

FENUGREEK SEEDS

Sadgir Ravina*¹, Arote Sanika*², Ekhande Aditi*³, Godase Sakshi*⁴

^{*1,2,3,4}Matoshri Radha College Of Pharmacy, Virgaon, India.

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ABSTRACT

In human and animal models, fenugreek extracts show promising physiological and pharmacological qualities, and it was helpful after eight weeks of resistance training without it. The goal of this study is to present a thorough and scientific examination of the research on how fenugreek extracts affect muscular function. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement requirements were followed in conducting a thorough web search. To find every scientific study on the impact of fenugreek on muscle and exercise or sport, publications from May 1981 to May 2021 were found using the major medical and scientific search engines. Six appropriate randomised controlled trials (RCTs) were included in the qualitative analysis out of the 81 studies that were obtained. Fenugreek supplementation was found to significantly improve muscle strength, lean body mass, submaximal performance index, repetitions to failure (muscle endurance), and body fat in four RCTs. Fenugreek extracts had a substantial impact on the rate of muscle glycogen resynthesis during post-exercise recovery, according to one of the two remaining experiments, but not the other. These two experiments have a small sample size (less than ten), making them poor. Additionally, supplementing fenugreek glycoside with saponins and saponins showed significant androgenic and anabolic action without causing any negative clinical consequences.

Supplementing with fenugreek and creatine enhanced creatine absorption without requiring a substantial carbohydrate intake. For athletes, fenugreek extracts can therefore be a beneficial natural supplement and ergogenic assistance. However, before using the fenugreek supplement, it is best to be aware of doping and liver and kidney damage.

I. INTRODUCTION

Legume that is a member of the Fabaceae family is fenugreek (*Trigonella foenum-graecum* Linn). Fenugreek seeds contain around 175 different chemicals [1].

Steroid saponin chemicals, fibres, phenolic acid compounds, protodioscin, flavonoids, hydrocarbons, alkaloids, terpenes, fatty acid glycosides, carbohydrates, amino acids, and their derivatives are among the active ingredients found in fenugreek [2].

In the context of the "new world," fenugreek (*Trigonella foenum-graecum*), an ancient medicinal plant with long-standing historical recognition, has gained the designation of "old world" crop. For millennia, people from many cultures have used fenugreek seeds for their therapeutic benefits.[3]

The tiny, golden-brown seeds' rich nutritional profile and the presence of bioactive substances give them a wide range of health advantages. [4]

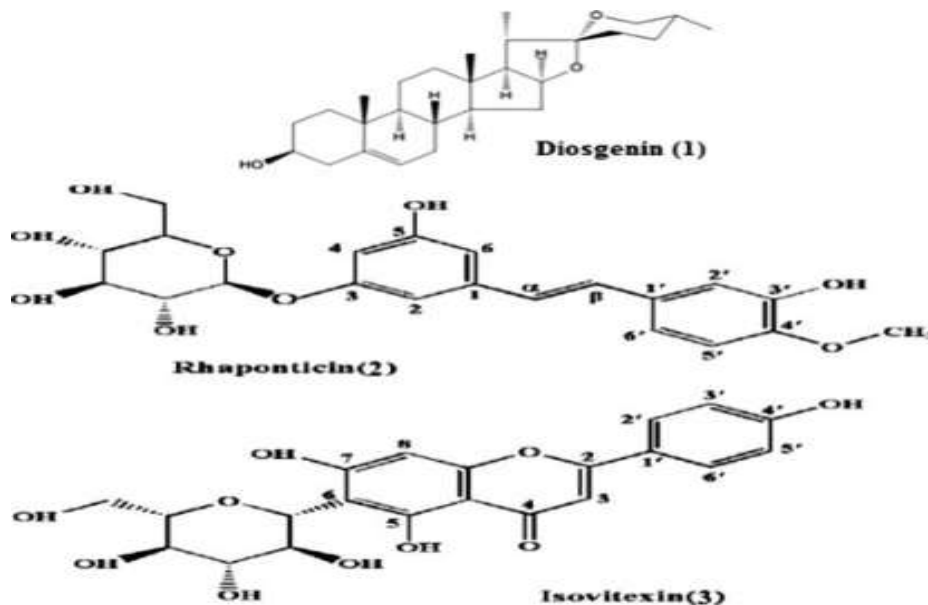
It is a well-known spice in human cuisine. Fenugreek's seeds and green leaves have long been used in medicine and as food, dating back thousands of years. It has been used to change the texture of food ingredients and enhance their flavour and colour. Fenugreek spice seeds have antibacterial, stomach stimulant, hypocholesterolemic, lactation assistance, anorexia treatment, antidiabetic, galactagogue, hepatoprotective, and anticancer effects. Fenugreek's antidiabetic and hypocholesterolemic properties, among other positive physiological benefits, are mostly due to its inherent dietary fibre content, which has great nutraceutical potential. [5]

