Archives of Current Research International

Volume 25, Issue 5, Page 716-730, 2025; Article no.ACRI.136327
ISSN: 2454-7077

Decoding Fenugreek's Cholesterol-Lowering Mechanism: A Critical Review of its Therapeutic Potential

Nadendla. Rama Rao [a], Akula. Venkata Bhuvaneswar [a*], Anagani. Bhavya Sri [a], Pragada. Santhosh Kumar [a], Karedla. Sravani [a], Gollapothu. Krupanidhi [a], Maddineni Chiranjeevi [a], Ravuri. John Baniyan [a] and Nagam. Venkata Pavan Aditya [a]

[a] Department of Pharmacology, Chalapathi Institute of Pharmaceutical Sciences, Chalapathi Nagar, Lam-522034, Guntur, Andhra Pradesh, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: https://doi.org/10.9734/acri/2025/v25i51245

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://pr.sdiarticle5.com/review-history/136327

Review Article

Received: 17/03/2025
Accepted: 19/05/2025
Published: 27/05/2025

ABSTRACT

Background: Dyslipidemia is a major modifiable risk factor for cardiovascular diseases, the leading cause of mortality worldwide. The consolidation of interest in plant-based interventions has Spurred further examination of traditional medicinal herbs for their effect on lipid levels. Fenugreek (Trigonella foenum-graecum), an herb found in the traditional Ayurvedic and Chinese matrix, has emerged as a promising functional food. This is based on its phytochemical profile, in addition to its cardioprotective and health-promoting functions.

**Corresponding author: Email: akulabhuvan6@gmail.com;*

Cite as: *Rao, Nadendla. Rama, Akula. Venkata Bhuvaneswar, Anagani. Bhavya Sri, Pragada. Santhosh Kumar, Karedla. Sravani, Gollapothu. Krupanidhi, Maddineni Chiranjeevi, Ravuri. John Baniyan, and Nagam. Venkata Pavan Aditya. 2025. "Decoding Fenugreek's Cholesterol-Lowering Mechanism: A Critical Review of Its Therapeutic Potential". Archives of Current Research International 25 (5):716-30. https://doi.org/10.9734/acri/2025/v25i51245.*

Objective: This review sought to evaluate the lipid-lowering effects of fenugreek, describe potential biochemical and pharmacological mechanisms, and evaluate the clinical relevance of fenugreek is dyslipidemia and other metabolic states

Methods: A comprehensive literature search was conducted using PubMed, Scopus, and Google Scholar, to identify relevant preclinical studies, clinical trials, and imaging and mechanistic studies published in the past 20 years. The key inclusion model was studies examining the effects of fenugreek seed, extract, or derived compounds on lipid profiles and cardiovascular characteristics in human and non-human subjects.

Results: The chemical analysis revealed that fenugreek seeds are high in soluble dietary fiber (galactomannan), and abundant bioactive constituents, such as, steroidal saponins (e.g., diosgenin), flavonoids, polyphenols, alkaloids (e.g., trigonelline), and amino acids. Such constituents exert numerous lipid-modulating properties, such as: inhibit cholesterol absorption in the intestine; increase bile acid secretion; increase lipolytic enzymes; and downregulate the hepatic HMG-CoA reductase, which is the rate-limiting enzyme in cholesterol biosynthesis. Animal studies show that supplementation with fenugreek has significantly lowered total cholesterol, low density lipoprotein- cholesterol (LDL-C) and triglycerides, while simultaneously raising high density lipoprotein-cholesterol (HDL-C). The relatively few human clinical trials have also shown some encouraging data but sample sizes are too small and the studies too short in duration for any statistically valid claims. However, some literature exists documenting favourable changes in lipid profiles associated with fenugreek in patients diagnosed with hyperlipidemia, type 2 diabetes and metabolic syndrome. Fenugreek was also found to be highly palatable and offer multiple forms of consumption i.e. whole seeds, defatted powder (flour), aqueous extracts and nutraceutical formulations; thus, supporting potential for promotion, uptake and long-term consumption as dietary therapy.

Conclusion: Fenugreek shows significant potential as an affordable, natural tool for the prevention and treatment of dyslipidemia and cardiovascular disease risk. Its diverse lipid-lowering mechanisms, benign safety profile, and straightforward incorporation into the diet classify it as a candidate for both pharmacological and dietary components of cardiovascular care. However, the present evidence base is limited by methodologic challenges, differences in primary extract type, and a lack of large and well-designed randomized controlled trials. Future research should focus on developing standard doses of fenugreek combined with safety and effectiveness studies designed and executed in large clinical trials to enable evidence-based recommendations for its inclusion in evidence-based treatment protocols.

Keywords: Saponins; flavonoids; fiber; lipid metabolism; hypercholesterolemia; fenugreek; cholesterol-lowering; dyslipidemia; cardiovascular health; HMG-CoA reductase; hyperlipidemia.

1. INTRODUCTION

Cardiovascular diseases (CVDs) are the leading cause of morbidity and mortality worldwide, with dyslipidemia (particularly, hypercholesterolemia) as a major contributing risk factor (Chehregosha et al., 2024, Amit et al., 2023, Wang et al., 2023). Increased total cholesterol, especially low-density lipoprotein cholesterol (LDL-C) plays a major role in the development of atherosclerosis, which can lead to myocardial infarction and stroke. Although statins are now commonly regarded as first-line therapy for the management of dyslipidemia, and are generally prescribed without thought to long-term side effects, some of which may include: hepatotoxicity, the development of myopathy, increased risk of type 2 diabetes, and/or financial costs associated with long-term pharmacotherapy, the exploration of another lipid lowering strategy that is both safe and inexpensive is warranted (Mt., 2022, Mohammad-Sadeghipour et al., 2020, Askarpour et al., 2020).

Complementary and adjunct strategies utilizing plant-based therapies and functional foods have garnered attention in the past few years as methods to assist in achieving and maintaining lipid homeostasis (Badiee Gavarti et al., 2024, Vajdi et al., 2024, Heshmat Ghahdarihani et al., 2020, Baset et al., 2020). Trigonella foenum-graecum (fenugreek) is emerging as a promising candidate due to its documented use in historical traditional systems of medicine, as well as its phytochemical complexity (Chehregosha et al.,

2024, Mansourian et al., 2023). Fenugreek seeds are a unique source of soluble fiber (primarily galactomannan), steroidal saponins, flavonoids, alkaloids, and other bioactive value. These compounds possess lipid lowering, hypoglycemic, and anti-inflammatory properties (Hosseini et al., 2022, Shahin and Jafari, 2023, Bakhtiar et al., 2024, Skrzypiec Spring et al., 2025, Lee Ødegård et al., 2024).

Several scientific studies have clarified how fenugreek reduces lipid metabolism (Sivakumar et al., 2024). Fenugreek modulates lipid metabolism by reducing intestinal cholesterol absorption, increasing bile acids excreted in stools, and inhibiting hepatic HMG-CoA reductase activity, the rate-limiting enzyme in cholesterol synthesis (Berhe et al., 2025, Sarker et al., 2024, N. and T., 2025). Moreover, the potential role of fenugreek in improving glycemic control and insulin sensitivity assists us in understanding how fenugreek can disturb integrated and additive pharmacological effects which transcend its lipid-lowering properties in the management of cardiometabolic conditions (Boutaj, 2024, Kumar et al., 2025, Matthewman et al., 2024, Lee et al., 2025).

