

# Therapeutic Potential of Fenugreek (*Trigonella foenum-graecum*) as an Additive in Medicines: A Comprehensive Review

Deepak Tomar<sup>1</sup>, Javeria Khan<sup>2</sup>, Kartik Sharma<sup>3</sup>, Simran<sup>4</sup>, Kajal Sherawat<sup>5</sup>, Namra Masud<sup>6</sup>, Lavdeep Singh<sup>7</sup>, Amulya Jindal<sup>8</sup>, Kirti Gupta\*

<sup>1</sup>Assistant professor, SRM Modinagar College of Pharmacy, SRM Institute of Science and Technology (Deemed to Be University), Delhi-NCR Campus, Modinagar, Ghaziabad, Uttar Pradesh, India

<sup>2</sup>Assistant Professor, Department of Pharmacy, ABSS Institute of Technology, NH 119, Salarpur, Meerut, Uttar Pradesh, India

<sup>3</sup>Assistant Professor, Department of pharmaceutical technology, Meerut Institute of Engineering and Technology, Meerut, India

<sup>4,5</sup>Assistant Professor, Meerut Institute of Technology, Meerut, Uttar Pradesh, India

<sup>6</sup>Assistant Professor, School of Pharmacy, Bharat Institute of Technology, Meerut, Uttar Pradesh, India

<sup>7</sup>Assistant Professor, Kharvel subharti college of Pharmacy, Swami Vivekanand Subharti University, Meerut-250005, Uttar Pradesh, India

<sup>8,\*</sup>Department of Pharmaceutical Technology, Meerut Institute of Engineering and Technology, Meerut-250005, Uttar Pradesh, India

## Abstract

This study investigates the potential uses of *Trigonella foenum-graecum* (fenugreek) as an additive in medicine formation. Fenugreek is a plant known for its medicinal properties and is rich in bioactive compounds such as alkaloids, flavonoids, saponins, and fibers. These compounds contribute to its various therapeutic properties, including anti-inflammatory, antioxidant, antidiabetic, anticancer, and immune-enhancing effects.

The study highlights the role of fenugreek as an additive in medicines targeting different health concerns. It can be incorporated into medicines for promoting digestion, managing diabetes, enhancing male reproductive health, and supporting respiratory, women, and cardiovascular health. Additionally, fenugreek may have benefits for skin care, weight management, liver health, antimicrobial activity, wound healing, anti-aging effects, hair and scalp health, bone health, neuro protection, and gastrointestinal health.

The extraction of fenugreek seeds can be performed using methods such as maceration and Soxhlet extraction, with appropriate solvents. Phytochemical screening of fenugreek seeds reveals the presence of compounds like alkaloids, saponins, flavonoids, coumarins, and steroids. These compounds contribute to the various health benefits associated with fenugreek.

## I. INTRODUCTION

*Trigonella foenum-graecum*, commonly known as fenugreek, is a plant that has been widely used for its medicinal properties for centuries. It is native to the Mediterranean region and is now cultivated in various parts of the world<sup>1,2</sup>. Fenugreek is not only valued for its culinary uses but also for its potential health benefits. In medicine formation, fenugreek is often utilized as an additive due to its numerous therapeutic properties.

The mucilaginous seeds of fenugreek are renowned for their numerous medicinal properties, including being a tonic, emollient, carminative, demulcent, diuretic, astringent, emmenagogue, and expectorant, restorative, aphrodisiac, and vermi fugal. They have historically been used to treat ailments such as mouth ulcers, chapped lips, and stomach irritation<sup>3</sup>. In Iranian traditional medicine, these seeds are valued as a tonic and for their ability to lower blood sugar levels<sup>4</sup>. The biological and pharmacological effects of fenugreek are attributed to its diverse constituents, which include steroids, N-compounds, polyphenolic substances, volatile constituents, amino acids, and more<sup>5</sup>. Fenugreek seeds are composed of 45-60% carbohydrates, predominantly mucilaginous fiber (galactomannans), 20-30% proteins rich in lysine and tryptophan, 5-10% fixed oils (lipids), pyridine alkaloids such as trigonelline (0.2-0.38%), choline (0.5%), gentianine, and carpaine. They also contain flavonoids like apigenin, luteolin, orientin, quercetin, vitexin, and isovitexin, free amino acids including 4-hydroxyisoleucine (0.09%), arginine, histidine, and lysine, as well as calcium, iron, saponins (0.6-1.7%), glycosides that yield steroidal saponins upon hydrolysis (such as diosgenin, yamogenin, tigogenin, neotigogenin), cholesterol, sitosterol, vitamins A, B1, C, and nicotinic acid, and volatile oils (n-alkanes and sesquiterpenes) present at a concentration of 0.015%.