The seeds of fenugreek are renowned for being mildly sweet and pleasantly bitter. The seeds, which can be crushed or whole, are used to flavour a variety of meals, primarily teas, curry powders, and spice blends. A corneous, rather thick covering of white, semi-transparent endosperm envelops the firm, yellow embryo in the centre of fenugreek seeds [6]. Fenugreek seeds have drawn a lot of interest in a number of areas, such as nutrition, health, and innovative uses of nanotechnology. This review article focusses on a thorough examination of fenugreek seeds and looks at its many uses.

Seeds

Chemical Composition

The highest levels of saponin (4.63 g/100 g) and protein (43.8 g/100 g) were found in the endosperm, according to the chemical makeup of fenugreek, which includes seeds, husk, and cotyledons. Husk, on the other hand, has more total polyphenols. By using the free-radical scavenging method, the extracts of fenugreek seed and endosperm husk at a concentration of roughly 200 µg demonstrated antioxidant activity 72%, 64%, and 56%, respectively [7]. Fenugreek seeds are commercially extracted and contain 0.1–0.9% diosgenin. Figure depicts the structure of diosgenin. Under ideal growing conditions, fenugreek seed plant tissue cultures have been shown to produce up to 2% diosgenin and lower levels of trigogenin and gitongenin. The saponin (fenugrin B) is also found in seeds. It has been discovered that fenugreek seeds contain alkaloids, such as trigonelline, gentianine, and carpaine. When trigon is roasted, its high content of coumarin compounds and elline is broken down into nicotinic acid and related pyridines [8]. It is thought that polyphenol chemicals like rhaponticin and isovitexin are the main bioactive substances found in fenugreek seeds [9].



An investigation into human perspiration following fenugreek consumption revealed that the following elements are the main causes of the potent maple-syrup odour seen in perspiration—including the following: camphor, terpinen-4-ol, 3-octen-2-one, pinene, and 2,5-dimethylpyrazine; nonetheless, it was shown that 2,5-dimethylpyrazine was a significant contributor to sweat odour [10]. The chemical components of l-isopropylbenzaldehyde, neryl acetate, and β-caryophyllene are displayed in Table Chemical constituents of fenugreek.

S. no.	Chemical constituents of fenugreek
Alkaloids	Trimethylamine, Neurin, Trigonelline, Choline, Gentianine, Carpaine and Betain
Amino acids	Isoleucine, 4-Hydroxyisoleucine, Histidine, Leucine, lysine, L-tryptophan, Arginine
Saponins	Graecunins, fenugrin B, fenugreekine, trigofenosides A–G
Steroidal saponogens	Yamogenin, diosgenin, smilagenin, sarsasapogenin, tigogenin, neotigogenin, gitogenin, neogitogenin, yuccagenin, saponaretin
Flavonoids	Quercetin, rutin, vitexin, isovitexin
Fibers	Gum, neutral detergent fiber

Lipids	Triacylglycerols, diacylglycerols, monoacylglycerols, phosphatidylcholine phosphatidylethanolamine, phosphatidylinositol, free fatty acids. [11]
Other	Coumarin, lipids, vitamins, minerals. 28% mucilage; 22% proteins; 5% of a stronger-swelling, bitter fixed oil.

II. MATERIALS AND METHODS

This systematic review and meta-analysis was carried out using a planned methodology that adhered to the guidelines provided by the Cochrane Handbook [12]. The results were published in accordance with the Preferred (PRISMA) declaration [13].

Search approach:

Using MeSH terms and keywords, an electronic literature search was conducted in the Cochrane Library databases through November 9, 2022. The search strategy made use of the following keywords: (Fenugreek OR Trigonella) AND (Intervention OR "controlled trial" OR "randomised OR random OR randomly OR placebo OR "clinical trial" OR trial OR "randomised clinical trial" OR RCT OR trial OR trials "Cross-Over Studies" OR "Cross-Over" OR "Cross-Over Study" OR parallel OR "parallel study" OR "parallel trial") AND ("diabetes" OR "type 2 diabetes mellitus" OR "T2DM" OR "type 2 diabetes" OR "type 2 diabetes" OR "glycemia" OR "Hyperglycemia" OR "T2D" OR "prediabetes"). There were no restrictions on the language or year of the search. The EndNote program was used to download the search results.