Hypercholesterolemia is an important risk factor for cardiovascular diseases, which remain the leading cause of morbidity and mortality worldwide (Hareem et al., 2024, Bakhtiar et al., 2024, Sousa et al., 2024, Morshedi, 2024, Manivannan et al., 2024). Increases in cholesterol, particularly low-density lipoprotein cholesterol, may lead to atherosclerosis-one of the prime causes of heart attacks or strokes. While statins and other pharmacological agents remain established strategies, side effects complement high prices in the search for alternatives. In plant-based diets and lifestyle interventions, several mechanisms have been proposed that incorporate efficient methods of reinstituting cholesterol homeostasis and ameliorating the high cholesterol condition in the majority of animals (Vadivel et al., 2024, Kumar et al., 2024, Gaikwad et al., 2025, Gupta et al., 2024, Mushannavar and Nadiger, 2025).

These include fenugreek (Trigonella foenum-graecum), which has emerged in recent times as a natural remedy for both medicinal and nutritional purposes (Kao et al., 2025, Qu et al., 2025, Rezazadehfar et al., 2024, Sakhai et al., 2025, Hu et al., 2025). A high lipid-modulating potential of fenugreek usually depends upon developing fenugreek seeds as food and animal nutrition (Ali et al., 2025, Azizi et al., 2025, Rewers et al., 2024, Ghareeb et al., 2024, Tayel et al., 2024). Fenugreek has a long history of use in traditional medicine and agricultural contexts, treated as a remedy for a wide variety of diseases, from digestive disorders to diabetes. Scientific studies indicate the presence of diverse bioactive constituents in fenugreek, including soluble fiber, saponins, and flavonoids (Benitto et al., 2025, Chang et al., 2024). These active components are responsible for the medicine effects of fenugreek (Vishwakarma et al., 2024). Its ability to modify lipids together with its potential for assisting in glycemic control points out fenugreek as a multifunctional candidate in the prevention and management of cardiovascular disease (Aldholmi et al., 2024).

Dyslipidemia is one of the most important risk factors for cardiovascular diseases (CVD) that account for a significant share in the mortality count around the world (Garg and Debnath, 2025, Pagano et al., 2025). Some of the currently available therapies have been shown to achieve very good control over cholesterol levels; nevertheless, statins in particular seem to be related to various harmful side effects in some patients (Kavaliunaite et al., 2025). Therefore natural, herbal alternatives are being investigated (Pande, 2025). This medicinal herb used by various cultures has been found to possess significant lipid-lowering property (Wang et al., 2024). The present review hereby thrown to the light of fenugreek involvement in raising the status of blood cholesterol through its mechanism of action, efficacy, and clinical applications which will further promote this natural remedy for clinical use (Lindi et al., 2024, Razon et al., 2024, Naaz et al., 2024, Sethi et al., 2024).

This review highlights the growing body of evidence around the biochemical components, pharmacological mechanisms and clinical effectiveness of fenugreek in the treatment of hypercholesterolemia (Al-Subaiyel and Abdellatif, 2024, Pooja et al., 2024). A synthesis of in vitro, animal and human clinical study evidence is provided, to bring forth its efficacy and safety as a natural product, as well as, the implications for the development of functional foods / nutraceuticals through the incorporation of fenugreek as one option in combined and multi-targeted systems (Corbetta et al., 2024, Han et al., 2025, Morshidi et al., 2025). This review places fenugreek's lipid lowering impact in a

potential clinical rationale and help contextualize fenugreek, from a traditional remedy to a usable evidence-based rational (Singh et al., 2025, Danish et al., 2024).

2. METHODOLOGY

This review is grounded in an extensive search of scientific literature, utilizing databases such as PubMed, Scopus, and Google Scholar (Siddiqui et al., 2024, Chen et al., 2025, Khamkar et al., 2025). The keywords used in the search included "fenugreek," "cholesterol-lowering," "dyslipidemia," and "lipid metabolism." Emphasis was placed on studies published between 2000 and 2023, concentrating on preclinical, clinical, and mechanistic research (Hafeez et al., 2024, Sasirekabai et al., 2025, Shakil et al., 2024, Rizzo et al., 2025).

3. LITERATURE REVIEW

Fenugreek is extensively researched for its anti-lipidemic properties. A reduction in serum total cholesterol, LDL, and triglycerides has been reported in both animal research and in human studies, with a corresponding increase in HDL (Shahid et al., 2024, Liaqat et al., 2025, Omran and Ghani, 2024, Sekhar et al., 2024). Its peculiar phytochemical composition is described as attributing to these effects (Faturoti and Ogidi, 2025, Erten et al., 2025).

3.1 Biochemical Composition of Fenugreek

Fenugreek seeds comprise certain bioactive compounds that drive their health benefits: Soluble fiber: It is rich in galactomannan soluble fiber, which plays an important role in cholesterol depletion. Saponins:

These are the substances that bind with cholesterol and bile acids-it reduces their absorption and increases excretions. Flavonoids and polyphenols: Acting as scavengers of reactive oxygen species, antioxidants mitigate oxidative stress and aid lipid metabolism. There are other components too: Proteins, amino acids, and alkaloids also add to the therapeutic potential of fenugreek (De and Mishra, 2024).

3.2 Mechanism of Action

1. **Lowering absorption of cholesterol:** The soluble fibres present in Fenugreek form with in the gastrointestinal tract a gel-like mass which traps cholesterol and bile acids hence inhibiting absorption (Sadan et al., 2024).

2. **Increase bile-acid excretion:** The saponins in Fenugreek bind bile acids and assist in their excretion. This causes liver cholesterol to be utilized by the liver for synthesizing new bile acids (Sharma et al., 2025).

3. **Modulation of lipid metabolism:** Fenugreek influences the enzymes in lipid synthesis and degradation whereby HMG-CoA reductase is known to reduce the production of LDL-cholesterol (Subbuvel et al., 2025, Kemper et al., 2025).

4. **Antioxidant:** The flavonoids contained in fenugreek exert beneficial effects via combating oxidative stress-a known contributor in the pathogenesis of dyslipidemia and atherosclerosis (Shahzad et al., 2024).

3.3 Preclinical and Clinical Evidence

In vitro and *in vivo* studies have provided reasonable evidence that fenugreek has a lipid-lowering property. Fenugreek supplementation has been shown in hypercholesterolemic rats and rabbits to markedly reduce total and low-density lipoprotein plus triglycerides while raising high-density cholesterol (Dahab et al., 2024). This mechanism appears to be increased bile acid excretion and improved lipid metabolism (Hachouf et al., 2025). Several human trials corroborated findings from animal studies. Key highlights include: Clinical study, for example, demonstrated significant lowering of total and LDL cholesterol in fenugreek-supplemented hyperlipidemics. Fenugreek-treated diabetic patients have shown improved lipid profiles and glycemic control, thus indicating dual benefits of fenugreek (Khalil et al., 2024, Jambor et al., 2025).

3.4 Dosage and Safety

The working dose for cholesterol management might range anywhere between 5-25 grams each day, either taken in the form of seed powder or as extracts or capsules (Babaei et al., 2025). In general, fenugreek is well-tolerated, with some reports of mild gastrointestinal side effects-such as bloating and diarrhea (Naaz et al., 2024, Mate et al., 2024). It has been considered safe in long-term studies as well as an effective one. Uses that can be applicative in Functional Foods

Presenting Functional Foods with fenugreek holds the simplest method of leveraging its cholesterol-lowering application. Fenugreek-enriched bread, teas, or supplements are desired by increasingly health-conscious consumers (Prosad Banik et al., 2024) Fig. 1.

