

Fenugreek (*Trigonella foenum-graecum* L.) and its necessity [Review Paper]

Budhaditya Ghosh, Indrani Chandra*, Sabyasachi Chatterjee

Department of Biotechnology

The University of Burdwan, West Bengal, India.

Introduction

Trigonella foenum-graecum L. (Fenugreek) commonly known as methi (in Hindi) has been used as a culinary spice, a flavoring agent and as a medicinal plant from ancient time. Fenugreek is a leguminous, herbaceous, rainfed crop included among the seed spices is about 30-60 cm tall, leaflets are about 2-2.5 cm long, flowers are 1-2 cm long, axillary, sessile and cultivated throughout the country. Among the spices, the Fenugreek is used as esoteric food adjacent to enhance the flavor and colour of the food and make it tasty and also used to modify the texture of food.

Therapeutic utility indicates a plant as medicinal plant. Today Medicinal plants are found to use in different traits like pharmaceuticals, nutraceuticals, cosmetics and food supplements etc. Not only that, they are also used as traditional sources of medicine. Among the list of those important medicinal plants, Fenugreek is one of them. The seeds and plants are basically hot and dry and also they are suppurative, aperient, and diuretic. They have some useful aspect in dropsy, chronic cough, enlargement of the liver and the spleen. The leaves of Fenugreek is useful for both internal and external swellings and burns and also used to prevent the hair falling off (yunani)(Kritikar *et al.*,1991, Prajapati *et al.*,2003) . The seeds are considered as carminative, tonic and aphrodisiac. Fenugreek is used to ease child birth as well as it helps to increase the milk flow of mother. Egyptian women are still taking Fenugreek for menstrual pain and tourist use it as hilba tea to remove stomach problem. Not only that the plant is also recommended for use in dyspepsia with loss of appetite, in diarrhoea of puerperal women, and in rheumatism (Kritikar *et al.*,1991, Prajapati *et al.*,2003). An infusion of seeds is given to small-pox patients as a cooling drink (Kritikar *et al.*,1991). Fenugreek seed contains various bioactive compounds like flavonoids (quercetin, rutin, vetexin), saponins (graecunins, fenugrin B, Fenugreekine), amino acids (isoleucine, 4-hydroxyisoleucine, histidine, leucine, lysine). As medicinal plant it shows its activity against allergies, appetite / loss of catarrh, bronchial, cholesterol, diabetic retinopathy, gas, gastric disorders, lung infections, mucus excessive, throat/sore, abscesses, anemia, asthma, boils, body odour, bronchitis, cancer, swollen eyes, fevers, gallbladder problems, heartburn, inflammation, sinus problems, ulcers, uterine problems etc. A study in India showed that Fenugreek seed is used to reduce the blood sugar and other harmful fats. Not only therapeutic, Fenugreek also used as spices worldwide. The leaves are used as green leafy vegetables in the diet. Fenugreek seeds are bitter in taste and have been in use for over 2500 years. Fenugreek is a leguminous herb belonging to fabaceae, cultivated throughout the world specially in the Asia and North African countries. In different languages it has different names, as *Fenugrec* (French), *Methi* (Hindi), *Bockshorklee* (German), *Fienogreco* (Italian), *Pazhitnik* (Russian), *Alholva* (Spanish), *Koroha* (Japanese), *Hulba* (Arabian), *Halba* (Malaya), and *K'u-Tou* (China). India is the major producer of Fenugreek and its main consumers are culinary and medicinal users. In the indigenous system, it is effective against anorexia, and as gastric stimulant.

Scientific Classification

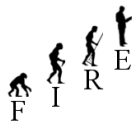
Kingdom: Plantae

Division: Magnoliophyta

Class: Magnoliopsida

Order: Fabales

Family: Fabaceae



Genus: *Trigonella*

Species: *foenum-graecum*

Bionomial name: *Trigonella foenum-graecum*

Morphology of Seed

1. **Appearance:** Solid- rhomboidal seeds, 3 to 5 mm long, 2 mm thick. Hard, pebble-like.
2. **Colour:** Yellowish brown or light brown.
3. **Odour:** Spicy.
4. **Taste:** Bitter.

