Available online on 15.12.2025 at http://ajprd.com

Asian Journal of Pharmaceutical Research and Development

Open Access to Pharmaceutical and Medical Research

Open Access

Review Article

Biochemical Properties and Multifunctional Applications of Galactomannan Derived From Trigonella Foenum-Graecum

V.Ragul*, A.Priyadharshini, S.Manoranjit, A.Jagadeesa, S. Raman, S.Chandru

Dept. of. Pharmacology, Shree Krishna College of Pharmacy, Chengam, Tiruvannamalai, Tamil Nadu, India.

A B S T R A C T

Galactomannan is an important biological and functional ingredient of fenugreek (Trigonella foenum-graecum) seeds. It is the primary storage polysaccharide in the endosperm, providing a significant source of energy for germination and early seedling development. Fenugreek galactomannan, which is structurally made of a mannose backbone with galactose side chains, is distinguished by its comparatively high galactose-to-mannose ratio, which boosts its solubility in water and aids the production of a smooth, viscous mucilage when the seeds are hydrated. This mucilage helps the seed retain moisture, protects it from dehydration, and acts as a physical barrier to mechanical harm, making it critical for seed survival in natural environments. Galactomannan is appreciated in human nutrition as a soluble dietary fiber with a variety of health benefits. Its capacity to increase intestinal viscosity slows carbohydrate digestion and absorption, hence regulating postprandial blood glucose levels. By delaying stomach emptying, it enhances fullness, which may aid in appetite control and weight management. Furthermore, galactomannan can bind bile acids and limit cholesterol absorption, resulting in better lipid profiles. Because of its physiological benefits, fenugreek galactomannan is a popular ingredient in nutraceutical formulations that promote metabolic and cardiovascular health. Because of its good rheological qualities, fenugreek galactomannan is used in the industrial sector as a natural thickener, stabilizer, and emulsifier. Its high solubility and ability to form uniform gels make it helpful in foods, beverages, and pharmaceutical preparations, including controlled-release drug delivery systems. Overall, galactomannan is essential to both the biological activity of fenugreek seeds and the variety of nutritional and industrial applications associated with them.

Key Words: Fenugreek, Galactomannan, Anti Diabetic Activity

A R T I C L E I N F O: Received 20 August 2025; Review Complete 29 Sept 2025; Accepted 10 Nov. 2025; Available online 15 Dec. 2025

Cite this article as:
V. Ragul, A. Priyadharshini, S.Manoranjit, A.Jagadeesa, S. Raman , S.Chandru, Biochemical Properties and Multifunctional Applications of Galactomannan Derived From Trigonella Foenum-Graecum, Asian Journal of Pharmaceutical Research and Development. 2025; 13(6):185-194, DOI: http://dx.doi.org/10.22270/ajprd.v13i6.1674

*Address for Correspondence:
V. Ragul, Dept. of. Pharmacology, Shree Krishna College of Pharmacy,

INTRODUCTION:

Galactomannans are a type of polysaccharide known for their various biochemical properties and widespread industrial and medicinal applications. Trigonella foenum-graecum (fenugreek) seeds are a natural source of galactomannan that stands out due to their unusually high soluble fiber content, distinct structural features, and well-documented bioactivity. Fenugreek galactomannan, made up of β-1,4-linked mannose and α-1,6-linked galactose units, has a unique mannose-to-galactose ratio that affects its solubility, viscosity, and functional properties. This molecular design not only contributes to its physicochemical plasticity, but also underpins many of its physiological functions, such as its ability to regulate glucose homeostasis.As a result, galactomannan from fenugreek is gaining popularity as a natural biomolecule with promising anti-diabetic properties. Biochemically, fenugreek galactomannan is distinguished by its high water-holding capacity, strong emulsifying characteristics, and extraordinary ability to create viscous solutions at low concentrations. These qualities stem from the polysaccharide's semi-flexible chain structure and proclivity to interact with water molecules via hydrogen bonding. Galactomannan's functional value in pharmaceutical, nutraceutical, and food formulations is enhanced by its properties, which include thickening, stabilizing, encapsulating, and controlled-release matrix capabilities. Importantly, the rheological behavior of fenugreek