4. CHALLENGES AND FUTURE DIRECTIONS

Challenges and Future Directions Further large-scale and long-term clinical studies will be required to better define the standard treatment dose for its clinical use, and properly to study fenugreek against various groups of patients. Investigating the synergistic effects of fenugreek along with other natural products or drugs could lead to further insights into fenugreek's therapeutic potential (Khorrami et al., 2024, Rath et al., 2024) Fig 2. Table 1.

5. DISCUSSION

Fenugreek is a potent natural alternative for managing dyslipidemia, with a strong evidence base stemming from clinical studies (Muluye et al., 2024, Shaaban et al., 2024). There is no uniformity regarding the dosage and preparations available in applications. Further, its combinational prowess with any existing drug needs further studies to establish this palette (Kumar and Singh, 2024, Almuzaini et al., 2024, Ashour et al., 2024). Fig. 1 shows the dose-response association between fenugreek supplementation (in grams per day) and the % reduction in LDL cholesterol.

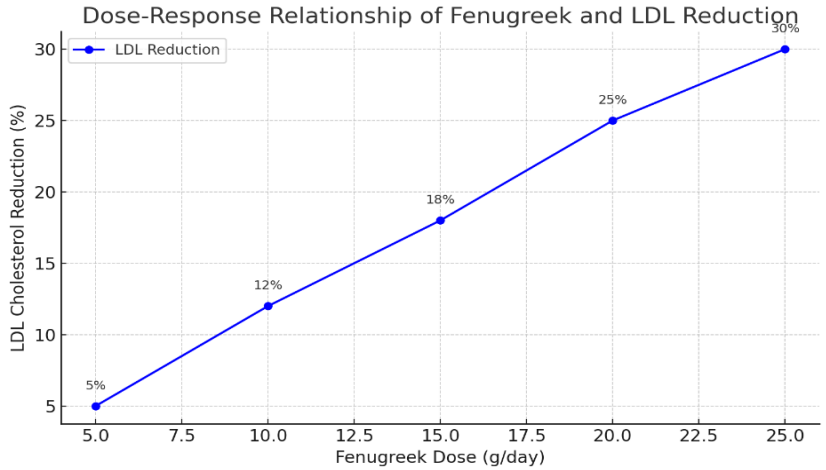

Fig. 1. Dose-response relationship between fenugreek supplementation (in grams per day) and the percentage reduction in LDL cholesterol

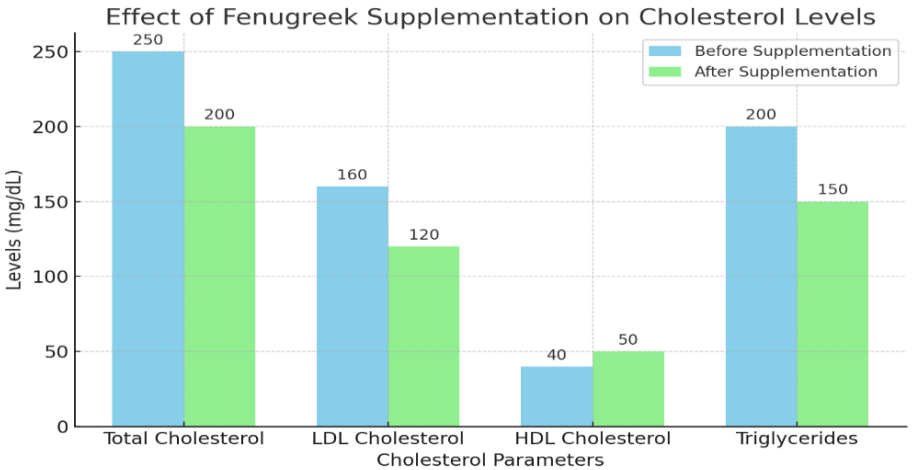

Fig. 2. Effect of fenugreek supplementation on cholesterol levels. It compares total cholesterol, LDL cholesterol, HDL cholesterol, and triglycerides before and after supplementation

Table 1. Clinical and preclinical effects of fenugreek on blood cholesterol lowering activity

Study type	Population	Dose	Duration	Total cholesterol reduction (%)	LDL reduction (%)	HDL increase (%)	Triglyceride reduction (%)
Clinical trail	Hyperlipidemic patients	10 g/day	8 weeks	15%	20%	5%	18%
Clinical trail	Diabetic patients	25 g/day	12 weeks	10%	15%	10%	12%
Preclinical study	Hypercholesterolemic rats	5% of diet	6 weeks	25%	30%	15%	20%

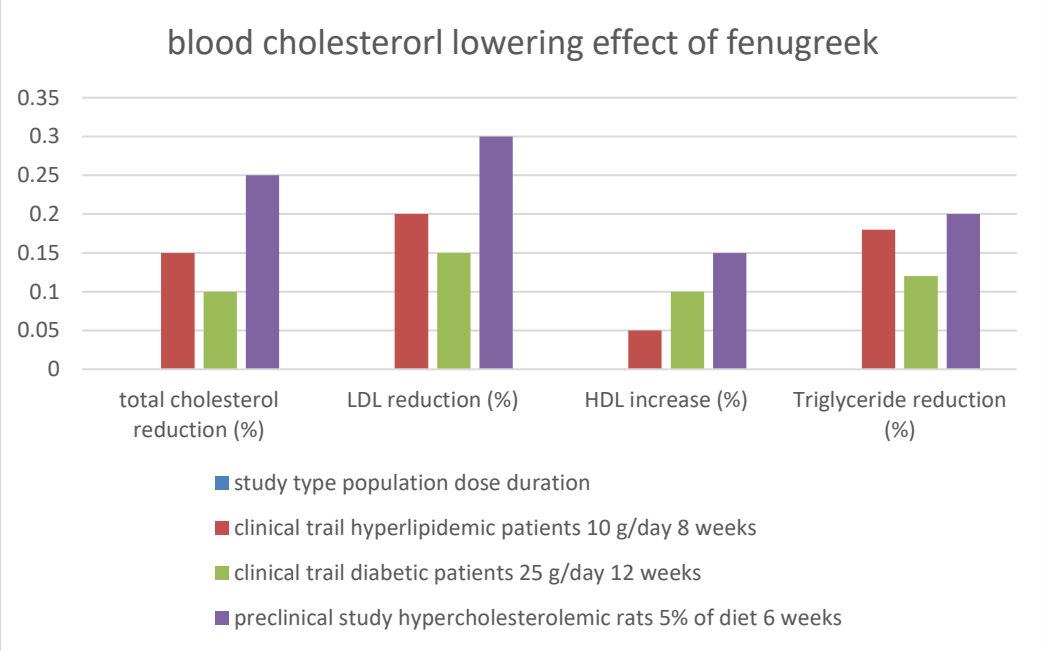

Fig. 3. Graphical representation of clinical and preclinical effects of fenugreek on blood cholesterol lowering activity

As the dose increases, the reduction in total LDL in the blood decreases, and Fig. 2 depicts the effect of fenugreek on LDL, HDL, and triglycerides. It will compare the level of LDL reduced before and after supplementation, and Fig. 3 will explain clinical and preclinical data on the effect of fenugreek supplementation in hyperlipidemia, diabetic patients, and a preclinical study on hypercholesterolemic rats, concluding that fenugreek is effective in LDL reduction.

