



***Trigonella foenum-graecum* L. : A REVIEW OF ITS ETHNOBOTANY, PHARMACOLOGY AND PHYTOCHEMISTRY**

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ABSTRACT

Trigonella foenum-graecum (Fabaceae) is a medicinal plant. It is traditionally used in the treatment and prevention of several ailments. Pharmacological investigations showed anti-bacterial, anti-diabetic, anti-cancer, anti-diarrheal, anti-inflammatory activities. Phytochemical analysis showed the presence of quinone, flavones, flavonoids, phenols, tannins, terpenoids, lactones, alkaloids and polypeptides. The result of several studies indicated that *Trigonella foenum-graecum* may be used as an effective therapeutic remedy in the prevention and treatment of various ailments.

Keywords : Galactomannan, Immemorial, Phytochemicals, Plucking, Streptozotocin,

I. INTRODUCTION

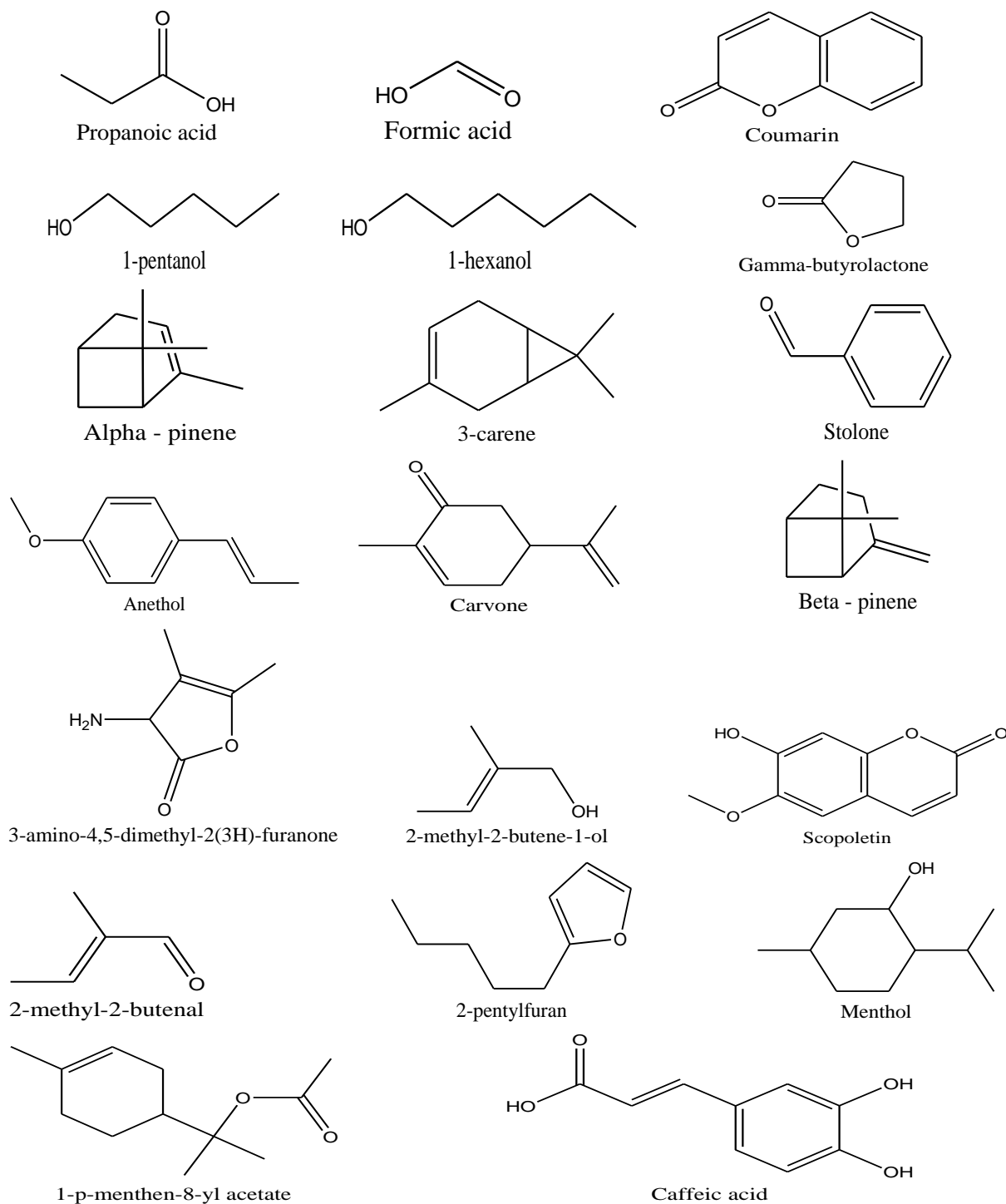
Plants have been rich source of medicinal agents since time immemorial. They have remained main components of various traditional systems of medicine. Plant species has remained a good source of anti-infective agents which have fewer side effects (1). Recently the WHO (World Health Organization) estimated that 80% of people worldwide rely on herbal medicines for some aspects. Many developing countries all over the world have intensified their efforts in documenting the ethnomedicinal data and scientific research on medicinal plants. It is estimated that there are 250000 to 500000 species of plants on earth (2). There are about 47000 plant species in India, out of which 7500 plant species are of medicinal value. Only 800 plant species are used in the preparation of herbal drugs.