Phytochemical Constituents

The main chemical components of *Trigonella foenum-graecum* are fibers, flavonoids, polysaccharides, saponins, fixed oils and some identified alkaloids (Mohammad *et al.*,2006, Amin *et al.*,2005). Mature seeds mainly contain amino acid, fatty acid, vitamins, saponins and a large quantity of folic acid (84mg/100g). It also contains disogenin, gitogenin, neogitogenin, homorientin saponaretin, neogigogenin, and trigogenin that are listed below (Kim su ji *et al.*,2006, Mohammad *et al.*,2006). The endosperm of the seed is rich with galactomannan. The young seeds mainly contain carbohydrates.

Beneficial aspects of Fenugreek

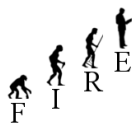
Fenugreek seeds are rich with vitamin E. Fresh Fenugreek leaves are beneficial for indigestion, flatulence and in sluggish liver treatment. Regular use of fresh Fenugreek leaves paste helps hair grow, preserves natural color, keeps hair silky and also cures dandruff. Fenugreek Seeds made in gruel, are given to nursing mothers to increase the flow of milk and also reduce the amount of calcium oxalate in the kidney which causes kidney stones. In animal studies, Fenugreek appeared to lowering the chance of developing colon cancer by blocking the action of certain enzymes. Traditional Chinese herbalists used Fenugreek for kidney problems. Fenugreek is currently used as a source of the steroid diosgenin , one of its active constituent from which other steroids can be synthesized. Not only that Fenugreek has a broad range of pharmacological profile but also it has antidiabetic activity, antiplasmodic activity, hypolipidemic activity, immunological activity, antibacterial activity, anthelmintic activity, anti-inflammatory, analgesic activity and antioxidant activity (Yadav *et al.*,2011).

Propagation through Tissue Culture

Tissue culture of Fenugreek is necessary for either plant regeneration or for the production of secondary products of economic interest. Among the products, diosgenin and trigonelline have higher therapeutic properties. It has been analyzed and compared by studying the accumulation of diosgenin during different stages of growth of leaf, shoot apical meristem, root apical meristem, callus cultured with different concentrations of 2,4-dichloro-phenoxyacetic acid (2,4-D) and the result indicates that the level of diosgenin is increased about 30% than source plant. In another study it was reported that callus induction of *Trigonella foenum-graecum* L. in MS medium supplemented with 2.0 mg L⁻¹ NAA was better and thus may be utilized for faster growth of Fenugreek and hence metabolites production (Bashri *et al.*,2013) .

Urotoxic Activity

Cyclophosphamide (CP) is commonly used as an anti-cancer drug which has toxic effect to its reactive metabolites. The study of toxicity caused by the exposure to CP and L-buthionine-SR-sulfoximine (BSO) by Fenugreek extract was evaluated by measuring lipid peroxidation (LPO) and anti-oxidants in urinary bladder in mice. Fenugreek, a medicinal herb, showed protective effect not only on LPO but also on the enzymatic



anti-oxidants. Cyclophosphamide treated animals showed a significant decrease in the activities of glutathione S-transferase (GST), glutathione reductase (GR), glutathione peroxidase (GP) and catalase (CAT) on respect to the controls. Pre-treated Fenugreek extract restored activities of all the enzymes and thus showed an overall protective effect on additive effect of CP and BSO (Bhatia *et al.*,2005).