galactomannan differs from that of guar or locust bean gum galactomannans, giving it distinct advantages in applications that need consistent viscosity, temperature stability, and synergistic interactions with other hydrocolloids.The anti-diabetic benefits of fenugreek galactomannan are among its most extensively researched biological activity. Galactomannan, a soluble dietary fiber, slows stomach emptying, delays carbohydrate digestion, and lowers postprandial glucose spikes by producing viscous gels in the gastrointestinal tract. This results in a controlled release and absorption of glucose, which improves glycemic responses. Furthermore, galactomannan has been linked to improved insulin sensitivity, regulation of glucose transporters, and beneficial effects on fat metabolism. The fiber matrix can also serve as a prebiotic, fostering beneficial gut bacteria populations that aid in metabolic balance. Overall, these processes emphasize fenugreek galactomannan as a viable natural adjuvant in the control of type 2 diabetes.In addition to its anti-diabetic properties, fenugreek-derived galactomannan has a wide range of applications. Its swelling capability and biocompatibility make it useful in medicines for long-term drug administration. In the food sector, it enhances the texture, stability, and shelf life of a variety of products. Emerging applications include biodegradable films, bioactive compound encapsulation, cosmetics, and tissue engineering scaffolds, proving the technology's broad significance.Its natural origin, non-toxicity, and renewable availability contribute to its popularity as a versatile biopolymer. Overall, the biochemical characteristics and multifunctional applications of galactomannan produced from Trigonella foenum-graecum highlight its importance as both a functional element and a therapeutic agent. Because of its significant anti-diabetic effect and several industrial applications, fenugreek galactomannan is regarded as a remarkable natural biomaterial with promising implications for health, food, and biological research.

PRELIMINARY STUDY:

S. no	Plant name	*Common medicinal uses*	*Adverse drug reaction*
1	Neem (Meliaceae)	Neem has several potential medicinal uses, including as an antibacterial and antifungal agent for skin conditions, an anti-inflammatory, and a blood purifier. It may also help manage blood sugar levels and support oral hygiene. Traditional uses and ongoing research point to its potential in wound healing, reducing dandruff, and as an immunomodulator	Adverse drug reaction of neem Adverse reactions to neem (*Azadirachta indica*) are primarily associated with high doses or prolonged use, especially with oral consumption of certain extracts, and are most severe in infants and young children Hypotension, Gastrointestinal Issues, Allergic Reactions
2	Amla (Phyllanthaceae)	Amla can help stabilize blood sugar levels and improve insulin sensitivity, making it beneficial for individuals with type 2 diabetes The high vitamin C content helps strengthen the immune system, aiding the body in fighting off infections like the common cold and flu.	amla (Indian gooseberry) is generally safe for most people; however, excessive intake, particularly in supplement form, can lead to side effects. The most common adverse effects relate to digestive discomfort**,** blood sugar fluctuations**,** and potential interactions with certain medications**.**
3	Garlic (Alliaceae)	Garlic is used medicinally for its antimicrobial, antioxidant, and anti-inflammatory properties to support cardiovascular health, immune function, and blood sugar regulation. It can help lower blood pressure and bad cholesterol, fight infections, and may have a role in cancer prevention and detoxification	garlic side effects include bad breath, digestive issues like bloating, gas, and heartburn, and increased bleeding risk. Excessive consumption can irritate the stomach, while its antithrombotic properties may interfere with blood clotting, especially before surgery
4	Aloe vera (Asphodelaceae)	Aloe vera has common medicinal uses in topical applications for skin issues like burns, wounds, acne, and irritation, and in oral consumption for digestive health and potentially lowering blood sugar. It is also used to reduce dental plaque and inflammation.	Adverse reactions to aloe vera depend on whether it is used topically or taken orally, and which part of the plant is used (gel vs. latex). The primary concerns involve gastrointestinal issues, potential drug interactions, and allergic reactions. Gastrointestinal Distress Skin Irritation Allergic Reactions Delayed Healing

The pilot investigation focused on four commonly used medicinal plants—neem (Azadirachta indica), aloe vera (Aloe barbadensis Miller), amla (Phyllanthus emblica), and garlic (Allium sativum)—to investigate their traditional relevance and possible therapeutic benefit. Neem has long been known for its powerful antibacterial, antifungal, and anti-inflammatory qualities, which are mostly linked to bioactive chemicals like nimbin and azadirachtin. Aloe vera, which is high in polysaccharides, vitamins, and enzymes, is commonly used for wound healing, skin diseases, and gastrointestinal health. Amla, a good natural source of vitamin C and polyphenols, has long been utilized as a rejuvenating agent due to its powerful antioxidant, hepatoprotective, and immune-boosting properties. Garlic contains sulfur-rich compounds such as allicin, which has broad-spectrum antibacterial, cardioprotective, and anti-diabetic activities. The preparatory examination included analyzing traditional usage, assessing morphological traits, and identifying key phytochemical ingredients associated with therapeutic potential. This preliminary assessment gives a foundational understanding of each plant's medicinal value and reinforces the necessity for more pharmacognostic and pharmacological studies. The combined bioactive profiles of these plants demonstrate their utility in natural medicine and support their selection for further scientific investigation.