Criteria for Inclusion and Exclusion:

To determine the effects of fenugreek on glycemia, we included studies in which subjects were healthy, had T2DM, or were prediabetic. The intervention was limited to the consumption of fenugreek alone, in any form or at any dose. Only randomized controlled trials with at least 7 days of intervention were included. The outcomes of interest were FBG, PPG, HbA1c levels. Studies without a control group and those that did not report baseline values were not included. We also excluded studies that used combinations of other herbs with fenugreek for the intervention. Narrative reviews, observational studies, animal studies, case reports, and letters were also excluded

Study selection

The selection procedures and study screening were conducted in accordance with PRISMA guidelines. After downloading the database search results into Endnote, they were transferred to the Rayyan software for initial inspection. Two independent reviewers (MS and GB) conducted the initial screening by reading the abstracts and titles. Discussions with the other reviewers (PKB and PSM) helped to settle disagreements. To find possible research, a comprehensive full-text reading was done following the initial screening.

Extracting data and evaluating its quality

Utilising a preset standard form, data extraction and quality assessment are performed. From each article, the following information was taken: the name of the author, the country of publication, the year, the sample size, the study design, the characteristics of the subjects, the combination of drugs, the form and dosage of fenugreek, the length of the intervention, and the outcomes of interest. We assessed each included study's risk of bias using the Cochrane Collaboration's "Risk of Bias" assessment tool. The Cochrane Handbook's risk of bias evaluation guidelines addressed the following specific categories of bias: reporting, attrition, detection, performance, selection, and additional sources of bias [14]. To indicate "low risk," "high risk," or "unclear risk" of bias, each item was evaluated and assigned a "yes," "no," or "unclear" rating.

Statistical Analysis

Forest plots and data evaluation were done using STATA version 16. The trials' heterogeneity was taken into account using a random-effects model [15]. The significance level was set at $p < 0.05$, and mean differences and 95% CI were computed for the outcome variables. The tau squared (τ^2) and I-squared statistics were used to evaluate tests for heterogeneity among included studies [15]. If the relevant outcome was available for at least three trials, a meta-analysis was conducted. The presence of publication bias was assessed visually using a

funnel plot. Sensitivity analysis was used to ascertain the impact of individual studies on results, and meta-regression was used to ascertain the effect of any variable.

THERAPEUTIC POTENTIAL OF FENUGREEK SEEDS

The bioactive ingredients in fenugreek seeds determine their potential for medicinal use. Alkaloids like trigonelline are among them, along with proteins, amino acids, flavonoids, steroidal saponins, coumarin, lipids, vitamins, minerals, and galactomannan fibre. Due to its rich phytochemical composition, fenugreek seeds have been shown to have antidiabetic [16;17], hypolipidemic, anti-obesity, anti-cancer, anti-inflammatory, antioxidant, and antibacterial properties. This has been supported by substantial pharmacological and clinical evidence.

1. Antidiabetic potential:

The use of fenugreek as an antidiabetic treatment for people with type I and type II diabetes has received a lot of attention. In a number of experimental configurations, it has been extensively utilised as a source of antidiabetic components that are extracted from its seeds, leaves, and extracts [20]. It has been observed that fenugreek's bioactive ingredients, such as galactomannan, saponins, trigonella, diosgenin, and 4-hydroxyisoleucine, have beneficial benefits on diabetes. Numerous components have been identified and their effects on blood sugar have been demonstrated by numerous investigations [21]. Rats' intestinal and liver glycogen enzyme activities are regulated by fenugreek saponins, which also increase the amount of glycogen in the liver, decrease blood glucose, and boost oral glucose tolerance [22].

2. Hepatoprotective Effects:

Supplementing with antioxidants can effectively cure or control liver impairments. Diosgenin, saponins, flavonoids, and polyphenols are among the constituents that have hypolipidemic, hypocholesterolemic, and antioxidant qualities. In one study, 200 mg/kg of fenugreek daily enhanced the lipid profile and collagen content in hepatotoxic Wistar rats [23]. In a different study, fenugreek increased lipid excretion in faeces, which decreased lipid aggregation in the liver. Triglycerides, cholesterol, low-density lipoproteins, very low-density lipoproteins, and serum total cholesterol were all markedly decreased. The cholesterol and high-density lipoprotein fractions, however, did not alter [24]. Fenugreek's active ingredients, including galactomannan and 4-hydroxyisoleucine, enhanced lipid metabolism and reduced blood glucose levels. Fenugreek may help reduce hepatic and metabolic damage that follows ischemia-reperfusion. It was discovered that fenugreek was useful in lessening ischemia-reperfusion damage. Flavonoids and polyphenols have been demonstrated to be beneficial in the treatment of hepatic ischaemia. Rats exposed to fenugreek extract demonstrated hepatoprotective effects by having significantly lower levels of circulating serum aspartate aminotransferase (AST), alanine aminotransferase (ALT), and lactate dehydrogenase (LDH) [25].