Chemo Preventive or Antitumor activity

Cancer is the second leading cause of death worldwide. Fenugreek seed extract showed potential protective activity against 7, 12-dimethylbenz (a) anthracene (DMBA)-induced breast cancer in rats at 200 mg/kg. Fenugreek seed extract significantly inhibited the DMBA-induced mammary hyperplasia and decreased its incidence. Epidemiological study stated a mechanism that implicates apoptosis which also might mediate the Fenugreek's antibreast cancer effects (Amin *et al.*,2005).

Anticancer Activity

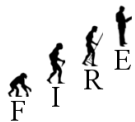
Apoptosis is a type of cell death. It was identified in previous studies that Flavonoids produced several biological effects, as apoptosis inducing activity and all (Chen *et al.*,2003). Flavonoids and catechins were first shown to be apoptotic in human carcinoma cells (Ahamed *et al.*,2000). Similar observation has since been extended to lung tumor cell lines (Valette *et al.*,1984), colon cancer cells, breast cancer cells, prostate cancer cells (Hannan *et al.*,2003), stomach cancer cells (Zia *et al.*,2001), brain tumor cells, head and neck squamous carcinoma (Ramesh *et al.*,2004) and cervical cancer cells (Mishkinsky *et al.*,1967), and it was also published that other food flavonoids inhibits carcinogenesis in animal models. They all induce apoptosis in tumor cells (Puri *et al.*,2002, Devi *et al.*,2003, Thakran *et al.*,2003). Fenugreek extract has also been shown to have stimulatory effects on macrophages. The present study establishes that Fenugreek has appreciable anti-cancer activity. Through it is not possible to identify the most effective anti-cancer constituent of Fenugreek at this point but based on the published studies, flavonoids seem to be most favourable for eliciting anti-tumorigenic effect.

Antidiabetic Influence

It has been well recognized that dietary fiber offers substantial benefits to persons with diabetes mellitus. The mechanism of Fenugreek action in human is not properly understood but animal studies have revealed the ability of dietary fiber to delay gastric emptying, suppress release of the gastric inhibitory peptides and insulinotropic hormones (Srinivasan *et al.*,2005). Several researchers reported that treatment with a decoction of Fenugreek seed improved diabetes and suppressed glycosuria in mild diabetes and brought improvement in severe diabetic condition (Srinivasan *et al.*,2005). Fenugreek contains fiber to an extent of 51.7%, containing 19.2% mucilaginous fiber, and 32.5% neutral fiber, respectively. It also contains an alkaloid named trigonelline, which has an effect on glycosuria. National Institute of Nutrition, India have demonstrated the beneficial effect of Fenugreek in both type-1 and type-2 diabetes with the help of different clinical trials on animals. There are so many reports available on the antidiabetic property of Fenugreek seeds, listed below. The observations have been made in diabetic rats (Shami *et al.*,1974, Madar *et al.*,1984, Amin *et al.*,1988, Nahar *et al.*,1992, Khosla *et al.*,1995, Raju *et al.*,2001), in diabetic mice (Ajabnoor *et al.*,1988), in diabetic rabbits (Jain *et al.*,1987, Moorthy *et al.*,1989) and in diabetic dogs (Ribes *et al.*,1984) and revealed a beneficial hypoglycemic effects because of Fenugreek seeds .

Cholesterol-lowering Effects

Cholesterol and fecal bile acid excretion are increased by Fenugreek. A reaction between bile acid and Fenugreek derived saponin is responsible for the formation of too large micelles in the digestive tract to absorb. Another hypothesis attributes the cholesterol lowering where the fiber-rich gum portion of seed reduces the



rate of hepatic synthesis of cholesterol. It is likely that both mechanisms contribute the overall effect (Yadav *et al.*,2011).

Antioxidant Effect

Scientist evaluated that polyphenol-rich extract of Fenugreek seed have potential effect against hydrogen peroxide (H₂O₂) - induced oxidation in normal and diabetic human erythrocytes (RBCs) (Yadav *et al.*,2011).