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

One of the primary reasons fenugreeks is used as an additive in medicine is its rich content of bioactive compounds. The seeds of fenugreek contain a variety of beneficial compounds, including alkaloids, flavonoids, saponins, and fibers. These compounds are known to possess several medicinal properties, such as anti-inflammatory, antioxidant, antidiabetic, anticancer, and immune-enhancing effects<sup>6,7</sup>.

Fenugreek has been traditionally used to promote digestion and alleviate gastrointestinal issues. It is known to stimulate the production of digestive enzymes and bile, aiding in the breakdown of food and improving overall digestion. This makes it a valuable additive in medicines aimed at treating digestive disorders like indigestion, constipation, and gastritis. The seeds of fenugreek also exhibit hypoglycemic properties, making them beneficial for individuals with diabetes or prediabetes. The soluble fiber present in fenugreek helps slow down the absorption of glucose in the intestines and improves insulin sensitivity, leading to better glycemic control. As an additive, fenugreek can be incorporated into medicines designed to manage diabetes and regulate blood sugar levels.

Fenugreek possesses anti-inflammatory and antioxidant properties, which can contribute to its inclusion in medicine formulations. These properties make fenugreek potentially useful in managing inflammatory conditions like arthritis and reducing oxidative stress in the body. It may also aid in enhancing the body's natural defense mechanisms and strengthening the immune system.

In addition, fenugreek has been studied for its potential role in enhancing male reproductive health. It has been traditionally used as an aphrodisiac and is believed to improve libido and sexual performance. Some studies have suggested that fenugreek may increase testosterone levels and improve sperm quality, which may be beneficial for individuals with certain fertility issues. As an additive, fenugreek can be incorporated into medicines targeting male reproductive health.<sup>8,9</sup>

It is important to note that while fenugreek is generally considered safe for consumption, it may interact with certain medications and cause adverse effects in some individuals. Therefore, it is always advisable to consult a healthcare professional before using fenugreek or any medicine containing fenugreek as an additive, especially if you have any underlying health conditions or are taking other medications.

## **II. TRIGONELLA FOENUM-GRAECUM (FENUGREEK) HEALTH BENEFIT:**

**Respiratory Health:** Fenugreek has been traditionally used to alleviate respiratory issues such as cough, bronchitis, and congestion. It contains compounds that possess expectorant and mucolytic properties, helping to loosen and expel mucus from the respiratory tract. As an additive in medicines, fenugreek can be incorporated into cough syrups, respiratory tonics, and herbal remedies aimed at promoting respiratory health<sup>10</sup>

**Women's Health:** Fenugreek has long been recognized for its potential benefits in women's health. It is often used to stimulate milk production in nursing mothers due to its galactagogue properties. Fenugreek seeds contain phytoestrogens that can mimic the effects of estrogen in the body, making it potentially useful in managing symptoms associated with menopause and menstrual discomfort. Medicines formulated for women's health concerns may include fenugreek as an additive.

**Skin Care:** Fenugreek has been traditionally used for various skin conditions, including eczema, acne, and wounds. It possesses anti-inflammatory and antimicrobial properties that can help soothe skin irritations and prevent bacterial growth. As an additive, fenugreek can be included in topical creams, ointments, or lotions targeting skin health and providing relief for certain skin conditions.

**Weight Management:** Fenugreek seeds are known to have a satiating effect, which can aid in appetite control and weight management. The

soluble fiber in fenugreek helps create a feeling of fullness, potentially reducing food intake. As an additive, fenugreek can be incorporated into weight management supplements or formulations designed to support healthy weight loss.<sup>11, 12</sup>

**Cardiovascular Health:** Fenugreek has been investigated for its potential cardiovascular benefits. It has been shown to help reduce total cholesterol, LDL cholesterol, and triglyceride levels, while also increasing HDL cholesterol levels. These effects may be attributed to the presence of soluble fibers and saponins in fenugreek. Medicines targeting cardiovascular health may utilize fenugreek as an additive to support lipid profile management and overall heart health.<sup>13, 14</sup>

**Anti-inflammatory Effects:** Fenugreek contains compounds such as flavonoids and alkaloids that exhibit anti-inflammatory properties. These properties make it useful in the formulation of medicines targeting inflammatory conditions like arthritis, gout, and inflammatory bowel disease. Fenugreek may help reduce pain, swelling, and inflammation associated with these conditions.