II. SCOPE OF REVIEW

The review of *Trigonella foenum-graecum* was primarily needed to bridge the gaps in between traditional uses and *in-vitro* pharmacological/biological studies. Previous reviews were based on simple ethnobotanical uses and few pharmacological activities of the species. Hence, an attempt was made to update the complete information on botany, phytochemistry and pharmacological activities of the species.

The information provided was taken from different sources like worldwide accepted scientific database Scopus(<http://www.scopus.com>), ScienceDirect(<http://www.sciencedirect.com>), PubMed(<http://www.ncbi.nlm.nih.gov/pubmed>), Springerlink(<http://www.springerlink.co.in>), GoogleScholar(<http://scholar.google.co.in>) and

recognized books. The review highlighted the traditional uses of the species in Indian system of medicine, phytoconstituents isolated from various parts of the plant (Figure1) and different biological activities reported on various extracts. The traditional uses, reported biological/pharmacological activity, isolated compounds of *Trigonella foenum-graecum* might be useful for scientists and researchers to find out new entities.



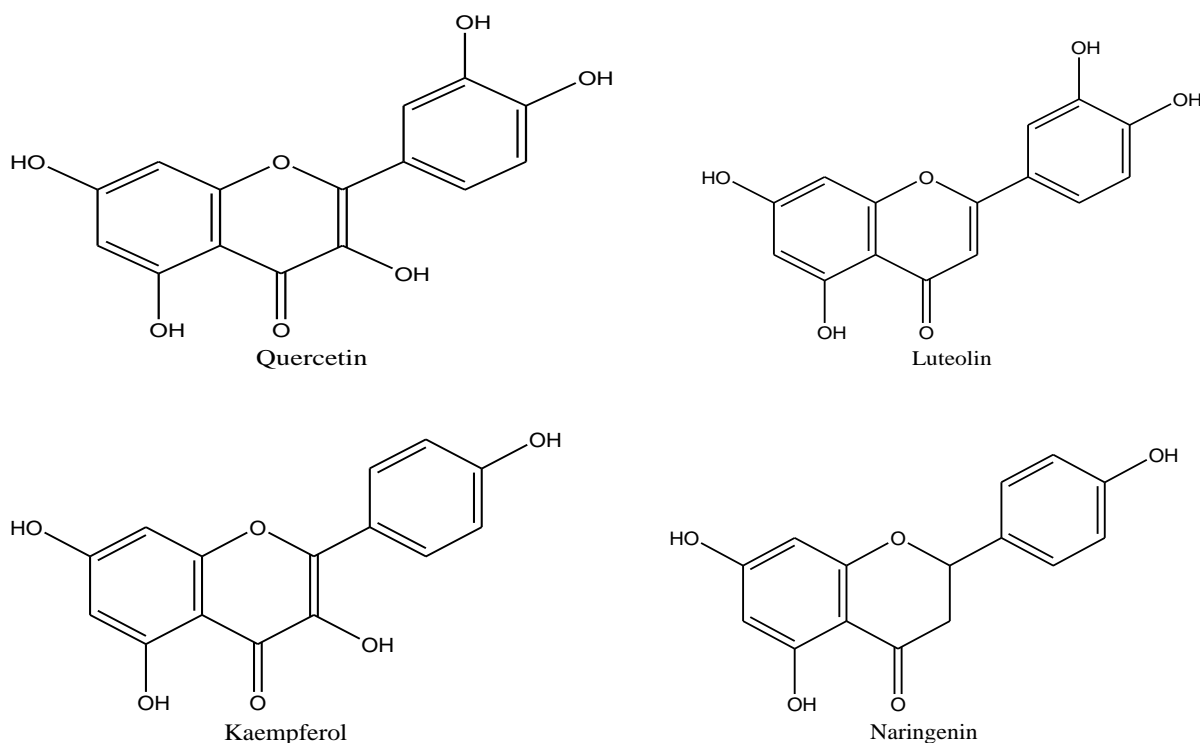


Figure 2: Structure of some major constituents of *Trigonella foenum-graecum*

III. BOTANY

1.1 Origin and Distribution. It originated in central Asia ~ 4000 B.C. It is native to southern Europe, Mediterranean region and Western Asia. Its geographical distribution is Middle East, India, China, Central and Southern Europe, Mediterranean region, North Africa, United states.