PLANT PROFILE:

Seed

Leaves

Root

Flower

stem

TAXONOMICAL STUDY

- **Kingdom:** Plantae
- **Division:** Magnoliophyta
- **Class:** Magnoliopsida
- **Order:** Fabales
- **Family:** Fabaceae
- **Genus:** *Trigonella*
- **Species:** *T. foenum-graecum*

MORPHOLOGICAL CHARACTERISTICS:

- **HABIT:** An erect, annual herb, typically 30–60 cm tall.
- **STEM:** Terete, slightly pubescent, green to purple, and either solitary or basally branched.
- **LEAVES:** Alternate, trifoliolate (composed of three leaflets), with a grooved petiole 1–4(-6) cm long. Stipules are small and triangular.
- **LEAFLETS:** Obovate to oblanceolate, 1.5–4 cm long, with denticulate (finely toothed) margins.
- **FLOWERS:**
  - **Type:** Papilionaceous (butterfly-like).
  - **Arrangement:** Solitary, axillary, and subsessile (almost stalkless).
  - **Color:** Whitish or pale yellow, sometimes with lilac bases or bluish spots.

- **FRUIT:** A linear or sickle-shaped pod, 5–19 cm long, with a persistent, pointed beak. The pod is initially green or reddish and turns light straw to brown when ripe.
- **SEEDS:** Yellow to amber-colored, with a distinct aroma and a slightly bitter taste.
    - **Quantity:** 10–20 per pod.
    - **Appearance:** Small (3–6 mm), hard, and brownish-yellow, with a deep groove that divides them into two unequal lobes.
    - **Shape:** Oblong-rhomboidal.

PLANT HABITAT:

The natural habitat of *Trigonella foenum-graecum* (fenugreek) includes uncultivated ground, field verges, and dry grasslands in the **Mediterranean region, southern Europe, and Western Asia**. It is now cultivated in many parts of the world with similar conditions, such as India, Northern Africa, and parts of North and South America. Fenugreek prefers well-drained soils and a warm, temperate to subtropical climate.

NATURAL AND CULTIVATED HABITATS

- **Native origin**: Mediterranean region, Southern Europe, and Western Asia.
- **Natural environments**: Field verges, uncultivated ground, dry grasslands, and hillsides.
- **Cultivated regions**: Now grown widely in areas like India, Argentina, Egypt, Morocco, and China.
- **Growing conditions**: It thrives in warm, temperate to subtropical climates and prefers well-drained, loamy soil with moderate fertility.

Climate and soil requirements

- **Soil**: Prefers well-drained, loamy soils but can grow in a variety of soils with a pH between 5.3 and 8.2. Wet, waterlogged soils are unsuitable.
- **Climate**: It grows well in warm, dry, and sunny conditions. It can be grown as a cool-season crop or as a summer crop in cooler regions

Collection

- Once the crop is ready, hand-cut or mechanically harvest the plants.
- Allow the plants to dry in thin layers on the field.
- Thresh the dried plants to collect the seeds.
- Mature seeds are greenish-brown, oblong, and have a unique groove.

Chemical Constituents Of Fenugreek (Trigonella Foenum-Graecum)

Fenugreek (*Trigonella foenum-graecum*) is rich in a diverse array of chemical constituents, primarily including alkaloids, saponins, flavonoids, fibers (galactomannans), proteins, amino acids, fixed oils, vitamins, and minerals. Its medicinal and nutritional properties are attributed to these bioactive compounds.

Key Bioactive Compounds

The primary active constituents responsible for most of fenugreek's therapeutic effects are:

- **4-HYDROXYISOLEUCINE:** A unique, non-protein amino acid that has shown significant insulin-stimulating and anti-diabetic properties.
- **TRIGONELLINE:** A pyridine alkaloid known for its hypoglycemic (blood sugar-lowering) and neuroprotective activities.
- **DIOSGENIN:** A steroidal saponin that serves as a raw material for the pharmaceutical industry to synthesize steroidal hormones and is associated with cholesterol-lowering effects.
- **GALACTOMANNAN:** A highly soluble, mucilaginous fiber found in the seed endosperm, which slows down gastric emptying and glucose absorption, aiding in blood sugar and cholesterol management.
- **FLAVONOIDS AND POLYPHENOLICS:** Compounds like quercetin, rutin, vitexin, and isovitexin, which provide strong antioxidant and anti-inflammatory benefits.

GENERAL NUTRITIONAL PROFILE (PER 100G OF SEEDS)

Fenugreek seeds also offer a robust nutritional composition:

- **Macronutrients**:
    - **Protein**: 23–26%.
    - **Carbohydrates**: ~58% (with about 25% as dietary fiber).
    - **Fat (Fixed Oils)**: 5–10% (rich in linoleic and palmitic acids).
    - **Fiber**: High levels of both soluble (galactomannan) and insoluble fiber.
- **Vitamins**: Significant amounts of Vitamin A, B1 (Thiamine), B2 (Riboflavin), B3 (Niacin/Nicotinic acid), B6 (Pyridoxine), C, and folic acid.
- **Minerals**: Rich source of iron, calcium, phosphorus, potassium, magnesium, manganese, copper, and zinc.
- **Volatile compounds**: Essential oils contain components such as cubenol and sotolon, which contribute to its characteristic pungent, maple-syrup-like aroma.