**Anticancer Potential:** Some studies suggest that fenugreek may possess anticancer properties. It contains bioactive compounds that exhibit antioxidant and cytotoxic effects, potentially inhibiting the growth and spread of cancer cells. As an additive, fenugreek may be incorporated into medicines aimed at cancer prevention, supportive care during cancer treatment, or complementary therapy.<sup>15</sup>

**Liver Health:** Fenugreek has been used traditionally to support liver health and promote liver detoxification. It may help protect the liver from damage caused by toxins and oxidative stress. As an additive, fenugreek can be included in medicines targeting liver disorders, including fatty liver disease, hepatitis, and liver detoxification.

**Antimicrobial Activity:** Fenugreek possesses antimicrobial properties that can help fight against certain bacteria, fungi, and viruses. It may be used as an additive in medicines aimed at treating microbial infections, including respiratory infections, skin infections, and urinary tract infections.<sup>16</sup>

**Wound Healing:** Fenugreek has been used topically to promote wound healing. It contains compounds that aid in tissue regeneration and have antimicrobial effects, which can help prevent infection and facilitate the healing process. Fenugreek-based additives may be included in wound ointments, creams, or dressings to support wound healing.

**Anti-aging Effects:** The antioxidant properties of fenugreek can help combat oxidative stress and reduce the signs of aging. It may be used as an additive in anti-aging formulations, skincare products, or supplements targeting skin health and promoting a youthful appearance.

**Hair and Scalp Health:** Fenugreek has been traditionally used to improve hair strength, promote hair growth, and address scalp conditions like dandruff and itching. It contains compounds that nourish the hair follicles and provide moisture to the scalp. Fenugreek-based additives may be incorporated into shampoos, conditioners, or hair treatments to support hair and scalp health.

**Anti-Diabetic Effects:** Fenugreek has been traditionally used to manage diabetes and regulate blood sugar levels. It contains compounds that can help improve insulin sensitivity, inhibit carbohydrate digestion and absorption, and promote glucose utilization. As an additive, fenugreek can be incorporated into medicines aimed at managing diabetes and supporting overall glycemic control.

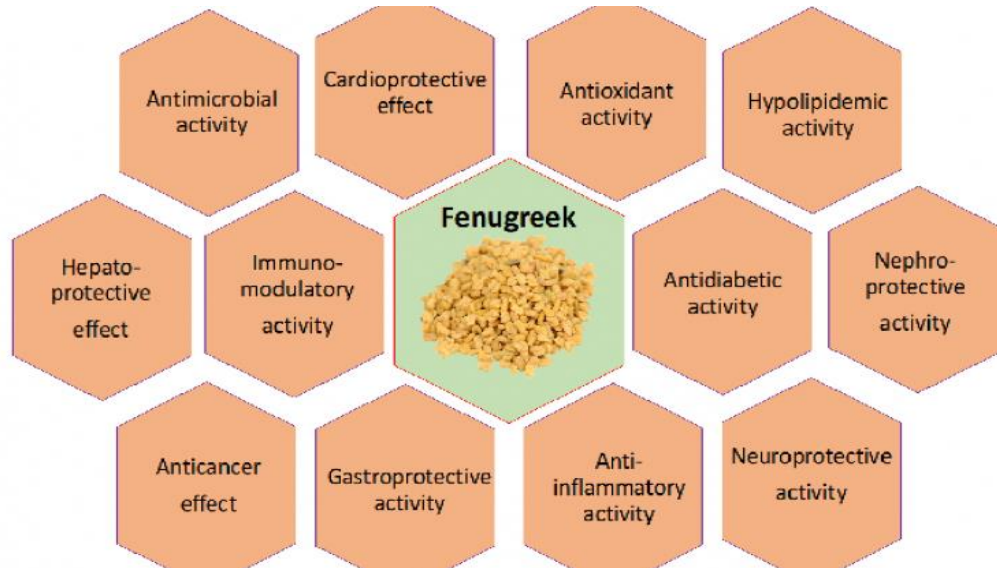
**Bone Health:** Fenugreek is rich in minerals such as calcium, magnesium, and phosphorus, which are essential for maintaining bone health. It may be used as an additive in medicines targeting osteoporosis, fractures, and other bone-related conditions. Fenugreek can help support bone density, mineralization, and overall skeletal health.

