



UNLOCKING THE HEALTH BENEFITS OF *GYMNEMA SYLVESTRAE*

M. Karthick^{1*}, S. Bhuvaneshwari², D. Janani² and S. Pavithra²

¹Asst. Professor, Department of Pharmacognosy, K. K. College of Pharmacy, Gerugambakkam, Chennai-600128, Tamil Nadu, India.

²Students of B. Pharm (4th Year)

*Corresponding Author: M. Karthick

Asst. Professor, Department of Pharmacognosy, K. K. College of Pharmacy, Gerugambakkam, Chennai-600128, Tamil Nadu, India.

Article Received on 25/08/2023

Article Revised on 15/09/2023

Article Accepted on 05/10/2023

ABSTRACT

Gymnema sylvestre is a plant that has been used in traditional medicine for thousands of years. The plant's medicinal value include bitter, acrid, thermogenic, digestive, liver-tonic, anodyne, and anti-inflammatory properties. The phenolic compounds of this plant are known as stigmaterol and triterpenoid saponins. These compounds have a wide range of pharmacological significance as a naturopathic medication since ancient times. In this review, we will focus on the pharmacodynamics of this medicinal plant, as well as its therapeutic potential for diabetes, obesity, cardiovascular disorders, and dietary supplements in the food industry.

KEYWORDS: *Gymnema sylvestrae*, Anti-oxidant, Gymnemic acids, Anti-Diabetic.

INTRODUCTION

Plants are a key source of our contemporary medicine and a major trumpcard for drug discovery research. Only 5 to 15% of plants have been researched for their potential as medicines, despite the fact that about 25% of contemporary medications are derived from plant sources.^[1] By using chromatographic methods, it was discovered that *Gymnema sylvestre* stems contain a number of chemical substances that have medicinal value, including stigmaterol and triterpenoid saponin. Stigmaterol which is responsible for hypoglycemic, anticancer activity and anti-tumor activity is due to triterpenoids.^[2-5] The leaves of the plant contain saponins of the oleanane and dammarane types^[6] Additionally, it also includes cardiac glycosides, anthraquinones, etc^[7] The ethanolic extract of plant demonstrated considerable 1,1-diphenyl-2-picrylhydrazyl radical scavenger action and superior antioxidant activity.^[8] Methanolic extract of plant showed anti-inflammatory effects in rats when carrageenan-induced inflammation was given to Wistar rats^[9] This plant was proved to have high antioxidative potential and hydroxyl free radical scavenging activity against DPPH, with hydroxyl free radical inhibition at a level of 59%^[10] It has a radical-scavenging action against ferric superoxide and hydrogen peroxide.^[11] Clinical studies have demonstrated that this plant can reduce blood sugar, triglycerides, total cholesterol and thereby reduces body weight, in addition to raising the blood's availability of insulin and C-peptide.^[12] In the Ayurvedic medical system and Indian Pharmacopoeia, *Gymnema sylvestre* is listed as one of the main botanicals used to

treat diabetes.^[13] Although this plant has various beneficial characteristics that demonstrate its value, there isn't much research, particularly clinical trials on it.

BOTANICAL DESCRIPTION AND TAXONOMY OF *Gymnema sylvestre*

Gymnema sylvestre is a delicate species with a sluggish rate of growth. In the arid woods of central and Southern India and other parts of Asia, it emerges as a densely branched, woody plant that may climb to the top of trees.^[14-15]

Taxonomical Classification



Fig. 1: *Gymnema sylvestriae*.

Kingdom	Plantae
Sub-kingdom	Tracheobionta
Super division	Spermatophyta
Division	Magnoliophyta
Class	Magnoliopsida
Subclass	Asteridae
Order	Gentianales
Family	Asclepiadaceae
Genus	<i>Gymnema</i> R. Br.
Species	<i>Sylvestre</i>

Table 1: Taxonomy.