Antimicrobial Activity

The leaf and seed extract with different organic solvents were found effective against various bacteria like *Escherichia coli*, *Salmonella typhi* and *Staphylococcus aureus* and fungus like *F. oxysporum* f. sp. *lycopersici* (FOL) and *F. oxysporum* f. sp. *radicis-lycopersici* (FORL) etc (Yadav *et al.*,2011 and Omezzine *et al.*,2014).

Analgesic Activity

Aqueous and methanolic extract of Fenugreek seed showed a potential analgesic activity by using tail flick method in comparison to established an analgesic drug as diclofenac potassium (Yadav *et al.*,2011).

Potential Danger

Except that Fenugreek has some side effect too as it may increase the risk of bleeding, may reduce potassium levels in the blood, may cause loose stools in some women, facial swelling, breathing difficulty. Not only that it can produce uterine contractions, hypoglycemia in some mothers etc (Yadav *et al.*,2011).

Conclusion

Fenugreek is used as spices for preparation of various dishes as well as to cure many diseases. *Trigonella foenum graecum* established itself as a medicinal plant due to its different activities such as anticancer, anti-inflammatory, antiseptic, aphrodisiac, astringent, bitter, demulcent, emollient, expectorant, anthelmintic, wound healing and gastro protective. Not only that it is one of the primary supplement used for type II diabetics or noninsulin-dependent diabetes mellitus (NIDDM). Fenugreek is not only a very rich source of polysaccharide galactomannan but also it is the source of saponins such as diosgenin, yamogenin, gitogenin, tigogenin, and neotigogenins. It also contains flavonoids, amino acid, alkaloids and other bioactive constituents like mucilage, volatile oils etc. Not only valuable activities, it has some side effects too as it may increase the risk of bleeding, may reduce the potassium levels in the blood, numbness, facial swelling, breathing problem and fainting like a cause of an allergic reaction, and also dizziness, diarrhoea and gastric problems. The consumption of Fenugreek has been proved safe for human life and may be easily implemented for health benefit, through its rich fiber content and other bioactive components. Fenugreek seed helps not only to reduce the low density cholesterol and triacylglycerol but also used to reduce blood sugar level with its high concentration of phytochemicals.

Alkaloides	Trimethylamine, Neurin, Trigonelline, Choline, Gentianine, Carpaine and Betain.
Amino acids	Isoleucine, 4-Hydroxyisoleucine, Histidine, Leucine, lysine, L-tryptophan, Argenine.
Fibers	Gum, neutral detergent, fiber.
Flavonoids	Quercetin, rutin, vetixin, isovetixin.
Saponins	Graecunins, fenugrin B, Fenugreekine, trigofenosides A-G.
Steroidal saponogens	Yamogenin, diosgenin, smilagenin, sarsapogenin, tigogenin, neotigogenin, gitogenin, neogitogenin, yuccagenin,saponaretin.
Other	Coumarin, lipids, vitamins, 28% mucilage, 22 % proteins, 5 % of a stronger-swelling, bitter fixed oil.

Table 1. List of Phytochemical constituents present in Fenugreek.

