant activities of fenugreek (*Trigonella foenum graecum*) seeds, *Food Chemistry* 2007; 103: 31–37.

[19]. Satish K. Verma, Santosh K. Singh, Abhishek Mathur, *In vitro* cytotoxicity of *Calotropis procera* and *Trigonella foenum graecum* against human cancer cell lines, *Journal of Chemical and Pharmaceutical Research,* 2010: 2(4):861-865.

[20]. Bhatia, K., Kaur, M., Atif, F., Ali, M., Rehman, H., Rahman, S., Raisuddin, S, Aqueous extract of *T. foenum-graecum* L. ameliorates additive urotoxicity of buthionine sulfoximine and cyclophosphamide in mice. *Food and Chemical Toxicology,* 2006; 44: 1744–1750.

[21]. Bin-Hafeez B, Haque R, Parvez S, Pandey S, Sayeed I, Raisuddin S., Immunomodulatory effects of fenugreek (*Trigonella foenum graecum* L.) extract in mice, *Int Immunopharmacol.* 2003; 3(2): 257-65.

[22]. Savita Vyas, Rajendra Prasad Agrawal, Pooja Solanki and Piyush Trivedi, analgesic and anti-inflammatory activities of *Trigonella foenum graecum* (seed) extract, *Acta Poloniae Pharmaceutical Drug Research*, 2008; 65 (4): 473-476.

[23]. Kapil G. Malviya, Mukesh W. Babhulkar, Prashant Y. Mali and Vinod D. Rangari, Evaluation of analgesic potential of *Trigonella foenum-graecum* (Fenugreek) seeds in rats by using tail flick method, *Journal of Pharmacy Research* 2010; 3 (7): 1680-1681.

[24]. Khanra Ritu, Chatterjee Atanu, Singh Bhupender Pal, Goel Ashutosh, Sen Kalyan, Antimicrobial activity of ethanolic extract of *Trigonella foenum graecum,*

International Research Journal of Pharmacy 2010: 181-183.

[25]. Wagh Pritee, Rai Mahendra, Deshmukh S K and Marta Cristina Teixeira Durate, Bio-activity of oils of *Trigonella foenum-graecum* and *Pongamia pinnata, African Journal of Biotechnology* 2007; 6 (13): 1592-1596.

[26]. Rohini R. M., Nayeem N. & DasA. K. Diuretic effect of *Trigonella foenum graecum* seed extracts. *The Internet Journal of Alternative Medicine*. 2009; 6 (2).

[27]. Neveen Helmy Abou El-Soud, M.Y. Khalil, J.S. Hussein, F.S.H. Oraby and A.R. Hussein Farrag, Antidiabetic Effects of Fenugreek Alkaliod Extract in Streptozotocin Induced Hyperglycemic Rats, *Journal of Applied Sciences Research*, 2007; 3(10): 1073-1083.

[28]. Datta Debranjan, Shanbagh Tara, a study of anti-inflammatory activity of alcoholic extract of seeds of *Trigonella foenum graecum* (fenugreek) on wister strain rat, *International Journal of Pharma Research and Development*, 2010; 2: 81-86.

[29]. S. Kaviarasan, G.H. Naik, R. Gangabhagirathi, C.V. Anuradha, K.I. Priyadarsini, In vitro studies on antiradical and antioxidant activities of fenugreek (*Trigonella foenum graecum*) seeds, *Food Chemistry* 2007; 103: 31–37.

[30]. S. Sreeja, V.S. Anju & S. Sreeja, In vitro estrogenic activities of fenugreek *Trigonella foenum graecum* seeds, *Indian J Med Res* 2010; 131: 814-819.

[31]. Pandian R Suja, Anuradha CV and Viswanathan P, Gastroprotective effect of fenugreek *Trigonella foenum-graecum* seeds, on experimental gastric ulcer in rats, *J Ethnopharmacol*, 2002; 81(3): 393-397.

[32]. Radha Moorthy, KM Prabhu & PS Murthy, antihyperglycemic compound from fenugreek seeds, its purification and effect in diabetes mellitus, *Indian Journal of Experimental Biology*, 2010; 48: 1111-1118.

[33]. Urmila Aswar, V Mohan, SL Bodhankar, Effect of trigonelline on fertility in female rats, *International Journal of Green Pharmacy*, 2009, 3(3): 220-223.