6. CONCLUSION

Inhibition of cholesterol absorption, induction of bile acid excretion, and hepatic lipid synthesis regulation are different mechanisms of action. The evidence to support the use of fenugreek for hyperlipidemia reduction is found in clinical and preclinical studies. The widespread formulation of fenugreek already provides an alternative dietary intervention that could replace the introducing of hyperlipidemia treatment. Recommendations for future research include dosage standardization, long-term safety and effectiveness, and acceptability in various populations. Therefore, it appears to be economical, widely acceptable, and more promising in the present milieu to provide an answer to modifications in lipid profiles against cardiovascular risk.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

ACKNOWLEDGEMENT

The institutions whose assistance made it possible to access the literature and the resources deserve our extended gratitude, as do the authors who have conducted works which fed into this review. We also thank the peer reviewers for their constructive insight on this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

Aldholmi, M., Ahmad, R., Hago, S., & Alabduallah, A. (2024). A validated trigonelline-based method for the standardization and quality control of *Trigonella foenum-graecum* L. *F1000Research, 13*, 1350.

https://doi.org/10.12688/f1000research.157659.3

Ali, U., Makhdoom, S. I., Javed, M. U., Khan, R. A., Naveed, M., Abbasi, B. H., Aziz, T., Alshehri, F., Al Asmari, F., Al Joufi, F. A., & Alwethaynani, M. S. (2025). Fenugreek seeds as a natural source of L-arginine encapsulated lipid nanoparticles against diabetes. *Scientific Reports, 15*(1), 7016. https://doi.org/10.1038/s41598-025-90675-z

Almuzaini, N. A. M., Sulieman, A. M. E., Alanazi, N. A., Badraoui, R., & Abdallah, E. M. (2024). Mass spectrometric based metabolomics of the Saudi cultivar of fenugreek (*Trigonella foenum-graecum* L.): A combined GC-MS, antimicrobial and computational approach. *Pharmaceuticals, 17*(12), 1733. https://doi.org/10.3390/ph17121733

Al-Subaiyel, A., & Abdellatif, A. A. H. (2024). Eco-friendly synthesis of silver nanoparticles by *Trigonella foenum-graecum*: Formulations, characterizations, and application in wound healing. *Drug Development and Industrial Pharmacy, 50*(11), 927–937. https://doi.org/10.1080/03639045.2024.2431934

Amit, A., Shubhangi, V., Daphale, A., Chhajed, N., & Bhise, K. (2023). Effect of fenugreek (Trigonella foenum-graecum) seed powder on lipid profile: A single blind placebo controlled study. *Journal of Medical and Scientific Research, 11*(2), 114–118.

Ashour, M., Khairy, H. M., Bakr, A., Matter, M., & Alprol, A. E. (2024). Seaweed liquid extract as novel sustainable solutions for phycobioremediation plant germination, and feed additive for marine invertebrate copepod. *Scientific Reports, 14*(1), 29553. https://doi.org/10.1038/s41598-024-80389-z

Askarpour, M., Alami, A., Campbell, M. S., Venkatakrishnan, K., Hadi, A., & Ghaedi, E. (2020). Effect of fenugreek supplementation on blood lipids and body weight: A systematic review and meta-analysis of randomized controlled trials. *Journal of Ethnopharmacology, 253*, 112538. https://doi.org/10.1016/j.jep.2020.112538

Azizi, M., Saeb, H., Nazari, M., Aroiee, H., & Morshedloo, M. R. (2025). Assessment of the phenotypic and physicochemical traits of nine Iranian endemic fenugreek (*Trigonella foenum-graecum* L.). *Scientific Reports, 15*(1), 3303. https://doi.org/10.1038/s41598-025-86947-3

Babaei, M. J., Ebrahimi, A., Heidari, P., Azadvari, E., Gharanjik, S., & Chaghakaboodi, Z. (2025). Titanium dioxide-mediated regulation of enzymatic and non-enzymatic antioxidants, pigments, and diosgenin content promotes cold stress tolerance in *Trigonella foenum-graecum* L. *Scientific Reports, 15*(1), 1837. https://doi.org/10.1038/s41598-024-84472-3

Badiee Gavarti, M., Askari, A., Roohafza, H., Askari, M., Teimouri Jervekani, Z., Kaveh, S., Kermanialghoraishi, M., Sadeghimahoonak, A., & Sadeghi, M. (2024). The effect of the fenugreek hydrolyzed protein on the lipid profile in patients with mild to moderate hypercholesterolemia: A confirmatory triple blind randomized controlled clinical trial. *Phytomedicine Plus, 5*, 100691. https://doi.org/10.1016/j.phyplu.2024.100691

Bakhtiar, Z., Hassandokht, M., Naghavi, M. R., & Mirjalili, M. H. (2024). Nutritional value, phytochemical composition, and antioxidant potential of Iranian fenugreeks for food applications. *Scientific Reports, 14*(1), 21166. https://doi.org/10.1038/s41598-024-71949-4

Baset, M. E., Ali, T. I., Elshamy, H., El Sadek, A. M., Sami, D. G., Badawy, M. T., & Aboutif, S. S. (2020). Antidiabetic effects of fenugreek: A comparison between oral and intraperitoneal administration in animal study. *International Journal of Functional Nutrition*. https://doi.org/10.3892/ijfn.2020.2

Benitto, J. J., Vijaya, J. J., Saravanan, T. G., Manikkam, R., & Budhi, B. H. (2025). Microwave synthesized $NiZrO_3$@GNP and $NiZrO_3$@MWCNT nanocomposites: Enhanced antimicrobial efficacy against biofilms and *Mycobacterium smegmatis*. *3 Biotech, 15*(2), 35. https://doi.org/10.1007/s13205-024-04201-5

Berhe, Z., Awas, T., Dejen, A., Adane, M., Akele, B., Adal, M., & Hailu, F. (2025). Unlocking the genetic potential of Ethiopian fenugreek (Trigonella foenum-graecum L.) genotypes for future breeding. *Heliyon, 11*(4), e42321.

https://doi.org/10.1016/j.heliyon.2025.e42321

Boutaj, H. (2024). A comprehensive review of Moroccan medicinal plants for diabetes management. *Diseases, 12*(10), 246. https://doi.org/10.3390/diseases12100246

Chang, W., Guo, J., Yang, Y., Zou, L., Fu, Y., Li, M., Li, L., Li, C., Wang, X., Zhao, X., & Wu, C. (2024). *Semen Trigonellae* alleviates LPS-induced depressive behavior via enhancing the abundance of *Ligilactobacillus* spp. *Food Science & Nutrition, 12*(11), 9414–9427. https://doi.org/10.1002/fsn3.4475

Chehregosha, F., Maghsoumi-Norovzabad, L., Mobasseri, M., Fakhr, L., & Tarighat Esfanjani, A. (2024). The effect of fenugreek seeds dry extract supplement on glycemic indices, lipid profile, and pro-oxidant antioxidant balance in patients with type 2 diabetes: A double-blinded randomized clinical trial. *PubMed, 16*(3), 184–193.