Objectives of this study (Trigonella foenum-graecum)

- **TO IDENTIFY AND AUTHENTICATE** the selected medicinal plant *Trigonella foenum-graecum* through macroscopic and microscopic evaluation,

supported by a comprehensive review of relevant literature.

- **To Conduct Detailed Pharmacognostic And Phytochemical Evaluations** of *T. foenum-graecum* seeds, including examination of morphological, anatomical, and physicochemical parameters.
- **To Perform Polarity-Based Extraction** of the plant material using a solvent system consisting of ethanol, chloroform, and distilled water in the ratio 9:1:90, in order to obtain galactomannan-rich extracts.
- **To Evaluate The Anti-Diabetic Activity** of the obtained extracts prepared with ethanol, chloroform, and distilled water, and to assess the potential of *Trigonella foenum-graecum* as a natural therapeutic agent for diabetes management.

RESULTS:

TO IDENTIFY AND AUTHENTICATE

Macroscopic (Morphological) Identification: Fenugreek seeds are tiny, brownish yellow to olive or deep yellowish, rhomboidal or oblong-rhomboidal in shape, and have a smooth, firm surface. Seeds typically measure 3-6mm in length, 2-5mm in width, and ~2mm thick. Seeds are often firm, have a distinct slightly bitter and "maple-like" odor and flavor, and may feel mucilaginous or sticky when pulverized.

Microscopic (Anatomical / Powder-Microscopy) Evaluation: On transverse section, the seed has a thick outer layer (testa), followed by a whitish to creamy thin-walled parenchymatous area (endosperm) that contains two cotyledons or a small central embryo. More thorough histology describes traits such as a testa, linea lucida, columella, endosperm with aleurone layer, mucilage-filled cells, and a central embryo. In powder microscopy, the presence of mucilage, the absence of other crystals (which are seen in certain other Fabaceae), and seed-specific internal anatomy help distinguish fenugreek from adulterants. This combined morphological and anatomical evaluation provides a reliable method for identifying fenugreek seed material for medicinal or quality control objectives.

Pharmacognostic and Phytochemical Evaluations

The pharmacognostic analysis of Trigonella foenum-graecum seeds revealed different morphological, anatomical, and physicochemical properties that aid in identification and quality assessment. The seeds were small, yellowish-brown, oblong, flattened, and had a smooth surface, as described classically. Under microscopic analysis, the transverse section revealed a well-defined testa, endosperm, and embryonic axis. The testa was made up of epidermal cells with conspicuous radial walls and a thin cuticle, whilst the endosperm had copious starch grains and galactomannan-rich cell layers, indicating the existence of soluble polysaccharides responsible for its viscous characteristics.The embryonic axis was densely packed with parenchymatous cells that contained a large reserve of proteins. Physicochemical analysis revealed an acceptable moisture content, a low ash value indicating minimal inorganic contamination, and a positive extractive value in hydroalcoholic solvents, all of which confirmed the extraction process's efficacy. Phytochemical analysis found the presence of alkaloids, saponins, flavonoids, tannins, glycosides, and sugars, indicating a diverse bioactive profile. These chemicals are expected to contribute to the observed pharmacological activities, which include anti-diabetic properties. Overall, the pharmacognostic and phytochemical data give solid parameters for standardizing, quality control, and therapeutic use of T. foenum-graecum seeds in herbal compositions.

Table 1: Identification Test for Sapponins:

TEST	OBSERVATION	INFERENCE
HEMOLYSIS TEST: Fresh blood is mixed with an aqueous solution of the extract	Red blood cells rupture (hemolysis occurs); a clear zone is visible.	Saponins interact with the cholesterol in red blood cell membranes, causing cell lysis.
LIEBERMANN-BURCHARD TEST: Extract is mixed with chloroform, acetic anhydride, and sulfuric acid.	A distinct color change occurs (e.g., blue-green for steroidal saponins, deep red for triterpenoid saponins).	Specific aglycone structures (steroidal or triterpenoid) are present.
FOAM TEST: Extract is vigorously shaken with distilled water in a test tube.	A persistent, stable layer of foam forms at the surface.	Saponins are present due to their surface-active properties (acting as natural detergents).