This shrub is pubescent in nature and has just sprung stems and branches.^[16] It has a tap root system.^[17] Cylindrical, branching, rigid, twining, terete internodes, 0.7–17.2 cm long, and 2–10 mm in diameter are the characteristics of the stems^[17-18]. The leaves are 2.5–6 cm long, often oval or elliptic, and feature a distichous phyllotactic opposite arrangement pattern^[16]. The petioles of the leaves are 1-2 cm long, smooth above, with a rounded base and thickly velvety pubescent beneath. The leaves are acute or briefly acuminate.^[18-19]

TRADITIONAL USES

Gymnema sylvestriae is described as the treatment for urinary disorders and glycosuria in the ancient medical text of Shushruta.^[20] According to the traditional medicine, Ayurveda, and homoeopathic schools of medicine, it is a medicinal plant with a variety of possible uses.^[16] The Ayurvedic medical system has traditionally utilised it to treat ailments brought on by phlegm and piles, as well as diabetes, malaria, and snake bites^{[13][19]}. Asthma, bronchitis, amenorrhoea, leukoderma, haemorrhoids, jaundice, renal and vesicle calculi, cardiopathy and dyspepsia are among conditions for which the herb is given in Ayurveda.^[20-22] Additionally, many plant components, including the roots, stem, and leaves, have been utilised in traditional medical systems as cardiostimulant, digestive, diuretic, laxative, stimulant, stomachic, and uterine tonics.^[22]

PHYTOCHEMISTRY OF *Gymnema sylvestriae*

Utilising chromatographic methods, it was discovered that *Gymnema sylvestriae* stems contain a number of chemical substances that have medicinal value, including stigmasterol and triterpenoid saponin. The therapeutic potential of stigmasterol compounds is extensive and includes anti-diabetic, hypoglycemia, antioxidant, and anti-cancer properties. In several investigations, triterpenoid saponins also demonstrated anti-tumor, anti-fungal, hepatoprotective, and antidiabetic potential.^[2-5] Gymnemic acids and gymnema saponins, which are categorised as oleanane saponins, are the main chemical

components of this plant. *Gymnema sylvestriae* leaves contain saponins of the oleanane and dammarane types^[6]. Additionally, this plant's leaves include cardiac glycosides, anthraquinones, saponins, tannin, quinones, flavonoids, and phenols.^[7,23]

ANTIDIABETIC

One of the most significant medicinal herbs for the treatment of diabetes in India is *Gymnema sylvestriae*. An active component obtained from this plant that has anti-diabetic properties is gymnemic acid. Numerous studies have been conducted worldwide on this plant's anti-diabetic properties. On diabetic rabbits treated with alloxan, Shanmugasundaram et al. (1983) investigated the anti-diabetic efficacy of *Gymnema*.^[4-5] They demonstrated how *Gymnema* dried leaf powder controls blood sugar levels and preserved its homeostasis. Additionally, it controlled the amounts of sorbitol dehydrogenase, phosphorylase, and gluconeogenic enzymes. Data indicated that using *Gymnema* leaf extracts may help type 2 diabetes individuals renew or repair their pancreatic beta cells. After the subjects serum samples were taken, higher levels of insulin were detected.

Perfect Keto

What is *Gymnema Sylvestre*?

Gymnema sylvestre is a plant native to Asia, Africa, and Australia. Leaves have historically been used in traditional Ayurvedic medicine.

It's now used as a dietary supplement, and it's available as a liquid extract, in capsule form, and as an herbal tea.



Potential Health Benefits of *Gymnema Sylvestre*

- Reducing sugar cravings
- Promoting weight loss
- Blood sugar regulation
- Improving heart health

Possible Side Effects of *Gymnema Sylvestre*

- Shakiness
- Sweating
- Muscle problems
- Low blood sugar levels
- Weakness

Dosage

Tea
1 teaspoon steeped in 6 to 7 oz of hot water for 5 to 15 min.

Capsules
600 mg per day



G. sylvestre is available in multiple forms. The proper dosage depends on which type you purchase. When in doubt, it's best to stick to the recommended daily dosage on your supplement label.