Chen, W., An, D., Ye, S., Li, S., Li, J., & Li, B. (2025). Fenugreek gum improves the rheological properties of konjac glucomannan in dynamic simulated digestion system and delays its gastric emptying. *International Journal of Biological Macromolecules, 288*, 138713. https://doi.org/10.1016/j.ijbiomac.2024.138713

Corbetta, P., Lonati, E., Pagliari, S., Mauri, M., Cazzaniga, E., Botto, L., Campone, L., Palestini, P., & Bulbarelli, A. (2024). Flavonoids-enriched vegetal extract prevents the activation of NFκB downstream mechanisms in a bowel disease *in vitro* model. *International Journal of Molecular Sciences, 25*(14), 7869. https://doi.org/10.3390/ijms25147869

Dahab, A. A., Bayomy, H. M., El-Salam, H. S. A., Almasoudi, S. E., Ozaybi, N. A., Mahmoud, G. A., Atteya, A. K. G., & El-Serafy, R. S. (2024). Seed disinfection treatments minimized microbial load and enhanced nutritional properties of fenugreek sprouts which alleviated diabetes-negative disorders in diabetic rats. *Nutrients, 16*(16), 2635. https://doi.org/10.3390/nu16162635

Danish, S., Hussain, G. S., Hussain, M. B., Elgorban, A. M., & Datta, R. (2024). Unveiling the potential of *Agrobacterium fabrum* and γ-aminobutyric acid for mitigation of nickel toxicity in fenugreek. *Scientific Reports, 14*(1), 11042. https://doi.org/10.1038/s41598-024-61894-7

De, A., & Mishra, S. (2024). Synthesis of fenugreek gum-based metal-organic framework (FG/Zr-AIPA MOF) composite beads for sequestration of heavy metal ions from aqueous solution. *Environmental Science and Pollution Research International, 31*(22), 32571–32587. https://doi.org/10.1007/s11356-024-33315-9

Erten, F., Er, B., Ozmen, R., Tokmak, M., Gokdere, E., Orhan, C., Morde, A. A., Padigaru, M., & Sahin, K. (2025). Effects of integrated extracts of *Trigonella foenum-graecum* and *Asparagus racemosus* on hot flash-like symptoms in ovariectomized rats. *Antioxidants, 14*(3), 355. https://doi.org/10.3390/antiox14030355

Faturoti, A. O., & Ogidi, C. O. (2025). Inclusion of antimicrobial and antioxidant spices into milk candy towards enhancement of nutrient contents and bio-functional activities. *Heliyon, 11*(3), e42249. https://doi.org/10.1016/j.heliyon.2025.e42249

Gaikwad, A. B., Yadav, S., Kumari, R., Maurya, W., Rangan, P., Singh, R., & Singh, G. P. (2025). Chromosome scale genome assembly of *Trigonella corniculata* (L.) L. (Nagauri pan / Kasuri methi), an important spice. *Scientific Data, 12*(1), 509. https://doi.org/10.1038/s41597-025-04858-4

Garg, A., & Debnath, A. (2025). Thermodynamic origin of fenugreek phytochemical binding to the ASC pyrin domain for inflammation inhibition. *Physical Chemistry Chemical Physics, 27*(8), 4211–4221. https://doi.org/10.1039/d4cp04644g

Ghareeb, R. Y., Jaremko, M., Abdelsalam, N. R., Abdelhamid, M. M. A., El Argawy, E., & Ghozlan, M. H. (2024). Biocontrol potential of endophytic fungi against phytopathogenic nematodes on potato (*Solanum tuberosum* L.). *Scientific Reports, 14*(1), 15547. https://doi.org/10.1038/s41598-024-64056-x

Gupta, R. S., Grover, A. S., Kumar, P., Goel, A., Banik, S. P., Chakraborty, S., Rungta, M., Bagchi, M., Pal, P., & Bagchi, D. (2024). A randomized double-blind placebo-controlled trial to assess the safety and efficacy of a patented fenugreek (*Trigonella foenum-graecum*) seed extract

in Type 2 diabetics. *Food & Nutrition Research, 68*. https://doi.org/10.29219/fnr.v68.10667

Hachouf, M., Aouacheri, O., Saka, S., Marzocchi, A., & Carlo Tenore, G. (2025). Phenolic profiling, *in vitro* antiglycation, antioxidant activities, and antidiabetic effect of Algerian *Trigonella foenum-graecum* L. in rats administered a β-cell toxicant. *Chemistry & Biodiversity, 22*(1), e202401183. https://doi.org/10.1002/cbdv.202401183

Hafeez, A., Shahid Ali, S., Akhtar, J., Naz, S., Alrefaei, A. F., Albeshr, M. F., Israr, M., & Ullah Khan, R. (2024). Impact of coriander (*Coriandrum sativum*), garlic (*Allium sativum*), fenugreek (*Trigonella foenum-graecum*) on zootechnical performance, carcass quality, blood metabolites and nutrient digestibility in broiler chickens. *Veterinary Quarterly, 44*(1), 1–7. https://doi.org/10.1080/01652176.2023.2300948

Han, B., Dong, X., Li, M., Wang, Z., Shi, C., Zhou, Q., Liu, Z., & Yan, L. (2025). Morphological diversity variation of seed traits among 587 germplasm resources of *Medicago* genus and 32 germplasm resources of *Trigonella* genus. *Scientific Reports, 15*(1), 3059. https://doi.org/10.1038/s41598-025-87185-3

Hareem, M., Mahmood, S., Danish, S., Iqbal, R. K., Alarfaj, A. A., & Alharbi, S. A. (2024). Influence of indole acetic acid, arginine and mango fruit waste biochar on nutrients, chlorophyll contents and antioxidants of fenugreek in salt affected soil. *Scientific Reports, 15*(1), 167. https://doi.org/10.1038/s41598-024-84048-1

Heshmat Ghahdarihani, K., Yekhiasl, N. M., Amerizadeh, A., Teimouri Jervekani, Z., & Sadeghi, M. (2020). Effect of fenugreek consumption on serum lipid profile: A systematic review and meta-analysis. *Phytotherapy Research, 34*(9), 2230–2245. https://doi.org/10.1002/ptr.6758

Hosseini, E., Mohseni, M., & Ghaffari, S. (2022). The impact of fenugreek supplementation on serum cholesterol and triglyceride levels in hypercholesterolemic individuals: A systematic review and meta-analysis. *Nutrition & Metabolism, 19*(4), 101–112. https://doi.org/10.1186/s12986-022-00660-7

Hu, Q., Tang, X., Long, R., Pan, X., Shi, S., Liu, J., Pan, Y., Li, L., Gong, L., Liao, W., Zheng, P., Luo, X., Wang, Q., Luo, M., Fu, C., Li, R., & Xiao, H. (2025). Self-assembled nano-delivery system of fenugreek polysaccharides: Effects on curcumin bioavailability and molecular mechanisms. *International Journal of Biological Macromolecules, 286*, 138294. https://doi.org/10.1016/j.ijbiomac.2024.138294

Jambor, T., Goc, Z., Zuscikova, L., Greifova, H., Kovacik, A., Kovacikova, E., Pec, M., & Lukac, N. (2025). Phytochemical screening and monitoring of intercellular changes in murine Leydig cells after the treatment of *Trigonella foenum-graecum* L. microgreens *in vitro*. *Physiological Research, 74*(1), 115–128. https://doi.org/10.33549/physiolres.935484

Kao, C. C., Shih, J. W., Huynh, H. T. L. K., Chang, C. H., Lawal, B., Iamsaard, S., Azizah, N., Ritmaleni, R., Lin, J. K., Huang, P. Y., Wu, A. T. H., & Liu, M. C. (2025). Nutraceutical evaluation of trigonelline's therapeutic potential by targeting bladder cancer stem cells and cancer-associated fibroblasts via downregulation of TGFβ3/GLI2/YAP1 signaling hub. *International Journal of Medical Sciences, 22*(5), 1194–1207. https://doi.org/10.7150/ijms.107228

Kavaliunaite, E., Andersen, T. E., Lindholt, J. S., & Stubbe, J. (2025). Daily fenugreek intake does not attenuate abdominal aortic aneurysm growth in rats. *Vasa*. Advance online publication. https://doi.org/10.1024/0301-1526/a001185

Kemper, L., Herrmann, F., König, S., Falcone, F. H., & Hensel, A. (2025). Galactomannan and Vicilin from fenugreek seeds (*Trigonella foenum-graecum*) impair early pathogen-host interaction of *Campylobacter jejuni* with intestinal cells via JlpA. *Planta Medica, 91*(5), 293–301. https://doi.org/10.1055/a-2536-8392

Khalil, A. M., Sabry, O. M., El-Askary, H. I., El Zalabani, S. M., Eltanany, B. M., Pont, L., Benavente, F., Elshewy, A., & Fayek, N. M. (2024). Identification of cyclooxygenase-II inhibitory saponins from fenugreek wastes: Insights from liquid chromatography-tandem mass spectrometry metabolomics, molecular networking, and molecular docking.