1.2 Taxonomic Status

Domain	:	Eukaryote
Kingdom	:	Plantae
Divison	:	Magnoliophyta
Class	:	Magnoliopsida
Order	:	Fabales
Family	:	Fabaceae
Genus	:	<i>Trigonella</i>
Species	:	<i>foenum-graecum</i>

1.3 Plant Description. *Trigonella foenum-graecum* is an erect, annual, aromatic herb, up to 30-45cm high, leaves are pinnately compound, trifoliate attenuated towards the base and with toothed margins. Leaves are light green in color and petiolated. The first trifoliate leaf appears 5-8 days after germination. The size of leaves is approx. 20-50× 8-17mm. Flowers are small, triangular, axillary and sessile. Flowers are hermaphrodite and pollination takes place through insects. The pollen grains may be oval or circular. White and yellow colored flowers arise from the leaf axils and are arranged singly or in little groups of twos. Fruits are narrow, long and oblong. Size of

pod is 80-150×2-4 mm and it ends with an elongated beak. Fruits ripen in summer and harvested in autumn. Pods contain 10-20 small seeds. Seeds are smooth, hard, elongated and flat. Seeds are yellow brown in colour. It has pungent and aromatic seeds. Seeds are quadrangular and a groove in central part divides each seed into 2 parts: larger 2-5 cm long and smaller 15-3.5 cm. The pod shape gives the name “goat’s horn” to the plant.

3.4 Vernacular Names. *Trigonella foenum-graecum* has many common names depending upon the languages spoken in a particular region. The names used in different languages are presented in Table 1.

Table 1: Vernacular names of *Trigonella foenum-graecum*

Language	Vernacular Name
Hindi	Methi, Sag methi, Kasuri methi
English	Fenugreek, Bird foot, Greek hayseed
Sanskrit	Methika, Chandrika
Malayalam	Ventiyam, Vendiyam, Uluva
Punjabi	Metha, Shamli, Methi, Methini
Bengali	Methis, Methi-shak, Methuka
Marathi	Methi
Gujarati	Methi, Methini, Bhaji
Urdu	Methi
French	Trigonella Fenugrec
Italian	Fieno Greco, Trigonella
Kashmiri	Meth

3.5 Cultivation. Fenugreek is best grown as an annual crop from seeds which are sown following the line sowing method. The land should be prepared for ploughing. The irrigation channels are made along the alternate rows of bed. The seeds should be treated with rhizobium culture before sowing. Seeds are pre-soaked for 12 hours prior to sowing. Low humidity is required. Seeds are sown during mid-late spring. The seeds germinate within 6-8 days after sowing. The optimum soil temperature at planting > 10 °C. It grows well in well drained loamy soil. The soil pH should ranges from 5.3 -8.2. Plants are frost tolerant (vegetative stage only). Harvesting is done in 30-40 days for herb and 105-140 days for seeds. Plucking (hand harvesting) is done for herb and machine is used for harvesting the seed. Seeds should be stored below 12% moisture and under dry and cool conditions.

3.6 Diseases and Pests. Generally the plant is disease free but sometimes pests attack it. The common diseases of fenugreek: - cercospora leaf spot cercospora traversiana, charcol rot macrophomina phaseolina, powdery mildew, downy mildew. The pest of fenugreek is mainly “aphid”. Aphid sucks the sap of tender parts of plants and affects the growth.



IV. ETHNOMEDICINAL USES

It reduces cholesterol level. The seeds and leaves decrease blood pressure. Seeds also prevent constipation (3). Its seeds contain 25% “galactomannan” which reduces cardiovascular disease. It controls diabetes. It helps to reduce fever when taken with lemon and honey. Protect from cancer. Seeds used for healthy heart. The seeds induce growth and reproduction hormones. Seeds and leaves of fenugreek have gastro-protective and hepatoprotective activity (4). Fenugreek leaves paste use for long and lustrous hair. The seeds relieve any irritation of skin and skin damage and remove swelling and pain. Seeds are used in preparation of plaster and ointments. Seeds and leaves of fenugreek possess antioxidant effect (5). Its seeds also possess hypoglycemic effect (6).

