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Review Article

A Mini-review of Galactomannas and Diosgenin in Fenugreek

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ABSTRACT

Introduction: Galactomannas are polysaccharides similar to cellulose and starch. **Methods:** A literature search was conducted in Medline, Scopus, PubMed and Google scholar databases. The keywords were fenugreek, health benefits, bioactive components, galactomannans, diosgenin and pharmaceutical science. **Results:** Fenugreek galactomannan is a heteropolysaccharide which reduces blood glucose level as normalize the surface activities inside the small intestine. They are also used in food products in order to increase the thickness of the water content. The most important health benefits of galactomanna are reduction in LDL cholesterol levels in hypercholesterolemic, blood lipids, as well as to reduce blood pressure and fibrinolysis. Diosgenin is an isospirostane derivative and the product of acids or enzymes hydrolysis process of dioscin and protodioscin. **Conclusion:** Diosgenin shows biological activities including antioxidant, anti-diabetes, anti-inflammatory, anti-cancer and anti-adipogenic effects.
Key words: Fenugreek, Health Benefits, Bioactive Components, Galactomannans, Diosgenin, Pharmaceutical Science.

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INTRODUCTION

Traditional Chinese Medicine (TCM) has a history of thousands of years. It is formed by summarizing the precious experience of understanding of life, maintaining health and fighting diseases accumulated in daily life, production and medical practice.[1-3] Among the species of medicinal plants, some are confined to folk medicine and some are used as occasional or local substitutes for the main species listed in the Materia Medica.[4,5] Fenugreek (*Trigonellafoenum graecum* L.) is an annual, self-pollinating legume grown as a spice, medicinal crop with tremendous nutraceutical properties and as a forage legume crop.[6] It is grown annually in India, Ethipia, Egypt, Turkey, northern Africa, the Mediterranean, western Asia, northern Iran and in Canada. Major chemical constituents reported from fenugreek are shown in Table 1. Researchers have investigated multifaceted therapeutic benefits of fenugreek seeds against a variety of ailments including, diabetes, cancer, hyperlipidemia, inflammation, neurotoxicity, hepatotoxicity, ulcers, wound, bacterial effects and many studies have also documented its toxicological profile.[7] The most important medicinal properties of fenugreek are presented in Table 2. Pharmacological and therapeutic benefits of fenugreek is presented in Table 3.

GALACTOMANNA

Galactomannans are polysaccharides that are isolated commercially from the seeds of guar, carob, fenugreek and tara plants.[10] Galactomannans (GM) are the most widely used polysaccharides after cellulose and starch.[10] Fenugreek galactomannan is a heteropolysaccharide which is readily soluble in water and is very effective in reducing blood glucose levels and normalize the surface activities inside the small intestine.[11,12] The galactomannans have variable galactose:mannose (G:M) ratios and distribution of galactopyranosyl units along the mannan chains.[13] Galactomannan has lower water holding capacity compared to guar gum.[14] One of the most important usage of galactomannans is that they are used in food products in order to increase the thickness of the water content. The galactomannan has a mannose backbone grafted with galactose units. Jiang *et al.*[11] reported that the main component of fenugreek seeds is galactomannan structurally composed of a 1→4 beta-D-mannosyl backbone substituted by a single galactose untit α-linked at the C-6 oxygen. Doyle *et al.*[15] found that the solubility of galactomannans increase with increasing content of galactose. Trigonelline and Galactomannan is shown in Figure 1.

HEALTH BENEFITS OF GALACTOMANNAN

The soluble nature of galactomannan fiber from fenugreek has been linked to numerous human health benefits, including the reduction in LDL cholesterol levels in hypercholesterolemic, the reduction of blood lipids, blood pressure and fibrinolysis in healthy men.[16] Hannan *et al.*[17] also reported that it has significant role in improving glucose homeostasis in type 1 and type 2 diabetes by delaying carbohydrate digestion and absorption. Rampogu *et al.*[18] revealed that galactomannan can be ascribed as potential drug candidate against breast cancer and type 2 diabetes rendered by higher molecular dock scores, stable molecular dynamics (MD) simulation results and lower binding energy calculations. Kamble *et al.*[19] discovered that the low molecular weight galactomannans (GAL) fraction from fenugreek seeds (LMWGAL-TF) had promising dose-dependent anti-hyperglycemic effects in animal chronic metabolic disorder diabetes mellitus (DM) models. Hamden *et al.*[20] indicated that fenugreek galactomannan displays a number of promising properties and attributes for future application as therapeutic agents in biotechnology and bioprocess-based technologies. Majeed *et al.*[21] noted that galactomannan from fenugreek seed showed prebiotic potential which may play an important role in modulating gut flora by acting as substrate to beneficial microbes.