Phytochemical Analysis, 35(4), 690–707. https://doi.org/10.1002/pca.3322

Khamkar, P. P., Wagh, K. S., Nangare, S. N., Mali, S. S., & Patil, G. S. (2025). Development of mesalamine loaded-fenugreek gum decorated pectin microspheres for colonic drug delivery: *Ex-vivo* and *in-vitro* characterizations. *Annales Pharmaceutiques Françaises, 83*(3), 514–528. https://doi.org/10.1016/j.pharma.2024.11.006

Khorrami, M., Samsampour, D., Badi, H. N., & Qaderi, A. (2024). Genetic and phytochemical evaluation of M2 generation mutants of fenugreek (*Trigonella foenum-graecum* L.) induced by gamma rays and ethyl methane sulphonate (EMS). *Molecular Biology Reports, 51*(1), 1154. https://doi.org/10.1007/s11033-024-10090-x

Kumar, A., & Singh, N. (2024). Embracing nutritional, physical, pasting, textural, sensory and phenolic profile of functional muffins prepared by partial incorporation of lyophilized wheatgrass, fenugreek and basil microgreens juice powder. *Journal of the Science of Food and Agriculture, 104*(7), 4286–4295. https://doi.org/10.1002/jsfa.13314

Kumar, S., Praveen, B. M., & Sudhakara, A. (2024). A sustainable approach towards extraction of diosgenin from fenugreek seeds using polystyrene/divinyl benzene resin. *Steroids, 212*, 109519. https://doi.org/10.1016/j.steroids.2024.109519

Kumar, S., Praveen, B. M., Sudhakara, A., Sherugar, P., & Puttaiahgowda, Y. M. (2025). Extraction of diosgenin using different techniques from fenugreek seeds: A review. *Steroids, 214*, 109543. https://doi.org/10.1016/j.steroids.2024.109543

Lee Ødegård, S., Gundersen, T. E., & Drevon, C. A. (2024). Effect of a plant extract of fenugreek (Trigonella foenum-graecum) on testosterone in blood plasma and saliva in a double blind randomized controlled intervention study. *PLoS One, 19*(9), e0310170. https://doi.org/10.1371/journal.pone.0310170

Lee, J. Y., Bang, J., Kim, J., Baek, K. S., Oh, D., & Lee, Y. H. (2025). Effect of fenugreek extract on testosterone propionate induced benign prostatic hyperplasia. *International Journal of Molecular Sciences, 26*(3), 1261. https://doi.org/10.3390/ijms26031261

Liaqat, I., Ibtisam, R., Hussain, M. I., Muhammad, N., Andleeb, S., Naseem, S., Ali, A., Latif, A. A., Ali, S., Aftab, M. N., Bibi, A., & Khalid, A. (2025). Medicinal plants exhibited promising potential to inhibit biofilm formation by catheter-associated bacteria in UTI patients from Lahore, Pakistan. *Journal of Oleo Science, 74*(2), 221–232. https://doi.org/10.5650/jos.ess24212

Lindi, A. M., Gorgani, L., Mohammadi, M., Hamedi, S., Darzi, G. N., Cerruti, P., Fattahi, E., & Moeini, A. (2024). Fenugreek seed mucilage-based active edible films for extending fresh fruit shelf life: Antimicrobial and physicochemical properties. *International Journal of Biological Macromolecules, 269*(Pt 2), 132186. https://doi.org/10.1016/j.ijbiomac.2024.132186

Manivannan, H. P., Veeraraghavan, V. P., & Francis, A. P. (2024). Identification of molecular targets of trigonelline for treating breast cancer through network pharmacology and bioinformatics based prediction. *Molecular Diversity, 28*(6), 3835–3857. https://doi.org/10.1007/s11030-023-10780-x

Mansourian, M., Rezaei, F., & Vahdat, S. (2023). Fenugreek seeds and its effects on lipid profile in patients with hyperlipidemia: A randomized clinical trial. *Journal of Clinical Nutrition, 45*(7), 820–829.

Mate, P. S., Verma, V. C., Agrawal, S., Jaiswal, J. P., Kumari, V. V., Kumar, R., Kumari, M., Gaber, A., & Hossain, A. (2024). Effect of fenugreek (*Trigonella foenum-graecum* L.) seed extract on glycemic index, *in vitro* digestibility, and physical characterization of wheat (*Triticum aestivum* L.) starch. *Journal of Food Science, 89*(11), 7626–7639. https://doi.org/10.1111/1750-3841.17411

Matthewman, C., Krishnakumar, I. M., & Swick, A. G. (2024). Review: Bioavailability and efficacy of 'free' curcuminoids from curcumagalactomannoside (CGM) curcumin formulation. *Nutrition Research Reviews, 37*(1), 14–31. https://doi.org/10.1017/S0954422423000033

Mohammad Sadeghipour, M., Afsharinasab, M., Mohamadi, M., Mahmoodi, M., Khanamani

Falahati Pour, S., & Hajizadeh, M. R. (2020). The effects of hydroalcoholic extract of fenugreek seeds on the lipid profile and oxidative stress in fructose fed rats. *Journal of Obesity and Metabolic Syndrome, 29*(3), 198–207.

Morshedi, I. (2024). In vitro protective effects of total extract and fractions of fenugreek (Trigonella foenum-graecum L.) on red blood cells. *Clinical Laboratory, 70*(11). https://doi.org/10.7754/Clin.Lab.2024.240421

Morshidi, N. A. A. B., Uddin, M. S., Lee, J., Han, S. I., & Kim, J. H. (2025). Anticancer activity of *Trigonella foenum-graecum* (fenugreek) seed extract by inducing apoptosis in pancreatic cancer cell. *American Journal of Translational Research, 17*(2), 832–843. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC11909546/

Mt, A. (2022). Health benefits and improvement of fenugreek (Trigonella foenum-graecum L.) crop. *Journal of Agriculture Research Advances, 4*(03), 33–44.

