



FENUGREEK (TRIGONELLA FOENUM-GRÆCUM L.): A MULTIFACETED ETHNO-BOTANICAL RESOURCE WITH THERAPEUTIC NUTRACEUTICAL AND COSMECEUTICALS POTENTIAL

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Abstract

Fenugreek (*Trigonella foenum-graecum*) is an ancient medicinal plant that has been widely used in various traditional systems of medicine around the world. This research paper provides an original and comprehensive overview of its versatile applications encompassing traditional medicine, culinary traditions, and cosmetic formulations. Fenugreek, native to the Mediterranean region, has a rich history dating back thousands of years. In Ayurveda, the traditional Indian system of medicine, fenugreek is highly regarded for its potential to treat various ailments, including digestive disorders, respiratory problems, and reproductive health issues and overall body functioning. In recent years, scientific research has delved into its bioactive components and potential therapeutic applications. Studies have highlighted the presence of alkaloids, flavonoids, and other phytochemicals in fenugreek, which contribute to its diverse biological activities. These include antioxidant, anti-inflammatory, antimicrobial, antidiabetic, anticancer, and hepatoprotective effects, among others. Apart from its medicinal applications, fenugreek holds an esteemed place in the culinary traditions of many cultures. The seeds are widely used as a spice and flavouring agent in dishes across the Indian subcontinent, the Middle East, and North Africa. Furthermore, it has been employed as a cosmetic ingredient for centuries. Fenugreek extracts, pastes and oils are commonly used in hair care and skin ailments like acne, eczema, and inflammation. In conclusion, the wealth of ethnobotanical knowledge surrounding fenugreek provides a valuable resource for developing new medicinal and culinary innovations and promoting sustainable practices in the context of global health and well-being.

Keywords – Ayurveda, Fenugreek, Nutraceutical

Introduction-

Fenugreek also known as *Trigonella foenum-graecum* L. is an herbaceous plant that belongs to the Fabaceae family. With a rich history of cultivation and utilization spanning over thousands of years, fenugreek has been recognized for its diverse medicinal properties and nutritional benefits in various traditional systems of medicine. The plant is native to the Mediterranean region, specifically the Middle East and South Asia, and has gained widespread popularity worldwide due to its therapeutic

potential.¹ Fenugreek has been a subject of interest for researchers and scientists due to its unique chemical composition and associated health benefits. The plant contains a plethora of bioactive compounds, including phytochemicals like steroidal saponins (diosgenin), fenugreekine (alkaloid), galactomannan (carbohydrate), 4-hydroxy isoleucine (amino acid) among several others which contribute to its medicinal properties.² These active constituents have been investigated extensively for their potential roles in promoting human health, ranging from improving digestion to managing various chronic conditions. One of the prominent uses of fenugreek is in traditional medicine systems such as Ayurveda and traditional Chinese medicine (TCM). In these systems, fenugreek seeds, leaves, and extracts have been employed to treat a wide array of ailments, including digestive disorders, respiratory problems, diabetes, inflammation, menstrual disorders, and male reproductive health issues³ Moreover, fenugreek has also gained recognition for its potential as a galactagogue, a substance that promotes milk production in lactating women⁴.

The scientific research has delved into the various mechanisms of action underlying fenugreek's therapeutic effects. The studies have highlighted its anti-inflammatory, antioxidant, anti-diabetic, hypocholesterolemic, immunomodulatory, and anticancer properties, among others.⁵ These findings have provided a scientific basis for understanding the traditional uses of fenugreek and have opened up avenues for its exploration as a potential source of novel therapeutic agents.

Name, Classification, and Plant Characteristics



Trigonella foenum-graecum is an angiosperm plant that belongs to Rosaceae order, Legouminosae family, subfamily of Papilionaceae and Trigonella L. genus of the Trifolia group⁶. The fenugreek plant is herbaceous, annual can grow up to 50 cm in height. Often glabrous, twisted, or with dispersed tomentums, this plant bears a single stem. Three tiny obovate to oblong leaflets and leaflets dispersed from a single point make up the oval, serrated leaves. Insects pollinate the pale yellow or whitey purple flowers, which range in diameter from 0.8 to 1.8 cm. Curved pods that are 3 to 11 cm long and contain 5 to 20 angled seeds that are 4 to 6 mm long are the fruits. The flavor of seeds is bitter and fragrant, and they range in color from pale yellow to brown.

