

A Review of Therapeutic and Medicinal Uses of Fenugreek (*Trigonella foenum-graceum* L.)

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www.jrasb.com || Vol. 3 No. 5 (2024): October Issue

Received: 17-09-2024

Revised: 26-09-2024

Accepted: 09-10-2024

ABSTRACT

Current lifestyle and excessive use of synthetic fertilizers in agriculture field promote an unhealthy lifestyle that urges the researchers looking for a healthy and beneficial diet. Numerous crop plants have nutritional, functional, nutraceutical, and therapeutic properties. Fenugreek (*Trigonella foenum-gracium*) is a popular crop known for these qualities and is beneficial in the human diet. It is an annual plant from the Leguminosae family that is commonly grown in the Mediterranean and Asian countries. It is mostly grown for its spices, though it can also be used for food (feed) and medicinal (antioxidant, antibacterial, anti-inflammatory, and hypoglycemic properties). Fenugreek is famous for its versatile uses, grown under moderate conditions (drought and salinity), white flowering herb, and self-pollinated plant. Fenugreek composition consists of various nutrients like vitamins, minerals, proteins, lipids, fibre, amino acids, and bioactive compounds that are used for medicinal purposes. Due to higher fibre content fenugreek is called a food stabilizer and emulsifying agent for changing food texture. Fenugreek has numerous health benefits, including the ability to lower blood sugar, heart problems, menstrual cramps, anti-cancer, reduce inflammation, and support healthy skin and hair. This review highlights the nutritional value of fenugreek with various health and medicinal benefits. Despite its multiple advantages, this review paper also discussed health problems associated with the usage of fenugreek, such as allergies and possible adverse effects linked with fenugreek use.

Keywords- fenugreek, nutritional value, beneficial, emulsifying, health problem.

I. INTRODUCTION

The increasing world population demand for wholesome nutrition products from the food industry has impulse industrialists to develop food that has high nutritive value, and healthy benefits, and defend the human body from diseases. Worldwide many functional foods contain many components such as vitamins, prebiotics, probiotics, dietary fibre, and minerals. In this respect, few herbs are famous for their nutritional and medicinal use (Khorshidian *et al.*, 2015). One of the first and best herbs, food, and medicinal plants is fenugreek. Fenugreek is a vigorous herb and chemurgic (organic raw material) crop that is used as spices in functional and traditional cuisines that increase color and flavor of food. This amazing plant is widely recognized for its exceptional nutritional value, medical applications, and employment in the physiological sector (where it is employed as an antioxidant, antibacterial, anticancer, antiulcer, and anti-diabetic agent) (Awulachew. 2023). It is cultivated in different regions including Pakistan, China, India, Iran, Afghanistan, Nepal, France, Spain, Morocco, Southern Africa and Southern Europe (Singh *et al.*, 2020).

II. NUTRITIONAL VALUE

A wide range of nutrients, bioactive compounds and phytochemicals (non-nutritive chemicals of plants) in leaves and seeds which are essential for healthy lifestyle, proper functioning of biological systems and in inhibition of disease has made fenugreek exceptional nutritive plant (Syed *et al.*, 2020; Awulachew. 2023; Faisal *et al.*, 2024). Fenugreek seeds composition including proteins (23-26%), fibre (25%), carbohydrates (58%) and fats (0.9%) respectively. Leaves of fenugreek contain protein, fibre and carbohydrates at a concentration of 4.4%, 1.1% and 6% respectively. Minerals also part of fenugreek composition like calcium (75 mg per 100g), potassium (603 mg/100 g), magnesium (42 mg/100 g), manganese and copper (0.9 mg/100 g), iron (25.8 mg/100 g) and zinc (220 mg/100 g). Fenugreek composition is full of supplements' like β -carotene (19mg per 100 g) and vitamins C (220 mg/100 g) (Wani and Kumar, 2018).

Vitamins A, B1, B2, C, choline, oleic and linoleic acids, niacin, carotene, calcium, iron, phospholipids, and amino acids are all abundant in fenugreek and are necessary for the healthy growth and development of the human body. Additionally, there are trace amounts of amino acids that include sulfur, such methionine, and cysteine, which are essential to human physiology. (2S, 3R, 4S) Fenugreek has a naturally occurring amino acid called 4-hydroxyisoleusine (Syed *et al.*, 2020). The protein found in fenugreek endosperm (histidine, globulin, lecithin, and albumin) is richer in lysine than that found in soybean protein. According to a recent study, fenugreek has a higher amino acid profile

than other plant proteins and is a rich source of protein. Feyzi *et al.* (2015) investigated on the isolation of fenugreek protein and found that it was of higher quality than soy protein. The fenugreek protein also contains glutamic acid and aspartic acid. According to a recent study, the profile of amino acids also includes globulins (27.2%), prolamins (7.4%), albumins (43.8%), and glutelins (17.2%). Elkadousy *et al.* (2020) conducted a study to evaluate protein quality of fenugreek and white lupine. Results concluded that fenugreek has highest total and essential amino acids with higher quality of cysteine and methionine as compared to the white lupine. Fenugreek protein preferred in traditional food due to their unique properties (foaming properties, denature at high temperature, stability with good solubility) as compared to soy protein which make it more effective (Nagulapalli *et al.*, 2017).