DIOSGENIN

Diosgenin (25R-spirost-en-3b-ol), is an isospirostane derivative, a compound that has attracted tremendous interest over the last decade.[22] It is a steroidal sapogenin and the product of acid or enzyme hydrolysis process of dioscin and protodioscin, mostly from *Dioscorea* and *Trigonella* species. Diosgenin is a biologically active phytochemical responsible for

Table 1: Major chemical constituents reported from fenugreek.[8]

1- Major polysaccharides: Galactomannans (consisting of galactose and mannose in the ration of 1:1).
2- Major steroidal sapogenins: Diosgenin [(25 R)-spirost-5-ene-3/-ol] yamogenin, tigogenin, neotigogenin, smilagenin and sarsasapogenin.
3- Dihydroxy steroidal sapogenins (minor sapogenins): Yuccagenin, gitogenin and neogitogenin.
4- Spirostanol saponins: Graecunin-B, C, D, E and G.
5- Triterpenoids.
6- Alkaloids: Trigonelline (methylbetaine derivative of nicotinic acid).
7- Flavonoids: Kaemfrol, afroside, quercetin, isoquercitrin, vitexin, isovitexin, orientin and luteolin.
8- Isoflavonoid phytoalexins: Medicarpin, maackiaian, vestitol and sativan.
9- Kaempferol glycosides: Lilyn.
10 -Phenolic compounds: Scopoletin, chlorogenic, caeffic acids, p-coumaric acids, hymercromone, coumarin and trigocoumarin.
11- Stercal sapogenin-peptide ester: Fenugreekine.

Table 2: The most important medicinal properties of fenugreek.[8]

1- Anti-diabetic and cholesterol lowering properties.
2- Anti-hyperthyroidism
3- Against thyroxine-induced hyperglycaemia.
4- Protection in cases of ethanol induced toxicity.
5- Anti-cancer effects.
6- Gastro-protective effect.
7- Antioxidant property.
8- Antinociceptive property.
9- Antimicrobial property.
10- Anthelmintic property.
11- Anti-sterility and anti-androgenic effects.
12- Anti-allergic property.
13- Wound healing property.
14- Anti-inflammatory and antipyretic actions.

Table 3: Pharmacological and therapeutic benefits of fenugreek.[9]

Disease/Disorders	Description
Diabetes	4-hydroxyisoleucine (amino acid) stimulates insulin production thereby control blood sugar level
	Polyphenolic compounds exhibit anti-diabetic effects
	Curative effects of fenugreek seed powder is a potential neuropathic medicine in diabetes
Cancer	Polyphenolic compounds from seed possess anti-carcinogenic activities
Hypercholesterolemia	Anti-oxidants from seeds control high blood cholesterol
	Flavonoids from ethyl acetate extracts of seeds exhibit hypcholesterolemic abilities
Myocardial infarction	Trigonelline (anti-oxidant) detoxification of free radicals, high lipid peroxidation and enzymes prevents Myocardial injuries
Skin irritation	Seeds extract reduces the skin irritation and pain
	Seed powder paste produces skin healing, moisturizing, smoothening, whitening
Indigestion and flatulence	
Inflammation	Reduces swelling and pain
	Mucilage from seed detoxify the oxidants and free radicals to reduce inflammation
Anemia	Prevents red blood cell oxidation
	being rich in iron (Fe) seeds are valuable to reduce anemia
	Restoration and Fe nutrition in iron deficiency patients
Immunodeficiency	Natural antioxidants help to strengthen immune system
	Immunomodulatory and Immune stimulatory effects
Aging	Antioxidants improves reduces cell death and aging
Kidney disorders	Protects functional and histopathologic abnormalities of kidney in diabetic patients
	Reduces catalase (CAT) contents and superoxide dismutase (SOD) activity in hypercholesterolemia patients
	Inhibit accumulation of oxidized DNA to prevent kidney injuries
Others	Respiratory disorders, bacterial infection, epilepsy, gout, chronic cough, paralysis, dropsy, piles, heavy metal toxicity, liver disorders and arthritis