ANTIOXIDANT

Compared to *A. bilimbi* and *C. frutescens*, this plant's ethanol extract demonstrated considerable 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging action and superior antioxidant capacity.^[8] In a study, *Gymnema sylvestre*'s antioxidant efficacy against DPPH was also noted. This plant was shown to be more effective in scavenging DPPH radicals, while in another, it was discovered to be able to lower LDL oxidation.^[24-25] This plant was shown to have high antioxidative potential and hydroxyl free radical scavenging activity against DPPH, with hydroxyl free radical inhibition at a level of 59.8% and DPPH inhibition at 87.3%, respectively.^[10]

Additionally, it was discovered to have considerable radical scavenging action against ferric super oxide and hydrogen peroxide, as well as antioxidant activity in a variety of circumstances, including those involving high fat diets, hydrogen peroxide, nitric oxide, and superoxide radicals induced oxidative stress in rats.^[26-28]

ANTI INFLAMMATORY

When carrageenan-induced inflammation was administered to Wistar rats, *Gymnema sylvestre*'s methanolic extract demonstrated anti-inflammatory action in the rats.^[9] This plant's methanolic extract considerably (p 0.05) decreased the oedema in the rat paws caused by carrageenan. In a different investigation, this plant's aqueous extract showed inhibitory efficacy against carrageenan-induced rat paw oedema and mouse peritoneal ascites.^[29] A 50% inhibitory dosage of 50–555 nmol/ear of this plant's ethanolic extract was also discovered to have inhibitory effects against TPA-induced inflammation.^[30]

Since time immemorial, the leaves of *G. sylvestre* are said to be anodyne, bitter, acrid, thermogenic, digestive, liver-tonic, and anti-inflammatory.^[31] in nature. The anti-inflammatory activities of *G. sylvestre* are due to the

plant's bioactive tannins and saponins.^[32] In the study on rats with granuloma and paw oedema brought on by cotton pellets, the aqueous extract of *G. sylvestre* leaf was examined for its anti-inflammatory activity at doses of 200, 300, and 500 mg/kg using the drug phenylbutazone as the reference. At a dose of 300 mg/kg, *Gymnema* aqueous extract was shown to significantly reduce paw oedema volume by 48.5% after 4 hours, whereas phenylbutazone significantly reduced paw oedema volume by 57.6%. Furthermore, in comparison to the control group, the aqueous extract at concentrations of 200 and 300 mg/kg showed a reduction in granuloma.^[33]

LIPID LOWERING ACTIVITY

It was discovered that *Gymnema sylvestre* leaf extract has extremely powerful hypolipidaemic action. The leaf extract was given to Wister female rats as part of a study. A high-fat diet was used to cause hyperlipidemia in these rats. This extract was found to drastically reduce cholesterol, Low-Density Lipoprotein (LDL) and triglyceride levels while efficiently raising High-Density Lipoprotein (HDL) levels.^[34] *Gymnema sylvestre* hydro-alcoholic leaf extract also shown to have lipid-lowering capability. In this experiment, rats were administered high cholesterol for seven days, and it was shown that these rats had greater levels of cholesterol, triglycerides, and LDL while having lower levels of HDL. *Gymnema sylvestre* extract was administered to these rats after seven days, and it was found to reduce the elevated levels of cholesterol, triglycerides, and LDL while increasing HDL levels.^[35-36] Due to the presence of acidic components such as flavonoids, saponins, tannins, etc., it has been hypothesised that this plant has the ability to decrease cholesterol levels. It was claimed in a number of additional studies to lower triglycerides, cholesterol, Very Low-Density Lipoprotein (VLDL), and Low-Density Lipoprotein (LDL) in diabetic rats.^[36-37]

DENTAL CARIES

Dental caries are infections of the teeth caused by a variety of gram-positive cariogenic bacteria, such as *S. aureus*, *S. mitis* and *S. mutans* as well as the fungus-like *Candida albicans*, which attaches to the tooth surface by releasing extracellular polysaccharides from sucrose and metabolises sugar into organic acids, primarily lactic acid, leading to demineralization of the tooth enamel.^[37-38] The *Gymnema sylvestre* leaf extracts in chloroform, petroleum ether and methanolic form were tested against microbial dental infections at concentrations of 25, 50 and 100 mg/mL and were found to be significantly effective against these carcinogenic bacteria, with the methanolic extract possessing the highest activity at the lowest concentration. Due to the plant's hydroalcoholic extract's high potential, "Gurmar Herbal tooth paste" is developed and manufactured.^[39]