Animal model	Effect demonstrated	Reference
Rats		
1) Diabetic rats	Hypoglycemic action of trigonelline.	Mishkinsky <i>et. al.</i> , 1967
2) Normal & Diabetic rats	Mild hypoglycemic effect.	Shami <i>et. al.</i> , 1974
3) Diabetic rats	Improved glucose tolerance .	Madar <i>et. al.</i> , 1984
4) Normal & Diabetic rats	Prevention of diabetes induction.	Amin <i>et. al.</i> , 1988
5) Normal & Diabetic rats	Hypoglycemic effect.	Nahar <i>et. al.</i> , 1992
6) Normal & Diabetic rats	Hypoglycemic effect.	Khosla <i>et. al.</i> , 1995,
7) Normal & Diabetic rats	Hypoglycemic effect.	Khosla <i>et. al.</i> , 1995,
8) Normal & Diabetic rats	Prevented increase in glucose during glucose tolerance test.	Khosla <i>et. al.</i> , 1995,
9) Normal & Diabetic rats	Anti-hyperglycemic effect of Fenugreek leaves.	Raju <i>et. al.</i> , 2001
10) Diabetic rats	Modulation of activities of gluconeogenic enzymes.	Raju <i>et. al.</i> , 2001
11) Diabetic rats	Modulation of activities of gluconeogenic glycolytic & lipogenic enzymes.	Raju <i>et. al.</i> , 2001
12) Diabetic rats	Hypoglycemic effect of alcoholic extract.	Devi <i>et. al.</i> , 2003
13) Diabetic rats	Fenugreek leaves countered hyperglycemia, hypoinsulinemia and glycated hemoglobin.	Devi <i>et. al.</i> , 2003
14) Diabetic rats	Orally administered sdf lowered serum fructoseamine, triglycerides, cholesterol.	Thakran <i>et. al.</i> , 2003
15) Diabetic rats	Restoration of the activities of enzymes of carbohydrate metabolism.	Thakran <i>et. al.</i> , 2003
16) Diabetic rats	Prevention of rise in fasting blood glucose by defatted seeds.	Thakran <i>et. al.</i> , 2003
17) Diabetic rats	Hypoglycemic effect of galactomannan-enriched endosperm	Ramesh <i>et. al.</i> , 2004

	fraction.	
Mice		
18) Normal/Diabetic mice	Hypoglycemic effect of decoction and ethanolic extract.	Ajabnoor <i>et. al.</i> , 1988
19) Normal mice	Hypoglycemic effect of aqueous/methanolic extract.	Zia <i>et. al.</i> , 2001
Rabbits		
20) Normal Rabbits	Hypoglycemic effect of fibre and saponin fraction.	Jain <i>et. al.</i> , 1987
21) Diabetic Rabbits	Isolation of hypoglycemic principle and its effectiveness.	Moorthy <i>et. al.</i> , 1989
22) Diabetic Rabbits	Improved glucose tolerance, Increased insulin levels, hypolipidemic effect.	Moorthy <i>et. al.</i> , 1989
23) Diabetic rabbits	Lowered fasting blood glucose and higher insulin secretion.	Puri <i>et. al.</i> , 2002
Dog		
24) Normal/Diabetic dogs	Defatted fraction hypoglycemic.	Ribes <i>et. al.</i> , 1984

Table 2. Effectiveness of Fenugreek (*Trigonella foenum-graecum* L.) on diabetes mellitus in animal studies



Fig 1. Fenugreek Plant



Fig 2. Fenugreek Seeds

Reference

1. Ahmad, N., Gupta, S., Mukhtar, H., 2000, "Green tea polyphenol epigallocatechin - 3 - gallate differentially modulates nuclear factor kappa B in cancer cells versus normal cells". Arch Biochem Biophys., 376, pp.338-346.
2. Ajabnoor, M.A., Tilmisany, A.K., 1988, "Effect of *Trigonella foenum-graecum* on blood glucose levels in normal and alloxan diabetic mice." J. Ethnopharmacol., 22, pp.45-49.
3. Amin Riyad, M., Abdul Ghani, Abdul Salam, S., Suleiman, S.M., 1988, "Effect of Fenugreek and lupine seeds on the development of experimental diabetes in rats." Planta Medica., 54, pp.286-290.
4. Amr Amin, Aysha Alkaabi , Shamaa Al-Falasi, Sayel, A. Daoud., 2005, "Chemopreventive activities of *T. foenum-graecum* (Fenugreek) against breast cancer Emirates." Cell Biology International., 29, pp.687-694.
5. Bhatia, K., Kaur, M., Atif, F., Ali, M., Rehman, H., Rahman, S., Raisuddin, S; 2005, "Aqueous extract of *T. foenum-graecum* L. ameliorates additive urotoxicity of buthionine sulfoximine and cyclophosphamide in mice". Food and Chemical Toxicology., 44 (2006), pp.1744-1750.