[34]. Wan-Li Xue, Xuan-She Li, Jian Zhang, Yong-Hui Liu, Zhi-Lun Wang and Rui-Juan Zhang, Effect of *Trigonella foenum-graecum* (fenugreek) extract on blood glucose, blood lipid and hemorheological properties in streptozotocin-induced diabetic rats, *Asia Pac J Clin Nutr* 2007;16 (Suppl 1):422-426.

[35]. Javan M, Ahmadiani A, Semnanian S, Kamalinejad M. (1997) antinociceptive effects of *Trigonella foenum-graecum* leaves extract. J ethnopharmacol. 58(2): 125-9.

[36]. Amr Amin, Aysha Alkaabi, Shamaa Al-Falasi and Sayel A. Daoud, Chemopreventive activities of *Trigonella foenum graecum* (Fenugreek) against breast cancer, *Cell Biology International* 2005, vol. 29(8), pp. 687-694.

[37]. Javan M, Ahmadiani A, Semnanian S, Kamalinejad M. (1997) antinociceptive effects of *Trigonella foenum-graecum* leaves extract. J ethnopharmacol. 58(2): 125-9

[38]. Jain SC, Lohiya NK, Kapoor A 1987 *Trigonella foenum-graecum* Linn.-a hypoglycemic agent. Indian Journal Of Pharmaceutical Science May-June:113

[39]. Wan-Li Xue, Xuan-She Li, Jian Zhang, Yong-Hui Liu, Zhi-Lun Wang and Rui-Juan Zhang, Effect of *Trigonella foenum-graecum* (fenugreek) extract on blood glucose, blood lipid and hemorheological properties in streptozotocin-induced diabetic rats, *Asia Pac J Clin Nutr* 2007;16 (Suppl 1):422-426.

[40]. Neeraj A, Rajyalakshmi P. Hypoglycemic effect of processed Fenugreek seeds in humans. Journal of Food Science and Technology 1996; 33(5): 427.

[41]. Renuka C, Ramesh N. and Saravanan K. Evaluation of the antidiabetic effect of *Trigonella foenum-graecum* seed powder on alloxaninduced diabetic albino rats, *International Journal of PharmTech Research*, 2009; 1 (4): 1580-158.

[42]. Jamal Ahmed Abdel-Barry, Mohammad H.H. Al-Hakiem, Acute intraperitoneal and oral toxicity of the leaf glycosidic extract of *Trigonella foenum-graecum* in mice, *Journal of Ethnopharmacology* 2000; 70: 65–68.

[43]. Bin-Hafeez B, Haque R, Parvez S, Pandey S, Sayeed I, Raisuddin S., Immunomodulatory effects of fenugreek (*Trigonella foenum graecum* L.) extract in mice, *Int Immunopharmacol.* 2003; 3(2): 257-65.

[44]. Syeda Birjees Bukhari, Muhammad Iqbal Bhanger and Shahabuddin Memon, Antioxidative Activity of Extracts from Fenugreek Seeds *Trigonella foenum-graecum, Pak. J. Anal. Environ. Chem.* 2008; 9 (2):78-83.

[45]. Fedelic Ashish Toppo, Aachna Akhand, dr. A.K. Pathak, pharmacological actions and potential uses of *Trigonella foenum-graecum*: a review, *Asian Journal of Pharmaceutical and Clinical Research* 2009; 2 (4): 29-38.

[46]. S. Kaviarasan, G.H. Naik, R. Gangabhagirathi, C.V. Anuradha, K.I. Priyadarsini, In vitro studies on antiradical and antioxidant activities of fenugreek (*Trigonella foenum graecum*) seeds, *Food Chemistry* 2007; 103: 31–37.

[47]. Subramanian Kaviarasan, Nalini Ramamurty, Palani Gunasekaran, Elango Varalakshmi and Carani Venkatraman Anuradha, fenugreek (*Trigonella foenum graecum*) seed extract prevents ethanol-induced toxicity and apoptosis in chang liver cells, *Oxford Journals Medicine Alcohol and Alcoholism* 2006; 41(3): 267-273.

[48]. Satish K. Verma, Santosh K. Singh, Abhishek Mathur, *In vitro* cytotoxicity of *Calotropis procera* and *Trigonella foenum graecum* against human cancer cell lines, *Journal of Chemical and Pharmaceutical Research*, 2010; 2(4): 861-865.