Fenugreek contains significant quantity of carbohydrate, comprises of 50% fibre, out of which 20 percent is insoluble and 30% soluble. Fenugreek seed is famous for its rich fibre content and consist of soluble dietary fibre content, especially mucilaginous fibre made of galactomannans (regulate blood sugar level) (Awulachew. 2023). Seeds are a good source of lipids fraction at the amount of 100 g/kg. In seeds the composition of lipids consists of glycolipids at a proportion of 5.4%, triglycerides at a proportion of 86.1%, diglycerides at a proportion of 6.3% and phospholipids at a proportion of 10.5% respectively. Small amount of monoglycerides, sterols and free fatty acids are also part of fenugreek seed (Faisal *et al.*, 2024). Based on conducted study it was proved that oleic acid content ranged from 13.30% to 19.0%, linoleic acid content was found between 34.85% and 42.2%, α -linolenic acid content ranged from 22.0% to 30.8%, content of palmitic acid was found between 3.85% and 13.10% and myristic acid content ranged from 0.10% to 1.38% (Bienkowski *et al.*, 2017).

Fenugreek seeds used as nutritional supplements due to the presence of phytonutrients which play a significant role in human body. The presence of bioactive compounds (flavonoids, saponins, alkaloids, trigocoumarins, trimethyl coumarins and choline) makes fenugreek beneficial for human use due to their numerous medicals benefits. Saponins are well known for its cholesterol-lowering effects as well as flavonoids are powerful antioxidants with anti-cancer and anti-inflammatory properties. These properties boost human immune system against disease (Akbari *et al.*, 2019).

Nutritional compositions reported by different researchers showed in **table 1** proved that fenugreek is extraordinary plant with exceptional nutritive value.

III. MEDICINAL USES OF FENUGREEK

Fenugreek has several medicinal uses including anti-diabetic, anti-cancer, anti-fertility, anti-parasitic,

anti-microbial, hypoglycaemic and antioxidant etc. (Hajra and Paul, 2024). Additionally, it aids in lowering aberrant blood clotting and myocardial damage, both of which are connected to heart attacks and strokes. It also aids in lowering inflammation and obesity (Dhull *et al.*, 2024). Fenugreek has also been shown in several studies to have neuroprotective and anticarcinogenic qualities. Calcium, iron, chlorine, sulfur, and vitamins A and C are all abundant in fenugreek. It was once used as a tonic to relieve menstruation cramps and leg edema and weakness (Varshney and Siddique, 2023; Khathoon, 2024).

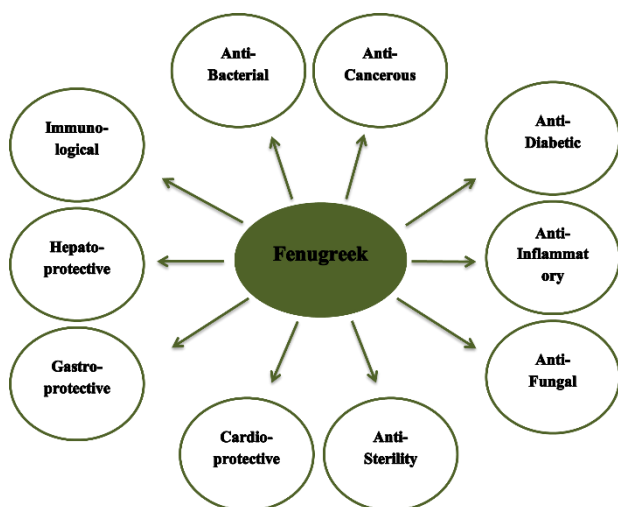


Figure 1: Medicinal Uses of Fenugreek

3.1 Anti-bacterial property

Among several herbal extracts the antimicrobial property of fenugreek has become prevalent. The antimicrobial properties of fenugreek against many bacteria including, *Aspergillus niger*, *Escherichia coli*, *Salmonella typhimurium* and *Staphylococcus aureus*. Results indicated that 100% concentrated oil of fenugreek has maximum inhibition of *Escherichia coli* than that of other bacteria's (Sulieman *et al.*, 2008). Six bacterial strains, comprising *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Salmonella typhi*, *Proteus mirabilis* and *Vibrio parahaemolyticus*, were examined with ethanolic extract of fenugreek seed. The results showed low to moderate activity, with the exception of *Staphylococcus aureus* and *E. coli* (Al-Timimi, 2019).

3.2 Anti-cancerous effects

Diosgenin is a bioactive compound present in fenugreek which is an anti-cancer agent (Das *et al.*, 2012). Various studies proved the fenugreek benefits of cancerous cells by induction of apoptosis. The leaves or seeds of fenugreek and their biological components play a significant role for the inhibition of tumor by moderating the activity of various genes comprising the induction of tumor suppressor genes and apoptosis, as well as the inhibition of tumor necrosis factors (Salam *et al.*, 2023).