V. PHARMACOLOGY

Trigonella foenum-graecum is known to possess medicinal value in traditional system and represented a wide range of pharmacological properties. In the proceeding text some of the available reports pertaining towards the important pharmacological potential of *Trigonella foenum-graecum* extracts are being discussed.

5.1 Antibacterial activity. Al-abdeen (7) fenugreek has a long history of medicinal uses in Chinese medicine and Kurdish area. The antibacterial activity of aqueous and some organic compounds extracts of stems, leaves, seeds and roots of fenugreek were tested against 3 Gram – negative and 1 Gram –positive bacteria by well diffusion and colony account methods. The microorganisms used were *Staphylococcus aureus*, *E.coli*, *Pseudomonas aeruginosa* and *Klebsiella spp.* All extracts of the plant did not exhibit any inhibitory activity against any of the microorganisms tested by each well diffusion and colony account technique.

Abdalah (8) study on the seeds extract of fenugreek with used the determined by using agar diffusion method to measurement the antibacterial activity on bacterial isolates that isolate from different sources: *Staphylococcus aureus*, *Streptococcus pyogenes*, *Pseudomonas aeruginosa*, *E.coli*, *Pseudomonas vulgaris*, *Klebsiella pneumonia*. The extract of Fenugreek seeds with conc. 1000, 500 and 250 mg/ml that inhibits growth of the bacteria *Streptococcus pyogenes*. The methanolic extract of fenugreek seeds with conc. 1000, 500, 250 and 125 mg/ml that inhibit the growth of the bacteria *Staphylococcus aureus*. The aqueous extract for the fenugreek seeds was less active then methanol extract against the growth of pathogenic bacteria. From this study support the use of fenugreek seeds as a natural extract was active against the pathogenic bacteria and may have a role as pharmaceutical and treatment from infectious diseases.

Premanath (9) the antimicrobial activity of various fenugreek extracts was screened by disc diffusion method and ethanol extract was found to be more potent. The minimum Inhibitory Concentration (MIC) of ethanol extract determined by broth dilution method showed a MIC value of 1 mg mL⁻¹ for *Staphylococcus aureus* and *Pseudomonas aeruginosa*.

Nandagopal *et al.* (10) evaluated the phytochemical analysis for antibacterial activity of the seed extracts of *Trigonella foenum-graecum L.* against pathogenic bacteria like gram positive (*Staphylococcus aureus*) and gram negative (*E. coli*, *Pseudomonas aeruginosa*, *Klebsiella pneumonia*) bacteria by *in vitro* agar well diffusion



method. The seed extracts showed more inhibitory action on *Klebsiella pneumonia* and *Pseudomonas aeruginosa* than *E. coli*, *Staphylococcus aureus*.

EINour *et al.* (11) investigate the antimicrobial activity of petroleum ether extract of seeds and callus derived from hypocotyls and cotyledons explants of fenugreek. Antimicrobial activities were tested against standard micro-organisms, *Bacillus subtilis* (NCTC 8236 G+Ve), *Staphylococcus aureus* (ATCC 29523 G+ve), *E. coli* (ATCC 25922 G – V), *Pseudomonas aeruginosa* (ATTC 27853 G-V), *Aspergillus niger* (ATCC 9763) AND *Candida albicans* (ATCC 7596) using paper disc method. Callus was induced on MS medium supplemented with 2 mg/l of diff. auxins (2, 4-D or NAA) + 0.5 mg/l Kinetin. The petroleum ether extract showed highest antimicrobial activity. Antibacterial activity of petroleum ether extract were recorded (17 ± 0.33 mm) and (15 ± 0.57 mm) of inhibition zone against *E. coli* and *Staphylococcus aureus* by conc. 250 mg/ml. It shows antifungal activity against *Aspergillus niger* and *Candida albicans* with max. zone of inhibition (20 ± 0.88 mm) against *A. niger* by conc. 250 mg/ml and (17 ± 0.57 mm)) of inhibition zone against *Candida albicans* by conc. 250 mg/ml.

5.2 Antidiabetic activity. Ismail (12) fenugreek seeds were powdered and used for the study. The study was performed for 16 weeks. It was having 20 NIDDM patients, whereas 5 patients were kept. Inclusion and exclusion criteria were formed for the study. Written consent was taken from the patients. Initial postprandial blood glucose level (PPBGL) was estimated at the time of enrolment in the study and then after each week during the entire period of the study. At the end of study, the initial and final readings were compared. There were significant changes in PPBGL of patients. Fenugreek powder 20 gm was found to be ant diabetic effect.