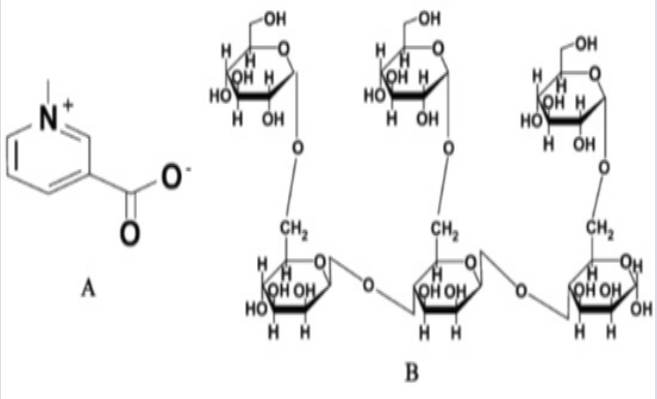

Figure 1: a: Trigonelline, b: Galactomannan.

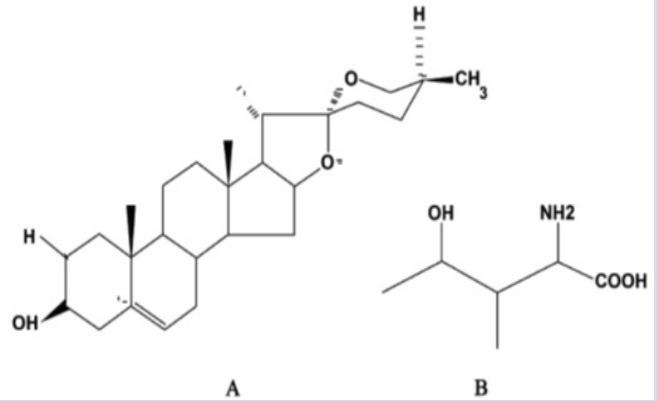

Figure 2: a: Diosgenin, b: 4-Hydroxyisoleucine.

different type of pharmacological activities, including as a functional food.[23] Chen *et al.*[24] found that diosgenin (3-O-{(β-D-glucopyranosyl-(1→3)-[β-D-glucopyranosyl-(1→6)-β-D-glucopyranosul-(1→4)-[α-L-rhamnopyranosyl-(1→2)-β-Dglucopyranoside}, CAS RN 512-06-1) is one of the most important precursors in the synthesis of steroidal drugs. The structures of diosgenin and 4-hydroxyisoleucine is presented in Figure 2.

HEALTH BENEFITS OF DIOSGENIN

Diosgenin has recently been shown to exert antiproliferative and proapoptotis actions on rheumatoid arthritis synoviocytes as well as on cancer cells *in vitro* and *in vivo*.[25] It has been reported that diosgenin, which is a steroidal sapogenin, exhibited biological activities including antioxidant, anti-diabetes, anti-inflammatory, anti-cancer and anti-adipogenic activities.[26] Haratake *et al.*[27] concluded that diosgenin can improve skin collagen content by shifting the dynamics of the fibroblasts from proliferation to differentiation via cell cycle arrest. They therefore revealed a new therapeutic potential of diosgenin for human breast cancer metastasis therapy. Khosravi *et al.*[28] observed that diosgenin improves sperm count, motility and viability, in addition to preventing of damage to seminiferous tubules in diabetic animals. Kanchan *et al.*[29] found that diosgenin is a promising candidate in diabetes-associated complications through its antioxidant and anti-inflammatory activity. Chen *et al.*[30] showed that diosgenin could also be a potential agent for treating human liver cancer.