3.3 Anti-diabetic effect

Diabetes is considered as complex metabolic disorder caused due to increase in level of glucose, resistance of insulin and improper action and secretion of insulin (Sharma *et al.*, 2020). Fenugreek is supposed to have several anti-diabetic compounds (Talapatra and Talapatra, 2015). Fenugreek contains several bioactive components such as trigonella, saponins, diosgenin, galactomannan and 4-hydroxyisoleucine that have positive effects in treating diabetes (El-Nagdy *et al.*, 2024). Fenugreek controls diabetes through different multi-physiological pathways by restoring the function of pancreatic β -cell and by inhibiting the activities of alpha-amylase and sucrose (Varshney and Siddique, 2023). Saponins regulate the activities of glycogen in liver and intestine lowers the level of blood glucose and improves glucose tolerance (Mi *et al.*, 2024).

The anti-diabetic effects of *Trigonella* seeds in an aqueous suspension made of *Cinnamomum verum* bark were examined by Sharma *et al.* (2020) in diabetic Wistar rats that had been given alloxan. Different doses of fenugreek seeds, cinnamon and glibenclamide were supplemented to rats for two weeks. It is also reported that fenugreek plant also has potential to inhibit enzymes that play a significant role in controlling diabetes i.e., α -amylase that helps in conversion of complex starch into oligosaccharides and α -glucosidase that works in conversion of polysaccharides into glucose (Fahad *et al.*, 2019).

3.4 Anti-inflammatory property

Abbas *et al.* (2016) used a hot plate to compare the anesthetic and anti-inflammatory properties of ethanolic extracts of fenugreek seeds with synthetic medicines, diclofenac sodium 8 and indomethacin, and acetic acid, which were administered to albino mice. They believed that fenugreek produced better outcomes than indomethacin. As a result, fenugreek seeds can be used to relieve inflammation and mild discomfort in place of synthetic medications.

Pundarikakshudu *et al.* (2016) investigated the anti-inflammatory effects of petroleum ether extract of Trigonella seeds on rats that had paw edema induced by carrageenan and formaldehyde, arthritis induced by complete Freund's adjuvant, and granuloma induced by cotton pellets.

The t-test result indicated that formaldehyde and carrageenan-induced inflammation was reduced by up to 37% and 85%, respectively. Tavakoly *et al.* (2018) used a randomized controlled trial with 48 T2D patients to investigate the anti-inflammatory and anti-oxidative effects of fenugreek seeds. The results showed that SOD activity had increased and C-reactive protein's high sensitivity had decreased. Conversely, no discernible alterations were observed in the functions of GPx, TAC, TNF- α , and IL-6.

3.5 Antifungal property

Because of their antifungal properties, a number of medicinal plants and the chemicals that are derived

from them are used to treat pathogenic fungus that are resistant to several drugs. It has been demonstrated that fenugreek extracts work well against pathogenic fungal strains, such as *Candida* species (Jasim *et al.*, 2013). The biggest zone of inhibition against *Microsporum gypseum* was demonstrated by fenugreek extract. The excessive utilization of secondary metabolites such as saponins, flavonoids, steroids, alkaloids, and tannins is what gives fenugreek its antifungal characteristics (Punit *et al.*, 2020).

When fenugreek seeds were extracted using petroleum ether, the maximal zone of inhibition against *Aspergillus niger* at a dose of 250 mg/ml was determined to be 20 ± 0.88 mm, and against *Candida albicans* at a concentration of 250 mg/ml, it was 17 ± 0.57 mm (ElNour and Ali, 2015). The novel defensin-like antifungal peptide (Tf AFP), with a molecular mass of 10.3 kDa, is found in *Trigonella foenum-graecum*, often known as fenugreek. It has been demonstrated that this peptide exhibits antifungal action against the fungal species *Rhizoctonia solan*, *Fusarium oxysporum*, and *Fusarium solani* (Oddepally and Guruprasad, 2015).

3.6 Anti-sterility and anti-fertility effects

According to Latif *et al.* (2019), fenugreek also has some benefits for reproductive health, such as regulating sex hormones, sperm count, sperm viability, and various other sexual disorders in both genders. The bioactive components of fenugreek, such as steroidal saponins, have anti-sterility and anti-androgenic qualities. Saponins bind to estrogen receptors in rats, hence controlling the ovarian hyperstimulation syndrome (Varshney and Siddique, 2023). Diosgenins increase growth hormones produced by the pituitary gland, which aid in controlling sexual behavior (Mansour *et al.*, 2021).

3.7 Cardioprotective effects

Pharmacological characteristics can be found in fenugreek constituents such as nicotinic acid, saponin, phytic acid, scopoletin, diosgenin, galactomannan, coumarin, fenugreekine, and trigonelline. Rats that had experienced an isoproterenol-induced myocardial infarction were used to study the effects of fenugreek (Haritha *et al.*, 2015). According to the study, fenugreek has a cardioprotective influence on rats because it boosts the activities of antioxidants that are both enzymatic and non-enzymatic (SOD, CAT, GPx, and GSH) (Majnu *et al.*, 2011).