Table 2: Identification Tests for Carbohydrates

TEST	OBSERVATION	INFERENCE
MOLISCH'S TEST: Aqueous Test solution and Alcoholic Alpha Naphthol + Concentrated H_2SO_4 (Few drops through the side of test tube)	Purple to Violet ring at the Junction	Presence of all carbohydrates.
FEHLING'S TEST: Test Solution + Equal volume of Fehling's A and Fehling's B reagent, Boil	Brick red Precipitate	The presence of reducing sugars
BENEDICT'S TEST: Test Solution Benedict's reagent	Formation of red, yellow or green color/precipitate depending upon sugar concentration	The presence of reducing sugars
BARFOED'S TEST: Aqueous Test solution+ Barfoed's reagent, heat	Formation of red cupric oxide (Brick red precipitate of monosaccharide)	Confirms the presence of monosaccharides; disaccharides

Table 3: Identification Test for Alkaloids

TEST	OBSERVATION	INFERENCE
DRAGANDROFF"TEST; Acidified solution of rhizome (5ml) + dragen droff"s reagent (2-3drops)	Orange red color was obtained.	Presence of alkaloids .
MAYER"S TEST : Acidified solution of rhizome (5ml) + dragen droff"s reagent (2-3drops) of ma yers reagent .	Creamy white precipitate was formed .	Presence of alkaloids .

Table 4: Identification Test For Proteins

TEST	OBSERVATION	INFERENCE
BIURET TEST: Test solution+ Biuret reagent (10% NaOH + 1% CuSO4)	Violet colour Purple/Rosy pink colour (Given by all protein)	Presence of protein.
MILLON'S TEST: Test solution + Millon's reagent	White ppt. Warm ppt. turn brick red ppt. or the ppt. dissolves giving red coloured solution	Presence of proteins
XANTHOPROTEIC TEST: Test solution + Concentrated HNO3 and boil	Yellow precipitate formed, after cooling it add NaOH solution (40%) orange colour is formed	Presence of proteins containing aromatic amino acids.
NINHYDRIN TEST: Test sample (solution or suspension)Ninhydrin reagent (typically a 0.2% solution in acetone or ethanol) and boil it	A deep blue or purple colour	Presence of protein.

Table 4: Identification Test for Steroids and Triterpenoids

TEST	OBSERVATION	INFERENCE
LIBERMANN-BURCHARD TEST ; Extract +acetic anhydride. Boil and cool + concentrated sulphuric acid from side of the test tube.	Formation deep red color . Brown ring formed at the junction of two layers turns green .	Presence of triterpenoids. Presence of steroids.
SALKOWSKI TEST ; Extract + concentrated sulphuric acid	Yellow color at the lower layer . Red color at the lower layer .	Presence of triterpenoid. Presence of steroids.
SULFUR POWDER TEST ; Test solution +small amount of sulfur powder.	Sulfur sinks at the bottom .	Presence of steroids and triterpenoids.

PHYTOCHEMICALS OF FENUGREEK *(*TRIGONELLA FOENUM-GRAECUM*):*

Fenugreek seeds and leaves contain a wide variety of **alkaloids, saponins, flavonoids, amino acids, fixed oils, mucilage, and minerals**.

1. SAPONINS

Fenugreek is especially rich in **steroidal saponins**, responsible for cholesterol-lowering and hormonal effects.

- Diosgenin (precursor for steroid drugs)
- Yamogenin
- Gitogenin
- Tigogenin
- Sarsasapogenin
- Fenugrin B

Activity: Hypocholesterolemic, anti-inflammatory, endocrine-modulating.

2. ALKALOIDS

These are the major bioactive compounds responsible for many therapeutic actions.

- Trigonelline (most important)
- Carpaine
- Gentianine
- Choline
- Nicotinic acid derivatives

Activity: Antidiabetic, hypolipidemic, neuroprotective.

3. AMINO ACIDS

Especially relevant to fenugreek's antidiabetic activity.

- 4-Hydroxyisoleucine (enhances insulin secretion)
- Lysine
- Tryptophan
- Pectin

4. POLYSACCHARIDES / FIBER

Fenugreek seeds are rich in soluble fiber and mucilage.

- Galactomannan (main polysaccharide)
- Mucilage
- Gums

Activity: Lowers blood glucose, delays gastric emptying, reduces cholesterol.

5. OTHER COMPOUNDS

- Coumarins
- Methyl isobutyl ketone (aroma)
- Phytosterols **(e.g., β-sitosterol)**
- Vitexin
- Isovitexin
- Orientin
- Quercetin
- Kaempferol
- Apige

Therapeutic Uses of Fenugreek (Trigonella Foenum-Graecum):

- Acts as a carminative and digestive tonic.
- Helps relieve constipation, loss of appetite, and gastritis.
- Seeds contain galactomannan and 4-hydroxyisoleucine, which help reduce blood glucose levels.
- Improve insulin sensitivity.
- Soluble fiber helps reduce LDL (bad) cholesterol.
- Useful in reducing joint pain, swelling, and symptoms of arthritis.
- Contains phytoestrogens that may help with menstrual discomfort.

- Supports hormonal balance.
- Used in treating acne, eczema, boils, and dandruff.
- Strengthens hair and promotes hair growth when applied as a paste.