3. Cardioprotective Effects:

Fenugreek seeds have been shown in studies to effectively reduce cholesterol, which suggests that they may also have cardioprotective effects [26]. Fenugreekine, coumarin, nicotinic acid, saponins, diosgenin, galactomannan, phytic acid, scopoletin, and trigonelline are among the pharmacologically significant components of fenugreek. Rats' myocardial infarction caused by isoproterenol was examined in relation to fenugreek. Through an increase in the activities of both enzymatic and non-enzymatic antioxidants (SOD, CAT, GPx, and GSH), the study demonstrated the cardioprotective impact of fenugreek in rats [27]. Because fenugreek has a powerful influence on blood lipid regulation, it can effectively prevent atherosclerosis by increasing HDL levels and decreasing LDL, triglycerides, and cholesterol [28]. As an effective antioxidant, fenugreek helps to alleviate metabolic imbalances and shield cardiac tissue from oxidative damage. In one study, rats with STZ-induced diabetes showed protection from the hydro-alcoholic extract of fenugreek seeds. The findings demonstrated that by modifying the expression of genes involved in apoptosis, fenugreek seed extract may be used to treat diabetic cardiomyopathy. Fenugreek has anti-oxidant and anti-apoptotic properties, as evidenced by reports of downregulated expression of the pro-apoptotic Bax gene and intercellular adhesion molecule and elevated expression of the anti-apoptotic gene Bcl2 [29].

4. Effects on Gastroprotection:

Unhealthy eating habits and lifestyle choices lead to peptic ulcers, gastric ulcers, nausea, vomiting, and discomfort in the abdomen. Numerous studies have demonstrated fenugreek's protective effects against gastrointestinal disorders. It has anti-inflammatory, anti-ulcer, gastroprotective, antioxidant, and anti-secretory qualities. The oral administration of fenugreek seeds to Albino rats resulted in a substantial decrease in ulcer severity as compared to the rats in the untreated group [30]. Rats pre-treated with fenugreek seeds showed a considerable reduction in mucosal damage, hyperaemia, submucosal oedema, and severe vascular congestion as indicated by HCl-ethanol induction [31].

Oral administration of 700 mg/rat of fenugreek seed gel fractions demonstrated anti-ulcerogenic properties. Significantly lower lesion formation, changed gastric secretion, decreased lipid peroxidation, and enhanced antioxidant ability of the gastric mucosa were all seen in the gel fraction [32].