Rafiq *et al.* (13) investigated the effects of Stevia leaf, methi (*Trigonella foenum-graecum*) seed. Diabetes was induced experimentally in rats with Streptozotocin (STZ; 55 mg/kg, intraperitoneal). Combination of stevia-methi extracts were orally administered daily at the rate of 100 mg/kg, 500 mg/kg, 500 mg/kg and 800 µg/kg respectively after 2 weeks of STZ injection for a period of 60 days. The combined stevia-methi extract showed potent hypoglycemic effect than stevia and methi alone. Stevia and methi extracts have hypoglycemic and body weight loss improving effects in STZ induced diabetic rats. Combination therapy showed better results. The use of combination of Stevia leaves and methi seeds extracts as ant diabetics.

Murtaza (14) diabetes is a major health problem. Diabetes is an oxidative stress related disorder. Plant secondary metabolites have long been known to have benefits against various oxidative stress related diseases including diabetes. One of the most promising vegetable providing treasures of such metabolites is fenugreek. This paper presents information on bioactive compounds of fenugreek and its strong antidiabetic power. The herb have potential to cure diabetes more than other plant species especially due to the presence of unique chemical constituents including quercetin, diosgenin, trigonelline, galactomanin and unusual amino acid 4 hydroxyl isolucine.

5.3 Anticancer activity. Amin (15) study cancer causes and treatment. Cancer is the second leading cause of death worldwide. Conventional therapies cause serious side effects. Cancer control may benefit from the potential that resides in alternative therapies .There is an increasing demand to utilize alternative concept to the prevention of cancer. In this report show a potential effect of fenugreek seeds against 7, 12-dimethylbenz9α)



anthracene (DMBA) - induced breast cancer in rats. At 200 mg/kg Fenugreek seeds extract significantly inhibited the DMBA- induced mammary hyperplasia and decreased its incidence. Epidemiological studies also implicate apoptosis as a mechanism that might mediate the Fenugreek's anti breast cancer protective effects. The study suggests significant chemo protective effects of Fenugreek seeds against breast cancer.

Chauhan *et al.* (16) present pharmacognostic, preliminary phytochemical studies and anticancer properties of *Trigonella foenum-graecum*. Fenugreek seeds showed protective activity against 7, 12-dimethylbenz (a) anthracene (DMBA) - induced breast cancer in rats at 200 mg/kg body weight. Fenugreek seeds extract inhibited DMBA- induced mammary hyperplasia and decreased its incidence. The ethanolic extract with an ED50 less than 10µg/ml in brine shrimp cytotoxicity assay was also observed to possess anti-tumor activity in A- 549 male lung carcinoma, MCF-7 female breast cancer and HT- 29 colon adenocarcinoma cell lines. The result establishes that fenugreek has anti- cancer activity.

3.5 Anti-diarrheal activity. Viruopaksha (17) fenugreek is important and useful to identify plants with anti-diarrheal activity. The study evaluate the effect of methanol and aqueous extracts of *Trigonella foenum-graecum* for its anti-diarrheal activity .The anti-diarrheal activity of methanol and aqueous extracts of was evaluated using castor oil induced diarrhea The effect of methanol and aqueous extracts on gastrointestinal tracts motility after charcoal meal administration and PGE2 induced intestinal fluid accumulation (enter pooling) .The plant extracts showed significant ($P<0.01$) inhibitor activity against castor oil induced diarrhea and PEG2 induced enter pooling tested at 250mg/kg. The methanolic extract showed $P<0.01$ and aqueous extract ($P<0.05$) reduction in gastrointestinal motility. The observations suggest that methanolic extract of TEG seed has significant anti-diarrheal activity compared to aqueous extract.

5.5 Anti inflammatory activity. Thinagaran *et al.*, (18) the anti- inflammatory activity of various extracts of *Trigonella foenum-graecum* leaves by in vitro HRBC membrane stabilization method was assessed. The % of membrane stabilization for 6 different extracts and diclofenac sodium were done at a conc. of 2 mg/ml. Methanolic extract showed the maximum membrane stabilization activity and was found to be $72.22\pm1.11\%$. The study supports the isolation and the use of active constituents from *Triognella foenum-graecum* leaves in treating inflammation.

Sharififar (19) study anti inflammatory effects of fenugreek. The methanolic extract of the plant seeds was partitioned using a liquid – liquid extraction procedure to give 6 major fractions. Following phytochemical screening of isolated fractions, the total extract and each fraction were evaluated by using carrageen an induced paw edema test. The methanolic extract exhibit effect at a dose of 100mg/kg. Among the test fractions, alkaline chloroform fraction (AKC) which was alkaloid positive in screening tests showed the most anti-nociceptive effect in a dose dependent method. AKC fraction was as effective as morphine (5mg/kg) .Both aqueous and acidified chloroform fractions (ACC) could inhibit paw edema at a different dose. The latter fraction dose dependent inhibited carrageen an induced paw edema. The results of phytochemical screening tests confirmed the presence of flavonoids in both ACC and aqueous fractions. It can be concluded that the alkaloid and flavonoid content of fenugreek seeds can be responsible for anti-nociception and anti - inflammatory effects of the plant.