ETHNOBOTANICAL USES

Gurmar is referred to as a destroyer of madhumeha (glycosuria) and other urinary ailments in the ancient Indian medical text Sushruta. It contains anti-inflammatory, anodyne, digestive, emetic, diuretic, stomachic, stimulant, anthelmintic, laxative, cardiotoxic, expectorant, antipyretic, and uterine tonic are all claimed properties of *G. sylvestre* extract.^[43] Jaundice, constipation, cardiopathy, asthma, bronchitis, amenorrhea, conjunctivitis, renal and vesical calculi, dyspepsia leukoderma and Parkinsonism could be treated with this herb^[44]. The root bark works as an expectorant, emetic, and analgesic for bodily aches, while the root liquid is effective for treating snakebite. In addition it treats respiratory and cardiac conditions, piles and colic discomfort.^[45]



CLINICAL STUDY REPORTS

In addition to numerous studies on animal models, various extracts of this plant have also been examined to investigate its therapeutic potential on human body. 58 people with type 2 diabetes participated in a 90 day trial where the levels of fasting and postprandial blood glucose as well as lipids were lowered^[12] Another study used *Gymnema* leaf extract to treat 64 persons with type 1 diabetes for 6 to 30 months, which resulted in reduced plasma glucose levels and need for exogenous insulin.^[31]

BIOAVAILABILITY AND TOXICITY

Gymnemic acid's complicated structure, poor lipid solubility, and difficulty passing through biomembrane make it difficult for the body to absorb it through the circulatory system. A phytosome has a greater ability to pass the lipid bio membrane and enter the systemic circulation, which results in higher absorption and utilisation in the body. In doxorubicin-induced cardiotoxicity in rats, the complex has antiapoptotic potential and cardioprotective effects.^[46] *Gymnema sylvestre* extract is safe when consumed at the prescribed doses, according to toxicology tests. High dosages may cause adverse reactions such hypoglycemia, muscular dystrophy, weakness, and profuse sweating^[47]. No harmful consequences were seen after Wistar rats were given 1.00% baseline powder (GSE) in their food for 52 weeks, and no animals perished as a result of the experiment. *Gymnema sylvestre* therapy for diabetic individuals has been linked to toxic hepatitis or drug-induced liver damage (DILI)^[48]

CONCLUSION AND FUTURE PROSPECTUS

The use of herbal remedies as molecular targets in drug research and in pharmacological applications is on the rise at the moment. Humanity is seriously threatened by the new trend of increasing illness incidence and the difficulties that come along with using prescription drugs. Natural remedies are an alternative to pricey pharmaceuticals since they are relatively safe and have fewer negative effects. Nearly 80% of the population is said to rely on natural therapies for their medical needs. Many bioactive substances, including alkaloids, quinine, paclitaxel, opium alkaloids, quinine, atropine, and cardiac glycosides can be found in plants.

Metformin, the first anti-diabetic medication, was a herbal preparation that was extracted from *Galega officinalis*. The extinction of medicinal plants due to urbanization and industrialization poses a significant threat to their commercial importance. *G. sylvestre*, a valuable medicinal plant and source of bioactive substances, is at risk of extinction due to continuous deforestation and lack of established lines or varieties. *In vitro* propagation and cell culture technologies for large-scale production of secondary metabolites with medicinal significance are promising approaches.

Various polyherbal formulations, such as Dihar and D-400 contain *G. sylvestre* extract, which has been used for

the treatment of Diabetes mellitus. The herb also has good prospects in dietary applications, with products like GNC Herbal Plus Standardized *G. sylvestre* (herbal supplement), Vitamin Shoppe *G. sylvestre* (sugar destroyer), *Gymnema gold* (Nutrigold), and Gurmar capsules (stimulates the heart and circulatory system and activates the uterus). In conclusion, *G. sylvestre* holds immense potential as a potent medication for diabetes, obesity, cardiovascular disorder and dietary supplements in the food industry.