History of Fenugreek

The history of fenugreek, can be traced back thousands of years, with its origins rooted in the ancient civilizations of the Mediterranean region and South Asia. This plant is an annual forage legume and a traditional spice crop that has been grown for centuries across the Indian subcontinent, leaving a lasting impact on traditional medicine, culinary practices, and cultural traditions.⁷ Fenugreek's earliest recorded use dates back to ancient Egypt, where it was employed as a medicinal herb and as a food ingredient. The seeds were found in the tombs of pharaohs, indicating its significance in their society. The ancient Egyptians believed that fenugreek had potent healing properties and used it to address digestive ailments, improve overall health, and even embalm the deceased.⁸ In ancient Greece and Rome, fenugreek was highly regarded for its medicinal properties. Also it was considered medicinal

and was used for this purpose by the ancient Egyptians. The Greek physician Hippocrates used it as a sedative herb. Other ancient Greeks used Fenugreek to treat infections. In Traditional Chinese Medicine it was used as tonic and for treatment of weakness and edema⁹ Fenugreek's presence in traditional Indian medicine, known as Ayurveda. In Ayurvedic texts, fenugreek is described as "Methika" and Methi seeds are described under the "ChaturbeejaVargas" of Bhavprakash.¹⁰ is considered pungent in taste, hot in potency, vitiates Rakta and Pitta, It treats anorexia, appetizing in nature, stimulates digestive fire and alleviates vitiated vata dosha¹¹. Fenugreek seeds and leaves have been incorporated into various formulations and remedies to address a wide range of health concerns. Fenugreek's culinary applications have also left a lasting impression on various cuisines around the world. It is a common ingredient in Middle Eastern, Indian, and Mediterranean dishes, where the seeds are used for flavouring, as a spice, or even sprouted for salads. Fenugreek leaves, known as "methi," are widely used in Indian cooking, adding a distinctive flavor and aroma to curries, dals, and vegetable dishes.

Nutritional Composition of Fenugreek Seeds:

Fenugreek is known for its culinary benefits in addition to its therapeutic benefits. The plant is used extensively as a spice that enhances food flavour while also supporting metabolic processes and general well-being. It is good source proteins with high amounts of essential and total amino acids. The following amino acid profile was found in fenugreek seeds: prolamins (74.00 g kg⁻¹), glute-lins (172.00 g kg⁻¹), globulins (272.00 g kg⁻¹), and albumins (438.00 g kg⁻¹)¹². Free amino acids, especially histidine and isoleucine, are abundant in fenugreek and may promote the release of insulin.¹³ Fenugreek seeds are characterized by varied mineral content, and some minerals, such as calcium, phosphorus, magnesium and sulfur, are found in significant concentrations though the environmental conditions, growing methods, and genotype all affect the amounts of biogenic components in fenugreek seeds¹⁴. The majority of fenugreek lipids are neutral fats, such as phospholipids (10.5%), glycolipids (5.4%), diglycerides (6.3%), and triglycerides (86.1%) with linoleic acid and α -linolenic. Fenugreek oil is strong antibacterial agent against *Salmonella typhimurium*, *Staphylococcus aureus*, *Escherichia coli*, and *Aspergillus niger*.¹⁵

Role of fenugreek as a medicinal agent in the management and prevention of various diseases.

Fenugreek, with its long history of traditional use, has gained scientific recognition for its diverse therapeutic properties. Its potential applications span across various diseases, including diabetes, cardiovascular disorders, digestive ailments, reproductive health issues, and inflammatory conditions. While existing research demonstrates promising results, further investigations are needed to establish optimal dosage, long-term safety, and potential drug interactions. Fenugreek represents a natural resource with immense medicinal potential, warranting continued scientific exploration to harness its benefits fully and develop evidence-based therapeutic interventions. Fenugreek, exhibits diverse therapeutic effects on various diseases. The bioactive compounds present in fenugreek contribute to its pharmacological properties and mechanisms of action. This brief overview explores some of the key mechanisms through which fenugreek works in different diseases.