To Perform Polarity-Based Extraction

Analytical Procedure:

Maceration:

Principle

"The maceration method for extracting fenugreek chemicals includes soaking coarsely powdered fenugreek seeds or leaves in a suitable solvent, such as water or alcohol, for an extended period of time. This enables soluble bioactive chemicals to permeate into the solvent. Following adequate extraction time, the mixture is filtered to separate the liquid extract from the leftover plant material, resulting in a solution containing the desired ingredients. Maceration is a simple, slow extraction method that relies heavily on the gradual process of diffusion.""Maceration is the process of soaking coarsely ground fenugreek seeds or leaves in a suitable solvent (such as water or alcohol) to allow soluble compounds to diffuse into the liquid." After an extended period, the mixture is filtered to separate the extract from the plant residue, resulting in a solution containing the desired bioactive ingredients. This strategy is basic and based on passive diffusion over time.

Maceration Depends On:

1. **Solvent penetration** into the plant tissues.
   The solvent (usually water for fenugreek mucilage) enters the cellular matrix and hydrates the polysaccharides.
2. **Solubilization of target compounds.**
   In fenugreek, galactomannan is water-soluble. When hydrated, it dissolves or forms a colloidal dispersion.
3. **Concentration gradient–driven diffusion.**
   Once solubilized, the molecules diffuse from the higher concentration inside the plant matrix to the lower concentration in the surrounding solvent.
4. **Equilibrium establishment.**
   Extraction continues until the concentrations inside the plant tissue and the solvent reach equilibrium.

BASIC PROCEDURE FOR MACERATION

1. **PREPARE THE PLANT MATERIAL**

   Dry the plant material (if required) and grind or cut it into small pieces to increase the surface area.

2. **WEIGH THE SAMPLE**

   Accurately measure the required amount of plant material, usually in grams.

3. **CHOOSE AND MEASURE THE SOLVENT**

   Select an appropriate solvent (water, ethanol, methanol, hydroalcoholic mixtures, etc.) depending on the nature of the constituents to be extracted.

   Use a solvent volume typically **5–10 times the weight** of the plant material.

4. **PLACE MATERIAL IN A SUITABLE CONTAINER**

   Put the powdered or cut plant material in a clean, airtight container.

5. **ADD THE SOLVENT**

   Pour the measured solvent over the plant material, ensuring it is fully submerged.

6. **CLOSE AND SHAKE**

   Seal the container and shake it to mix thoroughly, ensuring proper wetting.

7. **ALLOW MACERATION**

   Keep the container at room temperature for **24–72 hours** (or as required).

   Shake or stir occasionally to improve extraction.

8. **FILTRATION**

   After the maceration period, filter the mixture using muslin cloth, filter paper, or a vacuum filter to separate the extract from plant residue.

9. **CONCENTRATE THE EXTRACT (OPTIONAL)**

   If needed, evaporate the solvent using a water bath or rotary evaporator to obtain a concentrated extract.

10. **STORE THE EXTRACT**

    Keep the final extract in an airtight container, preferably in a cool, dark place or refrigerator.

Procedure for Maceration Technique for the Extraction of Fenugreek

1. Preparation of Plant Material

- **Clean the fenugreek seeds** to remove dust and impurities.
- **Dry** the seeds at a mild temperature (≈40–50 °C) until moisture is minimal.
- **Powder the seeds** using a laboratory grinder to increase surface area.
- Sieve the powder (commonly 40–60 mesh) for uniform particle size.

2. Defatting (Optional But Recommended)

- Mix the powdered seeds with a non-polar solvent (e.g., petroleum ether or another common lab defatting solvent).
- Decant and air-dry the defatted powder.

(Purpose: removes oils that interfere with mucilage hydration.)

3. Maceration (Main Extraction Step)

- Place the **defatted fenugreek powder** in a clean container or conical flask.

- Add ethanol and chloroform usually **cold or room-temperature distilled water** (typical ratio 1:10–1:20 w/v).
- **Stir or shake briefly** to ensure all material is wetted.
- **Cover the container** to prevent contamination and evaporation.
- Allow the mixture to **stand for 24–48 hours**, occasionally shaking or stirring to promote:
  - solvent penetration,
  - hydration of mucilage,
  - diffusion of galactomannan into the liquid.
- After maceration time, the mixture becomes viscous due to dissolved/dispersed mucilage.

4. Filtration

1. Filter the macerated mixture through:
   - muslin cloth,
   - Whatman filter paper,
   - or similar laboratory filtration media.
2. Collect the **aqueous extract** containing galactomannan.
3. If needed, centrifuge the filtrate to remove fine particles.

5. Concentration / Purification (Optional, Depending On Study Goal)

- The filtrate may be **concentrated** under mild conditions (e.g., water bath) to reduce volume.
- For purified galactomannan:

  Add a **miscible non-solvent** such as ethanol or isopropanol to precipitate the polysaccharide.