Muluye, D., Getachew, P., Tekalign, T., Woldekidan, S., & Biftu, T. (2024). Evaluation of the antihyperglycemic and antihyperlipidemic effects of *Trigonella foenum-graecum* L. and *Coffea arabica* L. seeds in STZ induced diabetic mice: Impact on kidney and liver functions. *Pan African Medical Journal, 49*, 94. https://doi.org/10.11604/pamj.2024.49.94.44735

Mushannavar, L. S., & Nadiger, R. K. (2025). Spectral characterization of biosynthesized silver nanomodified poly(methyl methacrylate) resin for denture applications. *Journal of Indian Prosthodontic Society, 25*(2), 132–137. https://doi.org/10.4103/jips.jips_455_24

N. S., & T., M. (2025). Evaluation of polyherbal synergy against diabetes: In vitro analysis. *Future Science OA, 11*(1), 2468128. https://doi.org/10.1080/20565623.2025.2468128

Naaz, N., Choudhary, S., Hasan, N., Sharma, N., Al Aboud, N. M., & Shehata, W. F. (2024). Biochemical and molecular profiling of induced high yielding M3 mutant lines of two *Trigonella* species: Insights into improved yield potential. *PLOS ONE, 19*(7), e0305691. https://doi.org/10.1371/journal.pone.0305691

Naaz, N., Choudhary, S., Hasan, N., Sharma, N., Alharbi, K., & Abd El Moneim, D. (2024). Enhancing genetic variability in *Trigonella* species through sodium azide induction: Morpho-physiological and chromosomal amelioration. *Frontiers in Genetics, 15*, 1378368. https://doi.org/10.3389/fgene.2024.1378368

Omran, S. A., & Ghani, B. A. (2024). Effect of fenugreek oil on healing of experimentally induced buccal mucosal ulcer by immunohistochemical evaluation of Ki-67 expression. *Cell Biochemistry and Biophysics, 82*(3), 2363–2371. https://doi.org/10.1007/s12013-024-01347-0

Pagano, A., Dueñas, C., Bedotto, N., Elleuch, A., Khemakhem, B., El Abed, H., Tani, E., Goufa, M., Chachalis, D., & Balestrazzi, A. (2025). Exploring the genotoxic stress response in primed orphan legume seeds challenged with heat stress. *Genes, 16*(2), 235. https://doi.org/10.3390/genes16020235

Pande, S. (2025). Comparative potential of fenugreek (*Trigonella foenum-graecum* L.) and Indian gooseberry (*Phyllanthus emblica*) in enhancing sirtuin1 protein. *Food Chemistry, 477*, 143596. https://doi.org/10.1016/j.foodchem.2025.143596

Pooja, G., Senthil Kumar, P., Boobalan, C., & Rangasamy, G. (2024). Efficient removal of pharmaceutical contaminants from aqueous solution using plant-derived biosurfactant-assisted dissolved air flotation process. *Langmuir, 40*(52), 27676–27689. https://doi.org/10.1021/acs.langmuir.4c04520

Prosad Banik, S., Kumar, P., Bagchi, D., Paul, S., Goel, A., Bagchi, M., & Chakraborty, S. (2024). Fenfuro®-mediated arrest in the formation of protein-methyl glyoxal adducts: A new dimension in the anti-hyperglycemic potential of a novel fenugreek seed extract. *Toxicology Mechanisms and Methods, 34*(8), 877–885. https://doi.org/10.1080/15376516.2024.2358520

Qu, Y., Wang, Y., Xiao, H., Jiang, M., Cai, Q., Liu, Y., Zheng, Y., & Zhang, B. (2025). The chemical constituents and antihyperlipidemia effect of salt-processed

fenugreek seed. *Food Science & Nutrition, 13*(2), e70043. https://doi.org/10.1002/fsn3.70043

Rath, P., Prakash, D., Ranjan, A., Chauhan, A., Jindal, T., Alamri, S., Alamri, T., Harakeh, S., & Haque, S. (2024). Modulation of insulin resistance by *Silybum marianum* leaves, and its synergistic efficacy with *Gymnema sylvestre*, *Momordica charantia*, *Trigonella foenum-graecum* against protein tyrosine phosphatase 1B. *Biotechnology and Genetic Engineering Reviews, 40*(4), 3805–3827. https://doi.org/10.1080/02648725.2022.2162236

Razon, A. H., Alauddin, M., Farzana, N., Mazumdar, S., Amin, M. R., Tusher, M. M. H., Asrafuzzaman, M., Hasan, N., Rahman, M., Saiedullah, M., Rokeya, B., & Faruque, M. O. (2024). The intricate mechanisms of functional foods oyster mushroom and fenugreek on type 2 diabetic animal model. *Journal of Diabetes Research, 2024*, 6209785. https://doi.org/10.1155/jdr/6209785

Rewers, M., Lojko, A., Olszewska, D., Niklas, A., & Jedrzejczyk, I. (2024). Diversity of genome size, endopolyploidy and SCoT markers in 20 *Trigonella* (Fabaceae) species. *Journal of Applied Genetics, 65*(4), 693–703. https://doi.org/10.1007/s13353-024-00886-9

Rezazadehfar, P., Rezayian, M., Niknam, V., & Mirmasoumi, M. (2024). Elicitor-enhanced steroidal sapogenin accumulation in hairy root cultures of *Trigonella foenum-graecum*. *Scientific Reports, 14*(1), 19106. https://doi.org/10.1038/s41598-024-69625-8

Rizzo, M., Licata, P., Niutta, P. P., Pugliese, M., Macaluso, V., Costa, G. L., Bruschetta, G., & Bruno, F. (2025). An unusual outbreak of ochratoxicosis associated with *Trigonella foenum-graecum* ingestion in ruminants from different farms of Sicily. *Toxins, 17*(3), 120. https://doi.org/10.3390/toxins17030120

Sadan, M., Naem, M., Tawfeek, H. M., Khodier, M. M., Zeitoun, M. M., El-Khodery, S., Alkhamiss, A. S., Hassan, Y. A. H., & Abdellatif, A. A. H. (2024). Can silver nanoparticles stabilized by fenugreek (*Trigonella foenum-graecum*) improve tibial bone defects repair in rabbits? A preliminary study. *Open Veterinary Journal, 14*(5), 1281–1293. https://doi.org/10.5455/OVJ.2024.v14.i5.23

Sakhai, F. S., Movahedi, Z., Ghabooli, M., & Fard, E. M. (2025). Positive effect of *Serendipita indica* on fenugreek and its tolerance against cadmium stress. *Current Microbiology, 82*(4), 182. https://doi.org/10.1007/s00284-025-04148-7

Sarker, D. K., Ray, P., Dutta, A. K., Rouf, R., & Uddin, S. J. (2024). Antidiabetic potential of fenugreek (Trigonella foenum-graecum): A magic herb for diabetes mellitus. *Food Science & Nutrition, 12*(10), 7108–7136. https://doi.org/10.1002/fsn3.4440

Sasirekabai, R., Jayakumari, T., Anandhi, R., Shalini, R., Neethidevan, K., Praseetha, P. K., Ayyanar, M., & Ravichandran, K. (2025). Enhanced photocatalytic dye detoxification by banana peel derived enzyme inherited ZnO/g-C_3N_4 nanocomposite: Validation by soil health and seed germination analyses. *International Journal of Biological Macromolecules, 297*, 139812. https://doi.org/10.1016/j.ijbiomac.2025.139812

Sekhar, M. G., Ramudu Shanmugam, K., & Chakrapani, I. S. (2024). Trigonelline, a fenugreek bioactive compound protects heart tissue against alcohol intoxication: An *in-vivo* study focusing on antioxidant perspective. *Journal of Ayurveda and Integrative Medicine, 15*(4), 100963. https://doi.org/10.1016/j.jaim.2024.100963

Sethi, G., Sood, S., Bhardwaj, S. B., & Jain, A. (2024). *In vitro* evaluation of anti-microbial efficacy of *Trigonella foenum-graecum* and its constituents on oral biofilms. *Journal of Indian Society of Periodontology, 28*(3), 304–311. https://doi.org/10.4103/jisp.jisp_540_23