Effect on Obesity

The excessive and aberrant accumulation of fat in internal organs and adipose tissue is known as obesity. One of the main risk factors for insulin resistance and the subsequent onset of diabetes mellitus is obesity itself. Many animal studies have concluded reduction in body weight gain, body mass index, and visceral fat pad weights, alongside a marked improvement in dyslipidemia¹⁶. Fenugreek, fiber significantly increased feelings of fullness and satiety in obese subjects, leading to a reduction in energy intake at a subsequent ad libitum lunch. The mechanism behind this satiety effect is likely related to the high fiber content, particularly galactomannan, which can delay gastric emptying and increase the viscosity of gut contents, thereby promoting a feeling of fullness¹⁷. Diosgenin, a steroidal saponin found in fenugreek, was identified as a key player. Research

showed that diosgenin could promote the differentiation of smaller, more insulin-sensitive adipocytes while simultaneously inhibiting inflammation in adipose tissue of diabetic obese mice, thereby improving glucose metabolism

Effect on Diabetes

Fenugreek has shown promising effects in managing diabetes, primarily due to its ability to improve glucose metabolism and insulin sensitivity. Research suggests that fenugreek seed extracts can reduce fasting blood sugar levels, postprandial glucose spikes, and HbA1c levels in individuals with both type 1 and type 2 diabetes.¹⁸ Bio active compounds in fenugreek as Trigonelline acts by increasing Insulin resistance, cell regeneration¹⁹, increased glucose tolerance²⁰ and inhibition of intestinal glucose uptake²¹ making it beneficial for individuals with diabetes. Other saponins, such as diosgenin, have antioxidant and hypolipidemic properties and help to reduce the inflammatory changes in obese adipose tissues²². It stimulates the uptake of glucose into cells, reduces intestinal glucose absorption, and inhibits enzymes involved in carbohydrate digestion.²³ Fenugreek also enhances pancreatic beta-cell function and increases insulin secretion, thereby regulating blood sugar levels and improving glycemic control.²⁴

Effect on Cardiovascular diseases:

Fenugreek exerts positive effects on cardiovascular health through various mechanisms. Several studies have investigated the potential cardiovascular benefits of fenugreek. Its rich content of Galactomannans are complex carbohydrates that have been shown to lower cholesterol level and saponins, and flavonoids help reduce cholesterol levels by binding to bile acids and inhibiting their reabsorption, leading to increased excretion of cholesterol. Fenugreek supplementation has been shown to reduce total cholesterol, low-density lipoprotein (LDL) cholesterol, triglycerides, and blood pressure, while increasing high-density lipoprotein (HDL) cholesterol levels.²⁵ These effects suggest a potential role for fenugreek in the prevention and management of cardiovascular diseases. Fenugreek's antioxidant properties combat oxidative stress, reducing the risk of lipid peroxidation and preventing cardiovascular diseases. Moreover, fenugreek's vasodilatory effects may improve blood flow and reduce blood pressure, promoting cardiovascular health.²⁶

Effect on Digestive Disorders:

Fenugreek has traditionally been used to improve digestion and alleviate gastrointestinal discomfort. The research has indicated that fenugreek extracts possess anti-inflammatory and antioxidant properties, which can help reduce inflammation in the gastrointestinal tract and protect against oxidative damage.²⁷ Fenugreek reduces inflammation in the gastrointestinal tract by suppressing pro-inflammatory cytokines and inhibiting the activity of inflammatory enzymes.²⁸ Additionally, fenugreek's mucilaginous properties may provide a soothing effect on the gut lining, promoting healthy bowel movements and aiding in the management of conditions such as constipation and irritable bowel syndrome (IBS). Fenugreek has indeed been shown to modulate intestinal bacteria in several animal models²⁹ Even when diets and lifestyles are not ideal, metabolic resilience may be promoted by using fenugreek and/or other methods to keep a healthy population of gut bacteria in the context of a high-fat diet. In fact, although fenugreek provided protection against glucose intolerance and hyperlipidemia, but other lifestyle factors need to be considered.