CONCLUSION

Traditional medicine can be integrated into medical practice with western pharmaceutical sciences. Fenugreek is an annual forage legume mostly produced in Asia and Euro-Asia. It is also known as an important forage and spice crop. The important medicinal properties of fenugreek are anti-diabetic and cholesterol lowering properties, anti-hyperthyroidism against thyroxine-induced hyperglycaemia, protection in cases of ethanol induced toxicity, anti-cancer effects, gastro-protective effects, antioxidant properties, antinociceptive properties, antimicrobial properties, anthelmintic properties, anti-sterility and anti-androgenic effects, anti-allergic property, wound healing property and anti-inflammatory and antipyretic actions. Fenugreek galactomannan is a heteropolysaccharide which reduce level of blood glucose level, normalize the surface activities inside the small intestine; they are also used in food products in order to increase the thickness of the water content. The most important health benefits of galactomanna are reduction in LDL cholesterol levels in hypercholesterolemic, blood lipids, blood pressure and fibrinolysis. It displays a number of promising properties and attributes for future application as therapeutic agents in biotechnology and other pharmaceutical sciences. Diosgenin is an isospirostane derivative, it is a steroidal sapogenin and the product of acids or enzymes hydrolysis process of dioscin and protodioscin. Diosgenin shows different biological activity like antioxidant, anti-diabetes, anti-inflammatory, anti-cancer and anti-adipogenic. All in all, in conclusion as fenugreek seed is a rich source of so many important chemicals like complex carbohydrates (galactomannan), steroidal sapogeneins (diosgenin) and other bioactive components, it can be considered as an important medicinal crop for both humans and animals.

ACKNOWLEDGEMENT

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CONFLICT OF INTEREST

The authors declare no conflict of interests.

ABBREVIATIONS

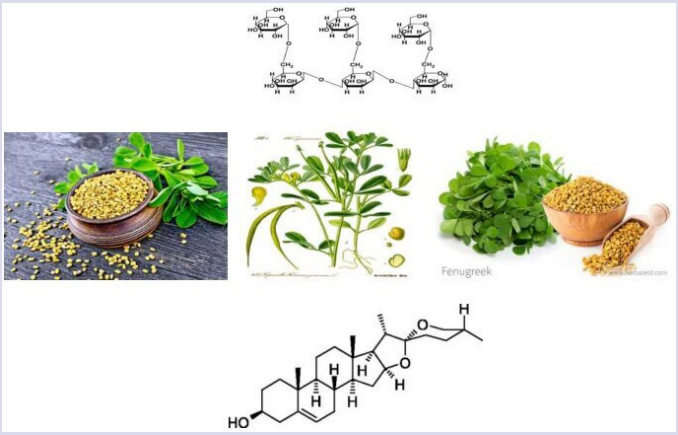
TCM: Traditional Chinese Medicine; **GM:** Galactomannans; **MD:** Molecular Dynamics; **LMWGAL-TF:** Low Molecular Weight Galactomannans Fraction from Fenugreek Seeds; **DM:** Diabetes Mellitus; **CAT:** Reduce catalase; **SOD:** Superoxide dismutase.

REFERENCES

1. Shahrajabian MH, Sun W, Cheng Q. Clinical aspects and health benefits of ginger (*Zingiberofficinale*) in both traditional Chinese medicine and modern industry. Acta Acta Agr Scand B-S P. 2019;69(6):546-56. DOI: 10.1080/09064710.2019.1606930
2. Shahrajabian MH, Sun W, Shen H, Cheng Q. Chinese herbal medicine for SARS and SARS-CoV-2 treatment and prevention, encouraging using herbal medicine for COVID-19 outbreak. Acta Agr Scand B-S P. 2020;1-7. DOI: 10.1080/09064710.2020.1763448
3. Shahrajabian MH, Sun W, Cheng Q. Chinese star anise (*Illicium verum*) and pyrethrum (*Chrysanthemum cinerariifolium*) as natural alternatives for organic farming and health care: A review. Aust J Crop Sci. 2020;14(03):517-23.
4. Shahrajabian MH, Sun W, Cheng Q. A review of astragalus species as foodstuffs, dietary supplements, a traditional Chinese medicine and a part of modern pharmaceutical science. Appl Ecol Env Res. 2019;17(6):13371-82.
5. Shahrajabian MH, Sun W, Cheng Q. Climate change, acupuncture and traditional Chinese herbal medicines. Pharmacogn Commun. 2019;9:91-5.
6. Thomas JE, Basu SK, Acharya SN. Identification of *Trigonella* accessions which lack antimicrobial activity and are suitable for forage development. Can J Plant Sci. 2006;86(3):727-32.
7. Wani SA, Kumar P. Fenugreek: A review on its nutraceutical properties and utilization in various food products. J Saudi Soc Agric Sci. 2016;17(2):97-106.