Raising HDL and reducing LDL, triglyceride, and cholesterol levels, fenugreek successfully prevents atherosclerosis, repairs metabolic imbalances, and shields cardiac tissue from oxidative damage. This is a result of its significant blood lipid level regulation (Heshmat-Gahdarijani *et al.*, 2020). It was demonstrated that fenugreek seed hydro-alcoholic extract prevented diabetes in rats given STZ-induced diabetes in a study by Bafadam *et al.* (2021). According to the findings, fenugreek seed extract may be able to treat diabetic cardiomyopathy by changing the expression of genes linked to apoptosis. Fenugreek's

anti-oxidant and anti-apoptotic properties have been shown by the downregulation of the pro-apoptotic Bax gene and intercellular adhesion molecule and the overexpression of the anti-apoptotic gene Bcl-2 (Bafadam *et al.*, 2021). In another study, fenugreek improved the elimination of fat in the stool, which decreased the liver's ability to accumulate fat. Significant reductions were observed in serum total cholesterol, triglycerides, low-density lipoproteins, very low-density lipoproteins, and cholesterol. The percentages of cholesterol and high-density lipoprotein, however, remained unchanged (Hassan *et al.*, 2006).

3.8 Gastroprotective effects

Unhealthy lifestyle and diet routine can cause various problems including abdominal discomfort, appetite loss, vomiting, nausea, peptic ulcer and gastric ulcer. Fenugreek possesses anti-inflammatory, anti-ulcer and gastroprotective and anti-secretory properties. A study was conducted on Albino rats in which fenugreek seeds were orally given to them and the results showed that the ulcers severity was reduced as compared to the untreated rats (Mahmood *et al.*, 2005).

The acute injuries of gastric induced by chemicals can be treated due to the presence of polyphenols in fenugreek (Selmi *et al.*, 2022). Gastric discomfort and appetite can also be improved through fenugreek seeds. The oral administration of fenugreek seeds enhances the salivary flow and activity of lactase (Liew *et al.*, 2023).

3.9 Hepatoprotective effects

Antioxidant supplements are a favorable way to treat or manage liver impairments. Polyphenols, diosgenin, flavonoids, and saponins are the components with hypolipidemic, hypocholesterolemic, and antioxidant properties (Parwez *et al.*, 2024). Pundarikakshudu *et al.* (2024) observed that 200 mg/kg of fenugreek per day enhanced the lipid profile and collagen levels in hepatotoxic Wistar rats.

Fenugreek's active ingredients, including galactomannan and 4-hydroxyisoleucine, reduced blood sugar and enhanced lipid metabolism. Fenugreek could avert hepatic and metabolic damage following ischemia-reperfusion. It has been discovered that fenugreek effectively lessens the harm that ischemia-reperfusion causes. Polyphenols and flavonoids have been demonstrated to be beneficial in the treatment of hepatic ischemia. Rats exposed to fenugreek extract had significantly lower levels of plasma serum (LDH), (ALT), and (AST), indicating the hepatoprotective properties of the extract (Taha, 2013).

3.10 Immunological property

Fenugreek has been found in various studies to have immunomodulatory effects on humoral immunity, leucocytic count, phagocytic index, serum globulins, and related genes. At 100 mg/g, mice administered three different dosages of fenugreek aqueous extract showed increased humoral immune activity and delayed sensitization. Both the phagocytic index and phagocytic

capability of macrophages were significantly elevated in the treated mice model (Bin-Haafiez et al., 2003). Along with gilt-head Sparus aurata, fenugreek (Trigonella foenum-graecum) has been shown to act as a dietary supplement, enhance skin mucosal immunity response by upregulating immune-related genes, and stimulate the immune system by increasing some enzymatic activities. Hematological parameters have also significantly improved (Guardiola et al., 2018).

Moreover, fenugreek extract strengthened the immune systems and increased the productivity of egg-laying hens (Zadeh et al., 2015). Following a six-week period of consistent, intense exercise and fenugreek supplementation, Ebrahimi et al. (2022) noted a notable amelioration in the immunoglobulin (IgG), lymphocyte, and leukocyte counts of obese females. The hematological parameters study (Chourasiya et al., 2019) found that the extract significantly ($p < 0.05$) boosted the Hb, RBC, and WBC count in the rat model at a dose of 400 mg/kg body weight. Thus, the ability of fenugreek to improve hematological parameters suggests that it could be used to increase immunity (Alkanand et al., 2024).

IV. THERAPEUTICAL USES IN HUMANS

Fenugreek was traditionally used to ease childbirth and increase milk flow (Abdou and Fathey, 2018). It is still used traditionally to treat a variety of ailments; for example, Egyptian women take it for menstrual pain and tourists drink it as hilba tea to ease stomach issues; fresh fenugreek leaves are used to treat indigestion, flatulence, and sluggish liver (Aher et al., 2016). If you frequently get mouth ulcers, you can gargle with an infusion of the leaves. For a common sore throat, the best treatment is a gargle made from the seeds (Bahmani et al., 2016). A mouthwash prepared from the seeds is the most effective for common sore throats. Fresh fenugreek leaf paste applied over the scalp regularly before the bath promotes hair growth, maintains natural colour, keeps hair silky, and also treats dandruff (Aburjai and Natsheh, 2003).