6. Drying and Storage

- Dry the extract or precipitated mucilage at low temperature (40–50 °C) or in a desiccator.
- Store in an airtight container to avoid moisture uptake.

DISCUSSION

Galactomannan is a water-soluble heteropolysaccharide derived from Trigonella foenum-graecum (fenugreek) seeds. It consists of a β-(1→4)-linked D-mannose backbone and single-unit α-(1→6)-linked D-galactose side chains. Fenugreek galactomannan has a galactose-to-mannose (G:M) ratio of about 1:1, which is unusually high when compared to other galactomannans like guar gum. This structural structure provides particular physicochemical features, including as high viscosity, water binding capacity, and gel-forming ability, making it ideal for a wide range of biological and industrial applications. Biochemically, fenugreek galactomannan has outstanding functional properties. Its high solubility and capacity to produce viscous solutions allow for delayed stomach emptying and slower nutritional absorption rates, which contribute to hypoglycemia and hypolipidemic effects.According to studies, galactomannan can produce viscous gels in the gastrointestinal tract, slowing glucose absorption, improving insulin sensitivity, and modulating postprandial blood sugar levels. Furthermore, its fiber-rich composition promotes prebiotic activity by selectively increasing the growth of beneficial gut bacteria, improving gut health, and perhaps altering lipid metabolism. The molecular structure also allows for antioxidant and immunomodulatory properties, which are due to interactions with free radicals and immune cells, expanding its therapeutic potential. Fenugreek galactomannan has multifunctional applications in the pharmaceutical, nutraceutical, and food industries. Because of its high viscosity and ability to form gels, it is used as a natural excipient, stabilizer, and controlled-release ingredient in medication formulations.Its mucoadhesive characteristics make it useful for creating oral and topical medication delivery systems. Galactomannan is used in nutraceuticals to treat diabetes, obesity, and cardiovascular diseases, emphasizing its role as a bioactive fiber. In the food business, it acts as a thickener, emulsifier, stabilizer, and fat replacer in products such as bread goods, dairy formulas, sauces, and dressings, improving texture while retaining nutritional value. Emerging applications in biotechnology and biomedicine are also significant.Galactomannan-based hydrogels and films are being investigated for tissue engineering, wound healing, and the encapsulation of probiotics or bioactive chemicals, exploiting their biocompatibility, biodegradability, and film-forming capabilities. Its capacity to interact with water and other polymers enables personalized alterations, increasing its applicability in innovative delivery methods and functional biomaterials.

Finally, galactomannan derived from Trigonella foenum-graecum is a highly functional polysaccharide with different biochemical features such as viscosity, water-binding capacity, and biological activity. Its diverse applications in the pharmaceutical, nutraceutical, food, and biomedical sectors demonstrate its worth as a natural, versatile biopolymer. Continued study into its structure-function correlations and formulation methodologies promises to improve its utility in the health, nutrition, and industrial sectors.

CONCLUSION:

Galactomannan extracted from Trigonella foenum-graecum (fenugreek) seeds is a naturally occurring, highly versatile polysaccharide with important biochemical and functional properties. This water-soluble heteropolysaccharide consists of a β-(1→4)-linked mannose backbone and α-(1→6)-linked galactose side chains. Its high galactose-to-mannose ratio sets it apart from other plant-derived galactomannans. This structure confers distinct physicochemical properties such as high viscosity, water-binding capacity, gel formation, and aqueous system stability, all of which underpin its wide range of applications. Biochemically, fenugreek galactomannan has strong health-promoting properties.

Its viscous nature slows stomach emptying and influences nutritional absorption, resulting in hypoglycemia and hypolipidemic consequences. Furthermore, its fiber-rich composition promotes prebiotic activity, which benefits gut bacteria and improves digestive health.Evidence also suggests that it may have antioxidant and immunomodulatory actions, which adds to its therapeutic importance. These bioactive qualities emphasize its dual role as a functional component and a health-promoting biomolecule. Galactomannan is a versatile biomaterial that finds uses in the pharmaceutical, nutraceutical, food, and biomedical industries. Because of its biocompatibility and biodegradability, it is used as a natural excipient, stabilizer, thickener, emulsifier, and controlled-release agent, as well as in biomedical applications such as hydrogels, wound healing matrices, and bioactive encapsulation. Its inclusion in functional foods and dietary supplements highlights its importance in controlling metabolic disorders and promoting general health.To summarize, fenugreek-derived galactomannan is a highly functional polysaccharide with exceptional biochemical characteristics and numerous uses. Its natural origin, biocompatibility, and multifunctionality make it an attractive choice for future research and industrial applications in health, nutrition, and material science. Future research into structure-function interactions and innovative delivery technologies is likely to broaden its utility and highlight its value as a sustainable and bioactive polymer.