5.6 Antioxidant activity. Thirunavukkarasu *et al.* (20) studied the effect of aqueous fenugreek seed extracts on lipid peroxidation and antioxidant status in rats with ethanol induced toxicity. The simultaneous administration of fenugreek seed aqueous extract with ethanol prevented the rise in lipid peroxidation and the enzymatic leakage and enhanced the antioxidant potential.

Randhir *et al.* (21) the antioxidant activity estimated by β -carotene assay was highest for lactoferrin (LE) and oregano extract (OE) elicited sprouts on day 2 and 4, respectively with an antioxidant protection factor (APF) of 1.47 for both. Higher antioxidant activity was observed during early germination. The antioxidant activities estimated by DPPH assay indicate that fenugreek sprout extract can quench the superoxide free radical and scavenge the hydrogen peroxide generated in the reaction mixture. OE elicited the highest levo dihydroxy phenylalanine (L-DOPA) synthesis of 1.59 mg/g FW, followed by FPH with 1.56 mg/g FW and LF 1.5 mg/g FW all on day 2 which was 24.5%, 23% and 20% higher than control. Higher L-DOPA content was observed in elicited fenugreek sprouts during early germination, correlating to high phenolics and antioxidant activity.

Ghaskadbi (22) *Trigonella foenum-graecum* has antioxidant properties were studied in germinated fenugreek seeds which are considered to be more beneficial than dried seeds. Different fractions of the germinated seeds were used to determine their antioxidant potential at different levels. The assays employed were ferric reducing antioxidant power, radical scavenging by 1, 1-diphenyl-2-picrylhydrazyl, ferrylmyoglobin /2, 2-azobis-3-ethylbenzthiazoline-6-sulfonic acid, oxygen radical absorbance capacity and inhibition of lipid peroxidation in mitochondrial preparations. An aqueous fraction of fenugreek exhibited the highest antioxidant activity. The quantity of phenolic and flavonoid compounds can be related to antioxidant activity the contents from these extracts were measured. HPLC analysis was carried out to detect polyphenols, flavonoids and other components. The study reveals significant antioxidant activity in germinated fenugreek seeds.

Kaviarasan *et al.* (23) an extract of fenugreek seeds was isolated for antioxidant activity using various in vitro assay systems. The seed extract exhibited scavenging of hydroxyl radicals (OH) and inhibition of hydrogen peroxide induced lipid peroxidation. The extract at high conc. acted as scavenger of DPPH and ABTS^{•+} radicals. The total phenolic content in the extract was determined spectrophotometrically according to the Folin-Ciocalteu procedure and expressed as mg gallic acid equivalents. The results indicate that the extract of fenugreek seeds contains antioxidants and protects cellular structures from oxidative damage.

Wojdylo (24) Total equivalent antioxidant capacities (TEAC) and phenolic contents of 32 spices extracts were calculated. The total antioxidant capacity was estimated by the following methods: ABTS^{•+} (2, 2-azobis-(3-ethylbenzthiazoline-6-sulfonic acid), DPPH and ferric reducing expressed as TEAC. The total phenolics were measured using a Folin-Ciocalteu assay. Qualitative and Quantitative of major phenolics by reverse-phase high-performance liquid chromatography (RP-HPLC) were also used. Major phenolic acids identified in analyzed species were caffeic, p-coumaric, ferulic and neochlorogenic, while predominant flavonoids were quercetin, luteolin, apigenin, kaempferol and isorhamnetin. Myricetin was detected only in *epilobium hirsutum*. Many investigated spices had high levels of phenolics and exhibited high antioxidant capacity. The TEAC values of the spices ranged from 1.76 to 346 μ M trolox/100 g dw, from 7.34 to 2021 μ M trolox/100 g dw, and 13.8 to 2133 μ M trolox/ 100 g dw for ABTS^{•+}, DPPH and FRAP, respectively. The total phenolic content, measured



using a Folin-Ciocalteu assay, ranged from 0.07 to 15.2 mg of gallic acid equivalents (GAE)/100 g dw. The herbs with the highest TEAC values were *Syzygium aromaticum*, *E. hirsutum* and the species belonging to the Labiatae and Compositae family. A positive relationship between TEAC (ABTS⁺ and FRAP) values and total phenolic content, measured by HPLC, was found only in family groups with many representative herbs within Labiatae and Composite.