REFERENCES

- Gurnani, N., Mehta, D., Gupta, M., and Mehta, B. K. Natural products: Source of potential drugs. *Afr. J. Basic. Appl. Sci.*, 2014; 6: 171–186. doi: 10.5829/idosi.ajbas.2014.6.6.21983.
- Matsuda, H., Murakami, T., Ninomiya, K., Inadzuki, M., and Yoshikawa, M. New hepatoprotective saponins, bupleurosides III, VI, IX, and XIII, from Chinese Bupleuri Radix: Structure-requirements for the cytoprotective activity in primary cultured rat hepatocytes. *Bioorg. Med. Chem. Lett.*, 1997; 7(17): 2193–2198. doi: 10.1016/S0960-894X(97)00418-6.
- Kaur, N., Chaudhary, J., Jain, A., and Kishore, L. Stigmasterol: a comprehensive review. *Int. J. Pharm. Sci. Res.*, 2011; 2(9): 2259–2265.
- Garai, S. Triterpenoid saponins. *Nat. Prod. Chem. Res.*, 2014; 2(6): 1000148. doi: 10.4172/2329-6836.1000148.
- Liu, Y., Xu, T.-H., Zhang, M.-Q., Li, X., Xu, Y.-J., Jiang, H.-Y., et al. Chemical constituents from the stems of *Gymnema sylvestre*. *Chin. J. Nat. Med.*, 2014; 12(4): 300–304. doi: 10.1016/S1875-5364(14)60059-5.
- Khranov, V. A., Spasov, A. A., and Samokhina, M. P. Chemical composition of dry extracts of *Gymnema sylvestre* leaves. *Pharm. Chem. J.*, 2008; 42(1): 30–32. doi: 10.1007/s11094-008-0051-8.
- Patel, M. R. Pharmacognostic and Phytochemical Evaluation of *Gymnema sylvestre* Leaf. *World J. Pharm. Pharm. Sci.*, 2017; 6(7): 1532–1538. doi: 10.20959/wjpps20177-9574.
- Rahman, M. M., Habib, M. R., Hasan, M. A., Saha, A., and Mannan, A. Comparative assessment on *In vitro* antioxidant activities of ethanol extracts of *Averrhoa bilimbi*, *Gymnema sylvestre* and *Capsicum frutescens*. *Pharmacog. Res.*, 2014; 6: 36–41. doi: 10.4103/0974-8490.122915.
- Kumar, A. R., Rathinam, K. S., and Kumar, C. A. Evaluation of Anti-inflammatory Activity of some selected species of Asclepiadaceae Family. *Int. J. Chem. Sci.*, 2012; 10(1): 548–556.
- Gunasekaran, V., Srinivasan, S., and Rani, S. S. Potential antioxidant and antimicrobial activity of *Gymnema sylvestre* related to diabetes. *J. Med. Plants*, 2019; 7(2): 05–11.
- Rachh, P. R., Patel, S. R., Hirpara, H. V., Rupareliya, M. T., Rachh, M. R., Bhargava, A. S., et al. *In-vitro* evaluation of antioxidant activity of *Gymnema*