Effect on Reproductive Health:

Fenugreek has been recognized for its potential benefits in reproductive health, particularly in males and lactating women. The studies have suggested that fenugreek supplementation may enhance testosterone levels, improve sperm count, and increase sperm motility through its influence on hormone regulation and antioxidant activity in men.³⁰ In lactating women, fenugreek has been traditionally used as a galactagogue, promoting milk production and it may increase prolactin secretion due to an estrogenic action, which decreases the secretion of dopamine (a prolactin secretion

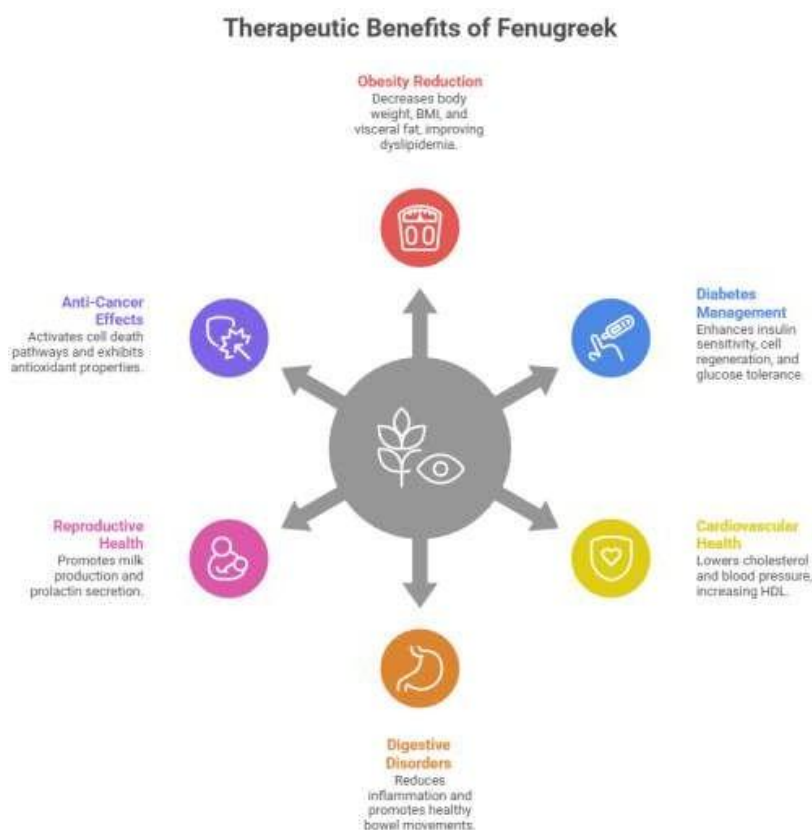
inhibitor) in the hypothalamus.³¹ The study's findings³² demonstrated that *T. foenum-graecum* treatment reverses the inflammatory and metabolic changes brought on by ovariectomy and may be used to treat menopause.

Anti-inflammatory and Antioxidant Effects:

The bioactive compounds present in fenugreek, including flavonoids and saponins, exhibit significant anti-inflammatory and antioxidant properties. It inhibits the activation of NF- κ B, a key transcription factor involved in inflammation, and decreases the release of pro-inflammatory cytokines.³³ Fenugreek's antioxidant properties neutralize harmful free radicals, protecting cells and tissues from oxidative damage and mitigating oxidative stress-related diseases. These properties make fenugreek a potential candidate for managing chronic inflammatory conditions, such as arthritis and inflammatory bowel disease (IBD). Additionally, fenugreek's antioxidant activity helps combat oxidative stress, which plays a crucial role in various diseases, including neurodegenerative disorders and cardiovascular conditions.

Anti-Cancer Effect

The varied number of studies demonstrated fenugreek's ability to selectively induce cytotoxicity in a wide array of cancer cell lines while demonstrating minimal or no toxicity toward normal, healthy cells. This selective pressure was observed in cancers of the breast, prostate, pancreas, liver, colon, and blood.³⁴ The ability of fenugreek extract to activate multiple cell death pathways was demonstrated when it was demonstrated to cause cellular death in human T lymphoma Jurkat cells by both apoptosis and autophagy, a process of regulated cellular self-digestion.³⁵ An important compound, apigenin, a flavonoid, was also implicated in the plant's anti-proliferative effects. The synergistic action of these and other constituents, including trigonelline, quercetin, and various saponins, likely accounts for the broad-spectrum activity observed with whole seed extracts, as they can act on multiple cellular targets and signalling pathways.