**Neuroprotective Properties:** Some studies suggest that fenugreek may have neuroprotective effects and could potentially benefit cognitive function and neurological disorders. It contains compounds that exhibit antioxidant and anti-inflammatory activities, which can help protect brain cells from damage and reduce neuro inflammation. As an additive, fenugreek may be incorporated into medicines aimed at supporting brain health and cognitive function.

**Antioxidant Activity:** Fenugreek is a rich source of antioxidants, including flavonoids and phenolic compounds. These antioxidants help protect the body against oxidative stress, which is linked to various chronic diseases and aging. Fenugreek-based additives in medicines may contribute to their overall antioxidant capacity, supporting cellular health and reducing oxidative damage.

**Gastrointestinal Health:** Fenugreek has been used traditionally to soothe gastrointestinal discomfort and support digestive health. It may help alleviate symptoms of gastric ulcers, acid reflux, and irritable bowel syndrome. Fenugreek contains mucilage, a gel-like substance that can coat the lining of the stomach and intestines, providing a soothing effect. As an additive, fenugreek can be incorporated into medicines targeting gastrointestinal health and digestive disorders.

**Antispasmodic Effects:** Fenugreek has been traditionally used as an antispasmodic agent to relieve muscle spasms and cramps. It may help relax smooth muscles in the gastrointestinal tract, urinary tract, and uterus. Fenugreek-based additives may be included in medicines designed to alleviate spasms and provide relief for conditions such as menstrual cramps or digestive spasms.



**Fig. 2- Pharmacological use of *Trigonella foenum-graecum* L.**

#### **Extraction of *Trigonella foenum-graecum* seeds (fenugreek)**

The extraction method for *Trigonella foenum-graecum* seeds, commonly known as fenugreek seeds, can vary depending on the desired compounds to be extracted. Here's a general method for extracting the active constituents from fenugreek seeds:

**Preparation:** Obtain high-quality fenugreek seeds and ensure they are clean and free from any impurities. Grind the seeds into a fine powder using a blender or a mortar and pestle.

**Solvent Selection:** Choose an appropriate solvent based on the desired compounds to be extracted. Common solvents used for fenugreek seed extraction include water, ethanol, and methanol. Each solvent has its advantages and limitations, so the choice depends on the specific compounds of interest.

#### **Maceration Extraction:**

- a) Weigh a specific amount of fenugreek seed powder. The amount can vary based on the scale of extraction and desired concentration of the extract.
- b) Place the fenugreek seed powder in a glass container.
- c) Add the selected solvent to the container, making sure the powder is fully immersed. The solvent-to-seed ratio can vary but is typically around 10:1 (v/w).
- d) Seal the container tightly to prevent evaporation or contamination.
- e) Allow the mixture to macerate at room temperature for a specific duration, typically 24 to 72 hours, with occasional shaking or stirring to enhance extraction.
- f) After the maceration period, filter the extract using filter paper or a filtration system to separate the liquid extract from the solid residue.<sup>17,18,19</sup>



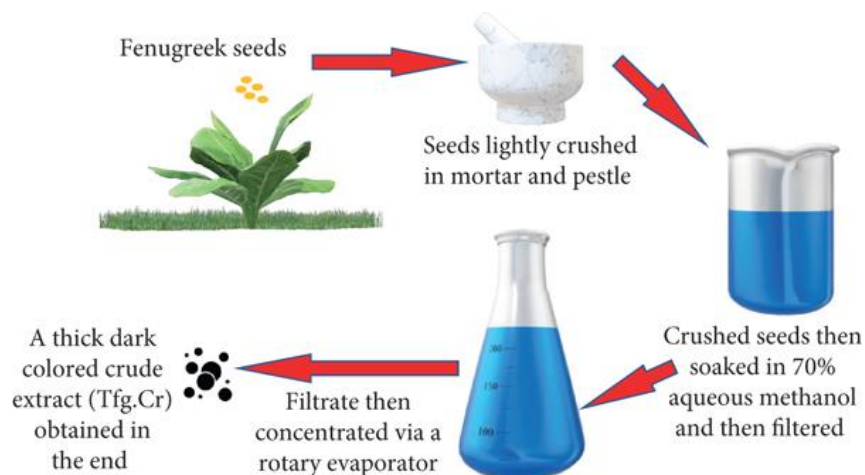


Fig. 3- Maceration process of Fenugreek (*Trigonella foenum-graecum* L.)