- sylvestre R.Br. leaf extract. *Rom. J. Biol. Plant Biol.*, 2009; 54(2): 141–148.
12. Kumar, S. N., Mani, U. V., and Mani, I. An Open Label Study on the Supplementation of *Gymnema sylvestre* in Type 2 Diabetics. *J. Die. Suppl.*, 2010; 7(3): 273–282. doi: 10.3109/19390211.2010.505901.
 13. Singh, V. K., Umar, S., Ansari, S. A., and Iqbal, M. *Gymnema sylvestre* for diabetics. *Journal of Herbs. J. Herbs Spices Med. Plants*, 2008; 14 (1–2): 88–106. doi: 10.1080/10496470802341508.
 14. Wu, X., Mao, G., Fan, Q., Zhao, T., Zhao, J., Li, F., et al. Isolation, purification, immunological and anti-tumor activities of polysaccharides from *Gymnema sylvestre*. *Food. Res. Int.*, 2012; 48(2): 935–939. doi: 10.1016/j.foodres.2012.02.006.
 15. Kapoor, L. D. *CRC Handbook of Ayurvedic Medicinal Plants*. S.I. (Boca Raton, Florida, USA: CRC Press). doi: 10.1201/9780203719473, 2017.
 16. Kanetkar, P., Singhal, R., and Kamat, M. *Gymnema sylvestre*: A Memoir. *J. Clin. Biochem. Nutr.* 41 (2), 77–81. doi: 10.3164/jcbrn.2007010, 2007.
 17. Najafi, S., and Deokule, S. S. Studies on *Gymnema sylvestre*-a medicinally important plant of the family *Asclepiadaceae*. *Trakia. J. Sci.*, 2011; 9(2): 26–32.
 18. Pramanick, D. D. “Anatomical studies on the leaf of *Gymnema sylvestre* (Retz.) R. Br. ex Schult. (*Apocynaceae*),” in *A magical herbal medicine for diabetes*. *Int. J. Herb. Med*, 2016; 4(1): 70–72.
 19. Kirtikar, K. R., and Basu, B. D. “Indian medicinal plants, vol. III,” in *Periodical Experts D-42 (Vivek Vihar Delhi)*, 1975.
 20. Nadkarni, K. M. “*Gymnema sylvestre*,” in *Indian Materia Medica with Ayurvedic Unani*, vol.I (Bombay, India: Popular Prakashan), 1986; 596–599.
 21. Sastry, B. S. *Gymnema sylvestre*. Chaukhambha, Varanasi, India: Bhav Prakash Nighantu, 1994.
 22. Mathew, M. *Aromatic and Medicinal Plants Research Station, Odakkali-A Centre for Promoting Medicinal and Aromatic Plants*. *Indian Coconut J. Cochin*, 2004; 34(10): 10–15.
 23. Senthilkumar, M. Phytochemical Screening and Antibacterial Activity of *Gymnema sylvestre* R.Br. Ex Schult. *Int. J. Pharm. Sci. Res.*, 2015; 6(6): 2496–2503. doi: 10.13040/IJPSR.0975-8232.6(6).2496-03.
 24. Rupanar, S. V., Pingale, S. S., Dandge, C. N., and Kshirsagar, D. Phytochemical screening and In vitro evaluation of antioxidant antimicrobial activity of *Gymnema sylvestre*. *Int. J. curr. Res.*, 2012; 8(12): 43480–43486. doi: 10.7897/2230-8407.080327.
 25. Ohmori, R., Iwamoto, T., Tago, M., Takeo, T., Unno, T., Itakura, H., et al. Antioxidant activity of various teas against free radicals and LDL oxidation. *Lipids*, 2005; 40(8): 849–853. doi: 10.1007/s11745-005-1447-4.
 26. Arun, L. B., Arunachalam, A. M., Arunachalam, K. D., Annamalai, S. K., and Kumar, K. A. In vivo anti-ulcer, anti-stress, anti-allergic, and functional properties of *Gymnemic Acid* Isolated from *Gymnema sylvestre* R Br. *BMC Complement Altern. Med*, 2014; 14(70). doi: 10.1186/1472-6882-14-70.
 27. Kishore, L., and Singh, R. Protective effect of *Gymnema sylvestre* L. against advanced glycation end-product, sorbitol accumulation and aldose reductase activity in Homoeopathic Formulation. *Indian J. Res. Homoeopathy*, 2015; 9(4): 240–248. doi: 10.4103/0974-7168.172866.
 28. Chakrapani, L. N., and Periandavan, K. Protective role of gymnemic acid in curbing high fat diet and high fructose induced pancreatic oxidative stress mediated type-2 diabetes in wistar rats. *Int. J. Pharm. Sci. Res.*, 2018; 9(5): 2130–2139. doi: 10.13040/IJPSR.0975-8232.9(5).2130-39.
 29. Diwan, P. V., Margaret, I., and Ramakrishna, S. Influence of *Gymnema sylvestre* on inflammation. *Inflammopharmacol*, 1995; 3(3): 271–277. doi: 10.1007/BF02659124.
 30. Yasukawa, K., Okuda, S., and Nobushi, Y. Inhibitory effects of *Gymnema* (*Gymnema sylvestre*) leaves on tumour promotion in two-stage mouse skin carcinogenesis. *J. Evid. Based Complement. Altern. Med*, 2014; 1–5. doi: 10.1155/2014/328684.
 31. C. K. Kokate, *Pharmacognosy*, vol. 12, Nirali Prakashan, 1999.
 32. P. V. Diwan, I. Margaret, and S. Ramakrishna, “Influence of *Gymnema sylvestre* on inflammation,” *Inflammopharmacology*, 1995; 3: 271–277.
 33. J. K. Malik, F. V. Manvi, K. R. Alagawadi et al., “Evaluation of anti-inflammatory activity of *Gymnema sylvestre* leaves extract in rats,” *International Journal of Green Pharmacy*, 2007; 2: 114–115.
 34. Shanmugasundaram, E., Rajeswari, G., Baskaran, K., Kumar, B., Shanmugasundaram, K., and Ahmath, B.. Use of *Gymnema sylvestre* leaf extract in the control of blood glucose in insulin-dependent diabetes mellitus. *J. Ethnopharmacol*, 1990b; 30(3): 281–294. doi: 10.1016/0378-8741(90)90107-5.
 35. Singh, D. K., Kumar, N., Sachan, A., Lakhani, P., Tutu, S., Nath, R., et al. Hypolipidaemic effects of *Gymnema sylvestre* on high fat diet induced dyslipidaemia in wistar rats. *J. Clin. Diagn. Res.*, 2017; 11(5). FF01–FF05. doi: 10.7860/JCDR/2017/27430.9859.
 36. Rachh, P., Rachh, M., Ghadiya, N., Modi, D., Modi, K., Patel, N., et al. Antihyperlipidemic Activity of *Gymnema sylvestre* R. Br. Leaf Extract on Rats Fed with High Cholesterol Diet. *Int. J. Pharmacol*, 2010; 6(2): 138–141. doi: 10.3923/ijp.2010.138.141.
 37. Dholi, S. K., and Rapparla, R. K. In vivo anti-diabetic evaluation of gymnemic acid in streptozotocin induced rats. *J. Pharm. Innov.*, 2014; 3(7): 82–86.
 38. Bishayee, A., and Chatterjee, M. Hypolipidaemic and antiatherosclerotic effects of oral *Gymnema sylvestre* R. Br. Leaf extract in albino rats fed on a high fat diet. *Phytother. Res.*, 1994; 8(2): 118–120. doi: 10.1002/ptr.2650080216.

