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Fenugreek (Trigonella foenum-graecum) as a Natural Antidiabetic Agent: A Systematic Review

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Womens collage of pharmacy, peth vadgaon

Abstract:

In Indian households, herbs have long held a valued place due to their healing properties. When processed into active compounds, they have been found to help prevent, alleviate, and sometimes cure many diseases. Trigonella, an ancient plant, has been found across Asia, Europe, Africa, and Australia. Traditionally, Trigonella foenum-graecum has been employed to address a wide range of health issues. This spice is widely recognized in traditional medicine for its uses as a galactagogue, antidiabetic agent, appetite suppressant, digestive stimulant, and antibacterial remedy.

Over recent years, numerous clinical and experimental studies have highlighted the various health benefits associated with fenugreek seeds. Reports indicate that over 500 million people aged between 20 and 79 are currently living with diabetes, with the vast majority—around 90 to 95 percent—diagnosed with type 2 diabetes, making it the predominant form. Although treatments such as insulin and oral medications are available, they are often challenged by factors like adverse effects, dependency on synthetic drugs, limited accessibility, and significant costs.

Fenugreek (Trigonella foenum-graecum Linn) has gained attention as a promising medicinal plant due to its notable therapeutic properties. Scientific investigations are increasingly directed toward exploring its biological and pharmacological traits to maximize its medicinal applications.

The findings of these investigations offer a comprehensive comprehension of fenugreek's biological action.

Keywords: Fenugreek, gastric stimulant, hypoglycaemic effect, and anti-diabetic.

1. Introduction: -.

Numerous studies have identified fenugreek as among the earliest herbs cultivated for its therapeutic value. It is especially recognized for its antioxidant properties found in both its seeds and leaves. Commonly known as "methi" in Hindi, Trigonella foenum-graecum L. has a long-standing history of use in cooking, traditional remedies, and as a natural flavoring agent. This rain-dependent, herbaceous plant typically grows to a height of 30–60 cm, bearing flowers about 1–2 cm in size and leaflets measuring approximately 2 to 2.5 cm.

Historical records show that carbonized fenugreek seeds were part of Indian trade between 2000 and 1700 BCE, originating from Punjab. Today, India is among the leading global producers of fenugreek, with an estimated annual yield ranging between 45,000 to 55,000 tonnes. This plant is now cultivated and used globally.

Fenugreek has demonstrated effectiveness in treating a broad spectrum of health conditions. These include ailments such as cancer, eye swelling, fevers, gallbladder issues, heartburn, inflammatory diseases, sinus infections, ulcers, reproductive system disorders, lung infections, respiratory congestion, throat inflammation, anemia, asthma, skin abscesses, and more. Its leaves are commonly consumed as part of the diet in the form of leafy greens.

Although the precise classification of species remains somewhat debated, sources such as Linnaeus have recognized 18 species within the Trigonella genus, part of a broader group of 260 species. Fenugreek seeds and leaves have long been incorporated into traditional practices for their therapeutic benefits. According to Gupta et al. (2021), fenugreek shows potential in managing chronic health conditions, including type 2 diabetes, digestive tract inflammation, lipid imbalances, and certain neurological disorders.

The ability of fenugreek to help regulate blood sugar is thought to involve glucagon-like peptide-1 (GLP-1) pathways, which help coordinate glucose levels with the body's needs. Moreover, the plant contributes to detoxification processes and boosts antioxidant defenses, thus lowering oxidative damage. Naturally occurring compounds in fenugreek, such as flavonoids and saponins, have been found to prevent tumor growth by interfering with carcinogen-DNA interactions.

Diosgenin, one of the key active components in fenugreek, has demonstrated anti-cancer properties by inducing apoptosis in malignant cells, slowing their proliferation, and preventing tumor spread. This compound is also associated with reproductive health benefits, including improved sperm count, mobility, and testosterone levels. Traditionally, fenugreek has been valued for managing metabolic and gastrointestinal conditions, protecting kidney function in diabetic individuals, and serving as a high-protein dietary supplement (containing approximately 20–30% protein).

Additionally, the plant's soluble fiber contributes significantly to its antidiabetic actions, helping to lower fasting blood glucose levels and improve glucose regulation in both healthy and diabetic animal models, indicating its potential for diabetes management.