Shaaban, A., Hemida, K. A., Abd El-Mageed, T. A., Semida, W. M., AbuQamar, S. F., El-Saadony, M. T., Al-Elwany, O. A. A. I., & El-Tarabily, K. A. (2024). Incorporation of compost and biochar enhances yield and medicinal compounds in seeds of water-stressed *Trigonella foenum-graecum* L. plants cultivated in saline calcareous soils. *BMC Plant Biology, 24*(1), 538. https://doi.org/10.1186/s12870-024-05182-6

Shahid, F., Arshad, A., Munir, N., & Jawad, M. (2024). Nutraceutical activities of *Trigonella foenum-graecum* and *Nigella sativa* seeds in the management of diabetes-induced in albino rats. *Journal of*

Food Science, 89(7), 4522–4534. https://doi.org/10.1111/1750-3841.17155

Shahin, S. A., & Jafari, S. M. (2023). The cholesterol lowering effects of fenugreek: A systematic review and meta-analysis. *Journal of Nutritional Biochemistry, 45*(5), 315–322. https://doi.org/10.1016/j.jnutbio.2023.108943

Shahzad, M. A., Younis, U., Ehsan, A., Alarfaj, A. A., Alharbi, S. A., & Ansari, M. J. (2024). Impact of gibberellic acid GA3, quantum dot biochar, and rhizosphere bacteria on fenugreek plant growth and stress responses under lead stress. *Scientific Reports, 14*(1), 29612. https://doi.org/10.1038/s41598-024-81072-z

Shakil, S., Akhtar, S. E., Ali, A., Antony, M., Antony, I., Mansour, E., Khawar Farooqui, S., Akbar, A., Alazazzi, H., Alsufyani, R., Alsufyani, M., Alawadhi, R., Ramtohul, R. K., Hadeed, S., Tabassi, A., Tabassi, A., & Almas, T. (2024). Enhancing glycaemic control and promoting cardiovascular health: The therapeutic potential of *Trigonella foenum-graecum* in diabetic patients – a systematic review and meta-analysis. *Annals of Medicine and Surgery (London), 86*(6), 3460–3467. https://doi.org/10.1097/MS9.0000000000001750

Sharma, S., Sharma, P., Singh, J., Bahel, S., Dutta, R., Vig, A. P., & Katnoria, J. K. (2025). Assessing cell viability and genotoxicity in *Trigonella foenum-graecum* L. exposed to 2100 MHz and 2300 MHz electromagnetic field radiations. *Plant Physiology and Biochemistry, 219*, 109311. https://doi.org/10.1016/j.plaphy.2024.109311

Siddiqui, I., Owais, M., & Husain, Q. (2024). Antimicrobial effects of peptides from fenugreek and ginger proteins using Fe_3O_4@PDA-MWCNT conjugated trypsin by improving enzyme stability & applications. *International Journal of Biological Macromolecules, 282*(Pt 5), 137197. https://doi.org/10.1016/j.ijbiomac.2024.137197

Singh, R., Meena, R. S., Choudhary, S., Meena, N. K., Meena, R. D., Verma, A. K., Mahatma, M. K., Yathendranaik, R., Lal, S., Shekhawat, P. K., & Bhardwaj, V. (2025). Deciphering agronomic traits, biochemical components, and color in unique green-seeded fenugreek (*Trigonella foenum-graecum* L.) genotypes. *Frontiers in Nutrition, 12*, 1542211. https://doi.org/10.3389/fnut.2025.1542211

Sivakumar, A., Thanu, A. S., Vishnumukkala, T., Ksv, A. B. G., Shetty, J. K., Jagadeesan, S., & Gopalakrishna, P. K. (2024). Management of diabetes mellitus using medicinal plants: A review. *Bioinformation, 20*(7), 705–710. https://doi.org/10.6026/973206300200705

Skrzypiec Spring, M., Pokrywka, A., Kuliczkowska Płaksej, J., Szeląg, A., & Bolanowski, M. (2025). Withania somnifera and Trigonella foenum-graecum as ingredients of testosterone boosting supplements: Possible clinical implications. *Advances in Clinical and Experimental Medicine, 34*(2), 295–303. https://doi.org/10.17219/acem/185743

Sousa, F., Bertrand, Y. J. K., Zizka, A., Cangrén, P., Oxelman, B., & Pfeil, B. E. (2024). Chloroplast genome and nuclear loci data for 71 Medicago species. *Data Brief, 54*, 110540. https://doi.org/10.1016/j.dib.2024.110540

Subbuvel, M., Mohan, R., Dubey, U., Gopalaswamy Pillai, U. T., & Kavan, P. (2025). Fabrication of nutritional edible bowls with wheat bran, multigrain powder, refined flour, flax seed powder, fenugreek essential oil, and jaggery. *Journal of the Science of Food and Agriculture, 105*(5), 2836–2842. https://doi.org/10.1002/jsfa.14057

Tayel, A. A., Ebaid, A. M., Otian, A. M., Mahrous, H., El Rabey, H. A., & Salem, M. F. (2024). Application of edible nanocomposites from chitosan/fenugreek seed mucilage/selenium nanoparticles for protecting lemon from green mold. *International Journal of Biological Macromolecules, 273*(Pt 1), 133109. https://doi.org/10.1016/j.ijbiomac.2024.133109

Vadivel, D., Djemal, R., García, J., Pagano, A., Trabelsi, R., Gdoura Ben Amor, M., Charfeddine, S., Ghanmi, S., Khalifa, I., Rekik, M., Amor, F., Ebel, C., Gdoura, R., Elleuch, A., Balestrazzi, A., Macovei, A., Hanin, M., & Dondi, D. (2024). Exploring seed characteristics and performance through advanced physico-chemical

techniques. *Scientific Reports, 14*(1), 24162. https://doi.org/10.1038/s41598-024-75236-0

Vajdi, M., Noshadi, N., Bonyadian, A., Pourteymour Fard Tabirizi, F., Abbasalizad Farhangi, M., & Askari, G. (2024). Therapeutic effect of fenugreek supplementation on type 2 diabetes mellitus: A systematic review and meta-analysis of clinical trials. *Heliyon, 10*, e36649. https://doi.org/10.1016/j.heliyon.2024.e36649

Vishwakarma, K., Badade, Z. G., Dhok, A., Kushwaha, A., & Ambad, R. (2024). Effect of *Trigonella foenum-graecum* in diabetic albino Wistar rats and their antioxidant properties. *Journal of Pharmacy & Bioallied Sciences, 16*(Suppl 4), S3392–S3394. https://doi.org/10.4103/jpbs.jpbs_872_24

Wang, H., Feng, Y., Liang, Y., Wang, K., Yang, X., Lai, M., Li, H., Yang, J., & Ji, X. (2024). Effects of separation and purification methods on antioxidation, hypoglycemic and DNA protection activity of fenugreek polysaccharide. *Chemistry & Biodiversity, 21*(8), e202400190. https://doi.org/10.1002/cbdv.202400190

Wang, Y., Zheng, Y., Liu, Y., Shan, G., Zhang, B., Cai, Q., Lou, J., & Qu, Y. (2023). The lipid lowering effects of fenugreek gum, hawthorn pectin, and burdock inulin. *Frontiers in Nutrition, 10*, 1149094. https://doi.org/10.3389/fnut.2023.1149094

Peer-review history:
The peer review history for this paper can be accessed here:
https://pr.sdiarticle5.com/review-history/136327