39. Kumar, V., Bhandari, U., Tripathi, C., and Khanna, G. Anti-obesity Effect of *Gymnema sylvestre* Extract on High Fat Diet-induced Obesity in Wistar Rats. *Drug Res.*, 2013; 63(12): 625–632. doi: 10.1055/s-0033-134985.
40. P. Marsh and M. Martin, *Oral Microbiology*, vol. 3, Chapman and Hall, London, UK, 1992.
41. M. S. Akhtar and V. Bhakuni, “*Streptococcus pneumoniae* hyaluronatylase: an overview,” *Current Science*, 2004; 86(2): 285–295.
42. B. ParimalaDevi and R. Ramasubramaniam, “Pharmacognostical and antimicrobial screening of *Gymnema sylvestre* R.Br, and evaluation of Gurmar herbal tooth paste and powder, composed of *Gymnema sylvestre* R.Br, extracts in dental caries,” *International Journal of Pharmaand Bio Sciences*, 2010; 1(3): 1–16.
43. K. R. Kirtikar and B. D. Basu, *Indian Medicinal Plants*, vol. 3, Periodicals Experts, Delhi, India, 1975.
44. M. Anis, M. P. Sharma, and M. Iqbal, “Herbal ethnomedicine of the Gwalior forest division in Madhya Pradesh, India,” *Pharmaceutical Biology*, 2000; 38(4): 241–253.
45. B. S. Sastry, *Gymnema sylvestre*, Bhav Prakash Nighantu, Chaukhambha, Varanasi, India, 1994.
46. R. A. Pathan, U. Bhandari, S. Javed, and T. C. Nag, “Anti-apoptotic potential of gymnemic acid phospholipid complex pretreatment in wistar rats with experimental cardiomyopathy,” *Indian Journal of Experimental Biology*, 2012; 50(2): 117–127.
47. Y. Ogawa, K. Sekita, T. Umemura et al., “*Gymnema sylvestre* leaf extract: a 52-week dietary toxicity study in wistar rats,” *Shokuhin Eiseigaku Zasshi*, 2004; 45(1): 8–18.
48. A. Shiyovich, I. Sztarkier, and L. Neshet, “Toxic hepatitis induced by *Gymnema sylvestre*, a natural remedy for type 2 diabetes mellitus,” *American Journal of the Medical Sciences*, 2010; 340(6): 514–517.