#### Soxhlet Extraction (optional):

- Weigh a specific amount of fenugreek seed powder and place it in a thimble or extraction chamber.
- Set up a Soxhlet extraction apparatus, consisting of a Soxhlet extractor, a round-bottom flask, and a condenser.
- Fill the round-bottom flask with the selected solvent.
- Connect the Soxhlet apparatus and heat the flask, allowing the solvent to reflux and repeatedly extract the target compounds from the fenugreek seeds.
- Continue the extraction process for several hours (usually 6-8 hours).
- Collect the extract in a separate container, and remove the solvent by evaporating it under reduced pressure using a rotary evaporator or by allowing it to evaporate naturally.
- Concentration and Drying:**
- If the extract obtained from either maceration or Soxhlet extraction is too dilute, concentrate it using an appropriate method such as rotary evaporation or freeze drying.
- Once concentrated, transfer the extract to a pre-weighed container and allow it to dry completely in a well-ventilated area or using a desiccator.
- Weigh the dried extract to determine the final yield.<sup>20</sup>

#### Phytochemical Screening:

The phytochemical analysis of *Trigonella foenum-graecum* seeds involves the identification and quantification of various bioactive compounds present in the seeds. Here are some of the key phytochemicals that have been reported in fenugreek seeds:

**Alkaloids:** A mixture of 1.0ml of the extract and 2.0ml of 2.0% Sulfuric Acid was heated for 2 minutes. The resulting solution was filtered, and a small amount of Dragendorff's reagent was introduced. An orange-red precipitate was detected in all of the extracts, indicating the presence of alkaloids. Fenugreek seeds contain alkaloids such as trigonelline and choline. Trigonelline is known for its potential antidiabetic properties.

**Saponins:** Each extract (1.0ml) was mixed with 5.0ml of distilled water and heated until boiling. The detection of saponins was signaled by the appearance of a frothy coating accompanied by a velvety haze of miniature bubbles. Fenugreek seeds are rich in saponins, including diosgenin and yamogenin. These compounds have been associated with various health benefits, including cholesterol-lowering and anticancer effects.

**Flavonoids:** To detect flavonoids, 1.0ml of each extract was mixed with 1.0ml of diluted 0.2M Sodium Hydroxide (NaOH) solution. Subsequently, 1.0ml of 10% Hydrochloric Acid (HCl) solution was added to the mixture. The presence of flavonoids was indicated by a color change from yellow to colorless in the solution. Fenugreek seeds contain flavonoids such as vitexin, isovitexin, quercetin, and luteolin. Flavonoids possess antioxidant, anti-inflammatory, and anticancer properties.<sup>21</sup>

**Coumarins:** The addition of 3 mL of 10% sodium hydroxide (NaOH) to a 2 mL aqueous plant extract, resulting in a yellow color, suggests the presence of certain classes of compounds in the extract. However, without further information, it is difficult to determine the exact compound responsible for the observed color change. Coumarins, including scopolamine and umbelliferone, are present in fenugreek seeds. These compounds have shown potential antimicrobial and antioxidant activities.

**Steroids:** The tests you mentioned are commonly used to detect the presence of steroids and sterols in plant extracts. Let me explain each test in more detail:

**Salkowski Test:** In this test, a few drops of concentrated sulfuric acid (H<sub>2</sub>SO<sub>4</sub>) are added to 1 mL of the plant extract in a test tube. If steroids are present in the extract, a red coloration will appear. This color change occurs due to the reaction between the sulfuric acid and the specific functional groups present in steroids.

**Liebermann's Reaction:** For this test, 3 mL of acetic anhydride is added to 3 mL of the ethanolic plant extract. The mixture is then heated and cooled. Afterward, a few drops of concentrated sulfuric acid (H<sub>2</sub>SO<sub>4</sub>) are added. If sterols are present in the extract, a blue color will develop. This color change is indicative of the presence of sterols and is a result of a complex reaction between the sulfuric acid, the sterols, and the acetic anhydride.