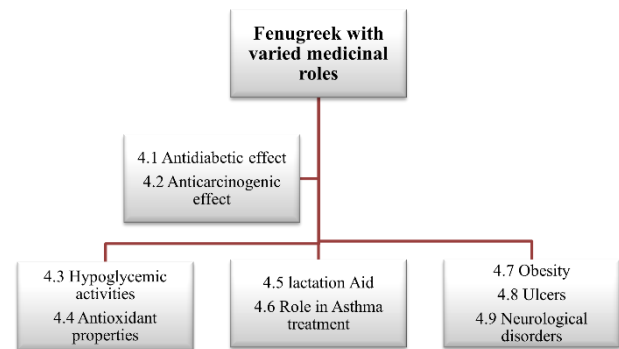


Figure 2: Fenugreek's Diverse Medicinal Applications

4.1 Antidiabetic activities

The soluble fibre in fenugreek slows down the breakdown and absorption of carbohydrates, which helps to keep glucose homeostasis stable (Srinivasan, 2006). Extensive gel formation and low viscosity of the ensuing gels inside the gut create delays in gastric emptying and shorten the intestinal transit time of the meal mass (Dhull et al., 2024). Patients with type II diabetes experienced a 25% reduction in blood glucose levels after consuming 100 g of fenugreek powder, which includes 50% dietary fibre, for ten days (Kassaian et al., 2009).

4.2 Anticarcinogenic Activities

The role of fenugreek against carcinogenic agents has been reported in different studies (Shabbeer et al., 2009). The steroid hormones cortisone and progesterone are synthesised from diosgenin ($C_{27}H_{42}O_3$), which exists in fenugreek and has been considered to have a potential advantage in the treatment of cancer because of its ability to block the expression of genes regulated by necrosis factor NFkappa B, reduce proliferation and osteoclastogenesis, and promote apoptosis brought on by cytokines and chemotherapeutic drugs. In the H-29 human colon cancer cell line, diosgenin from fenugreek has also been shown to hinder cell growth and activate apoptosis (Chaudhary et al., 2018).

Table 1. Comparative Analysis of Nutritional Profiles in Plant Seeds and Leaves.

Plant parts	Nutritional composition	References	Plant parts	Nutritional composition	References
Seeds	Proteins (23-26%), fibre (25%), carbohydrates (58%) and fats (0.9%)	(Al-Jasass and Al-Jasser, 2012; Wani and Kumar, 2018)	Seeds	Glycolipids (5.4%) Triglycerides (86.1%) Diglycerides (6.3%) Phospholipids (10.5%)	(Bienkowski et al., 2017)
Leaves	Protein (4.4%) Fibre (1.1%) Carbohydrates (6%)	(Wani and Kumar, 2018)	Seeds	7% fats 23.30% proteins 3% ash	(Agrawal et al., 2015)
Seeds	Amino acids profile globulins (27.2%), prolamins (7.4%), albumins (43.8%) and glutelins (17.2%)	(Kumari et al., 2022)	Seeds	Dietary fibres ingeminated seed were 31.90% and 77.10% and in germinated seed coat were 86.96% and 55.80%	(Shakuntala et al., 2011)

Seeds	Total lipids (7.5%) Neutral lipids (84.1%) Glycolipids (5.4%) Phospholipids—10.5%	(Hemavathy and Prabhakar, 1989)	Seeds	Carbohydrates (45-60%) Fixed oils (5-10%) Trigonelline (0.2-0.38%) Choline (0.5%) Saponins (0.6-1.7%)	(Mehrafarin <i>et al.</i> , 2010)
Seeds	Folate (57 µg/g) Thiamine (0.41 mg/g) Riboflavin (0.36 mg/g) Nicotinic acid (1.1 mg/g) Vitamin A (10-40 IU) Vitamin C (12 mg/g)	(Khorshidian <i>et al.</i> , 2015)	Seeds	Calcium (176 mg/g) Iron (33.5 mg/g) Zinc (2.5 mg/g) Phosphorus (296 mg/g) Selenium (6.3 µg/g)	(Khorshidian <i>et al.</i> , 2015)

4.3 Hypoglycemic activities

An abnormal drop in blood sugar levels is what defines the clinical condition known as hypoglycemia (Fatima *et al.*, 2018). Fenugreek seeds have been shown to produce hypoglycemic and hypocholesterolemic effects in animal tests (Srivastava *et al.*, 2022). According to recent studies, it improves glucose tolerance by increasing peripheral glucose absorption (Singletary, 2017). It also has a hypoglycemic impact since it affects the gastrointestinal tract and insulin receptors (Gupta *et al.*, 2021).

4.4 Antioxidant properties

Presence of flavonoids and polyphenols, fenugreek has antioxidant properties and it has been documented to exhibit protective effects against oxidation caused by hydrogen peroxide by shielding the erythrocytes from lipid peroxidation and hemolysis (Mashkor, 2014). The potent antioxidant properties of fenugreek are beneficial for the pancreas and liver (Beji *et al.*, 2016).