8. Acharya SN, Thomas JE, Basu SK. Fenugreek and alternative crop for semiarid regions of North America. Crop Sci. 2008;48(3):841-53.
9. Ahmad A, Alghamdi SS, Mahmood K, Afzal M. Fenugreek a multipurpose crop: Potentialities and improvements. Saudi J Biol Sci. 2016;23(2):300-10.
10. Zhang Z, Wang H, Chen T, Zhang H, Liang J, Kong W, *et al.* Synthesis and structure characterization of sulfated galactomannan from fenugreek gum. Int J Biol Macromol. 2019;125:1184-91.
11. Jiang JX, Zhu LW, Zhang WM, Sun RC. Characterization of galactomannan gum from fenugreek (*Trigonellafoenum-graecum*) seeds and its rheological properties. Int J Polym Mater Po Biomaterials. 2007;56(12):1145-54.
12. Rossi B, Campia P, Merlini L, Brasca M, Pastori N, Farris S, *et al.* An aerogel obtained from chemo-enzymatically oxidized fenugreek galactomannas as a versatile delivery system. Carbohydr Polym. 2016;144:353-61.
13. Ponzini E, Natalello A, Usai F, Bechmann M, Peri F, Muller N, *et al.* Structural characterization of aerogels derived from enzymatically oxidized galactomannans of fenugreek, sesbania and guar gums. Carbohydr Polym. 2019;207:510-20.
14. Rashid F, Hussain S, Ahmed Z. Extraction purification and characterization of galactomannan from fenugreek for industrial utilization. Carbohydr Polym. 2018;15:88-95.
15. Doyle JP, Lyons G, Morris ER. New proposals on hyperentanglement of galactomannans: Solution viscosity of fenugreek gum under neutral and alkaline conditions. Food Hydrocoll. 2009;23(6):1501-10.
16. Srinivasan K. Role of spices beyond food flavoring: nutraceuticals with multiple health effects. Food Rev Int. 2005;21(2):167-88.
17. Hannan JM, Ali L, Rokeya B, Khaleque J, Akhter M, Flatt PR, *et al.* Soluble dietary fibre fraction of *Trigonellafoenum-graecum* (fenugreek) seed improves glucose homeostatis in animal models of type 1 and type 2 diabetes by delaying carbohydrate digestion and absorption and enhancing insuling action. Br J Nutr. 2007;97(3):514-21.
18. Rampogu S, Parameswaran S, Lemuel MR, Lee KW. Exploring the therapeutic ability of fenugreek against type 2 diabetes and breast cancer employing molecular docking and molecular dynamics simulations. Evid Based Complmentary Altern Med. 2018. Article ID: 1943203, 12 pages.
19. Kamble H, Kandhare AD, Bodhankar S, Mohan V, Thakurdesai P. Effect of low molecular weight galactomannans from fenugreek seeds on animal models of diabetes mellitus. Biomed Aging Pathol. 2013;3(3):145-51.
20. Hamden K, Jaouadi B, Carreau S, Bejar S, Elfeki A. Inhibitory effect of fenugreek galactomannan on digestive enzymes related to diabetes, hyperlipidemia and liver-kidney dysfunctions. Biotechnol Bioprocess Eng. 2010;15(3):407-13.
21. Majeed M, Majeed S, Nagabhushanam K, Arumugam S, Natarajan S, Beede K, *et al.* Galactomannan from *Trigonellafoenum-graecum* L. seed: Prebiotic application and its fermentation by the probiotic *Bacillus coagulans* strain MTCC 5856. Food Sci Nutr. 2018;6(3):666-73.
22. Zhang X, Jin M, Tadesse N, Zhan G, Zhang H, Dang J, *et al.* Methods to treat the industrial wastewater in diosgenin enterprises produces from *Diosoreazingi berensis* CH. Wright. J Clean Prod. 2018;186:34-44.
23. Manasa P, Mohan RSVB, Sasikala V, Vangalapati M. Extraction of natural drug diosgenin from herbal plant *Tribulus terristris*. Int J Appl Innov Eng Manage. 2018;7:29-35.
24. Chen FX, Zhao MR, Ren BZ, Zhou CR, Peng FF. Solubility of diosgenin in different solvents. J Chem Thermodynamics. 2012;47:341-6.
25. Leger DY, Battu S, Liagre B, Cardot PJP, Beneytout JL. Sedimentation field flow fractionation to study human erythroleukemia cell megakaryocytic differentiation after short period diosgenin induction. J Chromatogr A. 2007;1157(1-2):309-20.
26. Sethi A, Singh RP, Shukla D, Singh P. Synthesis of novel pregnane-diosgenin prodrugs via Ring A and Ring A connection: A combined experimental and theoretical studies. J Mol Struct. 2016;1125:616-23.
27. Haratake A, Watase D, Setoguchi S, Nagata-Akaho N, Matsunaga K, Takata J. Effect of orally ingested diosgenin into diet on skin collagen content in a low collagen skin mouse model and its mechanism of action. Life Sci. 2017;174:77-82.
28. Khosravi Z, Sedaghat R, Baluchnejadmojarad T, Roghani M. Diosgenin ameliorates testicular damage in streptozotocin-diabetic rats through attenuation of apoptosis, oxidative stress and inflammation. Int Immunopharmacol. 2019;70:37-46.
29. Kanchan DM, Somani GS, Peshattiwar VV, Kaikini AA, Sathaye S. Renoprotective effect of diosgenin in streptozotocin induced diabetic rats. Pharmacol Rep. 2016;68(2):370-7.
30. Chen Z, Xu J, Wu Y, Lei S, Liu H, Men Q, *et al.* Diosgenin inhibited the expression of TAZ in hepatocellular carcinoma. Biochem Biophys Res Commun. 2018;503(3):1181-5.