6. Chen, Y.C., Shen, S.C., Lin, H.Y., 2003, "Rutinoside at C7 attenuates the apoptosis-inducing activity of flavonoids." *Biochem Pharmacol.*, 66, pp.1139-50.
7. Devi, B.A., Kamalakkannan, N., Prince, P.S., 2003, "Supplementation of Fenugreek leaves to diabetic rats. Effect on carbohydrate metabolic enzymes in diabetic liver and kidney". *Phytother. Res.*, 17, pp.1231-1233.
8. Faten Omezzine, Mohamed Bouaziz, Mejda Daami-Remadi, Monique S.J. Simmonds, Rabiaa Haouala, 2014, "Chemical composition and antifungal activity of *Trigonella foenum-graecum* L. varied with plant ploidy level and developmental stage". *Arabian Journal of Chemistry.*, <http://dx.doi.org/10.1016/j.arabjc.2014.03.013>.
9. Gausiya Bashri , Vijay Pratap Singh and Sheo Mohan Prasad., 2013, "A Review on Nutritional and Antioxidant Values, and Medicinal Properties of *Trigonella foenum-graecum* L." *Biochemistry & Pharmacology.*, <http://dx.doi.org/10.4172/2167-0501.1000118>.
10. Genet, S., Kale, R.K., Baquer, N.Z., 2002, "Alterations in antioxidant enzymes and oxidative damage in experimental diabetic rat tissues: effect of vanadate and Fenugreek (*Trigonella foenum-graecum*)." *Mol. Cell. Biochem.*, 236, pp.7-12.
11. Hannan, J.M., Rokeya, B., Faruque, O., Nahar, N., Mosihuzzaman, M., Azad Khan, A.K., Ali, L., 2003, "Effect of soluble dietary fiber fraction of *Trigonella foenum-graecum* on glycemic, insulinemic, lipidemic and platelet aggregation status of Type 2 diabetic model rats". *J. Ethnopharmacol.*, 88, pp.73-77.
12. Jain, S.C., Lohiya, N.K., Kapoor, A. 1987, "*Trigonella foenum-graecum* Linn: A hypo-Glycaemic agent". *Indian J. Pharm. Sci.*, 49, pp.113-114.
13. Khosla, P., Gupta, D.D., Nagpal, R.K., 1995, "Effect of *Trigonella foenum-graecum* (Fenugreek) on blood glucose in normal and diabetic rats." *Indian J. Physiol. Pharmacol.*, 39, pp.173-174.
14. Kim su ji, 2006, "Hypoglycemic and antihyperlipidemic effect of Fenugreek seeds in alloxan induced diabetic rats," *American journal of biochemistry and biotechnology.*, 2(4), pp.154-160.
15. Kirtikar and Basu., 1991, "Indian Medicinal plants", 1, pp.700-701.
16. Madar, Z., 1984, "Fenugreek (*Trigonella foenum-graecum*) as a means of reducing post-prandial glucose level in diabetic rats." *Nutr. Rep. Int.*, 29, pp.1267-1272.
17. Madar, Z., Arad, J., 1989, "Effect of extracted Fenugreek on post-prandial glucose levels in human diabetic subjects". *Nutr. Res.*, 9, pp.691-692.
18. Moorthy, R., Prabhu, K.M., Murthy, P.S., 1989, "Studies on the isolation and effect of an orally active hypoglycemic principles from the seeds of Fenugreek (*Trigonella foenum-graecum*)." *Diabetes Bulletin.*, 9, pp.69-72.
19. Nahar, N., Nur-e-Alam, Nasreen, T., Mosihuzzaman, M., Ali, L., Begum, R., Khan, A.K.A., 1992, "Studies of blood glucose lowering effects of *Trigonella foenum-graecum* seeds." *Med. Arom. Plants.*, Abstr. 14, pp.2264.
20. Prajapati, Purohit, Sharma and Kumar., 2003, "A Handbook of Medicinal Plants- A Complete Source Book", pp.523.
21. Puri, D., Prabhu, K.M., Murthy, P.S., 2002, "Mechanism of action of a hypoglycemic principle isolated from Fenugreek seeds." *Indian J. Physiol. Pharmacol.*, 46, pp.457-462.
22. Raju, J., Gupta, D., Rao, A.R., Yadava, P.K., Baquer, N.Z., 2001, "*T.foenum-graecum* seed Powder improves glucose homeostasis in alloxan diabetic rat tissues by reversing the altered glycolytic, gluconeogenic and lipogenic enzymes." *Mol. Cell. Biochem.*, 224, pp.45-51.
23. Ramesh, H.P., Srinivasan, K., 2004, "Isolation of galactomannan-rich endosperm of Fenugreek and study of its anti-diabetic influence in streptozotocin-induced diabetic rats." *Trends in Carb. Chem.*, 9, pp.99-103.
24. Ribes, G., Sauvaire, Y., Baccou, J.C., Valette, G., Chenon, D., Trimble, E.R., 1984, "Loubatieres- Mariani, M.M. Effects of Fenugreek seeds on endocrine pancreatic secretion in dogs". *Ann. Nutr. Metab.*, 28, pp.37-43.