4.5 Lactation aid

Subsequent research revealed that fenugreek contributes to the stimulation of lactation (Abdou and Fathey, 2018). Fenugreek is said to stimulate sweat production, which could affect the supply of breast milk because the breast is essentially a modified sweat gland (Ahmed, 2015).

4.6 Cholesterol-lowering effect

When administered 25 g of fenugreek fiber powder, which has about a 50% fiber content, on a regular basis, sixty people with diabetes, high cholesterol, and triglyceride levels showed a significant drop in their blood glucose, LDL cholesterol, and triglyceride levels (Fedacko *et al.*, 2016). Because soluble fiber can bind bile acids, which the body excretes rather than regenerates, it lowers blood cholesterol (Gurunath, 2006).

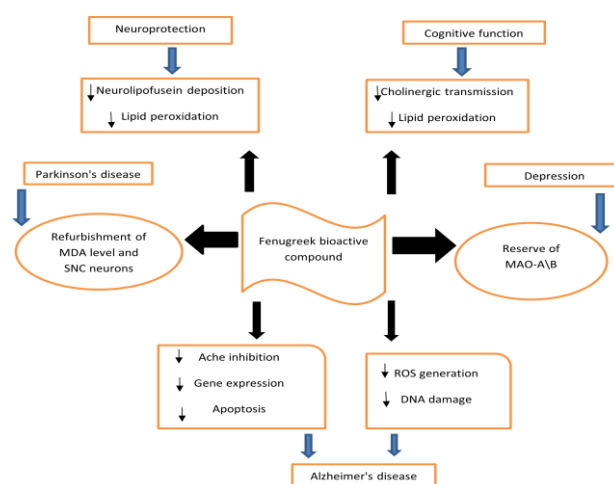


Figure 3: Fenugreek activity against neurological illness

4.7 Fenugreek against neurological disorders

Among neurological diseases, neuropathic pain is among the most prevalent. The pathogenesis of neuropathic pain appears to be significantly influenced by microglial cells and inflammatory cytokines, according to empirical findings (Hina Saleem *et al.*, 2024). Researchers have revealed the potential benefits of medicinal herbs in treating neurological diseases using animal models (Zameer *et al.*, 2018). In this regard, fenugreek has also been researched as a possible herbal remedy for neurological illnesses (Syed *et al.*, 2020). Furthermore, the bioactive substances found in fenugreek extracts shown the capacity to reduce the risk of a number of neurological diseases (Singh *et al.*, 2020). The benefits of fenugreek components against several neurological conditions, including as depression, Parkinson's disease, and Alzheimer's disease, have been demonstrated by numerous research (Foroumandi *et al.*, 2023).

4.8 Fenugreek against gall-stone and gastric ulcer

The effects of fenugreek seeds are similar to those of omeprazole, a medication used to treat digestive disorders such as gastritis, gastric ulcers, duodenal ulceration, and gastroesophageal reflux disease by blocking the proton pump (Pandian *et al.*, 2002). In a rat model where ethanol was used to induce stomach ulcers, the aqueous extract and gel component of fenugreek seeds affect mucosal glycoproteins, and ant-secretory

action aids in ulcer prevention (Khilko *et al.*, 2014). It is possible to avoid ethanol-induced mucosal damage and lipid peroxidation by enhancing the mucosa's capacity to tolerate oxidation from fenugreek seed consumption (Al-Asadi, 2014).

4.9 Fenugreek in asthma treatment

Breathing becomes difficult and narrowed due to inflammation of the bronchial tubes or airways, a common lung ailment known as asthma (Amin *et al.*, n.d.). The purpose of the study was to assess the safety and effectiveness of using seed extract supplements for mild cases of asthma. Following the TPM guidelines, the fenugreek syrup was added to the honey solution (Emtiazzy *et al.*, 2018). Flavonoids, which are low molecular weight polyphenols that are effective in treating and partially preventing asthma, are the main ingredient in fenugreek (Sun *et al.*, 2021). Numerous studies have shown that the flavonoids in fenugreek shield the airways from oxidative stress and stop lipid peroxidation. This displays the antioxidant qualities of the herb (Belguith-Hadriche *et al.*, 2010).

4.10 Fenugreek against obesity

Nucleotide hydroxyisoleucine has been shown in multiple studies to reduce fat-induced insulin resistance (Zhou *et al.*, 2020). The transition from mTNF to sTNF is thought to be caused by hydroxyl isoleucine down-regulating a tumour necrotic factor-transforming catalyst (Kumar *et al.*, 2014). The research also offers details on the signal transduction pathway and improved insulin confrontation that is brought on by obesity in adipocytes. Fenugreek dietary supplements have been shown to have a major impact on weight loss over a brief period (Konopelniuk, *et al.*, 2017).