[49]. Chen, Y. C., Shen, S.C., Lin, H.Y., Rutinoside at C7 attenuates the apoptosis-inducing activity of flavonoids. *Biochem Pharmacol* 2003; 66:1139-50.

[50]. Ahmad, N., Gupta, S., Mukhtar, H., Green tea polyphenol epigallocatechin – 3 – gallate differentially modulates nuclear factor kappa B in cancer cells versus normal cells. *Arch Biochem Biophys* 2000; 376:338.

[51]. Yang, G., Liao, J., Kim, K., Yurkow, E., Yang, C; Inhibition of growth and induction of apoptosis in human cancer cell lines by tea polyphenols. *Carcinogenesis* 1998; 19:611.

[52]. VanFurt, R; Current view on the mononuclear phagocyte system. *Immunobiology* 1982; 161: 178-85.

[53]. Natarajan B., Muralidharan A., R. Sat. Muralidharan, Satish R., Dhananjayan R. Neuropharmacological activity of *Trigonella foenum graecum* Linn. seeds *Journal of Natural Remedies,* 2007; 7/1: 160-165.

[54]. Chandrashekhar D. Khadse, Rajendra B. Kakde, *In vitro* anthelmintic activity of Fenugreek seeds extract against *Pheritima posthuma, Int. J. Res. Pharm. Sci.* 1, Issue-3, 267-269, 2010.

[55]. Palaniswamy M., Pradeep B. V., Sathya R. and Angayarkanni J., *In vitro* anti-plasmodial activity of *Trigonella foenum*–graecum L. *eCAM* 2008: 1 - 5.

[56]. Navayath Sushma & Thiyagarajan Devasena, Aqueous extract of *Trigonella foenum graecum* (fenugreek) prevents cypermethrin-induced hepatotoxicity and nephrotoxicity, *Hum Exp Toxicol*, 2010; 29: 311-319.

[57]. Taranalli A.D, Kuppast I. J, Study of Wound Healing Activity of Seeds of *Trigonella foenum graecum* in Rats, *Indian Journal of Pharmaceutical Sciences* 1996; 58(3): 117-119.

[58]. Chaitanya Sravanthi K, Sarvani Manthri, Srilakshmi S, Ashajyothi V, wound healing herbs – a review, *International Journal Of Pharmacy & Technology*, 2010; 2 (4): 603- 624.

[59]. Mazza G., Oomah B.D, Chemistry and pharmacology of fenugreek, in Herbs, Botanicals and Teas, eds. 2000, Technomic Publishing Co., Lancaster, USA.

[60]. Abdel-barry JA, Abdel-hassan IA, Jawad AM, Al-hakiem MH. Hypoglycaemic effect of aqueous extract of the leaves of *Trigonella foenum graecum* in healthy volunteers. *East Mediterr Health J*. 2000; 6(1): 83-8.

[61]. Zia, T., Siddiqui, I. A. and Nazrul-Hasnain, Nematicidal activity of *Trigonella foenum-graecum* L. *Phytotherapy Research*, 2001; 15: 538–540.

[62]. LokeshR. , Leonard Barnabas E. , Madhuri P., Saurav K. and SundarK. Larvicidal Activity of *Trigonella foenum graecum* and *Nerium oleander* Leaves Against Mosquito Larvae Found in Vellore City, India, *Current Research Journal of Biological Sciences* 2010; 2(3): 154-160.

[63]. Sadhukhan B, Roychowdhury U, Banerjee P, Sen S., Clinical evaluation of a herbal antidiabetic product, *J Indian Med Assoc.* 1994; 92(4):115-7.

[64]. "The Ayurvedic Pharmacopoeia of India", Part- I, volume II, First edition, Govt. of India Ministry of health Education, Page No. 107-108.

[65]. "The Wealth of India-A Dictionary of Indian Raw Materials and Industrial Procedures", National Institute of Science and Communication, Council of scientific and Industrial Research, New Delhi, India, 1998, Vol. X:Sp-W, Page No.299-30.

[66]. Solomon Genet, Kale, R.K. and Baquer, N.Z. (1999) Effect of vanadate, insulin and fenugreek (*Trigonella foenum-graecum*) on creative kinase level in tissues of diabetic rat. *Indian Journal of Experimental Biology* 37(2): 200–202.

[67]. Sudar Olli, Lalitha Guruprasad and P. B. Kirti, Characterization of defensin (Tfgd2) from *Trigonella foenum-graecum, Current Science*, 2007; 93: 3: 10: 365-368.