Fig 1. fenugreek seeds

Beneficial aspects of fenugreek

Fenugreek seeds serve as a notable source of vitamin E and are known to assist with digestive discomfort, including issues like gas and indigestion. The fresh leaves of this plant aid liver health and help with sluggish liver activity. Regular topical use of a paste made from these leaves can keep hair soft, support hair growth, and help reduce dandruff. A porridge made from fenugreek seeds is traditionally given to breastfeeding mothers as it enhances milk secretion and may help lower calcium oxalate accumulation, which is associated with kidney stones. Experimental studies on animals indicate that fenugreek may reduce the risk of colon cancer by inhibiting certain enzymes. In traditional Chinese medicine, fenugreek has long been used to address kidney-related health concerns. A key compound found in fenugreek is diosgenin, a plant-based steroid often used in the synthesis of various steroidal medications. Furthermore, fenugreek possesses diverse therapeutic attributes, such as easing pain, supporting immune health, controlling blood sugar, acting against parasites and bacteria, lowering cholesterol, and exhibiting anti-inflammatory and antioxidant activities.

Fenugreek Seed:

Fenugreek seeds have been historically used in natural healing practices to help with numerous health conditions, including skin burns, dermatitis, gout, digestive problems like diarrhea and bloating, and general stomach discomfort. These seeds are appreciated for their ability to naturally affect prolactin levels and support blood sugar regulation.

Research has indicated that fenugreek seeds possess several therapeutic properties. These include their potential to support blood sugar control, lower lipid levels, combat obesity, and possibly inhibit cancer growth. Additionally, they exhibit anti-inflammatory, antioxidant, antifungal, and antibacterial effects. These health-promoting actions are largely attributed to the seeds' active biochemical compounds.

Morphology of Fenugreek Seed:

1. Appearance: The seeds are hard, solid, and shaped like rhomboids. They typically measure between 3 to 5 millimeters in length and about 2 millimeters in thickness.
2. Color: They range in shade from light brown to yellowish-brown.
3. Odour: The seeds have a characteristic aromatic smell.
4. Taste: They possess a strong, bitter flavor.