V. FENUGREEK AS AN INGREDIENT IN VARIOUS FOOD PRODUCTS

5.1 Overview

In Egypt, India, China, and certain parts of Europe, dried seeds have long been used for their beneficial health qualities, which include galactagogue, antimicrobial, anti-inflammatory, insulinotropic, and rejuvenating effects. Fenugreek can change the texture of food because of its high protein and fiber content, especially gum, a soluble dietary fiber that weights about 20.9 mg/g in the seed (Visuvanathan *et al.*, 2022). The fiber content and flavor components have an impact on how meals feel to the senses. Soluble fibers can be used to make dairy products, cereal bars, yogurts, and healthy drinks. For convenient supplementation, it can also be produced as tablets or capsules with other vitamins and minerals (Rida Kanwal *et al.*, 2024). It can also be used to improve milkshakes, soups, sauces, desserts, and candy products. It can also be used to fortify bakery flour for a variety of products, including pizza, bread, bagels, muffins, cake mixes, tortillas, fried and baked corn chips, and noodles (Khorshidian *et al.*, 2016).

5.2 Historical significance as a culinary and medicinal herb

Fenugreek is a member of the Fabaceae family. Because of its yellowish-white, triangular blossoms, it was given the Latin name *Trigonella*, which translates to "little triangle" (Nehra, 2022). It is called Hulba (Arabic), Uluva (Malayalam), Moshoseitaro (Greek), Methi (Hindi, Urdu, Punjabi, and Marathi), Shoot (Hebrew), Dari (Persian), and heyseed (English). One of the first Fabaceae family medicinal herbs, fenugreek (*Trigonella foenum-graecum* L.) evolved in central Asia approximately 4000 BC (Ahmad *et al.*, 2016). An ancient Egyptian pharmaceutical record from 1500 BC called the Ebers Papyrus contains a detailed account of it along with its benefits. This crop is cultivated for commercial purposes in Argentina, North Africa, the Middle East, India, Pakistan, Afghanistan, Iran, Nepal, Egypt, France, Spain, Turkey, and Morocco (Flammang *et al.*, 2004).

5.3 Importance of fenugreek in various cuisines

In Indian cooking, fenugreek seeds are often used as a spice to increase flavor; its leaves, sprouting seeds, and young shoots are used as vegetables. The seeds are fragrant and have a hint of sweetness mixed with bitterness. They are well-known for their galactagogue, carminative, and antidiabetic properties, as well as their hypocholesterolemic traits. Fenugreek seeds can be boiled, pressure cooked, roasted, or allowed to germinate in order to improve their texture and flavor while also lessening their natural bitterness (Dhull *et al.*, 2021).

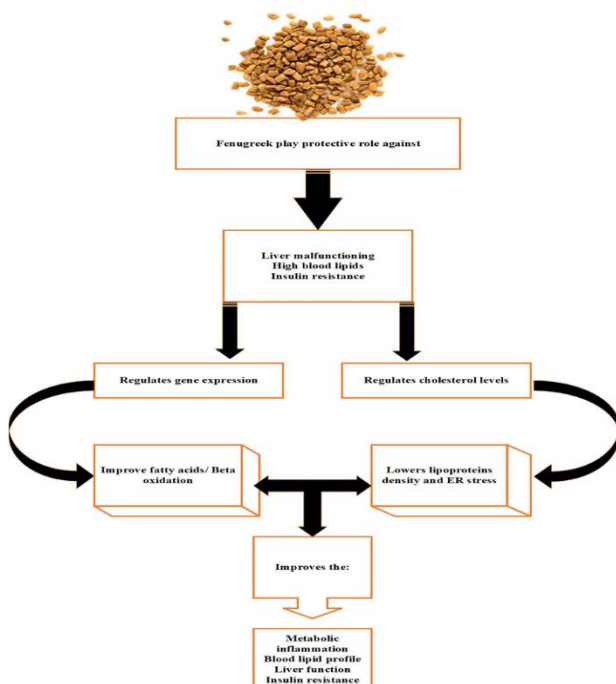


Figure 4: Protective Role of Fenugreek Against Metabolic Disorders

5.4 Culinary Uses

5.4.1. Fenugreek seeds

Fenugreek seeds have been recognized and esteemed as therapeutic substances since ancient times. The seeds of this plant are regarded as a valuable commercial source of a steroid called diosgenin, which holds significant relevance in the pharmaceutical business (Fatima *et al.*, 2018).

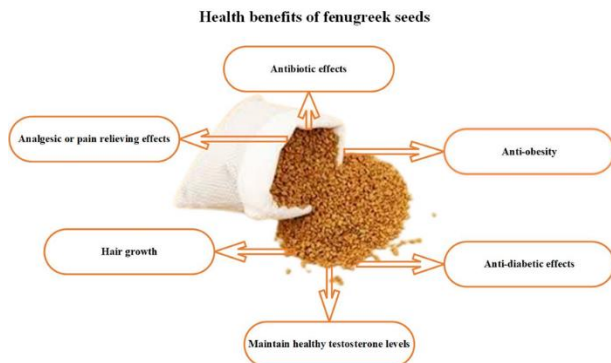


Figure 5: Comprehensive Health Benefits of Fenugreek Seeds

5.4.2. Fenugreek leaves

Several preparations were produced, primarily in the shape of a curry that is consumed alongside roti (Pakistani flat bread) during meals. Fenugreek, an herb, has been utilized as a culinary spice in European nations for many years. It continues to be a widely used ingredient in pickles, curry powders, and spice blends in Pakistan, India, Bangladesh, and other Asian countries (Weiss. 2002).