5. Anti-cancer Effects:

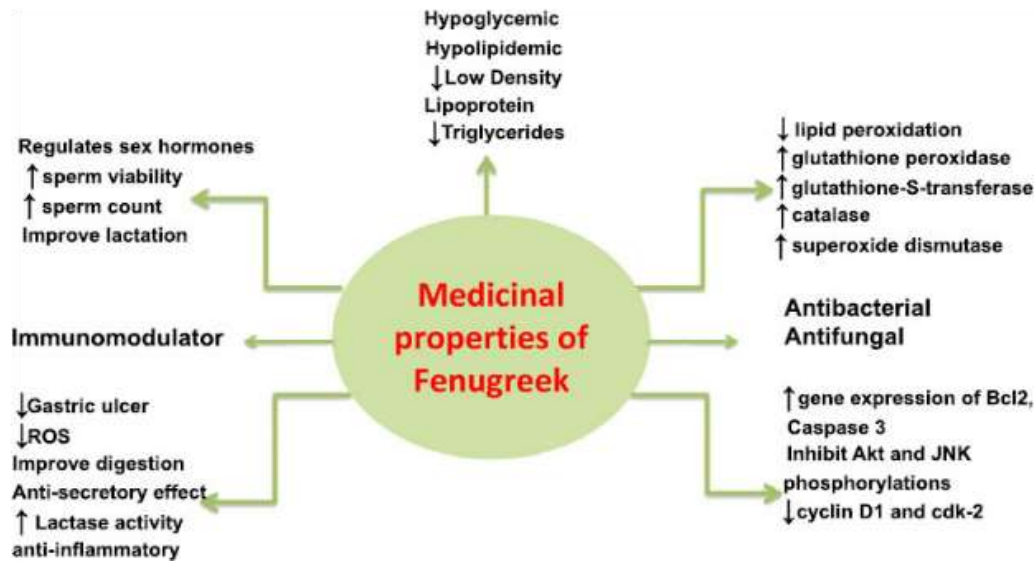
Diosgenin, a bioactive substance found in fenugreek, has anti-cancer properties [33]. By triggering apoptosis, fenugreek has been shown in numerous trials to be beneficial against malignant cells. By downregulating cyclin D1 and cdk-2, diosgenin stops the G1 phase of the cell cycle in both MCF-7 and MDA-231 cells. Diosgenin treatment resulted in p21 overexpression in the treated cells without p53 involvement. Additionally, it was discovered to play a role in both the up- and down-regulation of the protein implicated in cell death (both in vitro and in vivo) [34]. When compared to control cells, the treated cells' caspase 3 activity rose and their Bcl2 levels dropped in breast cancer (BCa) cells. The findings demonstrated that diosgenin affects the malignant cells' apoptotic mechanism. Diosgenin therapy downregulated Akt-mediated signalling, which is essential for the growth of breast cancer cells [34]. Because they suppress Akt and JNK phosphorylations, enhance the expression of apoptotic genes and caspase activity, and so stop cell division, thymoquinone and diosgenin have anti-neoplastic properties. These two bioactive ingredients have anti-proliferative qualities and work in concert [33].

6. Anti-sterility and Anti-fertility Effects:

The modulation of sex hormones, sperm viability, sperm count, and other sexual dysfunction in both sexes are among the reproductive health benefits of fenugreek. Fenugreek's bioactive ingredients, including steroidal saponins (yamogenin and diosgenin), have anti-androgenic and anti-sterility properties. In the rat model of Ovarian Hyperstimulation Syndrome, saponin has been shown to bind to oestradiol receptors and alter E2 activity [34]. By promoting pituitary growth hormones, diosgenin controls sexual activity [35]. Most commercially available cortisone, pregnenolone, progesterone, and other steroids are derived from diosgenin. Sex hormone levels, sperm count, and sperm viability were all changed in rats given fenugreek powder, oil extract, and aqueous extract [35].

7. Antifungal Property

Medicinal plants and chemicals extracted from them for their antifungal properties are being used as a result of multi-drug resistance types of pathogenic fungi. It has been demonstrated that fenugreek extract works well against harmful strains of Candida species [36]. Using 100 µl of concentration, a study on fenugreek ethanolic extract demonstrated the maximum zone of inhibition of 16.510+ 0.85 mm and 38.395% mycelial inhibition against *Microsporum gypseum*. Flavonoids, saponins, alkaloids, steroids, and tannins are some of the secondary metabolites that give fenugreek its antifungal properties [37]. The petroleum ether extract of fenugreek seeds has been shown to have a maximum zone of inhibition of 20±0.88 mm against *Aspergillus niger* at a dose of 250 mg/ml and a zone of inhibition of 17±0.57 mm against *Candida albicans* at the same concentration [38]. *Trigonella foenum graecum* (fenugreek) is the source of a unique defensin-like antifungal peptide (Tf AFP) with a molecular mass of 10.3 kDa. This peptide has been shown to have antifungal effects against *Rhizoctonia solan*, *Fusarium oxysporum*, and *Fusarium solani* [39].



III. CONCLUSION

The plant extract and its derivatives have long been shown to be effective in treating a wide range of conditions linked to medications or illnesses in both human beings and available experimental animals [40,41]. Because of its many benefits, such as its anti-diabetic, hepatoprotective, cardioprotective, anti-cancerous, anti-androgenic, and anti-sterility effects, fenugreek has been used for ages to treat a variety of illnesses. Fenugreek has been proven to have positive benefits on immunological functions as well as diabetes, reproductive problems, and hypolipidemic diseases in both in vitro and in vivo tests. Anticancer, antibacterial, gastroprotective, cardioprotective, antioxidative, antinociceptive, anthelmintic, anti-arthritic, and vascular protective activities are only a few of its many qualities. Its interactions with other medications, however, need further research. Additionally, its varied chemical makeup offers potential uses as medicinal agents in the future. Fenugreek is safe to consume and has been shown to be an essential component of our daily diet for health benefits. The role of fenugreek in the treatment of many illnesses has to be further examined via clinical trials.

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