25. Ribes, G., Sauvaire, Y., Costa, C.D., Baccou, J.C., Loubatieres-Mariani, M.M., 1986, "Antidiabetic effects of subfractions from Fenugreek seeds in diabetic dogs." *Proc. Soc. Exp. Biol. Med.*, 82, pp.159-166.
26. Shani, J., Goldschmied, A., Joseph, B., Ahronson, Z., Sulman, F.G., 1974, "Hypoglycaemic effect of *Trigonella foenum-graecum* and *Lupinus termis* seed and their major alkaloids in alloxan diabetic and normal rats." *Arch. Int. Pharmacodyn. Ther.*, 210, pp.27-37.
27. Sharma, R.D., Sarkara, A., Hazra, D.K., Mishra, B., Singh, J.B., Sharma, S.K., Maheshwari, B.B., Maheshwari, P.K., 1996, "Use of Fenugreek seed powder in the management of non-insulin dependent diabetes mellitus". *Nutr. Res.*, 16, pp.1331-1339.
28. Srinivasan, K., 2005, "Plant foods in the management of diabetes mellitus: Spices as potential antidiabetic agents." *Int. J. Food Sci. Nutr.*, 56, pp.399-414.
29. Thakran, S., Salimuddin, Baquer, N.Z., 2003, "Oral administration of orthovanadate and *Trigonella foenum-graecum* seed powder restore the activities of mitochondrial enzymes in tissues of alloxan-induced diabetic rats". *Mol. Cell. Biochem.*, 247, pp.45-53.
30. Valette, G., Sauvaire, Y., Baccou, J.C., Ribes, G., 1984, "Hypocholesterolemic effects of Fenugreek seeds in dogs." *Atherosclerosis.*, 50, pp.105-111.
31. Yadav. R, Kaushik .R, Gupta. D., 2011, "The health benefit of *Trigonella foenum-graecum* : A Review" *International Journal of Engineering Research and Applications (IJERA)*, 1, pp.032-035.
32. Z.mohamed, 2006, "Biochemistrastudy of anti diabetic action of the egyption plants Fenugreek and alanites." *Molecular and cellular biochemistry*, pp.173-183.
33. Zia, T., Hasnain, S.N., Hasan, S.K., 2001, "Evaluation of the oral hypoglycemic effect of *T. foenum-graecum* L. (Methi) in normal mice." *J. Ethnopharmacol.*, 75, pp.191-195.