PICTORIAL ABSTRACT



SUMMARY

- Traditional medicine can be integrated into medical practice with western pharmaceutical sciences.
- Fenugreek is an annual forage legume mostly produced in Asia and Euro-Asia. It is also known as an important forage and spice crop.
- The important medicinal properties of fenugreek are anti-diabetic and cholesterol lowering properties, anti-hyperthyroidism against thyroxine-induced hyperglycaemia, protection in cases of ethanol induced toxicity, anti-cancer effects, gastro-protective effects, antioxidant properties, antinociceptive properties, antimicrobial properties, anthelmintic properties, anti-sterility and anti-androgenic effects, anti-allergic property, wound healing property and anti-inflammatory and antipyretic actions.
- Fenugreek galactomannan is a heteropolysaccharide which reduce level of blood glucose level, normalize the surface activities inside the small intestine; they are also used in food products in order to increase the thickness of the water content.
- The most important health benefits of galactomanna are reduction in LDL cholesterol levels in hypercholesterolemic, blood lipids, blood pressure and fibrinolysis. It displays a number of promising properties and attributes for future application as therapeutic agents in biotechnology and other pharmaceutical sciences.
- Diosgenin is an isospirostane derivative, it is a steroidal sapogenin and the product of acids or enzymes hydrolysis process of dioscin and protodioscin. Diosgenin shows different biological activity like antioxidant, anti-diabetes, anti-inflammatory, anti-cancer and anti-adipogenic. All in all, in conclusion as fenugreek seed is a rich source of so many important chemicals like complex carbohydrates (galactomannan), steroidal sapogeneins (diosgenin) and other bioactive components, it can be considered as an important medicinal crop for both humans and animals.

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