Bukhari *et al.* (25) described antioxidant activity of fenugreek (*Trigonella foenum-graecum*). Fenugreek (*Trigonella foenum-graecum*) is an important spice; its dried seeds have wide application in food and beverages as a flavoring additive as well as in medicines. Crude extract of fenugreek were prepared by soxhlet extraction method with different solvents (methanol, ethanol, dichloromethane, acetone, hexane and ethyl acetate). Extracts were subjected for the measurement of total phenolic content (TPC) by Folin-Ciocalteu method as well as flavonoid content, chelating activity; reducing power and antioxidant/radical scavenging activity [1, 1-diphenyl-2-picryl-hydrazyl (DPPH) free activity scavenging activity]. Results from different parameters were in agreement with each other. The results tell that all extracts of the fenugreek exhibit antioxidant activity. These findings suggest that fenugreek extract could act as potent source of antioxidant.

Kaviarasan *et al.* (26) reported reduced level of lipid per oxidation products and protein carbonyl content, increased activities of antioxidant enzymes and restoring levels of thiol groups by administration of polyphenol extract of fenugreek seed to ethanol-fed rats.

Semalty (27) successive methanolic and direct ethanolic extracts of *Trigonella foenum-graecum* and *T. corniculata* seeds were prepared and were investigated for their potential antioxidant activity against DPPH free radicals. Seeds extracts of *T. corniculata* showed better antioxidant activity than that of *Trigonella foenum-graecum*. Ethanolic extract of *T. corniculata* was the most effective antioxidant among the extracts with 90.24% DPPH radical scavenging activity at 500µg mL⁻¹. The antioxidant activity of the increasing amount of the conc. It was concluded that the seeds of *T. corniculata* had better antioxidant than *T. foenum-graecum*. The ethanolic extracts showed significantly better activity than the successive methanolic extracts.

Naidu (28) fenugreek seeds were separated into husk and endosperm. The proximate composition of fenugreek seeds, husk and cotyledons showed that endosperm had the highest saponin (4.63 g/100g) and protein (43.8g/100g) content. Husk had higher total polyphenols (103.8 mg of gallic acid equivalent /g and TDF (77.1g/100g) comprising IDF (31.9G/100G) AND SDF (45.2 G/100g). At 200µg conc., extracts of husk, fenugreek seed and endosperm exhibited 72%, 64% and 56% antioxidant activity by free radical scavenging method.

Premanath *et al.* (29) the study of antioxidant activity of *Trigonella foenum-graecum* leaves in chloroform, hexane, methanol, ethanol and water extracts were carried out. Total phenolic content was estimated by Folin-Ciocalteu method while the flavonoid content was determined using aluminum chloride method. Estimation of total phenolic and flavonoid contents revealed that the ethanol extract had the highest phenolic and flavonoids contents of 4.9 and 0.47mg g⁻¹. The antioxidant activities of the leaves were evaluated by various in vitro assays (DPPH scavenging activity, lipid per oxidation inhibitory activity and superoxide scavenging activity). The solvent extracts tested for antioxidant activities, ethanol extract had the highest activity compared to other



solvent extracts. It had a total antioxidant activity of $47 \mu\text{M Fe (II) g}^{-1}$ and an inhibitory conc. (IC_{50}) value of 0.3 and 0.7 mg mL^{-1} for per oxidation inhibitory activity and DPPH scavenging activity. The results suggest that ethanol extract of fenugreek is a potential source of phenolic antioxidants.

Sravanthi (30) study aims on antioxidant potential in *Trigonella foenum-graecum* L. (Ajmer methi variety). Leaves have been used for the determination and quantification of antioxidant constituents and free radical scavenging activities for treatment and prevention of various disease like diabetes mellitus, atherosclerosis, cataract, rheumatism, cancer and other auto immune disease like ageing and antioxidants like phenols, flavonoids, flavonols, proanthocyanin, anthocyanin, total carotenoid, β -carotene, antioxidant enzyme systems like catalase, peroxidase, polyphenol oxidase, glutathione reductase activities and free radical scavenging assays like FRAP, ABTS, DPPH were evaluated. The result showed highest phenolic content $38.3 \pm 0.5 \text{ mg/g dry wt.}$ and FRAP free radical scavenging was $10 \pm 0.05 \%$ recorded maximum than the other assays.