2.Botanical description: -

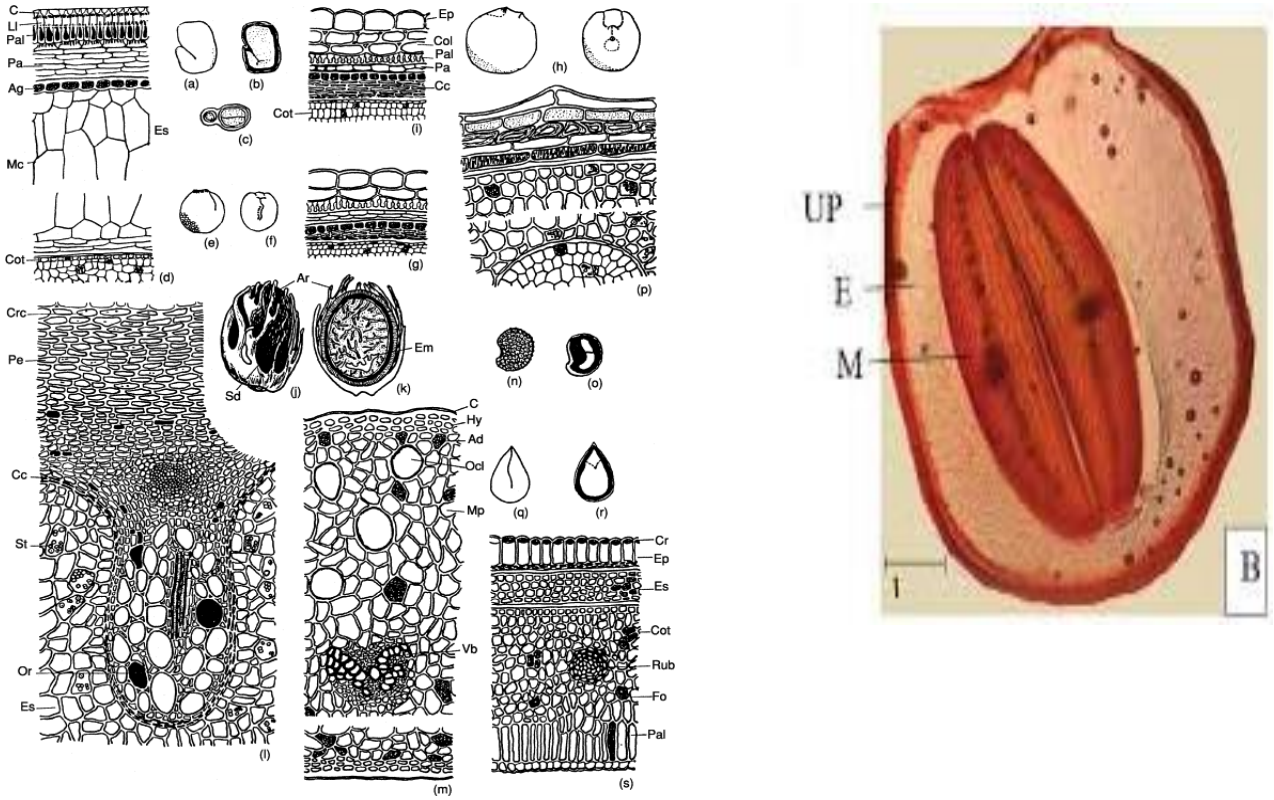


Fig 2. Treansverse section of fenugreek

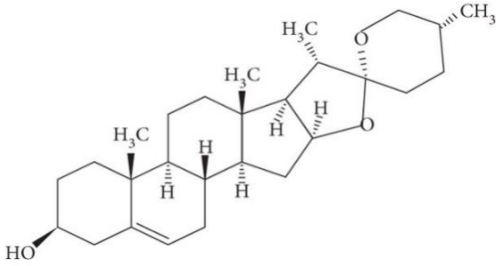
3.Chemical composition: -

Fenugreek seeds are a valuable source of essential nutrients such as proteins, vitamins, and minerals. Among these, lecithin is a key component that significantly enhances the seeds' protein content, with an approximate value of 25.4 grams per 100 grams of seeds. Besides lecithin, the seeds contain several proteins and amino acids like globulin, albumin, histidine, lysine, and 4-hydroxyisoleucine, though their exact proportions may not always be specified in standard references.

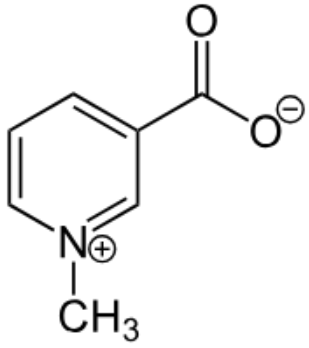
These seeds are also an important source of vitamins. For every 100 grams, they offer around 1040 IU of vitamin A, 12 mg of niacin, 6 mg of vitamin B6 (pyridoxine), 0.6 mg of vitamin B1 (thiamine), 0.41 mg of vitamin B2 (riboflavin), 0.36 mg of nicotinic acid, and nearly 57 micrograms of folate.
In terms of mineral content, fenugreek seeds possess substantial amounts of calcium (176 mg), phosphorus (296 mg), and iron (33.5 mg) per 100 grams. They also contain smaller yet beneficial quantities of selenium (approximately 6.3 µg), manganese (1.22 mg), zinc (2.5 mg), and magnesium (191 mg). The presence of these nutrients supports the inclusion of fenugreek seeds in customary dietary habits and traditional medicinal applications.

Fenugreek fiber-

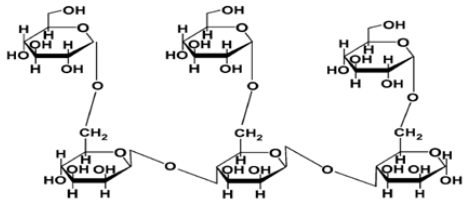
Fenugreek seeds provide a significant amount of dietary fiber, which is made up of complex carbohydrates that are resistant to digestion. This fiber is important for maintaining digestive wellness. It is mainly categorized into two types: soluble and insoluble. Soluble fiber blends with water to create a gel-like consistency, while insoluble fiber contributes to stool bulk. Fenugreek, along with other legume-based plants like beans and guar, is considered a rich source of soluble fiber. In contrast, fruits and vegetables generally contain more insoluble fiber. In fenugreek, this fiber is sourced from its endosperm.



(Steroidal saponin)



Trigonelline (alkaloid)



Galactomannan (mucillaginous fiber)

Fig 3: Fenugreek's bioactive chemical constituents.

Fenugreek seeds are notable for having one of the highest fiber contents among natural foods. Approximately 50% of the seed's dry weight is fiber, with about 30% being soluble fiber. It can form gel-like structures, much like the fiber present in sources such as guar gum, oat bran, and psyllium husk. The other 20% is made up of insoluble fiber, which helps enhance stool bulk, similar to the fiber content found in wheat.