**H<sub>2</sub>SO<sub>4</sub> Test:** In this test, the ethanolic extract of the plant is treated with a few drops of concentrated sulfuric acid (H<sub>2</sub>SO<sub>4</sub>). The appearance of a violet, blue, or green color in the solution indicates the presence of sterols. The exact color observed may vary depending on the specific sterols present in the extract. Fenugreek seeds contain steroidal compounds such as beta-sitosterol and stigma sterol. These compounds are known for their cholesterol-lowering effects and have been studied for their potential use in managing cardiovascular diseases.<sup>11</sup>

**Proteins and Amino Acids:** Fenugreek seeds are a good source of proteins and amino acids. They contain high levels of lysine, tryptophan, and arginine, among others.

**Fiber:** Fenugreek seeds are rich in dietary fiber, including soluble fiber like galactomannans. This fiber has been associated with various health benefits, such as improved digestion and blood sugar control.

**Essential Oils:** To identify the presence of essential oils in a plant extract of Fenugreek seeds, you can perform several tests commonly used for essential oil analysis. Here are a couple of approaches that can be employed:

**Organoleptic Evaluation:** This test involves assessing the aroma and flavor of the plant extract. Essential oils are volatile and possess characteristic aromas. In the case of Fenugreek seeds, the essential oil is known for its distinct, sweet, and somewhat nutty aroma. By smelling the plant extract, you can get an initial indication of the presence of essential oils.<sup>22</sup>

**Gas Chromatography-Mass Spectrometry (GC-MS):** GC-MS is a powerful technique for identifying and analyzing the components of essential oils. It separates the mixture into individual compounds and provides information about their molecular structures. A sample of the Fenugreek seed extract would be analyzed using GC-MS, and the resulting chromatogram and mass spectrum would help identify the specific compounds present in the essential oil.<sup>23</sup>

**Thin-Layer Chromatography (TLC):** TLC can be used to analyze the chemical composition of essential oils. It involves separating the components of the oil on a thin layer of adsorbent material, such as silica gel, and visualizing the separated compounds under appropriate detection methods. By comparing the resulting TLC profile with known reference standards or published data, you can determine the presence of characteristic compounds found in Fenugreek essential oil.

**Solubility Test:** Essential oils are generally soluble in organic solvents like ethanol, ether, or chloroform, but less soluble in water. You can perform a solubility test by adding a small amount of the plant extract to separate tubes containing water and an organic solvent. If the extract dissolves better in the organic solvent than in water, it suggests the presence of essential oils.

Fenugreek seeds also contain essential oils, primarily composed of compounds such as sabinene, beta-pinene, and limonene. These oils contribute to the characteristic aroma and flavor of fenugreek.<sup>24</sup>

### III. CONCLUSION AND RESULT

The conclusion of this study suggests that *Trigonella foenum-graecum* (fenugreek) has diverse therapeutic properties and can be used as an additive in medicine formulations targeting various health concerns. Fenugreek is rich in bioactive compounds such as alkaloids, flavonoids, saponins, and fibers, which contribute to its medicinal properties, including anti-inflammatory, antioxidant, antidiabetic, anticancer, and immune-enhancing effects.

Based on the findings, fenugreek can be incorporated into medicines for promoting digestion, managing diabetes, enhancing male reproductive health, and supporting respiratory, women's, and cardiovascular health. It may also have benefits for skin care, weight management, liver health, antimicrobial activity, wound healing, anti-aging effects, hair and scalp health, bone health, neuro protection, and gastrointestinal health.<sup>25</sup>

Extraction of fenugreek seeds can be performed using methods such as maceration and Soxhlet extraction with appropriate solvents. Phytochemical screening of fenugreek seeds reveals the presence of compounds like alkaloids, saponins, flavonoids, coumarins, and steroids, which contribute to the various health benefits associated with fenugreek.

It is important to note that while fenugreek is generally considered safe for consumption, it may interact with certain medications and cause adverse effects in some individuals. Therefore, it is advisable to consult a healthcare professional before using fenugreek or any medicine containing fenugreek as an additive, especially if there are underlying health conditions or other medications being taken.