Mashkor (31) fenugreek (*Trigonella foenum-graecum*) is a nutrient dense food rich in beneficial phytochemicals. In this study, 3 types of solvent extract of fenugreek seeds were used to examine the effects of extraction solvent on total phenolics content (TPC), DPPH and ferric reducing antioxidant power (FRAP) were found in 50% acetone extracts. The TPC for fenugreek seeds from 25.90-15.45 mg GAE/100g DW and antioxidant activity FRAP from 47.49-31.85 mg TE/100 g DW, DPPH were from 67.30%-43.61%). The largest amount of total phenol content which leads to more effective radical scavenging effect was shown by 50% acetone extract. Amount of phenolic compounds and antioxidant activities increased in acetone extract. Acetone 50% and methanol 50% solvent showed the greatest capability in extracting antioxidants and inhibiting the free radicals produced. It was concluded that extraction solvent play important roles on the phenolics compounds and their antioxidant compounds and their antioxidant activity of fenugreek seeds extract.

Pathak *et al.* (32) show the antioxidant activity of *Trigonella foenum-graecum*. With changes in eating habits and exposure to hazardous substances, the risk of oxidative damage is increasing which leads to various ailments. One way to protect one from these hazards is incorporation of naturally occurring antioxidants in daily diet that provide nutrition besides being a reservoir of numerous health's promoting phytochemicals. Methanolic extract of fenugreek seeds were evaluated for total phenolics content, antioxidant activity using various assay systems such as (III) reduction, inhibition of hydroxyl radical mediated 2-deoxy-D- ribose degradation, metal ion (Fe^{+}) chelation assay and DPPH radical scavenging assay. The results indicate that fenugreek is a very efficient antioxidant.

Norziah *et al.* (33) was aimed to investigate the efficacy of fenugreek seeds as a natural source of antioxidant. Fenugreek seed (FS) extracts were prepared using ethanol (75%), methanol (75%) and water as extraction solvents. Ethanol (E-FSP), methanol (M-FSP), Water (W-GeFS) and hot water (HW-FSP) extracts were obtained from ground FS, whilst water extract (W-GeFS) was obtained from germinated FS. The result shows that all extracts of ground FS exhibited antioxidant activities. Highest phenolic (156.3 mg GAE/g) and flavonoid (38.5 mg CE/g) content were found in W-GeFS. It showed strongest DPPH activity of 685 inhibition at a lower conc. (0.06 mg/ml). Highest vitamin C antioxidant capacity ($143.28 \text{ mg vitamin C/g}$) with an IC_{50} value of $42.1 \mu\text{g/ml}$ were found in W-GeFS.



Shinde *et al.* (35) *Trigonella foenum-graecum* used in Ayurvedic medicines. The data obtained will be used for detection of quality control of drug. TLC study of the alcoholic extract obtained from seeds were carried out and 7 compounds were separated. Phytochemical analysis of fenugreek seed extract show anticancer properties. Crude extract of fenugreek were prepared by soxhelt extraction method with different solvents (methanol, ethanol, dichloromethane, acetone, hexane and ethyl acetate). Extracts were used for measurement of total phenolic content (TPC) by Folin-Ciocalteu method, flavonoid content and antioxidant/radical scavenging activity (1,1-diphenyl-2-picryl-hydrazyl (DPPH)) free radical scavenging activity. The result reveals that all fenugreek extracts could act as potent source of antioxidants.

VI. PHYTOCHEMISTRY

Trigonella foenum-graecum is the unique source of various types of compounds having diverse chemical structures. Bioactive compounds isolate from fenugreek seeds include saponins (fenugreekine, diosgenin), alkaloids (trigonelline, gentianine, carpaine), amino acids (4-hydroxyisoleucin, arginine), flavonoids. The phenolic compounds isolated from *Trigonella foenum-graecum* is coumarin, scopoletin, chlorogenic acid, caffeic acid and p-coumaric acid. Seeds have been containing pyridine (trigonelline and gentianine), piperidine (carpaine) and steroidal (choline) group of alkaloids in smaller quantities. Terpenes and Terpenoids that present in it contain sabinene, 3-carene, menthol, α -pinene, β -pinene, β -terpineol, cineol, anethol, β -terpinyl acetate, carvone, 1-p-menthen-8-yl acetate, 1-pentanol, 1-hexanol, 2-methyl-2-butene-1-ol, 2-methyl-2-butenal, 2-pentylfuran, formic acid, propanoic acid, γ -butyrolactone, 5-alkylated γ -lactones, 3-amino-4,5-dimethyl-2(3H)-furanone.

VII. CONCLUSION

It is evident from the available literature that *Trigonella foenum-graecum* has been an agent for the treatment of skin diseases. The biological studies such as antibacterial, antidiabetic, anticancer, antidiarrhoeal, anti-inflammatory and antioxidant activities were noticeable in crude extracts of the plant. The study of pharmacology and phytochemicals may help to understand the relation between pharmacological effects and traditional uses of *Trigonella foenum-graecum*.

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