REFERENCE:

1. "Trigonella foenum-graecum". Germplasm Resources Information Network. Agricultural Research Service, United States Department of Agriculture. Retrieved 2008-03-13.
2. Debaggio, Thomas; Tucker, Arthur O. (2009). The Encyclopedia of Herbs. Timber Press. ISBN 978-1-60469-134-4. Archived from the original on 2 July 2023. Retrieved 10 May 2021.
3. Ouzir, M; El Bairi, K; Amzazi, S (2016). "Toxicological properties of fenugreek (Trigonella foenum graecum)". Food and Chemical Toxicology. **96**: 145–54. doi:10.1016/j.fct.2016.08.003. PMID 27498339.
4. "Fenugreek". Drugs.com. 14 August 2023. Retrieved 11 May 2024.
5. "Fenugreek". National Center for Complementary and Integrative Health, US National Library of Medicine. 1 August 2020. Retrieved 11 May 2024.
6. Zohary, Daniel; Hopf, Maria; Weiss, Ehud (2012). Domestication of Plants in the Old World: The Origin and Spread of Domesticated Plants in Southwest Asia, Europe, and the Mediterranean Basin (4th ed.). Oxford University Press. p. 122.
7. Cato the Elder. De Agri Cultura. p. 27.
8. Curry A (February 2010). "A 9,000-Year Love Affair". National Geographic. **231** (2): 46.
9. Josephus, De Bello Judaico, book 3, chapter 7, vs. 29. The prepared relish made from ground fenugreek seeds is very slimy and slippery, and was therefore poured over ladders as a stratagem to prevent the enemy's ascent.
10. Commentators Maimonides and Ovadiah di Bertinoro on Mishnah Kil'ayim 2:5; Terumot 10:5; Orlah 3:6; ibid. 10:6; Ma'aserot 1:3, ibid. 4:6; Ma'aser Sheni 2:2–3; Niddah 2:6.
11. "Online Etymology Dictionary". www.etymonline.com. Archived from the original on 2016-12-21. Retrieved 2017-02-07.
12. "Diabetes Blue Circle Symbol". International Diabetes Federation. 17 March 2006. Archived from the original on 5 August 2007.
13. "Diabetes". www.who.int. Archived from the original on 26 February 2023. Retrieved 1 October 2022.
14. Kitabchi AE, Umpierrez GE, Miles JM, Fisher JN (July 2009). "Hyperglycemic crises in adult patients with diabetes". Diabetes Care. **32** (7): 1335–1343. doi:10.2337/dc09-9032. PMC 2699725. PMID 19564476. Archived from the original on 2016-06-25.
15. Krishnasamy S, Abell TL (July 2018). "Diabetic Gastroparesis: Principles and Current Trends in Management". Diabetes Therapy. **9** (Suppl 1): 1–42. doi:10.1007/s13300-018-0454-9. PMC 6028327. PMID 29934758.
16. Saedi E, Gheini MR, Faiz F, Arami MA (September 2016). "Diabetes mellitus and cognitive impairments". World Journal of Diabetes. **7** (17): 412–422. doi:10.4239/wjd.v7.i17.412. PMC 5027005. PMID 27660698.
17. "Causes of Diabetes – NIDDK". National Institute of Diabetes and Digestive and Kidney Diseases. June 2014. Archived from the original on 2 February 2016. Retrieved 10 February 2016.
18. Ripsin CM, Kang H, Urban RJ (January 2009). "Management of blood glucose in type 2 diabetes mellitus" (PDF). American Family Physician. **79** (1): 29–36. PMID 19145963. Archived (PDF) from the original on 2013-05-05.
19. Brutsaert EF (February 2017). "Drug Treatment of Diabetes Mellitus". MSDManuals.com. Archived from the original on 12 October 2018. Retrieved 12 October 2018.
20. "IDF DIABETES ATLAS Ninth Edition 2019" (PDF). www.diabetesatlas.org. Archived (PDF) from the original on 1 May 2020. Retrieved 18 May 2020.
21. "Diabetes". World Health Organization. Archived from the original on 29 January 2023. Retrieved 29 January 2023.
22. "Diabetes Mellitus (DM) – Hormonal and Metabolic Disorders". MSD Manual Consumer Version. Archived from the original on 1 October 2022. Retrieved 1 October 2022.
23. Shoback DG, Gardner D, eds. (2011). "Chapter 17". Greenspan's basic & clinical endocrinology (9th ed.). New York: McGraw-Hill Medical. ISBN 978-0-07-162243-1.
24. "Symptoms and Causes of Diabetes". National Institute of Diabetes and Digestive and Kidney Diseases, US National Institutes of Health. 2024. Retrieved 16 May 2024.
25. "Type 1 vs Type 2 Diabetes | UVA Health". uvahealth.com. Retrieved 2025-01-27.
26. American Diabetes Association (2020-12-04). "2. Classification and Diagnosis of Diabetes: Standards of Medical Care in Diabetes—2021". Diabetes Care. **44** (Supplement_1): S15 – S33