5.5 Use in spice blends and seasoning

Fenugreek seeds are utilized as a spice to enhance the taste of specific varieties of cheese, primarily parmesan. Salads and cottage cheese spreads can be enhanced by including powdered or crushed seeds. Fenugreek augmented taste and fragrance of foods. It included into curry sauce and serve as a customary component of the Bulgarian spice chubritza. Fenugreek seeds are employed for the purpose of enhancing the taste of coffee and vanilla extracts (Sarwar *et al.*, 2020). Fenugreek seeds are consumed in their raw form as sprouts and are also utilized for therapeutic purposes (Ahmed Shah *et al.*, n.d.). In Ethiopia and Egypt, fenugreek is utilized in the process of making bread called methi, whereas the Swiss employ it for the purpose of enhancing the taste of cheese. In the United States, it is predominantly utilized for creating spice mixtures intended for stews and soups (Dahal, 2022). The seed has a spicy scent, while its flavor possesses a somewhat pungent and bitter taste. Gently toasting fenugreek seeds enhance their taste, bringing out a delightful combination of nutty and sweet notes reminiscent of maple syrup. It is commonly employed as a primary ingredient in the creation of commercial maple syrup, vanilla essence, butterscotch, and caramel. The

aromatic qualities of maple and fenugreek impart their taste to fake maple syrup (Sarwar *et al.*, 2020).

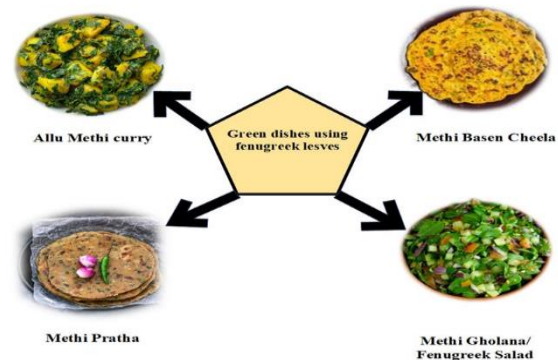


Figure 6: Green Dishes Using Fenugreek Leaves

5.6 Fenugreek in baked goods

To make biscuits of a decent caliber, fenugreek could be used for bakery goods like raw, soaked, and germinated flour. Fenugreek flour was added, which raised the amounts of total calcium, iron, protein, and dietary fibre (Hooda and Jood. 2005). Impact of stabilized rice bran fenugreek mixes on bread and cookie quality. Stabilized rice bran combined with wheat flour improved baking absorption, reduced loaf volume, raised the spread factor of cookies, and improved overall bread quality score. The physical and sensory qualities of the bread and cookies were enhanced by the further addition of fenugreek flour to rice bran (Chauhan and Sharma. 2000).



Figure 7: Hilbeh: A Traditional Palestinian Cake

5.7 Fenugreek as a flavor enhancer

A spice is a botanical ingredient that is fragrant or pungent and is dried. It can be made from roots, stems, bark, leaves, buds, flowers, fruits, and seeds, among other plant parts. It is applied as a taste enhancer in numerous culinary cultures (Manzoor *et al.*, 2019). Its use in many healing systems as a flavoring agent in food and for therapeutic reasons is supported by historical evidence (Balkrishna *et al.*, 2023).

VI. CHALLENGES AND CONSIDERATIONS

Adverse reactions encompass bloating, flatulence, diarrhea, gastrointestinal discomfort, vertigo, cephalalgia, and a distinctive scent resembling that of maple syrup in urine (Srivastava *et al.*, 2022).

Hypersensitive individuals may have trouble breathing, wheezing, facial puffiness, coughing, and serious allergic responses because of fenugreek use. Fenugreek has the potential to reduce blood sugar levels (Losso *et al.*, 2009).

VII. CONCLUSION

Fenugreek is old medicinal plant with vigorous chemical composition and exceptional nutritional value. Furthermore, presence of minerals, vitamins, proteins, lipids, amino acid and micronutrients make it more interesting in medical filed. Its nutritional composition, which includes high protein content, vital amino acids, and a variety of vitamins and minerals, makes it an effective dietary supplement. Fenugreek is widely used because of its health advantages, which include lowering blood glucose, LDL cholesterol, and triglycerides. However, in order to isolate bioactive molecules that are useful for the creation of cutting-edge medications and foods, more research is needed. This unique crop must be preferred for agriculture system due to their adaptability to adverse conditions like heavy metals, drought and salinity. Fenugreek's numerous therapeutic qualities, which include benefits for skin and hair as well as anti-diabetic and anti-cancer effects, highlighted its potential as a useful natural treatment. With its many health benefits shown by study, fenugreek presents itself as a potential herb for overall well-being. In conclusion, fenugreek is a diverse herb with a rich history and several culinary and medical applications. Culinary applications include spice mixes, seasoning, and integration into baked goods, demonstrating its versatility in the food business. When introducing fenugreek into one's diet, it is important to consider possible adverse reactions, allergies, and personal sensitivities. Fenugreek has bioactive compounds so it's thought to be safe for human use.

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