4.Pharmacological activity: -

a. Anti-diabetic activity:

Fenugreek seed extracts can assist in controlling blood sugar by slowing down how quickly glucose is absorbed and by extending the time it takes for the stomach to empty. The high fiber in the seeds helps reduce glucose intake in the intestine, leading to slower carbohydrate digestion and lower blood sugar. Fenugreek also supports the pancreas, helps maintain B cell health, and encourages insulin production. These benefits may be due to stimulating insulin output from current islet cells, enhancing glycogen synthetase function, and aiding glycogen storage in the muscles and liver. It also helps restore glycogen in muscles and liver, decreases inflammation, and influences lipid profiles and enzymes that respond to insulin. Moreover, it raises levels of antioxidant enzymes like glutathione and superoxide dismutase, which help safeguard the liver and pancreas. Its fiber content further improves how the body responds to insulin and enhances glucose handling in both type 1 and type 2 diabetes conditions.

b. Antioxidant activity:

Fenugreek seed extracts, prepared using Soxhlet extraction with different solvents such as ethanol, methanol, and acetone, have demonstrated strong antioxidant potential. Using the Folin–Ciocalteu technique, scientists evaluated the total phenolic content and tested for both metal ion binding and antioxidant effects, including DPPH radical neutralization. Among the various extracts tested, the one made with ethanol showed the most significant antioxidant activity. These effects are attributed to polyphenolic compounds in the seeds. Fenugreek also affects antioxidant enzymes like SOD, catalase, and GST. At low doses, fenugreek shows antioxidant effects, while at higher doses, it may exhibit pro-oxidant properties. This dual behavior influences its anti-diabetic and blood glucose-lowering capabilities.

c. Hypocholesterolemia property:

Atherosclerosis, a condition involving the accumulation of plaque in blood vessels, is often associated with elevated LDL and VLDL cholesterol. Reducing LDL is vital in lowering heart disease risk. Research has shown that spices, including fenugreek, can help reduce cholesterol levels. Human and animal studies support fenugreek's role in lowering cholesterol and promoting cardiovascular health.

d. Reduction and recovery of hepatotoxicity and genotoxicity in the liver:

A particular polysaccharide found in fenugreek seeds has shown potential in reducing liver injury caused by harmful substances such as thiamethoxam. The remedial effect appears to be dose-dependent, aiding in the recovery of both blood-related and genetic liver damage.

e. Cancer therapy:

Fenugreek has been used in traditional medicine for its potential in supporting cancer patients undergoing chemotherapy. The extracts protect against cell damage by modulating apoptosis and lipid peroxidation induced by agents such as cyclophosphamide. Flavonoids and catechins in fenugreek may induce cancer cell death. Diosgenin, a compound found in the seeds, has shown effects on human colon cancer cells by promoting apoptosis and halting cell division. Furthermore, fenugreek exhibits hepatoprotective effects, especially its polyphenolic components, which help shield the liver from damage caused by substances like ethanol.

f. Other medicinal uses: -

Fenugreek seeds support digestive health by enhancing the breakdown and absorption of food nutrients, potentially improving metabolic functions. They are commonly used as dietary supplements to maintain digestive balance. Additionally, fenugreek may help manage anemia and benefit women's health, particularly during childbearing years. Antibacterial properties of fenugreek have also been noted, with its extracts showing efficacy against various microorganisms.

Research indicates that fenugreek can modulate liver oxidative stress induced by chemicals like 1,2-dimethylhydrazine, reducing colon cancer risks in experimental models. Fenugreek has also been studied for its neurological benefits. It appears to inhibit acetylcholinesterase (AChE), an enzyme linked to Alzheimer's disease. The presence of trigonelline and other compounds contributes to these effects.

In traditional medicine, fenugreek is valued for its use in tonics aimed at enhancing mood and energy. It is also included in alcohol-based extracts, tinctures, and supplements used for skin conditions such as dermatitis and acne. The cosmetic industry utilizes fenugreek for its therapeutic and skin-conditioning benefits.

5.Conclusion: -

Fenugreek, a unique spice crop, is gaining renewed attention due to the resurgence of interest in traditional medicinal practices. Its seeds and leaves, rich in essential nutrients like proteins, lipids, fatty acids, and minerals, contribute significantly to fulfilling nutritional needs and promoting overall health. As an eco-friendly plant, fenugreek offers diverse possibilities for use across industries such as food and animal feed, pharmaceuticals, healthcare, and cosmetics, owing to its valuable nutritional and therapeutic properties. This review provides insights that may benefit individuals aiming to enhance their well-being through the inclusion of health-promoting compounds such as fatty acids and other beneficial natural ingredients in their diets.

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