Role of fenugreek for culinary purpose

Fenugreek has a longstanding history of culinary use across various cultures. Its unique flavour profile and aromatic qualities have made it a prized ingredient in numerous dishes and culinary traditions around the world.³⁶ Fenugreek's culinary applications are wide-ranging and diverse, making it a highly valued ingredient in many cuisines. Its unique flavour profile, encompassing bitter, nutty, sweet, and herbaceous notes, adds depth and complexity to dishes. Whether used in spice blends, curries, stews, sauces, breads, or pickles, fenugreek elevates the culinary experience, providing a distinct and memorable taste. Its contribution to the culinary world is a testament to its versatility and the appreciation of its unique flavour and aroma. Fenugreek seeds and leaves possess a distinct flavour that is difficult to replicate with other ingredients. The seeds impart a subtle yet potent bitter and nutty taste, while the leaves offer a slightly sweet and herbaceous flavour. This combination of flavors adds depth and complexity to a wide range of culinary creations.

Here, we will explore the culinary applications of fenugreek and delve into its contributions to flavour, aroma, and gastronomic experiences.

Spice Blends and Seasonings:

The primary forms of preparation leverage both the seeds and the fresh or dried leaves, each requiring specific handling to balance their potent organoleptic and medicinal qualities. Fenugreek is an integral component of many spice blends and seasonings, lending its unique flavour and aroma to create well-balanced and flavourful profiles. Roasting is one of the simplest seed preparation methods. Due to substances like sotolon, raw fenugreek seeds have a strong, bitter flavour. To significantly reduce this harshness and generate a pleasant, nutty, caramel-like scent, dry-roast them in a skillet until they are golden brown. Usually, these roasted seeds are then ground into a fine powder and included as a main ingredient to many spice mixtures. One essential ingredient in Indian cooking is fenugreek seed powder, which adds depth and complexity to garam masala, sambar masala, curry powders and Panch Phoron, a Bengali five-spice blend. The molecular structure of some phytochemicals may be altered by this thermal processing, which could affect their biological activity in addition to improving sensory properties as to enhance the taste of various curries, stews, and rice dishes. These blends are used to. Similarly, in Middle Eastern cuisine, fenugreek is often found in spice blends like za'atar, adding an earthy and herbaceous note to dips, marinades, and roasted meats.

Sprouting fenugreek seeds is another popular traditional approach. After soaking in water for a few hours, the seeds are let to sprout over the course of a few days. In order to increase nutrient accessibility and decrease anti-nutritional factors, this germination process activates enzymes that break down complex proteins and carbohydrates. Since they have a crisp texture and a milder flavor than raw fenugreek seeds, sprouted seeds are frequently used in salads or as a digestive aid.

Fenugreek seeds are a popular ingredient in pickles and chutneys due to their ability to enhance flavor and act as a natural preservative. In Indian cuisine, fenugreek seeds are often pickled and used as a condiment alongside meals.

The leaves of the fenugreek plant, both fresh and dried, are central to many regional dishes. Fresh green leaves are commonly chopped and added to lentil stews (dals), vegetable curries, and flatbreads like parathas. A classic example is *methi paratha*, a popular North Indian breakfast. Fresh Fenugreek leaves can also be used to make chutneys, adding a tangy and herbaceous element to these versatile accompaniments. Dried fenugreek leaves, known as *kasuri methi*, are a pantry staple in Indian kitchens. The leaves are harvested, sun-dried, and crumbled. This drying process concentrates their aroma and imparts a unique, savory, almost umami-like quality that is far less bitter than the fresh form. *Kasuri methi* is used as a finishing herb, sprinkled into dishes just before serving to add a final layer of aromatic complexity to curries, dals, and rice preparations.

A crucial but occasionally disregarded traditional method is fermentation. A common element in the batter for the fermented rice and lentil mainstays of *Idli* and *Dosa* in South Indian cooking are

fenugreek seeds. The seeds are soaked with rice and urad dal (black gram), mashed into a batter, and allowed to ferment for the entire night. During this fermentation process, the proteins and carbs are broken down by lactic acid bacteria and yeasts, giving dosas their crispy top and acidic taste. Through the degradation of phytic acid, this microbial process improves flavour and texture while also increasing the bioavailability of minerals.

Role of fenugreek as a cosmetic ingredient

Fenugreek, has been recognized for its medicinal properties for centuries. Beyond its traditional use as a culinary spice and herbal remedy, fenugreek has found its way into the world of cosmetics due to its potential benefits for skin and hair health. This review aims to explore the use of fenugreek as a cosmetic ingredient and its medicinal properties in promoting beauty and well-being.