Overall, this study highlights the potential of fenugreek as a valuable additive in medicine formulations, providing a natural and multifunctional approach to addressing various health concerns.<sup>26</sup>

## REFERENCE

1. K. Nadkarni, Indian Materia Medica, Popular Prakashan, Bombay, 2000.
2. L. D. Kapoor, CRC Handbook of Ayurvedic Medicinal Plants, CRC Press Inc., Boca Raton, 2000.
3. Duke AJ., 1986. Handbook of Legumes of World Economic Importance, Plenum Press, New York and London. pp: 345.
4. Hajimehdipoor H., Sadat-Ebrahimi SE., Amanzadeh Y., Izaddoost M., Givi E., 2010. Identification and Quantitative Determination of 4-Hydroxyisoleucine in *Trigonella foenumgraecum* L. from Iran. *J. Medicinal Plants*, 9 (6): 29 – 34.
5. Mehrafarin A., Qaderi A., Rezazadeh Sh., Naghdi Badi H., Noormohammadi Gh., and Zand E., 2010. Bioengineering of Important Secondary Metabolites and Metabolic Pathways in Fenugreek (*Trigonella foenumgraecum* L.). *J. of Medicinal Plants*, 9(35): 1–18.
6. S. Lininger, J. Wright, S. Austin, D. Brown, and A. Gaby, the Natural Pharmacy, Prima Health, Rocklin, 1998.
7. C. W. Fetrow and J. R. Avila, Professional's Handbook of Complementary and Alternative Medicines, Lippincott Williams and Wilkins, Philadelphia, 2004.
8. Kapoor LD. Handbook of Ayurvedic medicinal plants: Herbal reference library. Routledge; 2017 Nov 13.
9. Premila MS. Ayurvedic herbs: a clinical guide to the healing plants of traditional Indian medicine. Psychology Press; 2006.
10. Pole S. Ayurvedic medicine: the principles of traditional practice. Singing dragon; 2013.
11. Halberstein RA. Medicinal plants: historical and cross-cultural usage patterns. *Annals of epidemiology*. 2005 Oct 1; 15(9):686-99.
12. Krishna SS, Aiswarya Purushothaman AP. Warfarin interactions with complementary medicines, herbs and dietary supplements.
13. Daugherty NE, Smith KM. Dietary supplement and selected food interactions with warfarin.
14. Smith M. Therapeutic applications of fenugreek. *Alternative Medicine Review*. 2003; 8(1):20-7.
15. Kassaian N, Azadbakht L, Forghani B, Amini M. Effect of fenugreek seeds on blood glucose and lipid profiles in type 2 diabetic patients. *International Journal for Vitamin and Nutrition Research*. 2009 Jan 1; 79(1):34-9.
16. Naidu MM, Shyamala BN, Naik JP, Sulochanamma G, Srinivas P. Chemical composition and antioxidant activity of the husk and endosperm of fenugreek seeds. *LWT-Food Science and technology*. 2011 Mar 1; 44(2):451-6.
17. Al-Habori M, Al-Aghbari AM, Al-Mamary M. Effects of fenugreek seeds and its extracts on plasma lipid profile: a study on rabbits. *Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives*. 1998 Dec; 12(8):572-5.
18. Kapoor LD. CRC handbook of Ayurvedic medicinal plants. CRC press; 2018 Jan 18.
19. Pole S. Ayurvedic medicine: the principles of traditional practice. Singing dragon; 2013.
20. Panda H. Medicinal plants cultivation & their uses. Asia Pacific Business Press Inc.; 2002.
21. Warriar PK. Indian medicinal plants: a compendium of 500 species. Orient Blackswan; 1993.
22. Panda H. Medicinal plants cultivation & their uses. Asia Pacific Business Press Inc.; 2002
23. Savych A, Marchyshyn S, Mosula L, Bilyk O, and Humeniuk I, Davidenko A. Analysis of amino acids content in the plant components of the antidiabetic herbal mixture by GC-MS. *Pharmacia*. 2022 Jan 7; 69:69-76.
24. Haeri MR, Izaddoost M, Ardekani MR, Nobar MR, White KN. The effect of fenugreek 4-hydroxyisoleucine on liver function biomarkers and glucose in diabetic and fructose-fed rats. *Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives*. 2009 Jan; 23(1):61-4.
25. Shah SN, Bodhankar SL, Bhonde R, Mohan V. Hypoglycemic activity of the combination of active ingredients isolated from *Trigonella foenumgraecum* in alloxan induced diabetic mice. *Pharmacologyonline*. 2006 Jan 1; 1:65-82.
26. Renuka C, Ramesh N, Saravanan K. Evaluation of the antidiabetic effect of *Trigonella foenum-graecum* seed powder on alloxan-induced diabetic albino rats. *International Journal of Pharm Tech Research*. 2009; 1(4):1580-4.