Skin Health:

Fenugreek possesses several properties that make it a valuable addition to skincare products. Its anti-inflammatory and antioxidant properties help soothe and protect the skin from damage caused by free radicals and environmental stressors. Fenugreek also exhibits antimicrobial effects, potentially aiding in the prevention and management of skin infections. Fenugreek seeds are particularly rich in galactomannan, a water-soluble polysaccharide that constitutes a significant portion of their mucilaginous gum. This complex carbohydrate has a remarkable capacity to absorb and retain water—up to several times its own weight—forming a viscous, gel-like matrix upon hydration. This physical property is the foundational mechanism behind its emollient and humectant effects on the skin.

Acne Treatment:

The anti-inflammatory and antimicrobial properties of fenugreek make it a promising ingredient in acne treatment. It helps reduce redness and inflammation associated with acne breakouts and inhibits the growth of acne-causing bacteria. Fenugreek seed paste, often mixed with yogurt, honey, or rose water, is a common home remedy for dry, irritated, or inflamed skin. It is used to soothe conditions like eczema, sunburn, and minor wounds. The mucilage not only hydrates but also possesses mild anti-inflammatory and antimicrobial properties, which can aid in the healing process and protect compromised skin barriers.

Anti-Aging Effects:

Fenugreek is a rich source of bioactive compounds with potent free radical-scavenging capabilities, including flavonoids (such as apigenin and luteolin), phenolic acids, saponins (notably diosgenin), and alkaloids like trigonelline. These constituents function as antioxidants by neutralizing reactive oxygen species (ROS) and reactive nitrogen species (RNS), which are primary drivers of oxidative stress—a key pathological process in skin aging. Oxidative stress causes matrix metalloproteinases (MMPs), especially MMP-1, MMP-3, and MMP-9, to activate, which breaks down structural proteins like collagen and elastin and speeds up the aging process of the skin. Wrinkles occur and the skin loses its suppleness and firmness as a result of this enzymatic breakdown. Fenugreek's antioxidant activity may help reduce the appearance of fine lines, wrinkles, and age spots, promoting a more youthful and radiant complexion. However, there is a solid scientific basis for its usage in cosmeceutical formulations intended to promote young and radiant complexion due to the alignment between its chemical profile and the recognized routes of photoaging and intrinsic aging. To verify these potential advantages, future research should concentrate on topical application studies that measure collagen density, oxidative stress biomarkers, and clinical grading of wrinkles.

Hair Care:

Fenugreek has long been used in traditional hair care practices. It is rich in proteins, vitamins, and minerals that nourish and strengthen the hair follicles and reduces hair fall³⁷ Fenugreek also contains compounds that promote scalp health, such as lecithin, which moisturizes and hydrates the scalp, and

saponins, which help cleanse the hair and scalp. These properties make fenugreek a valuable ingredient in hair masks, oils, and shampoos, promoting healthier, shinier, and more voluminous hair. The antimicrobial and anti-inflammatory properties of fenugreek contribute to its potential effectiveness in managing dandruff and scalp conditions. Fenugreek can help combat the growth of fungus and bacteria on the scalp, which can contribute to dandruff and scalp irritation.

Conclusion

The present paper has provided a comprehensive overview of the numerous ethno-botanical properties of Fenugreek (*Trigonella foenum-graecum*). Through a thorough analysis of existing literature and traditional knowledge, we have explored its diverse applications in various domains. This small herb has shown immense potential in the field of traditional medicine. Its anti-inflammatory and antioxidant properties make it a valuable natural remedy for a wide range of ailments, including internal and external disease conditions. Furthermore, its ability to regulate blood sugar levels has garnered significant attention, particularly in the management of diabetes. The plant's rich content of vitamins, minerals, and phytochemicals contributes to its overall medicinal efficacy. Moreover, Fenugreek has demonstrated promising results in the culinary realm. Its unique flavor profile adds depth and complexity to various dishes, making it a popular ingredient in numerous cuisines worldwide. The seeds and leaves of Fenugreek are used in traditional recipes, providing not only taste but also health benefits such as improved digestion and enhanced lactation in nursing mothers. Fenugreek's medicinal properties extend beyond traditional medicine and find application in the realm of cosmetics. Its anti-inflammatory, antioxidant, antimicrobial, and moisturizing properties make it a versatile ingredient in skincare and hair care products. Fenugreek stands as a remarkable plant with immense ethno-botanical significance. Its medicinal, culinary, and agricultural applications make it a versatile resource with numerous potential benefits.

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